Iowa Department of Transportation

STANDARD SPECIFICATIONS FOR HIGHWAY AND BRIDGE CONSTRUCTION

SERIES 2012

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PREFACE

When referenced, the 2012 edition of the Iowa Department of Transportation's (Iowa DOT) Standard Specifications for Highway and Bridge Construction shall be used for contract work awarded by the Iowa DOT. They may also be incorporated by reference in other contract work on secondary, urban, local systems, or other contract work in which the Iowa DOT has an interest. As modified by the General Supplemental Specifications, these Standard Specifications represent the minimum requirements and may be modified by Supplemental Specifications, Developmental Specifications, and Special Provisions on specific contracts.

These Standard Specifications have been written so the Contractor's responsibilities are indicated by plain language using the Imperative Mood and Active Voice form. Sentences are of the form:

> Construct isolation joints at all points where driveways meet other walks, curbs, or fixtures in the surface.
>
> Ensure finished members are true to detailed dimensions and free from twists, bends, open joints, or other defects resulting from faulty fabrication or defective work.
>
> Personnel preparing the JMF shall be Iowa DOT certified in bituminous mix design.

The Contracting Authority's responsibilities are (with some exceptions) indicated by the use of the modal verb "will". Sentences are of the form:

> The Engineer will obtain and test density samples for each lot according to Materials I.M. 204.
>
> Payment will be the contract unit price for Fabric Reinforcement per square yard (square meter).

These standard specifications contain dual units of measure: the United States Standard measure (English units) and the International System of Units (SI or “metric” units). The English units are expressed first then followed by the metric units in parentheses. The measurements expressed in the two systems are not necessarily equal. In some cases the measurements in metric units is a “hard” conversion of the English measurement; i.e. the metric unit has been approximated with a rounded, rationalized metric measurement that is easy to work with and remember.

The proposal form will identify whether the work was designed and shall be constructed in English or metric units.

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Section 1101. Definitions

1101.01 GENERAL.

A. Wherever in these specifications or other contract documents the following definitions terms, or both, or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

In order to avoid cumbersome and confusing repetition of expressions in these specifications, it is provided that whenever anything is, or is to be, done, if, as, or, when, or where "contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered necessary, deemed necessary, permitted, reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected, or condemned," it shall be understood as if the expression were followed by the words "by the Engineer" or "to the Engineer."

B. The titles or headings of the sections and articles herein or referred to on the plans are intended for convenience of reference and shall not be considered as having any bearing on their interpretation.

C. The contract documents may reference specifications or standards that have been issued by organizations such as AASHTO, ASTM, ANSI, etc. In such instances the reference being made is to the specification or standard that is in effect four weeks prior to letting unless a specific date or year of issue is provided.

1101.02 DEFINITIONS OF ABBREVIATIONS.

Wherever the following abbreviations are used in these specifications or in the contract documents, they are to be construed the same as the respective expressions represented:

AA - Affirmative Action
AAN - American Association of Nurserymen
AAR - Association of American Railroads
AASHTO (or AASHO) - American Association of State Highway and Transportation Officials
ABI - Average Base Index
ABS - Acrylonitrile-Butadiene-Styrene
ACI - American Concrete Institute
AGC - Associated General Contractors of America
AIA - American Institute of Architects
AISC - American Institute of Steel Construction
ALS - American Lumber Standards
ANSI - American National Standards Institute
APA - American Plywood Association
API - American Petroleum Institute
APWA - American Public Works Association
ATSSA - American Traffic Safety Services Association
ARA - American Railway Association
AREA - American Railway Engineering Association
ARI - Air-Conditioning and Refrigeration Institute
ASA - American Standards Association
ASCE - American Society of Civil Engineers
ASLA - American Society of Landscape Architects
ASTM - American Society for Testing and Materials
AWPA - American Wood Preservers Association
AWS - American Welding Society
AWWA - American Water Works Association
BSC - Bituminous Seal Coat
CFR - Code of Federal Regulations
CLSM - Controlled Low Strength Material
CMP - Corrugated Metal Pipe
CPM - Critical Path Method
CRSI - Concrete Reinforcing Steel Institute
DBE - Disadvantaged Business Enterprise
DFT - Dry Film Thickness
DIP - Ductile Iron Pipe
DNR - Department of Natural Resources
DOT - Department of Transportation
EEI - Edison Electric Institute
EEO - Equal Employment Opportunity
EPA - Environmental Protection Agency
FHWA - Federal Highway Administration
FR - Federal Register
ESAL - Equivalent Single Axle Load
FSS - Federal Specifications and Standards

GGBFS - Ground Granulated Blast Furnace Slag
GRI - Geosynthetic Research Institute
GSA - General Services Administration
HDPE - High Density Polyethylene Pipe
HMA - Hot Mix Asphalt
IAC - Iowa Administrative Code
IMSA - International Municipal Signal Association
ID - Identification
I/D - Incentive/Disincentive
IMSA - International Municipal Signal Association
IEEE - Institute of Electrical and Electronics Engineers
IES - Illuminating Engineering Society
ICEA (or IPCEA) - Insulated Cable Engineers Association
IMSA - International Municipal Signal Association
ITE - Institute of Transportation Engineers
Materials I.M. - Materials Instructional Memorandum
MSDS - Material Safety Data Sheets
MUTCD - Manual on Uniform Traffic Control Devices
NCHRP - National Cooperative Highway Research Program
NEC - National Electrical Code
NEMA - National Electrical Manufacturers Association
NFPA - National Fire Protection Association
NSF - National Sanitation Foundation
OSHA - Occupational Safety and Health Administration
PE - Polyethylene Pipe
PCC - Portland Cement Concrete
PLS - Pure Live Seed
PVC - Polyvinyl Chloride Pip
RAP - Recycled Asphalt Pavement
RCAP - Reinforced Concrete Arch Pipe
RCP - Reinforced Concrete Pipe
SAE - Society of Automotive Engineers
SDR - Standard Dimension Ratio
SSPC - Steel Structures Painting Council
SUDAS - Statewide Urban Design and Specifications
UL - Underwriters' Laboratories, Inc.
US - United States
USC - United States Code
VCP - Vitrified Clay Pipe
VE - Value Engineering
VOC - Volatile Organic Compound

1101.03 DEFINITION OF TERMS.

Acceptable Work.
Work in reasonably close conformance with the contract requirements.

Addendum.
A revision to the contract documents written and issued after the notice to bidders, and prior to the advertised time for receipt of proposals. Changes reflected in the Addendum shall govern over all other contract documents.

Advertisement.
The public announcement, publication, or solicitation, as required by the Contracting Authority, inviting bids for work to be performed or materials to be furnished.

Affiliates.
Affiliate companies that have any individual who is an officer, director, or partner in both companies, or if one or more persons or entities own or control 20% or more of the stock of both companies.

Approval for Award.
The acceptance by the Contracting Authority of a bid.

Approved Equal (Equivalent).
A product or material that, upon review of the Engineer, is determined to meet or exceed the requirements called for by the specifications. Upon approval, the item will be allowed in lieu of the specified material or product.

Approximate Start Date.
A calendar day shown on the proposal on which it is anticipated, at the time of letting, that conditions will be such as to permit the Contractor to commence work.

Assignment of Contract.
The written agreement whereby the Contractor sells, assigns, or transfers rights in the contract to any person, firm, or corporation.

Award.
The execution of the contract.

Backslope.
The sloping surface of a cut, borrow pit, or ditch of which the downward inclination is toward the traveled way.

Bid Amount.
The aggregate sum obtained by totaling the amounts arrived at by multiplying the number of units of each class of work, as shown in the proposal form, by the unit price specified in the proposal form for that class of work.

Bid Bond.
See Proposal Guaranty.

Bidder.
An individual, firm, corporation, or joint venture submitting a bid for the advertised work.

Bid Item.
See Contract Item (Pay Item).

Board or County Board.
The County Board of Supervisors as constituted under Chapters 39 and 331, Code of Iowa.

Bridge.
Any structure, including supports, erected over a depression or an obstruction, such as water, a highway, or a railroad, and having a track or passageway for carrying traffic or other moving loads and having a length measured along the center of roadway of more than 20 feet (6.1 m) between undercopings of abutments or extreme ends of openings for multiple boxes.

Length. The length of a bridge structure is the overall length measured along the line of survey stationing back-to-back of backwall of abutments, if present, or otherwise end to end of the bridge floor, but in no case is less than the total clear opening of the structure.

Roadway Width. The clear width measured at right angles to the longitudinal center line of the bridge between the bottom of curbs or guard timbers or in the case of multiple height of curbs, between the bottoms of the lower risers.

Calendar Day.
Every day shown on the calendar.

Change Order.
A written order to the Contractor, signed by the Engineer, ordering a change in the performance of work or furnishing of materials, from that originally shown by the contract documents. Change orders duly signed and executed by the Contractor constitute authorized modifications of the contract, and may be performed at contract unit prices, agreed prices, or on a force account basis, as provided elsewhere in these specifications.

Channel.
A natural or artificial water course.

Chief Engineer.
A Professional Engineer licensed in the State of Iowa and appointed by the Director of the Department of Transportation.

Classes of Work.
The divisions made for the purpose of measuring and paying for labor to be performed or materials to be furnished according to the methods of construction involved, as indicated by the items for which bids have been received for each specific contract.

Commencement of Work.
Work will be considered commenced when the Contractor's operations are started on items of work covered by the contract documents and which require inspection within

the right-of-way; or when the Contractor notifies the Engineer, and the Engineer agrees, that the Contractor's equipment and personnel are available to the site, but the operations are prevented by weather or soil conditions.

Commission.
The State Transportation Commission as constituted under the laws of the State of Iowa (which is the party of the first part in the contracts let in behalf of the State, of which these specifications are a part).

Commissioner.
A member of the State Transportation Commission.

Completion Date.
The Date on which all work specified in the contract is completed.

Contract (Also Contract Documents).
The written agreement between the Contracting Authority and Contractor setting forth obligations of the parties thereunder, including but not limited to, performance of the work, furnishing of labor and materials, and basis of payment. The contract includes the following:

- Addendum,
- Contract bond,
- Contract form,
- Materials Instructional Memorandums,
- Notice to Bidders,
- Notice to Proceed,
- Plans,
- Proposal,
- Special Provisions,
- Standard Specifications, including General Supplemental Specifications,
- Developmental Specifications,
- Supplemental Specifications, and
- Any change orders and agreements which are required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

Contract Bond.
The bond executed by the Contractor and the Contractor's surety in favor of the party of the first part, guaranteeing the faithful performance of the obligation assumed by the contract and the payment of all debts pertaining to the work.

Contract Item (Pay Item).
A specifically described unit of work for which a price (either unit or lump sum) is provided in the contract.

Contract Period (Also Contract Time).
The number of working days allowed for completion of the contract, including authorized time extensions.

Contract Sum.
The aggregate sum obtained by totaling the amounts arrived at by multiplying the number of units of each class of work, as shown in the contract, by the unit price specified in the contract for that class of work.

Contract Unit Price.
The price bid by the Contractor for one unit of work, as defined by the specifications.

Contracting Authority.
The governmental body, board, commission, or officer having authority to award a contract.

Contractor.
The individual, firm, corporation, or joint venture contracting with the Contracting Authority for performance of prescribed work.

Contractor's Financial Statement.
The specified forms on which a contractor shall furnish required information as to the Contractor's ability to perform and finance the work.

Controlling Item of Work.
The Controlling Item of Work is the unique activity of a contract that will determine the duration of the construction period. The character of this work may change during the construction period. It is the work that could be in progress at any time that would have the greatest influence on the duration of the construction period.

County.
Party of the first part in the contract, let by a County Board of Supervisors, of which these specifications are a part.

County Auditor.
The auditor of the contracting county duly elected under Chapter 39, Code of Iowa.

County Engineer.
A Professional Engineer licensed in the State of Iowa and appointed by the County Board of Supervisors.

Culvert.
A structure not classified as a bridge or storm sewer which provides an opening under a roadway or embankment, except that such term shall not include tiles crossing the road, or intakes thereto, where such tiles are part of a tile line or system designed to aid subsurface drainage.

Deficient Work.
Work not in reasonably close conformance with the contract requirements, or otherwise inferior, but in the opinion of the Engineer, reasonably acceptable for its intended use and allowed to remain in place.

Department of Transportation (the Department).
The Department of Transportation, as defined in Iowa Code 307.

Developmental Specifications.
Additions and revisions to the standard, general supplemental, and supplemental specifications covering the development of new construction items or changes to a process. They only apply to a project when noted in the proposal form.

Divided Highway.
A highway with separate roadways for traffic in opposite directions.

Drainage Ditch.
An artificially constructed open depression, other than a road ditch, which is constructed for the purpose of carrying off surface water.

Employee.
Any person working on the project mentioned in the contract of which these specifications are a part, and who is under the direction or control, or receives compensation from, the Contractor or subcontractor.

Engineer.
For the Department, the Engineer is the Chief Engineer. For publicly owned projects, the Engineer is a Professional Engineer licensed in the State of Iowa and authorized representative of the Contracting Authority. For privately contracted projects, with improvements that will become publicly owned, the Engineer is the authorized representative of the public entity ultimately accepting ownership of the improvements. For all other projects, the Engineer is the owner's authorized representative.

The Engineer may act directly or through duly authorized representatives, acting within the scope of the duties assigned to the Engineer, or the authority given the Engineer.

Equipment.
All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for proper construction and acceptable completion of the work.

Extra Work.
Work not provided for in the contract, as awarded, but deemed essential to the satisfactory completion of the contract within its intended scope and authorized by the Engineer.

Extra work shall not include additional materials, equipment, and labor used due to natural variations in surface and subsurface conditions, except as specifically provided for elsewhere in the contract documents.

Foreslope.
The sloping surface of an embankment, ditch, or borrow pit of which the downward inclination is away from the traveled way.

General Supplemental Specifications.
Specifications adopted by the Department's Specification Committee subsequent to the publication of this book. They contain changes to the Standard Specifications and apply to all contracts. Published in April and October each year.

Grade Separation.
A structure, with its approaches, which provides for highway or pedestrian traffic to pass without interruption over or under a railway, another highway, road, or street.

Haul Road.
A corridor of land, when so designated in the contract documents, either private or public, of which the right to use is acquired by the Contracting Authority for the purpose of hauling equipment, materials, or machinery either as vehicles or vehicles with loads, where these vehicles or vehicles with loads exceed the provisions of Iowa Code 321, governing size, weight, and load. (Not to be confused with temporary Primary Road haul road.)

Independent Contractor.
Any person, firm, or corporation who contracts with the Contractor to perform a service for which the basis of payment is in terms of units of service rather than salary or wages.

Inspector.
The authorized representative of the Engineer assigned to make a detailed inspection of any or all portions of the work, or materials.

Institutional Road Project.
A project on the institutional road system of highways at any state institution.

Instruction to Bidders.
See Notice to Bidders.

Intermediate Contract Period.
A period of working days shown on the proposal form specifying the time of completion for a specific item or portion of work on a contract.

Interstate Project.
A Primary project on the Federal System of Interstate and Defense Highways. Includes projects on county and city road bridges over the Interstate.

Item.
See Contract Item.

Joint Bid.
A firm proposal submitted by two or more qualified bidders who have been authorized to bid jointly by the Contracting Authority on a specific proposal, in which case bidders will be held individually and collectively responsible for completion of the work involved in any contract resulting from such proposal.

Joint Venture.
The joining of two or more qualified contractors for the purpose of combining equipment, personnel, and finances in order to submit a bid on a single proposal.

Jurisdiction.
Political subdivision acting through its governing body or through the authorized representatives of such governing body when so authorized.

Jurisdictional Engineer.
See Engineer.

Laboratory.
The testing laboratory of the Contracting Authority or any other testing laboratory which may be designated in the contact documents.

Late Start Date.
A calendar day shown on the proposal form specifying the latest date on a contract that the Contractor is to commence work.

Legal Axle Load.
A maximum axle load of 20,000 pounds, as defined in Iowa Code 321.

Liquidated Damages.
The dollar amount, determined by the Department and set forth in the contract documents, as an estimate of the damage to the Contracting Authority or the public for delay in completion of the work.

Lump Sum.
The contract amount is complete payment for all work described in the contract documents and necessary to complete the work for that item. Changes in payment will be made for obvious errors or authorized additional work that was not included in the work to be bid by lump sum.

Major Item of Work.
Any contract item (pay item) for which the original contract amount plus authorized additions is more than 10% of the total original contract sum or $50,000, whichever is less.

Manhole.
See Utility Access.

Materials.
Any substances specified for use in the construction of the project and its appurtenances.

Materials Instructional Memorandum (Materials I.M.).
This is an instruction prepared by the Office of Materials. These may identify approved sources of various qualities or types of materials, sampling, testing, and approval procedures, and conditions for acceptance and use.

Maximum Density and Optimum Moisture Content.
The term maximum density and optimum moisture content as applied to soil, aggregate, and similar materials shall be construed as the maximum density described in AASHTO T 99, T 134, or T 180, as specified, and the corresponding optimum moisture as defined therein. The test methods will normally be AASHTO T 99, Method C; AASHTO T 134, Method B; and AASHTO T 180, Method C, as modified by the Materials I.M.s.

Median.
The portion of a divided highway separating the traveled ways for traffic.

Mobilization.
Preparatory work and operations for all items under the contract documents, including, but not limited to, those necessary for the movement of personnel, equipment, supplies, and incidentals to the project site; for the establishment of all offices, buildings, and other facilities necessary for work on the projects; and for all other work or operations which must be performed or costs incurred prior to beginning work on the various items on the project site. Mobilization may include bonding, permit, and demobilization costs.

Need Line.
A line or lines within the right-of-way, as shown on the plans or set by the Engineer, to define an area inside which disturbance is expected to complete work on the project and outside which permanent disturbance should be avoided.

Notice to Bidders.
That portion of the contract documents prepared and furnished by the Contracting Authority for the information of bidders submitting proposals, which notice specifies the provisions, requirements, and instructions pertaining to the method, manner, and time of submitting bids.

Notice to Proceed.
Written notice to the Contractor to proceed with the contract work including, when applicable, the date of beginning of contract time.

Optionally Combined Proposal.
The projects from two or more proposals combined by the Contracting Authority to allow the Contractor to bid all the projects as one contract.

Park Road Project.
A project on the park road system of highways and roads at any state park.

Pavement or Paving.
The pavement structure, or the upper surface of a pavement structure, or the materials of which the pavement structure is constructed.

Pavement Structure.
The combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

Plans.
The final plan, authorized for letting, which includes approved plans, profiles, cross sections, typical cross sections, working drawings, plan notes, standard plans, and supplemental drawings, or exact reproductions thereof, including modifications, altered plans, revisions, and amendments, which show the location, character, dimensions, and details of the work to be done.

Precast Concrete Units.
Conventionally reinforced (not prestressed) concrete structural units, formed, cast, and cured presumably in a central casting yard and later moved and incorporated into the finished structure.

Prestressed Concrete.
Concrete which is subjected to compressive stresses, after hardening, by means of high strength steel tendons, for the purpose of eliminating or minimizing tensile stresses in the concrete due to applied loads. Prestressed concrete may be prefabricated in a permanent plant or at the site, or it may be designed to be cast in place. Prestressed concrete may be either pretensioned, in which case the concrete is cast to engage the steel tendons which have been prestressed between fixed anchorages and released after the concrete has hardened, or post tensioned, in which case the steel tendons are cased in the concrete in suitable enclosures to prevent bond and are stressed by jacking and anchoring against the concrete after it has hardened.

Primary Project.
A project on the Primary Road System of Iowa and extensions thereof in cities and towns. Includes projects on county and city road bridges within an interchange of a Primary road with a county road or city road.

Profile Grade.
The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal center line of the roadbed. Profile grade means either elevation or gradient of such trace, according to the context.

Project.
The specific section of the highway together with all appurtenances and construction to be performed under a contract. A contract may involve the work covered by one or more projects.

Project Area.
The right-of-way between the project limits shown in the contract documents, and additional area which is necessary for the Contractor to place traffic control devices required by the contract documents or necessary to protect the work.

Proposal.
The offer of a bidder, on the prescribed form, to perform the work and to furnish the labor and materials at the prices quoted.

Proposal Form.
The form showing the location and description of the proposed work, the approximate quantities of work to be performed or materials to be furnished, the form and amount of the required proposal guaranty, and the contract period. The proposal form will also contain a reference to any special provisions or requirements which are supplemental to the standard specifications.

Proposal Guaranty.
The security furnished by the bidder with the proposal for a project(s), as guaranty the bidder will execute the contract for the work if the proposal is accepted.

Reasonably Acceptable.
Reasonably acceptable means acceptance with price adjustment of material or finished work that is incorporated and is not within reasonably close conformity with the contract documents, but at the discretion of the Engineer, it is determined that acceptable work has been produced. This is material or work for which a determination has been made to be accepted and remain in place.

Reasonably Close Conformity.
Reasonably close conformity means compliance with reasonable and customary manufacturing and construction tolerances where working tolerances are not specified. Where working tolerances are specified, reasonably close conformity means compliance with such working tolerances. Without detracting from the complete and absolute discretion of the Engineer to insist upon such working tolerances as establishing reasonably close conformity, the Engineer may accept variations beyond such tolerances as reasonably close conformity where they will not materially affect the value or utility of the work and the interests of the State.

Resident Bidder.
A person or entity authorized to transact business in this state and having a place of business for transacting business within the state at which it is conducting and has conducted business for at least three years prior to the date of the first advertisement for the public improvement.

Responsive Bid.
A bid submitted by a Contractor which is determined not to be an irregular proposal as defined by Article 1102.10 and fulfills the good faith effort recruitment requirements in Article 1102.17.

Right-of-Way.
The land area of which the right to possession is secured or reserved by the Contracting Authority for road purposes.

Road.
A general term denoting a public way for vehicular travel, including the entire area within the right-of-way.

Roadbed.
The area of the roadway between the tops of foreslopes.

Roadside.
The area within the right-of-way and outside the shoulder lines of a roadbed.

Roadway.
That portion of the right-of-way designed or ordinarily used for vehicular traffic.

Secondary Project (Secondary Road Construction Project).
A project on the Secondary Road System of Iowa and extensions thereof in cities and towns.

Shoulder.
That portion of the road bed contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Sidewalk.
That portion of the roadway primarily constructed for the use of pedestrians.

Skew or Skew Angle.
The complement of the acute angle between two center lines which cross. The angular deviation of the axis of a culvert or bridge from a true right angular crossing of a road.

Slope.
The inclination of a line or surface expressed as a ratio of horizontal distance to vertical distance.

Special Provisions.
Additions and revisions to the Standard, General Supplemental, Developmental, and Supplemental Specifications covering conditions particular to an individual project. They only apply to a project when noted in the proposal form.

Specialty Items.
Pay items designated in the contract documents as specialty items; usually minor items requiring equipment, skills, or crafts not ordinarily associated with the major types of work covered by the contract.

Specifications.
The general term comprising all the written documents, provisions, and requirements to which may be added or adopted Supplemental Specifications, Developmental Specifications, or Special Provisions, all of which are necessary for the proper performance of the contract documents.

Specified Starting Date.
A calendar day shown on the proposal on which date commencement of work is expected.

Speed Limit.
Refers to the legally established speed limit before construction and not the advisory speed during construction.

Standard Road Plans.
A manual of detailed drawings showing standardized design features, construction methods, and approved materials for repetitive use on Interstate, Primary, and Secondary road construction.

Standard Specifications.
The requirements contained herein applying to all contracts, and pertaining to the method and manner of performing the work, or to the quantity and quality of the materials to be furnished under the contract.

State.
The State of Iowa acting through its authorized representative.

Station (Metric Station).
One hundred linear feet (one hundred meters).

Street.
See Road.

Structures.
All objects constructed of materials other than earth, required by the contract documents to be built, or to be removed, but not including pavement, surfacings, base courses, and subbases. Includes bridges, culverts, intakes, drop inlets, retaining walls, cribbing, utility accesses, end walls, buildings, sewers, service pipes, subdrains, foundation drains, and other features which require engineering analysis.

Subbase.
The layer or layers of specified or selected material of designed thickness upon which a base course or pavement is constructed.

Subcontractor.
Any individual, firm, or corporation to whom the Contractor, with the written consent of the Contracting Authority, sublets any part of the contract.

Subgrade.
The top surface of a roadbed upon which the pavement structure and shoulders are constructed.

Substructure.
All of that part of the structure below the bearings of simple and continuous spans, and tops of footings of rigid frames, together with the backwalls, wingwalls, and wing protection railings.

SUDAS Standard Specifications.
Refers to specifications developed by the Iowa Statewide Urban Design and Specifications Program.

Superintendent.
The Contractor's authorized representative in responsible charge of the work.

Superstructure.
The entire structure except the substructure.

Supplemental Agreement.
Written agreement between the Contractor and Contracting Authority modifying the original contract.

Supplemental Specifications.
Specifications adopted subsequent to the publication of this book. They involve new construction items or changes to Standard Specifications. They only apply to a project when noted in the proposal form.

Surety.
The corporation, partnership, or individual, other than the Contractor, executing a bond furnished by the Contractor.

Target or Target Value.
When a target or target value is specified, a continuous and determined effort is expected to reach and maintain that value, as a goal.

Temporary Primary Road Haul Road.
Any Secondary public road or city street so designated by the Department in accordance with Iowa Code 313.

Temporary Structure.
Any structure required to maintain traffic during construction of the work and which will be dismantled when the work is completed. The temporary structure shall include the earth approaches thereto.

Traffic Control Device.
As defined in the MUTCD.

Traffic Control Zone.
The distance between the first advance warning sign and the point beyond the work area where traffic is no longer affected. This does not include work more than 12 feet (3.6 m) from the outside edge of the traveled way.

Traveled Way.
The portion of the roadway for the movement of vehicles, exclusive of shoulders.

Unacceptable Work (Also Defective Work).
Work not in reasonably close conformance with the contract requirements and ordered to be removed and replaced.

Unauthorized Work.
Work neither contemplated by the contract documents nor authorized by the Engineer, and work done contrary to the instructions of the Engineer.

Unit Price.
See Contract Unit Price.

Utility.
Includes all privately, publicly, municipally, or co-operatively owned structures and systems for supplying water, sewer, electric lights, street lights and traffic lights, gas power, telegraph, telephone, communications, transit, pipelines, and the like.

Utility Access.
An inline structure to allow personnel access and maintenance of underground utilities.

Utility Agency.
Means and includes: 1) all franchised utilities having utility system facilities with State or local jurisdiction right-of-way, including but not limited to gas electric, telephone, cable television, and communications; 2) communications systems allow by the State or local jurisdiction; and 3) all governmental agencies owning or operating governmental utility systems, including but not limited to water, sewer, traffic control, and communications.

Waters of the United States.
All waters, impoundments of waters, or tributaries of waters, including but not limited to lakes, rivers, streams, intermittent streams, mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, or natural ponds.

Work.
Work shall mean the furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the contract and the carrying out of all the duties and obligations imposed by that contract.

Work Area.
That portion of the project area in which construction activity is ongoing.

Working Day.
Any calendar day, exclusive of Saturdays, Sundays, or a recognized legal holiday, on which weather or other conditions (not under control of the Contractor) will permit construction operations to proceed for not less than 3/4 of a normal work day in the performance of a controlling item of work.

Working Drawings.
Stress sheets, shop drawings, erection plans, false work plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data which the Contractor is required to submit to the Engineer for approval.

Section 1102. Proposal Requirements and Conditions

1102.01 COMPETENCY AND QUALIFICATION OF BIDDERS.

A. Prospective bidders shall meet the Department's requirements for prequalification. To prequalify, a prospective bidder shall complete the required sections of the "Contractor's Financial - Experience - Equipment

Statement" (Form 650004) and submit it to the Department. The filing of this statement does not in itself constitute qualification. A prospective bidder shall receive definite approval of this statement to be placed on the qualified list before the bidder's proposals will be considered. The statement shall be filed with the Contracting Authority at least 5 calendar days before the date on which proposals are to be received.

B. In order to continuously remain on the qualified list, a prospective bidder must file Form 650004 with the Department for approval once each year and at such other times as the Department may request. Unless otherwise notified, the previously approved statement will expire 18 calendar months from the date of that statement. The prospective bidder will be dropped from the qualified list if a new statement has not been filed and approved by the expiration date.

C. The Contracting Authority will compute the Contractor's maximum prequalification amount based on the following prequalification formula:

MAXPREQ = [CURRENT+NONCURRENT+LL]×F

Where:

MAXPREQ = maximum prequalification amount

CURRENT = current assets minus current liabilities

NONCURRENT = (non-current assets minus non-current liabilities)/2 if > 0

NONCURRENT = (non-current assets minus non-current liabilities) if < 0

LL = approved authorization to loan letter

F = experience factor

D. The Contracting Authority will qualify Contractors into three categories:

1. Individually Prepared Statement.

a. An Individually Prepared Statement is a "Contractor's Financial - Experience - Equipment Statement" that has been completed by the prospective bidder. If the statement has been compiled by a CPA, but does not contain a CPA review or audit of the financial portion of the statement, it is still considered an Individually Prepared Statement.

b. When an Individually Prepared Statement is submitted to the Department, the maximum prequalification amount will be $200,000.

2. CPA Reviewed Statement.

a. A CPA Reviewed Statement is a "Contractor's Financial - Experience - Equipment Statement" that includes a current CPA review of the financial portion of the statement. The review must be completed by a CPA who is either registered to practice in Iowa or

registered in another state having reciprocal arrangements with Iowa.

b. When a CPA Reviewed Statement is submitted to the Department, an experience factor (F) ranging from 0.0 to 12.5, depending on the prospective bidder's past performance with projects let by the Department, will be used in the prequalification formula. A prospective bidder, who has been qualified to submit proposals with this type of statement, shall be limited to individual proposal sizes that do not exceed the lesser of $1 million or the maximum prequalification amount minus the bidder's amount of uncompleted work currently under contract. Any combination of proposals, however, may total more than $1million - as long as that total does not exceed the maximum prequalification amount minus the currently uncompleted work.

3. CPA Audited Statement.

a. A CPA Audited Statement is a "Contractor's Financial - Experience - Equipment Statement" that includes a current CPA audit of the financial portion of the statement. The audit must be completed by a CPA who is either registered to practice in Iowa or registered in another state having reciprocal arrangements with Iowa.

b. When a CPA Audited Statement is submitted to the Department, an experience factor (F) ranging from 0.0 to 12.5, depending on the prospective bidder's past performance with projects let by the Department, will be used in the prequalification formula. A prospective bidder, who has been qualified to submit proposals with this type of statement, shall be limited to work that does not exceed the maximum prequalification amount minus the bidder's amount of uncompleted work currently under contract. However, a prospective bidder shall be considered to have an "Unlimited" bidding capacity with the Department if they were awarded over $50 million of work (including that from other Contracting Authorities) during their past fiscal year and have a prequalification limit, by the formula, over $100 million.

E. A prospective bidder must complete contract work in the following categories in excess of the quantities listed below before qualification to submit proposals or receive awards for projects involving larger quantities than those listed. The contract work may be done as a contractor or subcontractor. All such completed contract work will be combined into one total for each category to determine the bidder's qualifications.

PCC Pavement	Square Yards (Square Meters) 100,000 (100,000)
Grading	Cubic Yards (Cubic Meters) 500,000 (400,000)
Bituminous Pavement	Tons (Megagrams) 50,000 (50,000)

Bridges	$200,000
Culverts	$100,000
Other classes of work	No Fixed Maximum

F. In all cases a bidder will be restricted to a specific dollar volume of contracts within reasonable limits of the bidder's ability to properly finance, equip, and perform the work within the specified contract period.

G. The necessary forms and instructions for furnishing the "Contractor's Financial - Experience - Equipment Statement" will be supplied by the Contracting Authority upon application.

H. For proposals involving only the furnishing of materials, granular surfacing, lighting, buildings, asbestos removal, salvage and removal, wells, traffic signals, pavement marking, or mowing, the following shall apply in lieu of the above requirements of this article:

Bidders submitting proposals must be recognized contractors engaged in the class of work provided for in the contract documents, and must possess all necessary licenses, certificates and resources to complete the work. Before the contract is awarded to a bidder, the bidder may be required to furnish evidence to the satisfaction of the Contracting Authority of the bidder's ability to perform and complete the contract.

1102.02 REDUCTION IN BIDDER QUALIFICATION RESTRICTIONS.

A. The requirements and conditions for bidder qualification as contained in Article 1102.01 may be reduced by the Contracting Authority either for contractors who have well established performance records in other fields or for contractors having adequate financial responsibility and experienced supervisory personnel available for the work that is under consideration or for both the above reasons.

B. Likewise, the requirements may be modified by the Contracting Authority for newly formed or reorganized firms or corporations whose basic organization is composed of individuals who are veterans of the construction industry, with proven records of satisfactory performance in the field in which they have elected to bid, provided, however, that they have adequate financial responsibility, equipment, and available experienced supervisory personnel.

1102.03 IMPOSITION OF INCREASE IN BIDDER QUALIFICATION REQUIREMENTS, SUSPENSION, AND DISQUALIFICATION.

A. The requirements and conditions for bidder qualification in Article 1102.01 may be imposed, reimposed, or increased, or a contractor may be suspended or disqualified.

1. The requirements and conditions for bidder qualification of a contractor may be imposed, reimposed, or increased if or when:

- **a.** The Contractor seriously delays commencement or completion of any work within the contract period or any extension thereof under circumstances that would normally give rise to a right in the Contracting Authority for liquidated damages or declaration of default, or
- **b.** The Contractor does any act or omits doing or performing any act which, in the judgment of the Contracts Engineer, evidences a material change in the Contractor's financial responsibility or work capability where, in the judgment of the Contracts Engineer, the same will materially prejudice the Contractor's ability to successfully prosecute such public improvement contracts, or the Contractor knowingly submits false information on the "Contractor's Financial - Experience - Equipment Statement" (Form 650004) or "Certification of Uncompleted Work Under Contract" (Form 650022) or other information concerning prequalification, or
- **c.** The Contractor takes or fails to take any action which the Contracts Engineer deems to warrant an imposition of increase in bidder qualification requirements.

2. A contractor may be suspended from bidder qualification if or when:

- **a.** The Contractor continually fails or refuses to remove and replace materials or work found by the Engineer not to be in reasonably close conformity with the contract documents or to correct such material or work so as to cause such materials or finished product to be reasonably acceptable work, or
- **b.** The Contractor continually and, in the judgment of the Contracts Engineer, without good cause therefore, fails to carry on the work in an acceptable manner or refuses to comply with a written order of the Engineer within a reasonable time, or
- **c.** The Contractor fails to perform with its own organization the work as required in Article 1108.01, or otherwise assigns or disposes of work or the contract or any part thereof without approval of the Contracting Authority, or
- **d.** The Contractor forfeits a proposal guaranty and fails to enter into the contract upon an offer of award by the Contracting Authority in response to a prior advertisement for bids for the same project or any combination of projects involving the project for which award is currently being considered, or
- **e.** The Contractor fails to comply with Equal Employment Opportunity/Affirmative Action requirements of the contract, or
- **f.** The Contractor fails to pay the subcontractor progress payments and retainage as required by Article 1109.05, or
- **g.** The Contractor continually takes actions, or continually fails to take actions, which present safety concerns for the Contracting Authority or the general public, or
- **h.** The Contracts Engineer deems a suspension is appropriate for reasons stated in Paragraph 1 above.

A suspension is intended to be for an indefinite period of time or, in the case of Paragraph d, for a specific project. A suspension shall continue until the Contractor resolves, to the satisfaction of the Contracts Engineer, the problem for which the suspension was made.

3. A contractor may be disqualified from bidder qualification if or when:
- **a.** The Contractor is currently debarred by some other state or Federal agency, or
- **b.** The Contractor subcontracts, employs, or otherwise uses services, for work of the Contracting Authority, of one who is debarred by the Contracting Authority or disqualified according to Article 1102.03, A, 3, a, except to fulfill agreements for work on existing contracts, or
- **c.** The Contractor is convicted of or pleads guilty or nolo contendere (no contest) to a charge of engaging in any conspiracy, combination, or other unlawful act in restraint of trade or of similar charges in any Federal court or a court of this or any other state, or
- **d.** The Contractor has offered or given gifts or gratuities to employees of the Contracting Authority in violation of State law or has had as an employee a person who was at that time also an employee of the Contracting Authority, or
- **e.** The Contractor has falsified documents or certifications, or has knowingly provided false information to the Department or the Contracting Authority, or
- **f.** The Contracts Engineer deems a disqualification is appropriate for reasons stated in Paragraph 1 or 2 above.

B. A disqualification is intended to be for a specified time. A disqualification will not exceed 36 months.

C. The Contracts Engineer will issue a written notice of any intent to disqualify or suspend a contractor, except when suspended for a specific project according to Article 1102.03, A, 2, d.

D. Should the Contractor believe that the increase in bidder qualification requirements, intended suspension, or intended disqualification is based on false, biased, or incomplete information or that the increase or intended action is severe or unwarranted, the Contractor may make a written request to the Contracts Engineer for an opportunity to be heard in a contested case pursuant to Chapter 17A, Code of Iowa, and 761 IAC, Ch. 13. If notice is given, the written request for a hearing shall be filed with the Contracts Engineer within 10 calendar days of receipt of the notice of intended agency action. If the basis of the intended disqualification is a criminal violation which is reasonably related to bidding and contracting procedures, the intended disqualification may be applied to the organization, including a person, firm, association, partnership, or corporation, to an affiliate, officer, representative, or employee thereof, and to any other such organization in which the organization or affiliate or the officer, representative, or employee has an interest as either officer or owner.

E. When a notice is given or when any action is contested, the Contracts Engineer will issue a notice of the final action taken.

1102.04 CONTENTS OF PROPOSAL FORMS.

A. Bidders will be furnished with proposal forms showing the location and description of the proposed work, the approximate quantities of work to be performed or materials to be furnished, the form and amount of the required proposal guaranty, and the contract period. The proposal form will also contain a reference to any special provisions or requirements which are supplemental to the standard specifications.

B. The statement, "By virtue of statutory authority preference will be given to products and provisions grown and coal produced within the State of Iowa where applicable," which is on the bidding document shall not be applicable to contracts involving Federal-aid participation in construction.

C. If a predetermined wage is shown on the proposal form, it will apply to all labor used on the project. This will include labor used in the production of aggregate, HMA, and ready mix PCC which is not produced in a commercial plant. The rulings of the U.S. Department of Labor will be used in determining what is a "roadside plant" where the predetermined wage will apply and a commercial plant where the predetermined wage will not apply.

Do not use composite crews for bridge and culvert work. Pay applicable prevailing wage rate for the classification which the employee is performing work.

D. The following bidding and letting regulations shall apply to all proposals for which the Department receives bids (includes projects on Interstate, Primary, urban, park and institutional roads, farm-to-market, and local county systems).

1. Contractors will be permitted to bid on proposals amounting in total to three times their adjusted prequalification rating (prequalification rating minus uncompleted contracts).

The adjusted prequalification rating will be determined at each letting, taking into consideration the amount of work under contract, equipment and personnel available, and construction periods, etc.

Approvals for award of contracts will not exceed any contractor's actual adjusted prequalification rating.

2. Contracts will be recommended for approval for award on the basis of the greatest total savings in the public interest. The determination of which proposals to be awarded will be based on the approval by the Department and even if the selected bids are later rejected by other contracting agencies, other projects will not be substituted.

3. Contractors will not be permitted to tie proposals or to designate on the bidding proposal the limit of the amount they will accept. Contractors may voluntarily lower their prequalification rating provided written request is on file at the Office of Contracts, Iowa Department of Transportation, Ames, Iowa, by noon of the working day prior to the letting.

1102.05 ISSUANCE OF PROPOSALS.

Requests for proposal forms to bid construction and maintenance contracts must be filed by noon of the working day prior to the letting. These requests should be on the request form provided by the Department. Unless otherwise specified, proposal forms will be furnished to qualified bidders who have filed properly completed "Certification of Uncompleted Work Under Contract" forms (Form 650022) with their request. Any contractor knowingly submitting any false information required by Form 650022 may be suspended from bidding as provided in Article 1102.03.

1102.06 NONSEGREGATED FACILITIES NOTICE TO PROSPECTIVE FEDERAL-AID SUBCONTRACTORS AND MATERIAL SUPPLIERS.

Certain requirements concerning nonsegregated facilities may be applicable to prospective subcontractors and material suppliers for Federal-aid projects. These are in the contract documents.

1102.07 ESTIMATE OF QUANTITIES.

A. The Proposal form will contain a Schedule of Prices that lists the items of work on the project(s). The Schedule of Prices, which shall be completed and submitted by each bidder, will be used for comparing bids for award of the contract.

B. Contract items listed in the Schedule of Prices will be either Unit Price or Lump Sum.

C. The contract documents may also include a list of items that are noted as incidental. Incidental work is normally minor in scope and is clearly described in the contract documents. The cost to complete incidental items shall be included in the contract unit price bid for the item to which they are listed as incidental. Additional payment will not be made for incidental items unless there are obvious errors or changes to the quantity of the incidental item. An item of work, normally paid for separately, and not listed in the contract documents as incidental, will be paid for in accordance with Article 1109.03, B.

1102.08 EXAMINATION OF PLANS, PROPOSAL FORM, SPECIFICATIONS, AND SITE OF WORK.

It is the responsibility of the bidder to examine the plans, proposal form, Specifications, Supplemental Specifications, Developmental Specifications, Special Provisions, the site of the work, and the state of the work of other contractors on the project to assure that all requirements of the proposal form and the plans are fully understood. It is the bidder's responsibility to understand the nature of the work and all reasonably ascertainable conditions which may affect performance under the

contract. The Contracting Authority does not warrant, implicitly or explicitly, the nature of the work, the conditions that will be encountered by the bidder, or the adequacy of the contract documents for the Contractor to perform the work.

1102.09 PREPARATION OF PROPOSALS.

A. Only contractors who have been authorized to bid a proposal may submit a bid for a contract. For bids submitted to the Department that exceed $1 million, the bidder shall use subparagraph 2 or subparagraph 3 below. The Department may wave this requirement for unique or isolated situations.

1. Submit the signed, original Bidding Document furnished by the Contracting Authority with a Schedule of Prices from the Estimating Proposal.

2. Submit the signed, original Bidding Document furnished by the Contracting Authority with the computer printout and diskette of the Schedule of Prices from the bidding software furnished by the Department.

3. Submit an electronic bid with digital signature using the bidding software furnished by the Department and the electronic bid submittal procedures of the Department.

B. The bidder shall be familiar with the requirements of the applicable specifications. The bidder shall specify a unit price in figures of dollars and cents for all pay items, except for Lump Sum items where the proposal line item bid amount must be shown. All the unit price figures shall be in ink, typed, or computer printed. The bidder may also specify the extension for each proposal line item and or the total amount of the bid. However, if there is a discrepancy between the unit bid prices, extensions, or total amount of bid, the unit prices shall govern. The bidder shall not alter the quantity, unit price, or the extension which has been provided for items which have been predetermined by the Contracting Authority.

C. If the proposal is made by a partnership or corporation, the name of the partnership or corporation, its agent, and its principal place of business shall be shown. The proposal shall be signed by an authorized agent of the partnership or corporation.

D. If the proposal is made on the basis of a joint bid, the proposal shall be signed by each of the joint bidders, unless the firms submitting the joint venture have a written request on file with the Department signed by each of the bidders which states the individual(s) who are authorized to sign the bidding documents for the joint venture.

E. By signing and submitting the proposal, the bidder:

1. Acknowledges the bidding requirements included in the bidding documents,

2. Agrees to perform all work that is necessary to complete the proposed work in the time specified. Work not covered by proposal will be paid for according to Article 1109.03,

3. Certifies compliance with the provision of the Code of Iowa listed in the bidding documents,

4. Gives an unsworn declaration on behalf of each person, firm, association, partnership, or corporation submitting a proposal, certifying that such person, firm, association, partnership, or corporation has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in connection with such contract, and is not under debarment currently by the Federal government for a criminal violation which is reasonably related to bidding and contracting procedures,

5. For Federal-aid contracts, certifies acknowledgment of the limitations of lobby activities shown in the bidding documents, and

6. For Federal-aid contracts, certifies the bidder does not maintain segregated facilities.

F. Cooperation and coordination will be required of all contractors and other agencies authorized to do work in the project area.

G. The attention of the bidder, for the work covered by a proposal and referred to as this work, is directed to the fact that contracts for work other than the work covered in this proposal may have been awarded, are being advertised for letting on the same date as this work, or may be awarded in the future.

H. Completion of work covered by this proposal may be contingent upon certain work covered by other contracts being performed on the project in advance of this work; likewise, completion of work covered by other contracts may be dependent upon completion of work covered by this proposal.

I. The proposal will list types of work involving other contracts anticipated to be let on the same letting date or sometime within the contract period anticipated for this work. The contract documents will also list other governmental agencies, railroads, utilities, or other parties who will have work with which it is known that this work must be coordinated.

J. The bidder is expected to become familiar with work already in progress or previously let on this project, the contract periods, the progress being made, and any other conditions regarding that work which may affect the bid or the bidder's performance under this contract.

K. The bidder on this work acknowledges these facts and agrees that it is in the public interest to have the work of certain contracts and agencies performed concurrently rather than consecutively. The bidder further agrees to cooperate and coordinate the work with that of other contractors or agencies

to the mutual interest of all parties doing work in the project area, whether by contract with the State, County, or City or necessary work being done by governmental agency or utility force.

L. By the submission of a bid on this work, the bidder acknowledges and agrees that investigation and inquiry has been made regarding the contracts for work with which this work must be coordinated.

M. In the event disputes arise between contractors or other agencies, or both, doing work on the project as to their mutual rights or obligations, the Contracting Authority or its authorized representative will, when requested to do so or the Contracting Authority's own motion, act as referee and define the rights of all interested parties with regard to the conduct of the work, which decision shall be final as provided in Article 1105.01.

N. If a prospective bidder, for a proposal for which the Department is accepting bids, is in doubt as to the true meaning of any part of the contract documents, the bidder may submit to the Contracts Engineer a request for additional information, explanations, or interpretations. Interpretations may be in the form of an addendum to the contract documents. The Contracting Authority will not be responsible for any information, explanation, or interpretation from any other source.

1102.10 IRREGULAR PROPOSALS.

Proposals will be considered irregular and may be rejected for any unauthorized changes in the proposal form or for any of the following reasons:

A. If on a form other than that furnished by the Contracting Authority, or if the form is altered or any part thereof is detached,

B. If there are unauthorized additions, conditional or alternate bids, or irregularities of any kind which may tend to make the proposal incomplete, indefinite, or ambiguous as to its meaning,

C. If the bidder adds any provisions reserving the right to accept or reject an award because of being low bidder on another proposal in the same letting,

D. If the bidder adds any provisions reserving the right to accept or reject an award or to enter into contract pursuant to an award,

E. If a bid on one proposal is tied to a bid on any other proposal, except as specifically authorized on the proposal form by the Contracting Authority,

F. If the proposal does not contain a unit price for each pay item listed, except in the case of authorized alternate pay items.

1102.11 PROPOSAL GUARANTY.

A. Each proposal shall be supported by a proposal guaranty in the form and amount prescribed in the proposal. Bids not so supported will not be read.

B. The proposal guaranty shall be in the form of a certified check or credit union certified share draft, cashier's check, money order, or bank draft drawn on a solvent bank or credit union. Certified checks or credit union certified share drafts shall bear an endorsement signed by a responsible official of such bank or credit union as to the amount certified. Cashier's checks, money orders, or bank drafts shall be made payable either to the Contracting Authority or to the bidder and, where made payable to the bidder, shall contain an unqualified endorsement to the Contracting Authority signed by the bidder or the bidder's authorized agent. Certified checks and credit union share drafts shall be certified, or the cashier's check shall be drawn and endorsed, in an amount not less than prescribed in the proposal.

C. A Proposal Guaranty/Bid Bond (Form 131084) may be used for the proposal guaranty in lieu of that specified above. Bid bonds will be declared invalid and bid proposals will not be considered if any of the following items are omitted or incorrect:

- Date of Letting
- Bid Order Number
- Name of Contractor
- Original Signature of Contractor: In case of joint venture bid, all contractors must sign.
- Name of the Surety Company
- Original Signature of Surety (if Surety's limitation is less than the amount of the bid bond, a certificate of reinsurance must be attached).

D. A Contractor's Annual Bid Bond (Form 650043) may also be used for the proposal guaranty in lieu of that specified above. The Annual Bid Bond shall contain the following items:

- Name of Contractor
- Original signature of the Contractor
- Date of signature
- Name of Surety Company
- Original signature of the Surety

1102.12 FILING OF PROPOSAL.

A. The proposal, proposal guaranty, and other supporting documents for each proposal shall be filed in an envelope, which is marked to indicate its contents. All proposals shall be filed with the Contracting Authority at the place designated in the notice to bidders, prior to the time advertised for opening of bids. Proposals received after the time of opening bids will be returned to the bidder.

B. The Contracting Authority may take bids on the same project as an individual proposal or part of an Optionally Combined Proposal. When an

Optionally Combined Proposal is designated, the consideration for award of contracts will be based on which of the following gives the lowest total cost:

1. The sum of the lowest responsible bid on each of the individual proposals.

2. The lowest responsible bid on the Optionally Combined Proposal.

1102.13 WITHDRAWAL OF PROPOSAL.

The bidder will be permitted to withdraw their proposal under one of the following three conditions:

A. The bidder may withdraw a proposal unopened if such a request is made in writing and received at the Department prior to the time specified in the advertisement for receiving bids. A proposal so withdrawn may be resubmitted as long as it is resubmitted prior to the deadline for receipt of bids.

B. If, after bids are open, the low bidder should claim a serious error in the preparation of the bid, and can support such a claim with evidence satisfactory to the Department, the bidder may be permitted to withdraw the bid and the bid guarantee may be returned. In such an event, action on the remaining bids will be considered as if the withdrawn bid had not been received. Under no circumstances will the bidder be permitted to alter the bid after the bids have been opened.

The Department will keep the bidder's proposal guarantee unless the bidder satisfies all four of the following conditions:

1. The mistake must be a clerical mistake as opposed to a mistake involving poor judgment concerning a construction process. The bidder must be able to produce bid preparation documentation to show how the clerical error occurred.

2. The bidder must immediately notify the Department as soon as the error is observed.

3. The scope of the mistake must be significant. The size of the mistake when compared to the overall project must be significant enough to cause major financial difficulties if the bidder is forced to complete the project at the price quoted.

4. The Department should not be placed in a worse position than if the bid had never been submitted.

C. The bidder may withdraw their bid from consideration if a contract has not been offered them within 30 calendar days after the letting and the bidder has not requested approval for award be deferred.

1102.14 PUBLIC OPENING OF PROPOSALS.
Proposals will be publicly opened and read at the time and place stipulated in the notice to bidders.

1102.15 FOREIGN CORPORATIONS.

A. Before entering into a contract involving construction or maintenance work, corporations organized under the laws of any other state shall file with the Contracting Authority a certificate from the Secretary of State of the State of Iowa showing that they have complied with all of the provisions of Code of Iowa 490, governing foreign corporations. For contracts involving only the furnishing of materials, the foregoing requirement does not apply.

B. When a contract not involving Federal-aid participation for a public improvement is to be awarded to the lowest responsible bidder, a resident bidder shall be allowed a preference as against a nonresident bidder from a state or foreign country which gives or requires a preference to bidders from that state or foreign country. The preference is equal to the preference given or required by the state or foreign country in which the nonresident bidder is a resident.

C. If another state or foreign country has a more stringent definition of a resident bidder, the more stringent definition is applicable as to bidders from that state or foreign country.

D. Any joint venture that includes a nonresident bidder will be considered nonresident, and the preference rule will be used.

1102.16 INCOME TAX DEDUCTION ON NONRESIDENT CONTRACTORS.
Each nonresident person or firm doing business as an individual and each nonresident co-partnership will be required, as precedent to receiving an award, to file a certificate issued by the State Tax Commission, as provided in Iowa Code 422.17, releasing the Contracting Authority from withholding any and all sums required by the provisions of Iowa Code 422.17.

1102.17 DISADVANTAGED BUSINESS ENTERPRISES.

A. General.

1. All contractors shall pursue affirmative action requirements to encourage and increase participation of disadvantaged individuals in business enterprises in all Federal-aid projects let by the Department, as set forth in this specification which is imposed pursuant to 49 CFR Part 26 Subpart A through F and Public Law 105-178, 112 Stat. 107 which supersedes all existing minority business enterprise regulations, orders, circulars, and administrative requirements concerning financial assistance programs that the United States Department of Transportation has issued.

2. The requirements set forth in this specification shall constitute the specific affirmative action requirements for project activities under this contract insofar as DBEs are concerned.

B. Disadvantaged Business Enterprise Policy.

The Contractor shall accept as operating policy and include in all subcontract agreements the following statement which is designed to promote full participation of DBEs as suppliers and subcontractors through a continuous, positive result-oriented program on contracts let by the Department:

"The Contractor, subrecipient, or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The Contractor shall carry out applicable requirements of 49 CFR part 26 in the award and administration of Department assisted contracts. Failure by the Contractor to carry out these requirements is a material breach of this contract, which may result in termination of this contract or such other remedy as the Contracting Authority deems appropriate."

C. Contractor's Affirmative Action Responsibilities.

The Contractor shall designate a responsible person or company official to serve as its DBE Liaison Officer. The DBE Liaison Officer shall:

1. Have the necessary statistics, funding, authority, and responsibility to carry out and enforce the intent of the firm's DBE policy and shall be responsible for developing, managing, and implementing the program on a day-to-day basis.

2. Use the current Directory of Certified DBEs to identify potential material suppliers and contractors.

3. Make every reasonable effort to involve DBEs in the performance of contracts, as suppliers and subcontractors, by soliciting quotations from the DBEs and incorporating them into the firm's bid.

4. Advise the Office of Employee Services, Civil Rights Team (OES-Civil Rights), of any known DBE not included in the current Directory of Certified DBEs.

5. Make every reasonable effort, at least 2 weeks prior to the time prices and quotations are to be submitted, to establish systematic written and/or oral contact with those DBEs that have been determined to have necessary potentials and capabilities to furnish needed materials and perform necessary work to be subcontracted.

6. Provide or arrange to assist certified DBEs with obtaining necessary bonding, analyzing plans and specifications, planning and managing work, and by providing other technical assistance.

7. Maintain complete records of negotiations with DBEs to reach agreeable prices, quotations, and work schedules.

8. Ensure that regularly scheduled progress payments are made to DBEs as required by the Iowa Code and the Standard Specifications.

9. Report to the Department all suspected instances of firms fraudulently claiming to be DBEs.

D. Counting DBE Participation Toward Meeting Goals.

1. The Contractor may count toward the goals only expenditures to DBEs that perform a commercially useful function towards the completion of a contract, including those functions as a subcontractor. Work performed by a DBE firm in a particular transaction may be counted toward the goal only if the Department determines that it involves a commercially useful function. The work performed by the DBE firm shall be necessary and useful to the completion of the contract, and consistent with normal highway construction industry practices in Iowa.

2. The bidder may count the following DBE expenditures towards the DBE commitment:
   a. **Projects where the DBE is the Prime Contractor** - The portions of the contract to be completed by certified DBE firms will be counted toward meeting the goal. Items of the contract subcontracted to non-DBE firms will not be counted in the commitment.
   b. **Portions of a bid from a Joint Venture** - A bid from a joint venture, between a DBE and non-DBE Contractor shall include a "Statement of DBE Commitments" (Form 102115), which is included in the bidding documents and in the computer software provided by the Department, listing the dollar value of the contract which will be completed by the DBE partner.
   c. **DBE Subcontractors** - The DBE subcontractor shall assume actual and contractual responsibility for provision of materials and supplies, subcontracted work, or other commercially useful functions of the items of work subcontracted to them. Cost of materials purchased from or the cost of equipment leased from the Contractor will not count toward the project DBE commitment.
   d. **Manufacturers** - The Contractor may count toward the DBE commitment 100% of its expenditures for materials and supplies required under a contract and obtained from a DBE manufacturer only if the DBE firm produces and supplies goods manufactured from raw materials or substantially alters them before resale.
   e. **Regular Dealers (e.g. Material Suppliers)** - The Contractor may count toward the DBE goal 60% of its expenditures for materials and supplies required under a contract and obtained from a DBE regular dealer only if the DBE firm performs a commercially useful function in the supply process. For purposes of this section, a regular dealer is a firm that owns; operates; or maintains a store,

warehouse, or other establishment in which materials or supplies required for the performance of the contract are bought, kept in stock, and regularly sold to the public in the usual course of business. To be a regular dealer, the firm shall engage in, as its principal business and in its own name, the purchase and sale of the products in question. A regular dealer in such bulk items as steel, cement, gravel, stone, and petroleum products need not keep such products in stock if it owns or operates the distribution equipment. If the DBE supplier does not own the distribution equipment, an acceptable lease containing the terms of the agreement shall be available. The Department may request a copy of this lease.

f. **Brokers and Packagers** - Brokers and packagers will not be regarded as regular dealers within the meaning of this section. Only the cost of the service performed may be used towards meeting the DBE commitment.

g. **Transportation or Hauling of Materials** - If a DBE trucking company picks up a product from a manufacturer or regular dealer and delivers the product to the Contractor, the commercially useful function performed is not that of a supplier, but that of a transporter of goods. Unless the DBE company is itself the manufacturer or a regular dealer in the product, credit only will be allowed for the cost of the transportation service. For transportation of materials by truck to be used toward meeting the DBE commitment, the following shall apply:

1) The DBE shall be responsible for management and supervision of the entire trucking operation that is to count toward the commitment. The DBE shall maintain strict records to verify the amount of hauling done by each trucker. These records shall be available to the Engineer, upon request.

2) OES-Civil Rights will maintain a truck roster for each DBE that performs trucking. Each truck on the truck roster shall be either owned by the DBE or controlled by the DBE under a lease. Trucks that are leased shall be from a firm that is in the commercial leasing business; the owner of the commercial leasing business cannot be a heavy-highway contractor. The DBE firm shall make available to the Department the lease agreement if requested.

3) To meet the DBE commitment, the following conditions shall be used:

a) At least one fully licensed, insured, and operational truck, listed on the truck roster under the DBE trucking company shown on the Form 102115, shall be hauling on the project at all times. The Contractor will receive credit for the fee paid to the DBE for these trucks.

b) Any truck on the truck roster of another DBE may be used. There is no limitation to the number of these trucks that can be used. The Contractor will receive credit for the fee paid to the DBE for these trucks.

c) A DBE trucker may also use trucks from a non-DBE firm, including an owner operator. The Contractor will receive credit toward the DBE commitment only for the fee or commission retained by the DBE trucker. The Contractor will not receive credit for the total amount paid for the truck because the DBE was a lessee rather than the actual provider of transportation services.

h. Commercially Useful Function.

- A DBE performs a commercially useful function when it is responsible for execution of the work of the contract and is carrying out its responsibilities by actually performing, managing, and supervising the work involved. To perform a commercially useful function, the DBE must also be responsible, with respect to materials and supplies used on the contract, for negotiating price, determining quality and quantity, ordering the material, and installing (where applicable) and paying for the material itself. The DBE must perform a commercially useful function consistent with common Iowa highway construction industry practices and the amount the firm is to be paid under the contract must be commensurate with the work it is actually performing by the DBE.
- DBE participation will not be counted if the DBE firm does not perform a commercially useful function (e.g. its role is limited to that of an extra participant in a transaction, contract, or project through which funds are passed in order to obtain the appearance of DBE participation).

  Interpretations by the Department regarding Commercially Useful Function participation by a DBE firm will be in accordance with 49 CFR, Part 26 Public Law 105-178, 112 Stat.107.

E. Contract Award Procedures.

The proposal will specify if the proposed contract has an established DBE goal or has no established DBE goal. The established DBE goal will be shown on the proposal as a percent of the total amount bid. The bidder may only use work on the federal aid projects on the proposal to achieve the DBE goal. The proposal may also designate the items of the federal aid project that are over utilized by DBE firms and cannot be used for DBE commitments.

1. Bidder's Responsibility.

It is the bidder's responsibility to determine the level of professional competence and financial responsibility of any proposed DBE subcontractor. The bidder shall ascertain that the proposed DBE subcontractor has suitable experience and equipment to perform a commercially useful function for work that is common industry practice in the Iowa highway construction industry. Subcontractor expenditures, which may be counted towards the DBE commitment, will include DBE

trucking, purchase of materials from a DBE manufacturer or supplier, or off-site services provided by a certified DBE firm.

2. Proposals with Established Project DBE Goals.

a. For proposals with established project goals the bidder will be required to complete Form 102115.

b. The bidder shall list the following information on Form 102115 that is submitted with their bid:

1) Certified DBE firms contacted,

2) Date that each DBE firm was first contacted concerning quoting on the proposal to be bid,

3) Whether each DBE firm submitted a quote on the proposal to be bid,

4) If the DBE firm is being used as part of the bidder's DBE commitment,

5) If used as part of the bidder's DBE commitment, the work items on the contract for which the DBE will be used,

6) If used as part of the bidder's DBE commitment, the "Amount To DBE" which has been committed to each DBE firm which will be used on the contract,

7) If the DBE firm is being used as a supplier (in which case, only 60% of the dollars paid to the DBE firm will count toward the DBE commitment), and

8) The "DBE Commitment" of each DBE firm which will be counted towards the total DBE commitment for the contract.

c. In cases where the required information is included on the form, but where discrepancies occur, the Office of Contracts will make the following calculations to determine the Contractor's DBE commitment. The DBE dollar commitment will be the sum of the amounts listed in the "Amount to DBE" column, adjusted for suppliers as provided in the specifications. The percent of DBE participation will be the DBE dollar commitment as determined above, divided by the total contract amount as defined by Article 1102.09. Each bidder's DBE participation commitment will be calculated to the nearest 0.1%. If two or more projects are combined on one proposal, the DBE commitment will be calculated using the sum of the DBE dollar commitments and the sum of the project totals.

d. The completed form shall be filled out in ink or be computer generated and submitted with the bidding documents. Failure to attach this completed form or submitting incomplete forms will cause the bid to be rejected as irregular, in accordance with Article 1102.10. Only DBE firms listed in the Directory for the current letting may be used.

3. Bidder Selection.

a. The successful bidder will be selected on the basis of having submitted the lowest responsive bid. Bidders shall make a Good Faith Effort to achieve the DBE goal in order to be responsive. Contractors who meet or exceed the proposed contract goal will be

assumed to have made Good Faith Effort to utilize DBE firms. DBE firms who bid as prime contractors will be considered to have met the goal.

b. The Department's process used to judge the Good Faith Effort of a bidder who has not met the established DBE goal is as follows:

1) 80% of the Goal.
A bidder who has achieved 80% of the established goal will be assumed to have made Good Faith Effort to achieve the goal.

2) 80% of the Average Commitment.
The Department has established the following objective measurement of Good Faith Effort. Good Faith Effort will be determined by calculating 80% of the average of the percentages of the goal and the DBE commitments submitted by all bidders satisfying Article 1103.01, and comparing the percent of DBE commitment of each bidder to that percentage average. The following example shows how the Department will compute the average DBE participation:

a) Only that amount of a bidder's DBE commitment that does not exceed the established goal will be used.

b) The amount of the goal will be used as the DBE commitment amount from DBE bidders who are bidding the project as the prime contractor.

c) The commitments to DBE firms who are affiliates of the bidder will not be included in the calculation.

d) The project DBE Goal will be included in the computation. Example:

80% of the Average Good Faith Effort calculation

Project Proposal has a 10% Goal for DBE participation	= 10.0%
Contractor "A" submits a commitment of 11.8%	= 10.0%
Contractor "B" submits a commitment of 7.0%	= 7.0%
Contractor "C" submits a commitment of 11.4% (of which 4.0% was committed to a DBE affiliate)	= 7.4%
Contractor "D" submits a commitment of 3.6%	= 3.6%
Contractor "E" is a DBE	= 10.0%
Sum of Commitments	= 48.0%
Average DBE Commitment	= 48.0 / 6 = 8.0%
80% of the Average Commitment = 80% of 8.0	= 6.4%

Contractors "A", "C", and "E" would all be responsive for meeting the DBE goal. Contractor "B" would be responsive for meeting 80% of the Average DBE Commitment. Contractor "D" would not be responsive for meeting 80% of the Average DBE Commitment. Should the low bidder's DBE commitment be lower than 80% of the average, with the contract goal included

in the calculation, that bidder will be considered non-responsive for Good Faith Effort to meet the project DBE goal. If the lowest bid is non-responsive due to lack of Good Faith Effort, the next bidder is compared to this 80% of the average commitment until a bidder is identified as having made a Good Faith Effort to achieve the DBE goal.

3) Contractors with History of Utilizing DBEs.

a) A bidder who has demonstrated their ability to utilize DBE firms on both Federal-aid and non-Federal-aid projects let by the Department in the 24 months prior to the letting will be assumed to have made a Good Faith Effort to achieve the project goal.

b) The Department's objective evaluation of prior usage of DBE firms will include all contracts let by the Department that were awarded to the Contractor during the 24 months prior to the letting. The calculation will include one point for each percentage of average DBE subcontracted dollars for the 24 months prior to the letting (e.g. an average 7.5% dollars subcontracted to DBE equals 7.5 points)

A contractor under consideration for having a history of utilizing DBE firms must have been awarded at least two contracts during the period being reviewed.

A contractor under consideration for having a history of utilizing DBE firms must have been awarded a dollar amount of contracts that exceed at least twice the dollar amount of the contract under consideration. For example, to be awarded a $1,000,000 contract, the contractor under review would have to have been awarded $2,000,000 in the Annual Good Faith Effort calculation.

The Annual Good Faith Effort points used for a letting would be based on the signed contractors and Request for Subcontract forms submitted by 5 calendar days before the letting. The number of points a contractor will need to be considered to demonstrate a history of utilizing DBE firms must exceed 67% of the Department's Annual DBE Goal (e.g. if the Department's annual DBE Goal is 7.8%, the contractor must have over 5.2 points). It is assumed that 67% of the DBE usage will be subcontract work and 33% of the dollars paid to DBE firms will be to DBE firms who have been awarded prime contracts.

4) Administrative Reconsideration of Project Specific Good Faith Effort.

a) Contractors who have not met the specified DBE goal or have not been determined to have demonstrated Good Faith Effort by the above methods can request administrative reconsideration of their Good Faith Effort.

b) Within 2 business days after the deadline for bid submittal, the Department will use the three Good Faith Effort methods to determine which bidders have made a Good Faith Effort to meet the DBE goal on each proposal for which bids were received. The Department will contact all otherwise lowest responsive bidders who have not met any of the Good Faith Effort criteria and offer that bidder an opportunity for an Administrative Reconsideration meeting with the Department's Administrative Reconsideration Committee. This committee consists of representatives from the Department's Offices of Contracts, Construction, and Employee Services. The bidder shall request the Administrative Reconsideration meeting within 1 business day of the Department's offer of an Administrative Reconsideration meeting.

c) Any bidder who has requested Administrative Reconsideration shall not adjust their DBE Commitment or provide any additional documentation of DBE firms contacted that were not listed on Form 102115. However, the bidder will be allowed to provide documentation on other Good Faith Efforts they did to utilize DBE firms that are listed on Form 102115. These efforts may include:

(1) Efforts to provide interested DBEs with adequate information about the plans, specifications, and requirements of the contract in a timely manner to assist them in responding to a solicitation.

(2) Written documentation of negotiation with certified DBE firms including the names, addresses, and telephone numbers of DBEs that were considered; a description of the information provided regarding the plans and specifications for the work selected for subcontracting; and evidence as to why additional agreements could not be reached for DBEs to perform the work.

(3) Written documentation of follow-ups made after the initial solicitations to encourage DBE firms to quote.

(4) Written documentation that the DBE firm's quote was not reasonable or that the DBE firm was not capable of performing the work for which they quoted. The fact that there may be some additional costs involved in finding and using DBE firms is not in itself sufficient reason for a bidder's failure to meet the contract DBE goal, as long as such costs are reasonable. Also, the ability or desire of a bidder to perform the work of a contract with its own organization does not relieve the bidder of the responsibility to make Good Faith Efforts.

(5) Written documentation of efforts to assist interested DBE firms in obtaining bonding, lines of credit, or insurance as required by the specifications.

(6) Written documentation of efforts to assist interested DBE firms in obtaining necessary equipment, supplies, materials, or related assistance or services needed for the project.

d) The determination made by the Administrative Reconsideration Committee shall be considered final.

F. Construction Period Requirements.

1. The Contractor shall use those DBEs for the amounts listed on Form 102115 as submitted with their bid. The Contractor shall give the DBE five calendar days to respond to any notice from the Contractor. The Contractor shall inform the Engineer of the reasons why a DBE will be unable to complete the work for which they were committed. The Contractor shall document their efforts to have another DBE perform the item or to have a DBE perform other items to replace the original DBE commitment amounts. Any request for substitution of a DBE subcontractor shall be made to the Engineer and approved by OES-Civil Rights.

2. The Contractor is allowed to offer construction assistance to DBE subcontractors, but only in areas where DBEs can benefit from their expertise or in situations arising from unforeseen emergencies or natural disasters. The assistance shall be short-term and involve only equipment, or workers that function as trainers. Before offering the assistance, the Contractor shall notify the Engineer and obtain the written approval of OES-Civil Rights.

3. Brokering of work by DBEs is not allowed and is a contract violation. A DBE firm involved in brokering of work may be decertified. Any firm involved in brokering of work, that engages in willful falsification, distortion, or misrepresentation with respect to any facts related to the project shall be referred to the U. S. Department of Transportation's Office of the Inspector General for prosecution under Title 18, U. S. Code, Section 100.20.

G. Post Construction Requirements.

1. Prior to receiving final payment, the Contractor shall provide to the Engineer certification of the dollars paid to each DBE firm, using Form 102116, Certification Of DBE Accomplishment. This certificate shall be submitted on all Federal-aid contracts and shall list the dollar amounts paid to all DBE firms on the contract. The certification shall be dated and signed by a responsible official legally representing the Contractor. Falsification of this certification will result in suspension of bidder qualifications according to Article 1102.03.

2. If the contract contained a DBE commitment, the Engineer will verify that the Contractor has attained the DBE commitment specified on Form 102115. If the commitment is not met and was less than the goal, the

price adjustment is the difference between the actual dollars paid and the commitment. If the commitment is not met and was greater than the goal the price adjustment is the difference between the actual dollars paid and the goal.

3. The penalty for failure to meet DBE commitments will then be reduced by the following amount:
- **a.** Underruns or deletion of contract items which were subcontracted to DBE firms.
- **b.** Designated work that the DBE failed to perform and concurrence to waive this work was received from the Department.

4. Failure to meet the specified DBE commitment to each DBE firm will result in a price adjustment of an amount equal to the difference between the actual DBE dollars paid and the Contractor's adjusted DBE commitment to that DBE firm.

H. Required Records.

The Contractor and subcontractors shall retain, for a period of not less than 3 years after final acceptance of a project, copies of canceled checks or other documentation that substantiates payments to DBE firms. These records shall be available at reasonable times and places for inspection by authorized representatives of the Department and Federal Agencies.

I. Sanctions for Failing to Comply with the Intent of the DBE Regulations.

1. DBE Firms.

The ability to be eligible to receive DBE goal work is a privilege made available to a select group of firms. Firms that abuse this privilege may have their ability to be counted towards the DBE goal restricted if the firm fails to perform their work consistent with common industry practices. Examples of not performing work consistent with common industry practice include, but are not limited to:
- **a.** Patterns of failing to perform a commercially useful function for work quoted to meet a DBE goal.
- **b.** Patterns of failing to complete the work with their own organization for work quoted to meet a DBE goal.
- **c.** Patterns of failing to pay for all labor and materials for the work they have subcontracted to meet a DBE goal.
- **d.** Patterns of failing to perform the work they have subcontracted.
- **e.** Patterns of failing to notify the prime contractor in a timely manner when their work schedule makes it impossible for them to begin subcontract work at the requested time.
- **f.** Patterns of failure to furnish documents (e.g. certified payrolls, material test reports, etc.) within the timeframes allowed by the specifications.

The Department will provide written notice to the DBE firm, informing them of any proposed sanction. The DBE firm will have 14 calendar days, from the receipt of the certified notification, to make a written

request for a hearing. The appeal hearing will be held with a three-person committee consisting of representatives from the Offices of Contracts, Construction, and Employee Services. If the Department does not receive a written request for a hearing, or if the DBE firm does not provide sufficient evidence at the hearing to refute the violations, the Department may suspend the DBE firm from the ability to be counted towards the commitment on projects with DBE goals. The duration of the suspension will be determined based on the severity of the violation and the number of prior suspensions of the DBE firm.

2. Prime Contractors.

Contractors who show a pattern of non-compliance with the DBE requirements of the contract may be suspended from bidding on contracts that have DBE goals. Examples that would indicate a lack of good faith effort to comply with the DBE requirements include, but are not limited, to:

- **a.** Patterns of performing work with their own organization, or having another company perform work, which was committed to a DBE firm to meet a DBE goal.
- **b.** Patterns of not keeping the DBE firms posted on the status of their projects, and not providing advance notification to the DBE when their subcontract work will be available to the DBE firm.
- **c.** Patterns of not promptly paying DBE firms for completed work in accord with Article 1109.05.
- **d.** Not treating DBE firms as they would any other subcontractor on the project.

The Department will provide written notice to the Contractor, informing them of any proposed sanction for failure to comply in good faith with the intent of the DBE regulations. The Contractor will have 14 calendar days, from the receipt of the certified notification, to make a written request for a hearing. The appeal hearing will be held with a three-person committee consisting of representatives from the Offices of Contracts, Construction, and Employee Services. If the Department does not receive a written request for a hearing, or if the contractor does not provide sufficient evidence at the hearing to refute the violations, the Department may suspend the Contractor from bidding on projects that have DBE goals. The duration of the suspension will be determined based on the severity of the violation and the number of prior suspensions of the Contractor for DBE sanctions. The sanctions may be extended beyond contracts with DBE goals if the Contractor’s treatment of DBE firms has extended beyond contracts assigned DBE goals.

1102.18 SPECIFIC AFFIRMATIVE ACTION RESPONSIBILITIES ON NON-FEDERAL-AID PROJECTS (TARGETED SMALL BUSINESS PROJECT PARTICIPATION).

A. General.

1. AA requirements are to encourage and increase participation of disadvantaged individuals in business enterprises in all state projects involving funds made available through the Department. This is required by Iowa Code Section 19B.7 and 541 Iowa Administrative Code Chapter 4. On projects let by the Department, funded in whole or in part by state funds, these requirements supersede all existing TSB enterprise regulations, orders, circulars, and administrative requirements.

2. TSB Directory information is available from:
Office of Employee Services, Civil Rights Team
Iowa Department of Transportation
800 Lincoln Way
Ames, IA 50010
Telephone 515.239.1422

B. Targeted Small Business.

A TSB is a small business, defined by Iowa Code 15.102(4), which is 51% or more owned, operated, and actively managed by one or more women or minority persons. Generally this is a for-profit small business enterprise under single management, which is located in Iowa.

C. Contractor's TSB Policy.

The Contractor is expected to promote participation of disadvantaged individuals in business enterprises as suppliers, manufacturers, and subcontractors through a continuous, positive result oriented program. The following statement should be included in the Contractor's operating policy:

It is the policy of this firm that TSB concerns, as defined in Iowa Code 19B.7 and 541 Iowa Administrative Code Chapter 4, shall have the maximum practical opportunity to participate in contracts funded in whole or in part by state funds through this firm (e.g. suppliers, manufacturers, and subcontractors).

The purpose of the Contractor's policy is to encourage and increase participation by TSBs in contracting opportunities made available by this firm in the performance of contracts let by the Department.

D. Positive TSB Effort Documentation.

1. Contractors are required to make positive efforts in utilizing TSBs on all non-Federal- aid projects let by the Department. The Contractor shall document all efforts made to include TSB participation in these projects. The documentation shall remain in the Contractor's project files for a

period of 3 years after the completion of the project and be available, upon request, for examination by the Department.

2. On proposals where a specific TSB goal has been established, the Contractor will be required to submit the TSB form with their bid. The TSB form will be provided by the Contracting Authority and used to document the TSB participation that shall be attained. The Contracting Authority will determine if the bidder has made adequate Good Faith Effort to meet the established goal. Bidders who fail to make such Good Faith Effort may have their bid rejected on the basis of being non-responsive to meeting the established TSB goal.

1102.19 EQUAL EMPLOYMENT OPPORTUNITY AND AFFIRMATIVE ACTION REQUIREMENTS.

A. General.

1. EEO and AA requirements will apply to all contracts let by the Department that equal or exceed $10,000.00. The requirements will also apply to any subcontracts that equal or exceed $10,000 if the subcontract involves a contract let by the Department.

2. On Federal-aid projects laws, executive orders, rules, regulations (28 CFR 35, 29 CFR 1630, and 41 CFR 60), and orders of the Secretary of Labor, as modified by this specification and imposed pursuant to 23 U.S.C. 140, shall constitute the EEO/AA standards for the Contractor's company-wide activities for contracts let by the Department and for subcontracts involved in such contracts. The Equal Opportunity Construction Contract Specifications, set forth under 41 CFR 60-4.3, and the provisions of the American Disabilities Act of 1990 (42 U.S.C. 12101 et seq.) set forth under 28 CFR 35 and 29 CFR 1630, are both incorporated by reference in contracts and subcontracts utilized by the Department.

3. On non-Federal-aid projects the Iowa Civil Rights Act of 1965, as amended; current Iowa Administrative Rules; and Iowa Executive Order 15 shall constitute the specific EEO/AA standards for the Contractor's company-wide activities for contracts let by the Department and for subcontracts involved in such contracts.

B. Definitions.

1. Affirmative Action.

a. The efforts exerted toward achieving equal opportunity through positive, aggressive, and continuous result-oriented measures to correct past and present discriminatory practices and their effects on the conditions and privileges of employment. These measures include, but are not limited to, recruitment, hiring, promotion, upgrading, demotion, transfer, termination, compensation, and training.

b. Women and minorities are both considered disadvantaged persons. They are however considered distinct and separate groups in regard to employer's good faith recruitment efforts.

2. Equal Employment Opportunity.
In hiring and employment practices, the absence of discrimination on the basis of race, religion, sex, color, national origin, age, disability, or other protected classification under Federal, state, or local law.

3. Journey-Worker.
A trained worker who is capable of performing all duties within a given job classification or craft.

4. Minority.
A citizen or lawful permanent resident of the United States and who is a member of one of the following racial groups:

a. Black: All persons having origins in any of the Black racial groups not of Hispanic origin.

b. Hispanic: All persons of Mexican, Puerto Rican, Cuban, Central or South American, or any other Spanish culture or origin, regardless of race.

c. Asian or Pacific Islanders: All persons having origins in any of the original peoples of the Far East, Southeast Asia, or the Pacific Islands. This area includes, for example, China, Japan, Korea, the Philippine Islands, and Samoa.

d. American Indian or Alaskan Native: All persons having origins in any of the original peoples of North America.

5. New Hire.
A new hire is not a recall or a rehire, and was originally hired within the previous 12 months. It is not required that the new hire was originally hired for a contract let by the Department, but they shall have worked on a contract let by the Department within the previous 12 months.

6. Recall.
A person who, after being involuntarily laid off by a contractor, is re-employed by that same contractor when the layoff is no longer necessary. In addition, to be defined as a recall, at least one of the following two criteria must have been met during the layoff period:

a. The former employee must have had no employment with other heavy highway contractors.

b. The former employee's health insurance or pension plan must have been maintained by the re-employing contractor.

7. Rehire.
A person who, after voluntarily terminating employment with a contractor because of a change in working conditions or circumstances, returns to employment with the same contractor. In addition, to be defined as a rehire, at least one of the following two criteria must have been met during the period of severed employment:

a. The former employee must have had no employment with other heavy highway contractors.
b. The former employee's health insurance or pension plan must have been maintained by the re-employing contractor.

8. Segregated Facilities.
Employee facilities that are separated on the basis of race, religion, color, national origin, age, or disability either by explicit directive or by fact because of habit, local custom, or any other reason. Examples of such facilities include, but are not limited to, the following: waiting rooms, work areas, restrooms and washrooms, restaurants and other eating areas, time clocks, locker rooms, storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities. The only exception to this definition is the provision of special accommodations, such as handicapped parking spaces, to make the workplace more accessible for those who are disabled.

9. Trainee/Apprentice.
A person receiving on-the-job training through a program approved or accepted by the United States Department of Labor, the FHWA, or the Department.

C. Contractor's/Subcontractor's EEO/AA Policy.
The Contractor/subcontractor, with the exception of manufacturers, suppliers, and hauling firms, shall have an EEO/AA policy approved by the Department prior to being awarded a contract or subcontract that equals or exceeds $10,000.00. The Contractor's/subcontractor's EEO/AA policy shall be re-approved on an annual basis through either the preparation or completion of a new EEO/AA policy or the review of an existing policy. When requesting re-approval under the latter option, the Contractor/subcontractor shall submit a written statement indicating that the existing policy has been reviewed. It shall further state that the policy is current with no revisions or, if revisions have been made, the revisions shall be signed and dated by their EEO/AA Officer and another company officer. The Contractor's/subcontractor's EEO/AA policy shall also include the following items:

1. The EEO/AA Operating Statement.
"It is the policy of this Company to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, religion, sex, color, national origin, age, or disability. Such action shall include: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship, pre-apprenticeship, and/or on-the-job training."

2. Designation and Job Responsibilities of the Company's EEO/AA Officer.

The Contractor/subcontractor shall designate an EEO/AA Officer to be responsible for and capable of effectively administering and promoting the Contractor's/subcontractor's EEO/AA program. Adequate authority and responsibility shall also be assigned to the EEO/AA Officer in order to perform these duties.

3. Affirmative Action Recruitment Plan.

The Contractor's/subcontractor's Affirmative Action Recruitment Plan shall be designed to seek out and obtain applications from women and minorities for all job openings and promotions. The plan shall also include the following provisions:

- **a.** At a minimum, the Contractor/subcontractor shall utilize one or more Iowa Workforce Development Centers or the AGC of Iowa Career Center website. When feasible, the Contractor/subcontractor shall commence a recruitment effort no later than 1 month prior to the date on which a hiring decision will be made.
- **b.** All solicitations and advertisements for employees, placed by or on behalf of the Contractor/subcontractor, shall include the notation: "An Equal Opportunity Employer."

4. Identification of Recruitment Methods.

When the Contractor/subcontractor is unable to obtain a reasonable flow of applications from women and minorities, the Affirmative Action Recruitment Plan shall identify specific methods used to exhaust all possible avenues of recruitment. Such methods may include:

- **a.** Maintaining a list of the names and locations of publications that have a large circulation among minority groups in the area from which the workforce would normally be derived, and placing recruiting advertisements in these publications.
- **b.** Utilizing public and private employee referral sources likely to yield applications from qualified women and minorities.
- **c.** If unionized, a strategy for obtaining union referrals of women and minorities through the Contractor's/subcontractor's collective bargaining agreement. If the union is unable to provide the Contractor/subcontractor with a reasonable flow of referrals of women and minorities within the time limit set forth in the collective bargaining agreement or other contract or understanding, the Contractor/subcontractor will go through independent recruitment efforts. As part of those efforts, the Contractor/subcontractor will attempt to obtain qualified, qualifiable, and/or trainable women and minorities, and will fill employment vacancies without regard to race, religion, sex, color, national origin, age, or disability.
- **d.** A plan for encouraging present employees to recruit women and minorities.
- **e.** Other specific actions the Contractor/subcontractor will take to ensure that a pool of woman and minority candidates is available from which to hire.

5. Facility Certification.
The Contractor/subcontractor shall certify that nonsegregated facilities are provided for their employees. In addition, certification shall state that no employee will be denied access to adequate facilities on the basis of sex or disability. If the Contractor/subcontractor provides employees with any facility that is segregated, work at the site with the segregated facility may be suspended.

D. Training and Promotion Plan.

1. General.
If the Contractor/subcontractor is planning to provide any training, the Contractor/subcontractor shall have a training and promotion plan. If the Contractor/subcontractor does not have a training and promotion plan, the Contractor's/subcontractor's EEO/AA policy shall state there is no plan. The Contractor/subcontractor shall have a plan, however, if they later decide to provide training for new or existing employees. Any training and promotion plan that is required shall include the following:

a. This training specification supplements subparagraph 7e of the Contract Provision entitled "Standard Federal Equal Opportunity Construction Contract Specification (Executive Order 11246)" and is in implementation of 23 U.S.C. 140(a).

b. The Contractor shall provide on-the-job training aimed at developing full journeymen in the type of trade or job classification involved.

c. As part of the Contractor's EEO/AA program, the Contractor shall provide training to a prescribed number of trainees. Training new and existing employees for the purpose of promotion is to be considered a part of doing business with the Department. No reimbursement payment will be made to the Contractor.

d. The number of trainees required shall be determined by the Contractor. The number of trainees will be determined by using the previous 3 year average of work actually performed by the Contractor including all prime and sub contract work with the Department. The Contractor shall provide the following number of trainees while under contract with the Department:

Under $4,999,999	No trainee requirement
$5,000,000 to $9,999,999	1 trainee
$10,000,000 to $19,999,9992	2 trainees
$20,000,000 to $29,999,9993	3 trainees
$30,000,000 or more	4 trainees

e. These training requirements are minimums and the Contractor is encouraged to have more than the minimum.

f. Completion of this required training shall be the responsibility of the Contractor and shall not be assigned to a Subcontractor.

g. This information may be verified by the Department.

2. Work Classifications.
The number of trainees shall be distributed among the work classifications on the basis of the Contractor's needs and the availability of journeymen in the various classifications within a reasonable area of recruitment. The Contractor will be credited for each trainee employed on the contract work who is currently enrolled or becomes enrolled in an approved program.

3. Minorities and Women.
Training and upgrading of minorities and women toward journeymen status is a primary objective of this training specification. Accordingly, the Contractor shall make every effort to enroll minority trainees and women by conducting systematic and direct recruitment through public and private sources likely to yield minority and women trainees to the extent that these persons are available within a reasonable area of recruitment. The Contractor shall be responsible for demonstrating the steps taken in pursuance of recruitment, prior to a determination of the Contractor being in compliance with this training specification.

4. Training.
a. An employee shall not be employed as a trainee in any classification in which an employee has successfully completed a training course leading to journeyman status or in which an employee has been employed as a journeyman. The Contractor shall satisfy this requirement by including appropriate questions in the employee application or by other suitable means. Regardless of the method used, the Contractor's records shall document the findings in each case.
b. The minimum length and type of training for each classification will be as established in the training program selected by the Contractor and approved by the Department. The Department will approve a program, if it is determined to meet the equal employment opportunity and affirmative action obligations of the Contractor and to qualify the average trainee for journeyman status in the classification concerned by the end of the training period. Furthermore, apprenticeship programs registered with the U. S. Department of Labor, Bureau of Apprenticeship and Training, or with a State apprenticeship agency recognized by the Bureau and training programs approved but not necessarily sponsored by the U. S. Department of Labor, Manpower Administration, or Bureau of Apprenticeship and Training, will also be considered acceptable provided it is being administered in a manner consistent with the equal employment and affirmative action obligations of Federal-aid highway construction contracts. Approval or acceptance of a training program shall be obtained from the Department prior to commencing work on the classification covered by the program.
c. It is the intention of these provisions that training is to be provided in the construction crafts rather than clerk-typists or secretarial-type positions. Training is permissible in lower level management positions, such as office engineers, estimators, etc., where the

training is oriented toward construction applications. Training in the laborer classification may be permitted provided that significant and meaningful training is provided and is approved by the division office of the Federal Highway Administration. Some offsite training is permissible as long as the training is an integral part of an approved training program and does not comprise a significant part of the overall training.

5. Payment of Trainees.

On contracts with a predetermined wage rate, trainees must be paid at least the journeyman's wage unless the trainee is enrolled in an approved U.S. Department of Labor (DOL) training program. Trainees in approved U.S. DOL training programs shall be paid the appropriate rates approved by the U. S. DOL or Iowa DOT.

6. Compliance.

a. A Contractor's compliance will be based on the number of trainees completing a training program during the construction season.

b. A Contractor that fails to meet the determined number of trainees will be allowed the opportunity to show that a Good Faith Effort was made trying to meet the training requirement. If the Contractor fails to show that a Good Faith Effort was made in meeting the training requirement, the Contractor may be suspended from bidding projects with the Department.

7. Records.

a. General.

1) The Contractor shall furnish the trainee a copy of the program the trainee will follow during the training. The Contractor shall provide each trainee with a certification showing the type and length of training satisfactorily completed.

2) The Contractor shall provide for the maintenance of records and furnish a report once per construction year documenting their performance under this training specification. The report shall be submitted to the Office of Employee Services with the Annual Company Wide Report of Total Employment on All Federal and Non-Federal Projects Let By the Iowa Department of Transportation. This report shall include but is not limited to, names of trainees, job classifications, gender, ethnic background, future status with the company and hours of training received. The Office of Employee Services may verify this information with the trainee.

b. Designation of Trainee and Promotional Job Classifications.

For each designated classification, the plan shall identify benchmarks specifying the types of work an employee will be doing after various intervals of time. For example, the plan might describe increasingly skilled levels of work to be performed after every 100 hours of training.

c. Notice of On-the-Job Training Programs and Training Entrance Requirements.
Methods to advise employees and job applicants of training programs and training entrance requirements.

d. Review of Training and Promotion Potential.
Methods to periodically review the training and promotion potential of women and minority employees, thus ensuring they have the opportunity to be upgraded.

e. Training Progress Review.
A method to routinely review the progress of each employee enrolled in training.

f. Maximum Trainee/Journey-Worker Ratio.
The maximum trainee/journey-worker ratio, by craft, that the Contractor/subcontractor intends to utilize; a maximum ratio of 1:3 is suggested.

E. Dissemination of Policy.
All members of the Contractor's/subcontractor's staff who are involved in the hiring, supervision, promotion, and discharge of employees shall be made knowledgeable of the Contractor's/subcontractor's EEO/AA policy. The following actions shall be taken as a minimum:

1. Periodic Review of Contractor's/Subcontractor's EEO/AA Policy.
Periodic meetings of supervisory and personnel office employees shall be conducted at least once every 6 months, at which time the Contractor's/subcontractor's EEO/AA policy and its implementation will be reviewed and explained. The meetings shall be conducted by the EEO/AA Officer.

2. Instruction of New Supervisory and Personnel Office Employees.
The EEO/AA Officer shall provide all new supervisory and personnel office employees with thorough instruction, covering all major aspects of the Contractor's/subcontractor's EEO/AA obligations, within 30 calendar days following the date they first reported for duty with the Contractor/subcontractor.

3. Instruction in Recruitment Procedures.
All personnel directly engaged in recruiting shall be instructed, by the EEO/AA Officer, in the Contractor's/subcontractor's procedures for locating and hiring women and minorities.

4. Employee Notification of EEO/AA Policies and Procedures.
The Contractor's/subcontractor's EEO/AA policy, as well as the procedures for its implementation, shall be brought to the attention of employees by means of meetings, employee handbooks, or other appropriate means.

5. Placement of EEO/AA Notices and Posters.

a. The Contractor shall place the following notices and posters on a bulletin board at the project site in areas readily accessible to employees and potential employees.

1) Notice provided by the Iowa DOT listing the names, addresses, and phone numbers of the Contractor and all approved subcontractors.

2) Publication OFCCP 1420, stating "Equal Employment Opportunity is THE LAW".

3) Form FHWA-1022, regarding any false statement, false representation, false report, or false claim made in connection with any Federal or Federal-aid highway or related project.

4) Form FHWA-1495, regarding wage rate information for a Federal-aid highway project, required only if Davis/Bacon predetermined wage rates apply to the project.

5) Current Iowa Predetermined Wage Rate Decision, identifying Davis/Bacon predetermined wage rates for the State of Iowa. The wage rate decision shall be arranged on a bulletin board so that all wage rate and classification information is visible.

6) Form 70-8025 Job Safety and Health.

7) WH-1420 Your Rights Under the FMLA Act of 1993.

8) WH-1462 Notice: Employee Polygraph Protection Act.

9) Form FHWA-1495A (Spanish version of form FHWA-1495), stating "Informacion Sobre Escalas De Salarios Proyecto De Carretera Con Ayuda Federal", required only if Davis/Bacon predetermined wage rates apply to the project.*

10) Form EEOC-P/S-1 (Spanish version of form EEOC-P/E-1), stating "La Igualdad de Oportunidades De Empleo Es LA LEY".*

* These forms are not required, but it is strongly recommended that these two Spanish notices be posted whenever the company employs and/or anticipates receiving applications from those who speak Spanish.

b. All required postings shall be in place when work commences on a project and shall remain in place through completion of the project.

c. Progress payments to the Contractor will not be made until these notices and posters are displayed at the required site.

F. Personnel Actions.

Wages, working conditions, employee benefits, and personnel actions of every type including hiring, upgrading, promotion, transfer, demotion, layoff, and termination shall be made without regard to race, color, religion, sex, national origin, age, or disability. The following procedures shall be followed by the Contractor/subcontractors. The EEO/AA Officer may appoint a designee to perform these functions.

1. Periodic Inspection of Project Sites.

Project sites shall be periodically inspected by the EEO/AA Officer to ensure that there is no discriminatory treatment of project site personnel

with regard to employee facilities and working conditions. The EEO/AA Officer shall document the dates of these inspections and provide the Contractor/subcontractor with a summary of the findings. The Contractor/subcontractor shall promptly take corrective action where evidence of discriminatory treatment is found.

2. **Periodic Evaluation of Wage Differentials.**
Wage differentials within each job classification shall be periodically evaluated by the EEO/AA Officer to determine whether there are any discriminatory wage practices. The EEO/AA Officer shall document the dates of these evaluations and provide the Contractor/subcontractor with a summary of the findings. The Contractor/subcontractor shall promptly take corrective action where evidence of discriminatory treatment is found.

3. **Periodic Review of Selected Personnel Actions.**
Selected personnel actions shall be periodically reviewed by the EEO/AA Officer to determine whether there is evidence of discrimination. The EEO/AA Officer shall document the dates of these reviews and provide the Contractor/subcontractor with a summary of the findings. The Contractor/subcontractor shall promptly take corrective action where evidence of discriminatory treatment is found.

4. **Review of Supervisors.**
An annual review shall be conducted to discuss each supervisor's performance with regard to the Contractor's/subcontractor's EEO/AA policy. The review shall include a discussion of each supervisor's adherence to the provisions of that policy.

5. **Investigation of Each Complaint, with Corrective Action if Necessary.**
An individual, group of individuals, or entity believing they have been subjected to discrimination prohibited by Title VI Nondiscrimination Provisions may file a written complaint with OES-Civil Rights. A formal, signed complaint shall be filed within 180 calendar days of the alleged occurrence.

   Upon receipt of the complaint, the OES-Civil Rights Coordinator will determine its jurisdiction, acceptability, need for additional information, and investigative merit of the complaint. In cases where the complaint is against one of the Department’s sub-recipients of federal highway funds or federal transition funds, the Department will assume the jurisdiction and will investigate and adjusticate the case.

   Once the Coordinator decides to accept the complaint for investigation, the complainant and the respondent will be notified in writing of such determination within five calendar days. The complaint will receive a case number and be logged into the OES-Civil Rights’ records identifying its basis, race, color, national origin, and gender of the complainant.

In cases where the Department assumes the investigation of the complaint, the Coordinator will provide the respondent with the opportunity to respond to the allegations in writing. The respondent will have 10 calendar days to furnish OES-Civil Rights their response to the allegations.

Within 40 calendar days of receipt of the complaint, the OES-Civil Rights investigator* will prepare an investigative report for the Director of the Department's Operations and Finance Division to review. The report will include a narrative description of the incident, identification of persons interviewed, findings and recommendations for disposition. *This may be the District/Division Title VI Liaison, Coordinator, or Title VI Specialist.

The investigative report and its finding will be sent to the Attorney General's Office for review. The Attorney General's Office will review the report and associated documentation and provide input within 10 calendar days.

Comments or recommendations from the Attorney General's Office will be reviewed by the Department's Operations and Finance Division. The Department's Operations and Finance Division will discuss the report and recommendations with the Title VI Coordinator. The report will be modified as needed and made final for its release.

Once the Department's investigative report becomes final, the parties will be properly notified of the outcome and appeal rights.

The Department's investigative report and a copy of the complaint will be forwarded to FHWA, Washington Division Office, within 60 calendar days of the receipt of the complaint.

If the complainant is not satisfied with the results of the investigation, they shall be advised of their rights to appeal the Department's determination to the FHWA - Washington Division Office, U.S. DOT or U.S. Department of Justice. Appeals shall be filed within 180 calendar days after FHWA's final resolution. Unless new facts not previously considered come to light, reconsideration of the Department's determination will not be available.

The Department will serve as appealing forum to a complainant that is not satisfied with the outcome of an investigation conducted by a Department sub-recipient. The Department will analyze the facts of the case and issue its conclusion to the appellant within 60 calendar days of the receipt of the appeal.

G. Records and Reports.

A Contractor/subcontractor shall keep records to document compliance with the EEO/AA requirements. The records shall be retained for a period of 3 years following completion of the contract work, and shall be available for

inspection, at reasonable times and places, by authorized representatives of the Department and the FHWA.

1. The Contractor/subcontractor shall keep records to document the following:

a. All of the Contractor's/subcontractor's efforts and progress toward locating, hiring, training, qualifying, and upgrading women and minorities. A detailed summary of these efforts and progress shall include a list providing the name, address, phone number, date of contact, and contact person of each referral source and each publication in which job vacancies were posted. In addition, dated copies shall be kept of all job orders, tear sheets, and newspaper ads, along with the specific job classification that was posted in each of these employment notices.

b. All company efforts and progress toward cooperating with unions, community organizations, and other recruitment sources for the purpose of increasing employment opportunities for women and minorities. A current file, providing the following information, shall also be maintained:

1) Name, address, and phone number of each woman and minority off-the-street applicant.

2) Name, address, and phone number of each woman and minority referred from a union, community organization, or other recruitment source.

3) The date on which action was taken with respect to each of the above individuals. If an individual was referred to the Contractor/subcontractor, but not employed by the Contractor/subcontractor, the reason(s) for not hiring the individual shall be documented. Similarly, if an individual was sent by the Contractor/subcontractor to a union hiring hall for referral, but not referred back to the Contractor/subcontractor by the union, the reason(s) for not making the referral shall be documented. Any additional actions taken with regard to either of these referrals shall also be documented.

c. Employment data, arranged both by race and sex within each race, for each of the following:

1) The number of individuals employed within each of the Contractor's/subcontractor's job categories.

2) The number of individuals employed as apprentices in all of the Contractor's/subcontractor's job categories combined.

3) The number of individuals employed as on-the-job trainees in all of the Contractor's/subcontractor's job categories combined. The data shall be provided for any employee who worked on any Federal-aid project and any non-Federal-aid project let by the Department during the week of peak employment for the previous 12 months. A grid of these required kinds of data is illustrated on Form 650037 7-99 (Iowa PR-1391); see Article 1102.19, G, 2, b. The number of individuals employed as on-the-job trainees in all of the Contractor's/subcontractor's job categories combined. The data shall be provided for any

employee who worked on any Federal-aid project and any non-Federal-aid project let by the Department during the week of peak employment for the previous 12 months. A grid of these required kinds of data is illustrated on Form 650037 7-99 (Iowa PR-1391); see Article 1102.19, G.

d. The name, race, sex, job classification, date of employment, and specific referral source(s) of each new employee utilized on any project let by the Department during the previous 12 months.

e. The name, race, sex, job classification, date of employment, date of last job change, hours worked during the previous 12 months, and current rate of pay of each employee utilized on any project let by the Department during the previous 12 months.

f. The name, race, and sex of each trainee and each employee who was terminated, transferred, demoted, or promoted while utilized on any project let by the Department during the previous 12 months. Records shall also include the dates for each of these actions, the previous and/or new job classifications, and the wage rates corresponding to those classifications.

g. The maximum trainee/journey-worker ratio, by craft, that was utilized on all projects let by the Department during the previous 12 months.

h. All meetings of supervisory employees that include a discussion, during the previous 12 months, of EEO/AA topics and requirements. Records shall also document the thoroughness of instruction explaining the company's EEO/AA obligations to new supervisory employees within 30 calendar days of their hiring or promotion date. Documentation of all meetings and training sessions shall be dated and signed by those in attendance. It shall also identify the specific EEO/AA topics that were discussed.

i. The provision, for all personnel directly engaged in recruitment, of thorough instruction on the company's procedures for locating and hiring women and minorities. The instruction shall be given by the EEO/AA Officer within the past 12 months. Documentation of the instruction shall be dated and signed by those in attendance, and shall also include the specific EEO/AA topics that were discussed.

j. The provision of information regarding the Contractor's/subcontractor's EEO/AA policy and the company's procedures for implementing the policy. The information shall be provided to all employees. Documentation should include the name of each employee receiving the information, along with the method and date of its distribution.

k. All EEO/AA on-site inspections by the EEO/AA Officer, or designee, on projects let by the Department during the previous 12 months. Observations made during the inspection shall include the following: poster reviews; identification of segregated and non-segregated facilities; stated, observed, or overheard employee EEO/AA concerns; and the method(s) of addressing those concerns.

l. Periodic evaluation of wage differentials within each job classification utilized on projects let by the Department during the previous 12 months.

m. Periodic review of selected personnel actions(s) to determine whether there is evidence of discrimination on projects let by the Department during the previous 12 months.

n. All pending Equal Employment Opportunity Commission, Department of Justice, and local and state Human/Civil Rights Agency cases, including a copy of each complaint and a summary of the Contractor's/subcontractor's investigation into each complaint.

o. Initiation of an investigation into each complaint of discrimination within 14 calendar days of the receipt of each complaint.

2. The Contractor/subcontractor shall submit the following documentation to the Office of Employee Services:

a. The Contractor's/subcontractor's EEO/AA policy, shall be submitted annually and include the following:

1) Age of the firm.

2) Annual gross receipts of the firm may be reported by designating the appropriate bracket below:

Less than $500,000
$500,000 - $1,000,000
$1 million - $2 million
$2 million - $5 million
$5 million - $10 million
$10 million - $20 million
$20 million - $50 million
over $50 million

b. Two annual reports, submitted in July of each year, which are titled "Federal-Aid Contractor's Annual Employment Report" and "Annual Company Wide Report of Total Employment on All Federal and Non-Federal Projects Let by the Iowa Department of Transportation." Report form numbers are 650038 7-97 (Iowa PR-1391) and 650039 5-97 (Iowa PR-1391), respectively. The reports shall provide employment data, arranged both by race and sex within each race, for each of the following:

1) The number of individuals employed within each of the Contractor's/subcontractor's job categories.

2) The number of individuals employed as apprentices in all of the Contractor's/subcontractor's job categories combined.

3) The number of individuals employed as on-the-job trainees in all of the Contractor's/subcontractor's job categories combined.

The annual data shall be provided during the last week in July for any employee who worked on any Federal-aid project and any non-Federal-aid project let by the Department. A grid of these required kinds of data is illustrated on both of the required report forms.

c. Immediate notification that a union having a collective bargaining agreement, contract, or other understanding with the

Contractor/subcontractor, has failed to refer to the Contractor/subcontractor a minority or woman who had been sent to the union hall by the Contractor/subcontractor for help in obtaining employment. The Office of Employee Services shall also be notified if the Contractor's/subcontractor's efforts to meet EEO/AA obligations have been impeded in any other way by a union referral process.

H. Non-compliance with EEO/AA Requirements.

Compliance with the Department's EEO/AA specifications and/or the Contractor's/subcontractor's EEO/AA policy will be enforced as follows:

1. Compliance through Informal Means, Including Conciliation and Persuasion.

If a Contractor/subcontractor is found to have violated the Department's EEO/AA specifications and/or the Contractor's/subcontractor's EEO/AA policy, reasonable efforts will be made, whenever possible, to secure the Contractor's/subcontractor's compliance through informal means, including conciliation and persuasion. Such efforts may require a written commitment by the Contractor/subcontractor to correct violations through a plan of specified remedial actions.

a. Violations are considered to be either deficiencies or minor deficiencies. Any of the following is considered to be a deficiency, all other violations are considered to be minor deficiencies:

1) Hiring employees from another company.
2) Failure to engage in a good faith recruitment effort.
3) Failure to use training hours assigned to a project.
4) A finding of probable cause with regard to a civil rights complaint.
5) Failure to utilize project assigned training hours on contracts.
6) Refusal to submit an EEO/AA policy.
7) Refusal to allow access to premises for an on-site compliance review.

b. The form of written agreement utilized for correcting deficiencies is called a conciliation agreement, whereas the form of agreement for resolving minor deficiencies is called a letter of commitment. If a letter of commitment is violated, the violation may be corrected through either a conciliation agreement or an enforcement proceeding. Violation of a conciliation agreement may lead to either a notice to show cause or an enforcement proceeding.

2. Compliance through Enforcement Proceedings or a Notice to Show Cause.

If conciliation efforts are unsuccessful, administrative enforcement proceedings may be initiated or the Contractor/subcontractor may be issued a show cause notice. The show cause notice will require the Contractor/subcontractor to show, within 30 calendar days, why monitoring, enforcement proceedings, or other appropriate action to ensure compliance should not be instituted. Enforcement proceedings may lead to a written notice prohibiting the violations, requiring the Contractor/subcontractor to provide whatever remedies are appropriate,

and/or imposing sanctions. Such sanctions may include withholding progress payments; termination of a contract, in whole or in part; or suspension for an indefinite or specified period of time.

3. Compliance with Executive Order 11246.
The Office of Federal Contract Compliance Programs, within the United States Department of Labor, is the only party having authority to determine enforcement of and compliance with Executive Order 11246 requirements incorporated in contracts and subcontracts utilized by the Department. Included among these requirements are the equal opportunity clause, contained in 41 CFR 60-1.4; the Notice of Requirement for Affirmative Action to Ensure Equal Employment Opportunity, contained in 41 CFR 60-4.2; and (3) the Standard Federal Equal Employment Opportunity Construction Contract Specifications, contained in 41 CFR 60-4.3.

Section 1103. Approval for Award and Award of Contract

1103.01 CONSIDERATION OF BIDS.

The Contracting Authority reserves the right to waive technicalities and to reject any or all proposals. Bidders may be denied a contract award for any one of the following reasons:

A. For failure to meet the Contracting Authority's requirements for qualification of bidders, as set forth in Articles 1102.01, 1102.02, 1102.03, 1102.15, 1102.16, and in the contract documents for the project.

B. For failure to maintain satisfactory progress on work already under contract.

C. For failure to meet promptly financial obligations undertaken in connection with other work under the existing contract or previous contracts.

D. For filing more than one proposal at any letting for the same work under the same or different names. However, affiliates will be allowed to bid against each other on proposals for the same contract. The Department, however, will only consider the lowest of the otherwise responsible affiliate bids for possible award. The proposals of the other affiliates bidding for that contract will be considered non-responsive for both DBE good-faith calculations and consideration for award of the contract.

E. For an unsatisfactory record of performance and cooperation on previous contracts.

F. For submitting an obviously unbalanced bid. An unbalanced bid shall be defined as a bid containing lump sum prices or unit bid prices which do not reflect reasonable actual costs plus a reasonable proportionate share of the bidder's anticipated profit, overhead costs, and other indirect costs to complete that item.

G. For having sublet or otherwise assigned work without the approval of the Contracting Authority.

H. For forfeiture of a proposal guaranty and failure to enter into contract upon an offer of an award by the Contracting Authority in response to a prior advertisement for bids for the same project or any combination of projects involving the project for which award is currently being considered.

I. For failure to file and maintain with the Contracting Authority a current Certificate of Insurance meeting the requirements of Article 1107.02.

J. For filing proposals exceeding the bidder's qualification rating in a manner not permitted by the Contracting Authority.

1103.02 APPROVAL FOR AWARD.

A. In the approval for award of contract, consideration will be given not only to prices bid but also to the mechanical and other equipment available to the bidder, the financial responsibility of the bidder, and the bidder's ability and experience in performance of like or similar contracts.

B. Approvals for award will be made as promptly as practical after bids have been opened and read. The Contracting Authority reserves the right to delay the approval for award for such time as is needed for consideration of bids and for receipt of concurrence in recommended approvals for award from other governmental agencies whose concurrence may be required.

1103.03 RETURN OF PROPOSAL GUARANTY.

Proposal guaranties will be returned to the unsuccessful bidder by mail promptly after the approval for award has been made. Return to the successful bidder will be made promptly after the filing of the contract documents.

1103.04 CERTIFICATE OF INSURANCE.

The Contractor's certificate of liability and property damage insurance described in Article 1107.02 shall be filed with the Contracting Authority on or before the execution of the contract and shall be maintained throughout the prosecution of the work and until final acceptance and completion of the contract. A separate verification shall be required for contracts awarded on the basis of joint bids.

1103.05 REQUIREMENT OF CONTRACT BOND.

On all contracts, the Contractor shall file an acceptable bond in an amount not less than 100% of the contract sum with the Contracting Authority; however, the amount of the contract bond does not need to include the predetermined costs for incentives or bonuses shown on the contract. One copy of the bond shall be executed on the standard form of the Department, and shall be submitted with the signed contract. This bond shall be held to cover all work included in the contract, whether performed by the Contractor or under a subcontract or assignment. The bond shall be executed by the Contractor and by a surety company authorized to do business in the State of Iowa. The Contractor shall not begin work on any contract before being notified, in

writing, that the required bond has been approved and accepted, or until the signed contract is returned.

1103.06 EXECUTION OF CONTRACT.
The bidder to whom a contract is being awarded shall execute and file two copies of such contract with the Contracting Authority.

1103.07 FAILURE TO EXECUTE CONTRACT.
Unless the time limit is modified by the contract documents, failure to execute a contract and file an acceptable bond within 30 calendar days of the date of the approval for award, herein provided, will be just and sufficient cause for annulment of the approval for award and for forfeiture of the proposed guaranty to the Contracting Authority.

1103.08 DISCLOSURE OF SUBCONTRACTOR.

A. A bidder awarded a contract with the Department shall disclose the names of all subcontractors who will work on the project or projects, or who the bidder anticipates will work on the project or projects. If a subcontractor named by a bidder awarded a contract is replaced, or if the cost of work to be done by a subcontractor is reduced, the bidder shall disclose the name of the new subcontractor or the amount of the reduced cost. If a subcontractor is added by a bidder awarded a contract, the bidder shall disclose the name of the new subcontractor.

B. The list of proposed subcontractors shall be submitted to the Office of Contracts with the performance bond and signed contract.

C. Failure to present the subcontractor list will cause the Contractor to be re-evaluated for future bidder qualification as per Article 1102.03.

D. These requirements are in addition to Article 1108.01.

Section 1104. Scope of Work

1104.01 INTENT OF PLANS AND SPECIFICATIONS.

A. The intent of the plans and specifications is to provide for the construction and completion of every detail of the work described therein. It shall be understood by the Contractor that the Contractor shall furnish all labor, material, tools, transportation, and supplies required for all or any part of the work to make each item complete in accordance with the spirit of the contract. It is understood that the apparent silence of the specifications as to any detail or the apparent omission of a detailed description concerning any point shall be regarded as meaning that only the best general practice is to prevail and that only first quality materials and first quality work are to be used.

B. For the purpose of design and the preparation of the Engineer's estimate, the Contracting Authority or its representatives may perform a reasonable amount of exploratory work to gain information relative to surface and subsurface conditions relating to types of soil, moisture content, and types and extent of rock strata. This information, when shown in the contract documents, represents a summary of conditions as of the date the survey was made; it is only an approximate estimation of the site conditions made merely to be suggestive to the Contracting Authority of construction conditions and quantities and classes of work. The appearance of this information in the contract documents will not constitute a guarantee that conditions other than those indicated will not be encountered at the time of construction. The bidder is advised that all information concerning the project or projects, compiled by the Contracting Authority preceding the design, is available for examination at the Contracting Authority's headquarters. The prospective bidder shall conduct an examination as provided in Article 1102.08 to be satisfied as to the character of the work to be done, the probable construction conditions, and any other reasonably ascertainable conditions and the potential effect these could have on the Contractor's performance under the contract. The Contractor's bid shall be prepared on the basis of this examination.

C. Any bidder interested in the work is authorized to make whatever additional investigation that is advisable. In making such additional investigation, the bidder is directed to the Engineer for information relating to available right-of-way. If there are, at that time, any parcels of land over which the Contracting Authority does not have jurisdiction, right of entry must be secured by the prospective bidder from those authorized to grant such permission. Investigational work performed by a prospective bidder on existing highways and streets open to traffic shall be performed in compliance with the requirements of the current Part VI of the MUTCD. All such additional investigational work shall be performed without costing or obligating the Contracting Authority in any way.

1104.02 SPECIAL WORK.

Any conditions not covered by these standard specifications are stated in the contract documents.

1104.03 INCREASED OR DECREASED QUANTITIES.

A. The Contracting Authority reserves the right to make such increase or decrease in the quantities of the work shown in the contract documents as may be considered necessary to complete fully and satisfactorily the construction included in the contract. The compensation to the Contractor for such changes will be as provided in Article 1109.03.

B. No significant change in quantities, as defined in Article 1109.16, shall be made by increasing or decreasing the length of road or roads to be improved as shown in the contract documents, without mutual written consent between the Contracting Authority and the Contractor; however, such notice

shall not be required for maintenance or restoration work ordered by the Engineer on temporary Primary haul roads.

1104.04 EXTRA WORK.
The Contracting Authority reserves the right to order, in writing, the performance of work of a class not contemplated in the contract documents but which may be considered necessary to complete satisfactorily the work included in the contract. This extra work will be paid for as provided in Article 1109.03, B.

1104.05 MAINTENANCE OF DETOURS.
Unless required by the contract documents, the Contractor will not be required to assume any responsibility in connection with the maintenance or marking of detours.

1104.06 REMOVAL OF STRUCTURES AND OBSTRUCTIONS.

A. The Contractor shall remove all materials, existing structures or part of structures that in any way interfere with the new construction. If specific payment for such work has not been provided in the contract, it will be paid for per Article 1109.03, B.

B. The Contractor shall remove all materials or structures found on the right-of-way which are not to remain in place or which have not been designated for use in the new construction. These materials, when removed from the project, shall become the property of the Contractor. The removal of pipe culverts will not be paid for directly but shall be considered as incidental work, and the cost of removal shall be considered to be included in the contract price for other items. Pipe culverts designated for salvage shall be removed by methods that will cause a minimum of damage to the pipe culverts. The removal of bridges or other masonry or monolithic concrete construction will be paid for. If the contract documents do not contain an item for this work, it will be paid for per Article 1109.03, B.

1104.07 RIGHTS IN AND USE OF MATERIALS FOUND ON THE RIGHT-OF-WAY.

A. Unless stated to the contrary in the contract documents, all materials such as stone, gravel, sand, timber, and structures or parts of structures found on the right-of-way of the highway or on land acquired for the work are the property of the Contracting Authority or the owner of the fee title to the land. If these materials are to be removed but use or salvage is not designated in the contract documents, they shall become the property of the Contractor, and the Contractor shall remove the materials from the project. When the Contractor is permitted to use materials found on the right-of-way, all excavations that the Contractor makes below the grade elevations shall be backfilled with other suitable materials so that the finished road will conform to the grade shown on the plans. Extra compensation will not be allowed for this backfilling.

B. When rock excavation is encountered, any portion of rock excavation which would otherwise be deposited in areas designated in the contract documents

and not be incorporated in the embankments may be processed and used, royalty free, by the Contractor in any other portion of the construction in which material of that quality would be acceptable. Deduction will not be made from excavation quantities for rock so used.

1104.08 CLEAN UP.

A. Holes resulting from operations of the Contractor, including removal of guardrail posts, fence posts, utility poles, or foundation studies, shall be filled and consolidated to finished grade as directed by the Engineer to prevent future settlement. Voids shall be filled as soon as practical, preferably the day created and not later than the following day. Portions of the right-of-way or project limits (including borrow areas and operation sites) disturbed by operations of the Contractor shall be restored to an acceptable condition. This operation shall be considered incidental to other bid items on the contract.

B. During construction, the Contractor shall remove all unused material and rubbish from the site of the work, remedy any objectionable conditions the Contractor may have created on private property, and leave the right-of-way in a neat and presentable condition. The Contractor shall not make agreements which allow salvaged or unused material to remain on private property within view of a road except when consistent with previous land use.

C. All ground occupied by the Contractor in connection with the work, which is within view of or adjacent to a road, shall be restored. Restoration shall include appropriate smoothing to its original condition and may include making the area suitable for cultivation and, where vegetation has been disturbed, seeding of the area. All material removed from the work site because of the final cleaning operation shall become the property of the Contractor.

D. Clean up shall be subject to approval of the Engineer and in accordance with applicable regulations.

1104.09 RIGHT-OF-WAY.

Right-of-way for the work will be provided without cost to the Contractor. Right-of-way will be made available to the Contractor on or before the date the notice to proceed is issued when the approximate starting date is designated, and on the date of execution of contract when the late start date or specified starting date is designated, unless a later date for right-of-way to be made available to the Contractor is designated in the contract documents. Permission of the property owner may be necessary to access some parcels prior to the letting.

The Contractor shall not disturb desirable grass areas or desirable trees outside construction limits. The Contractor shall not park or service vehicles and equipment or use these areas for storage of materials. Storage, parking, and service area(s) will be subject to approval of the Engineer.

1104.10 RAILROAD CROSSINGS.
Whenever the work involves construction with which railroad companies are concerned, the performance of the work is contingent upon arrangements with the railroad companies for the proposed construction. The performance of the work shall be in accordance with arrangements established by the Contracting Authority. The Contractor may make additional arrangements, such as establishment of temporary railroad crossings required by the Contractor for construction operations. The cost due the railroad for such arrangements shall be the responsibility of the Contractor. Claims will not be allowed for loss or damage caused by failure of the railroad to comply with provisions of the agreement with the Contracting Authority. The Contracting Authority will institute necessary legal action to enforce the conditions of its agreement with the railroad company.

Section 1105. Control of Work

1105.01 AUTHORITY OF ENGINEER.

A. The Engineer will decide all questions which may arise as to the quality and acceptability of materials furnished and work performed and as to the rate of progress of the work, all disputed and mutual rights between contractor, all contract documents, and all questions as to the acceptable fulfillment of the contract on the part of the Contractor. Except as provided in Article 1109.12, the Engineer's decisions will be final.

B. For authority to temporarily suspend work, see Articles 1105.07 and 1108.06.

1105.02 PLANS.

A. The final plans on file in the office of the Contracting Authority, show the location, typical construction details, and dimensions of the work contemplated. The work shall be performed in conformity therewith, except in case of error or unforeseen contingency.

B. The plans are made from careful surveys and represent the foreseen construction requirements. Any appreciable deviation from the plans made necessary to expedite construction, or because of error, shall be called to the attention of the other party, in writing, by the party discovering such conditions. If necessary, revised plans will be provided.

1105.03 WORKING DRAWINGS.

A. The plans will be supplemented by such working drawings as are necessary to adequately control the work. Working drawings shall be furnished by the Contractor, as required by the contract documents. When certification by a Professional Engineer licensed in the State of Iowa is required, the certification shall be in the appropriate branch of engineering, for the work specified in the contract documents. Working drawings may include shop drawings of fabricated materials, erection plans, falsework plans, cofferdam

plans, or other supplemental plans or data. Shop drawings for structures shall show fully detailed dimensions and sizes of all component parts of the structure. Prior to review of working drawings, any work done or material ordered shall be at the Contractor's risk. The Contractor shall understand that the Contracting Authority's review of working drawings submitted by the Contractor covers only requirements for strength and arrangement of component parts. The Contracting Authority assumes no responsibility for errors in dimensions and assumes the Contractor will use material complying with requirements of the contract documents or, where not specified, those of sound and reasonable quality, and will erect the subjects of such working drawings in accordance with recognized standards of first quality work or, when specified, in accordance with standards of the contract documents. If unanticipated and either unusual or complex construction procedures or site conditions occur, the Engineer may require the Contractor to submit such working drawings as, in the judgment of the Engineer, are necessary to satisfactorily complete the proposed construction.

B. For non-Primary projects, working drawings shall be submitted to the Engineer unless noted otherwise in the contract documents.

C. For Primary and Interstate projects, all submittals shall be processed by the Contractor and sent to the Review Office identified in Table 1105.03-1 below with a copy of the cover letter sent to the Resident Construction Engineer and District Materials Engineer. The cover letter shall include the following information:

- Date of submittal or resubmittal
- Project number
- Description of submittal
- Contractor’s name, address, and telephone number
- Number of submittal copies
- Fabricator’s name, address, and telephone number (if applicable).

Table 1105.03-1: Review Offices for Working Drawings

DESCRIPTION	REVIEW OFFICE	NUMBER OF COPIES	REVIEW TIME (calendar days)
Falsework for slab bridges	Bridges and Structures	2	30
Cofferdam design (when required)	Bridges and Structures	2	30
Reconstruction of substructure (detailed plans for supporting the superstructure)	Bridges and Structures	2	30
Steel Structures	Bridges and Structures	7	30
Detail plans for falsework or centering support of steel structures (i.e. erection plans)	Bridges and Structures	2	30

Steel and aluminum pedestrian hand rails	Bridges and Structures	2	30
Highway sign support structures (i.e. trusses, cantilevers, & bridge mounts)	Bridges and Structures	2	30
Precast concrete (i.e. deck panels, RCB culverts, noise wall panels, arch sections, etc.)	Bridges and Structures	2	30
Tower lighting	Bridges and Structures	2	30
Highway lighting	Traffic & Safety	2	30
Highway signing steel breakaway posts	Traffic and Safety	2	30
Traffic signalization*	Traffic and Safety	2	30
Highway signing - Type A & B signs	Traffic and Safety	2	30
Bridge components	Bridges and Structures	2	30
Pre-engineered steel truss recreational trail bridge	Bridges and Structures	2	30
MSE, segmental, & modular block retaining walls	Design (Soils Design Section)	Preliminary submittal: 3 design calculations, 3 shop drawings, & 3 field construction drawings Final submittal: 3 design calculations, 3 shop drawings, & 3 field construction drawings	30 14
Soil nail & tie-back retaining walls	Design (Soils Design Section)	6 final design plans	60
Intermediate foundation improvement (IFI) (i.e. stone columns, geopiers, etc.)	Design (Soils Design Section)	4 design calculations & 8 field construction drawings	30
Removal of box girder bridges	Bridges and Structures	2	30
Structural erection manual	Bridges and Structures	2	30
Temporary shoring	Bridges and Structures	2	30
Temporary sheet pile retaining wall	Bridges and Structures	2	30
Safety grates for RCB culverts	Bridges and Structures	2	30
* Submittal time shall be within 45 calendar days from the date of award of contract.			

D. Unless specified otherwise in the contract documents, Contractor submittal time shall be subject to the specified review time and the Contractor's need based on their schedule for the work.

E. When the contract documents specify submittals to be sent to the Design Consultant, copies of the cover letter shall be sent to the specified Review Office, Resident Construction Engineer, and District Materials Engineer.

1105.04 CONFORMITY WITH AND COORDINATION OF THE CONTRACT DOCUMENTS.

A. In case of a discrepancy between contents of the contract documents, the following items listed by descending order shall prevail:

1. Addendum

2. Proposal Form

3. Special Provision

4. Plans

5. Standard Bridge Plans, Standard Culvert Plans, and Standard Road Plans

6. Developmental Specifications

7. Supplemental Specifications

8. General Supplemental Specifications

9. Standard Specifications

10. Materials I.M.

B. Should there be a discrepancy between figures and drawings on any of the contract documents, the figures shall govern unless they are obviously incorrect.

C. The Contractor shall not take advantage of any apparent error, omission, or discrepancy in the contract documents. The Engineer will be permitted to make such correction in interpretation as may be deemed necessary for the fulfillment of the intent of the contract documents subject to compensation as provided in Articles 1109.03, 1109.04 and 1109.16. Written notice of changes in the contract documents will be given to the Contractor by the Engineer.

D. All work performed and all materials furnished shall be in reasonably close conformity with the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the contract documents.

E. If the Engineer finds the material or the finished product in which the material is used is not within reasonably close conformity with the contract documents but that reasonably acceptable work has been produced, the Engineer will then make a determination if the work shall be accepted and remain in place. In this event, the Engineer will document the basis of acceptance by contract modification which will provide for an appropriate adjustment in the contract price for such work or materials as is necessary to conform to the determination based on engineering judgment.

F. If the Engineer finds the material or the finished product in which the material is used or the work performed is not in reasonably close conformity with the contract documents and has resulted in an inferior or unsatisfactory product, the work or material shall be considered unacceptable work and shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

1105.05 SUPERVISION BY CONTRACTOR.

The Contractor or a competent Superintendent must be on the project when construction activities are taking place. This representative must be capable of reading and thoroughly understanding the contract documents and experienced in the type of work being performed. The Superintendent shall supervise, direct, and control the Contractor's operations, personnel, work, and the subcontractor's operations. The Superintendent shall have full authority to execute orders or directions of the Engineer without delay and to promptly supply such materials, equipment, tools, labor, and incidentals as may be required. The Contractor shall give the Engineer written notification of the name of the Superintendent. A copy of the official plans and specifications shall be available on the project site at all times.

1105.06 CONSTRUCTION STAKES.

A. Minimum standards for Construction Survey provided by the Engineer will meet the requirements of Section 2526. The Engineer will set the necessary center line, slope, and grade stakes promptly upon notification by the Contractor that stakes are needed.

B. For all structures, the Engineer will set stakes for roadway center line and such other stakes as are necessary to establish the location, elevation, and alignment of the structure. If requested by the Contractor, the Engineer will furnish stakes determining the center line of piers or pedestals, the faces of abutments, and angles of the wings or retaining walls. When these stakes or lines are given by the Engineer, the Contracting Authority will be responsible for the correctness thereof, and the Contractor shall be responsible for their proper use, interpretation, and preservation.

C. The Contracting Authority will not be responsible for delays due to lack of grade or line stakes unless the Contractor has given the Engineer a 24 hour written notice that such stakes will be needed and the Contractor's work is being conducted in a satisfactory manner and at the specified rate of progress.

D. The Contractor shall be responsible for the preservation of stakes and marks. If in the opinion of the Engineer any of the survey stakes or marks have been carelessly or willfully destroyed or disturbed by the Contractor, the cost of replacing them will be charged against the Contractor.

1105.07 AUTHORITY AND DUTIES OF INSPECTOR.

The Contracting Authority may appoint inspectors to represent the Engineer in the inspection of materials used in and work done under the contract. Such inspection may extend to any part of the work and to preparation or manufacture of materials to be used. The inspector will not be permitted to modify in any way the provisions of the contract documents or to delay the work by failing to inspect materials and work with reasonable promptness. An inspector is placed on the work to keep the Engineer informed as to its progress and the manner in which it is being performed. Results of inspection tests and examinations will be available to the Contractor on an informational basis. Absence or presence of representative test data does not alter the Contractor's responsibility for compliance with the contract documents in accordance with Article 1104.01. The inspector will not act as supervisor or perform other duties for the Contractor, nor improperly interfere with management of the work. The inspector will not be authorized to approve or accept any portion of the work. In case of dispute between the Contractor and inspector as to quality of materials or manner of performing the work, the inspector has authority to reject materials or suspend the work until the question at issue can be decided by the Engineer. Written notice of suspension of work will be given to the Engineer and Contractor by the inspector.

1105.08 INSPECTION OF WORK.

A. The Contractor shall furnish the Engineer with every reasonable facility for ascertaining whether the work is being performed in conformance with the contract documents. At any time before acceptance of the work, upon request of the Engineer, the Contractor shall remove or uncover such portions of finished work as the Engineer may direct. After examination has been made, the Contractor shall restore such portions of the work to the standard required by the contract documents.

B. If work thus exposed or examined proves acceptable, the uncovering or removing and replacing of covering, or the restoring of parts removed, will be paid for as extra work, except that no payment will be made for work involved in checking smoothness of pavement surfaces. If work thus exposed and examined proves unacceptable, the Contractor shall replace the defective work in accordance with the specifications. If work thus exposed and examined proves either unacceptable or deficient, the Contractor will be paid only for work as finally accepted.

C. Work done without the Engineer having been afforded ample opportunity to provide suitable inspection, or unauthorized work, may be ordered removed and replaced at the Contractor's expense, or may be excluded from the quantities measured for payment.

1105.09 REMOVAL OF DEFECTIVE WORK.

A. Any defective work shall be removed and replaced at the Contractor's expense.

B. Should the Contractor fail or refuse to remove defective work when so ordered by the Engineer, the Engineer has authority to order the Contractor to suspend further operations, and may withhold payment on estimates until such defective work has been removed and replaced in accordance with the contract documents. Continued failure or refusal on the part of the Contractor to correct defective work promptly will be sufficient cause for the Contracting Authority to declare the contract in default and to complete the work in accordance with Article 1108.11.

1105.10 UNAUTHORIZED WORK.
Unauthorized work or work done in excess of that provided by the lines and grades shown in the contract documents or as given by the Engineer will not be paid for.

1105.11 FINAL INSPECTION.
Upon notification by the Contractor or the Contractor's authorized representative that the work is completed, the Engineer shall make prompt final inspection of each item of work included in the contract. If the work is found not to be in accordance with the contract documents, the Contractor will be advised as to the particular defects to be remedied.

1105.12 RESTRICTIONS ON MOVING AND USE OF HEAVY EQUIPMENT.
The following restrictions shall apply to the moving and use of heavy equipment:

A. Movement of equipment to and from the project shall be in compliance with the laws governing the operation of vehicles on the highways of Iowa. Movement and operation of equipment over completed portions of pavements, HMA surfaces, base courses, and structures which are a part of the project shall be with legal axle loads, except as modified in this article.

B. In the case of earthwork and shouldering to be done in connection with either rigid or flexible pavement or pavement widening and resurfacing, earth moving equipment shall not be operated or driven on or across the pavement, except as authorized by the Engineer at designated equipment crossings.

When equipment crossings are specifically permitted, the Contractor shall designate before use the location and number of equipment crossings to be used. The location of all equipment crossings shall be subject to the approval of the Engineer. The Engineer will not approve equipment crossings in areas of limited sight distance or near structures or railroad crossings or at any other location which will place safety of the traveling public in jeopardy. At these equipment crossings, equipment having axle loads greater than the maximum permitted by law may be used.

Equipment crossings shall be 30 feet (10 m) in width measured along the center line of the road to be crossed and shall not be closer than 300 feet (100 m) to each other.

Within the prescribed limits, the Contractor may operate hauling equipment on the surface of the pavement or on a hauling bridge constructed by the Contractor.

If an equipment crossing is used, the existing driving surface on the through road shall be restored at the end of each day's operation to safely serve traffic at expected speeds. The Contractor may install pavement protection at equipment crossings to reduce the surface restoration at the end of each day's operation.

For each equipment crossing used, the Contractor shall, at the Engineer's option, either replace the pavement or pay the Contracting Authority at the rate of $7,500 on the basis of a two lane pavement.

If a hauling bridge is used, it shall support loaded hauling equipment with no contact with the pavement surface and will be subject to the Engineers approval. When a hauling bridge is used, no pavement replacement or payment to the Contracting Authority will be required.

Pavement protection installations and hauling bridges shall accommodate two lanes of public traffic. They shall be removed from the through road at the close of each day's operations.

C. Drag lines, cranes, or power shovels shall not be operated with any part of the machine resting upon a pavement, HMA surface, or base course except with approval of the Engineer and in accordance with restrictions in that approval.

D. For structures, the following equipment and material loads shall apply:

1. Only legal load vehicles and equipment will be permitted on structures unless approved by the Engineer.

2. Legal load vehicles and equipment will be subject to weight restrictions according to the posted limits.

3. All loads in spans where critical or damaged members, as indicated in the contract documents, are being repaired or replaced shall be subject to the approval of the Engineer.

4. Material loads stored on the structure shall be limited to a maximum weight of 20 tons (20 Mg). Distribution of load shall be governed by the following:

a. If the material load is greater than 200 pounds per square foot (9.5 kPa) and less than 500 pounds per square foot (23.9 kPa), the loaded area will be restricted to an area 5 feet by 10 feet (50

square feet) (1.5 m by 3 m (4.5 m^2)) with a clear spacing of 15 feet (4.6 m) between loaded areas.

b. If the material load is less than or equal to 200 pounds per square foot (9.5 kPa), the loaded area is only restricted by the 20 ton (20 Mg) maximum.

5. Construction vehicles and equipment not involved with the loading and unloading of stored material shall be restricted from operating within 10 feet (3 m) of the area where the material is stored.

All vehicle, equipment, and material loads exceeding the limitations as stated above shall be submitted to the Engineer for checking and review prior to subjecting the loads to the structure. The Contractor shall include in their submittal all details, calculations, and assumptions. The calculations shall be certified by a Professional Engineer licensed to practice engineering in the State of Iowa.

The above submittal requirements shall also apply to cranes or other construction equipments when:

a. Other components are added resulting in overall weight greater than legally allowed or granted by special permit.

b. The operational weight including construction loads is greater than legally allowed or granted by special permit.

c. Load distribution is altered during operation due to the use of outriggers or other devices.

E. Under no conditions shall machines equipped with metal lugs or similar projections on the treads be operated on the surface of a pavement, HMA surface, base course, or structures.

F. For building shoulders on completed pavements of any type, the maximum axle load used for equipment operating on pavement shall not exceed the legal axle load.

G. Crawler type equipment shall not be moved on or off a pavement or base course except at places where the compacted earth adjacent to slab is at least 2 inches (50 mm) higher than the surface of the pavement or base course. When heavy, crawler type equipment is moved on or off the edge of a pavement or base course, an adequate timber approach shall be built at the edge of slab to prevent overloading or otherwise damaging the edge of the slab.

H. Compacting equipment having axle loads greater than 20,000 pounds (9072 kg) may be used on the work under the following provisions:

1. The equipment shall be transported to and from the work and across the bridges on the work in compliance with laws of the State of Iowa.

2. For compaction of subbase, the weight (mass) of the equipment used shall not be greater than that of compaction equipment used in correction of the roadbed for grade and cross section.

3. For compaction of base course, the weight (mass) of the equipment used shall not be greater than the weight of the equipment used in compaction of the subbase on which the base is placed.

4. For compaction of surface courses, the weight (mass) of the equipment shall not be greater than that of equipment used in compaction of the base on which the surface course is placed.

I. For grading or any other type of work, no equipment having an axle load greater than 50,000 pounds (22,680 kg) shall be operated over a culvert except as may be authorized by the Engineer.

1105.13 TEMPORARY PRIMARY ROAD HAUL ROADS.

A. For Primary Road projects, the Department may designate any Secondary Road or city street, excluding officially designated temporary Primary Road detours, as a temporary Primary Road haul road, over which materials from any source are to be hauled, such as those listed below:

1. Soil for embankments or shouldering;

2. Sand, gravel, and crushed stone for base and subbase courses;

3. Roadway paving aggregates prior to mixing;

4. Granular surfacing or backfill;

5. Mixed HMA or PCC for paving, transported from the plant to the work site;

6. Broken or milled pavement.

B. Designation of temporary Primary Road haul roads shall be as follows:

1. When materials such as those listed, in an amount greater than 5000 tons (5000 Mg), are to be transported to the work by truck, and when requested by the Contractor, or on its own initiative, the Department will designate a temporary Primary Road haul road. In making such designation, the Department will only consider routes which are physically capable for such use. In addition, the Department will consider if the route submitted by the Contractor is practical and feasible regarding length of haul, road conditions, traffic, and maximum utilization of the Primary Road System. The designation will include a separate return route from the project if requested by the Contractor when granular surfaced roads are to be used for the return route. If a

separate return route is not requested by the Contractor, it will be designated by the Contracting Authority.

2. The Department reserves the right to designate as a temporary Primary Road haul road a route other than a route selected by the Contractor which is physically capable for such use; in this case, haul in excess of the route selected by the Contractor will be paid for by the Department. The Department will not designate, as a temporary Primary Road haul road, roads normally serving primarily as access to a regularly operated commercial source.

3. When temporary Primary Road haul roads are required, the Contractor shall submit the suggested haul route or routes to the Department within 21 calendar days after the approval for award. Haul route requests shall be submitted to the Engineer. These are to be the most reasonable and practical route or routes. They shall be suitable for use as the haul road or haul roads. In evaluating the feasibility of haul routes, the Contractor shall contact the appropriate local jurisdictions, prior to submitting the haul road request. Roads or bridges with load restrictions and low structural values will not be considered as feasible routes, physically capable of use by the Contractor. If the Contractor fails to provide haul road information within the time allowed, the Department will have the right to establish a route without increased compensation to the Contractor.

C. Primary Roads and temporary Primary Road haul roads for the project shall be used for delivery of materials for which routes are designated.

D. Prior to any revocation by the Department of the temporary Primary Road haul road designation, The Department will comply with Iowa Code 313.28 and 313.29. If restorative work is ordered to be done by the Contractor, payment will be made as extra work in accordance with Article 1109.03.

1105.14 PROTECTION OF WATER QUALITY AND WETLANDS.

A. The Contractor shall comply with the requirements of the Clean Water Act (33 U.S.C. 1344 and 33 CFR 323) and Executive Order 11990. When it becomes necessary for the Contractor to work in waters of the United States, the Contractor shall be aware that a Section 404 permit may be required.

B. When required, the Contracting Authority will obtain a Section 404 permit for essential work on the right-of-way prior to the award of the contract. The Contractor shall adhere to the requirements of the permit. Activities occurring in or across waters of the United States not specifically reviewed and approved in the permit are not authorized. If the Contractor desires to use construction methods that are not specifically approved by the permit, the Contractor shall be responsible for obtaining approval in the form of a new Section 404 permit from the U.S. Army Corps of Engineers and possibly Iowa DNR. The Contractor shall not use construction methods that require

additional mitigation by the Contracting Authority. The Contractor will not be granted additional compensation or contract time due to their request for a new permit. If, however, due to no fault of the Contractor, a Section 404 permit modification involving activities within the right-of-way is deemed necessary by the Engineer, additional contract time and/or compensation may be considered.

C. Projects that are regulated by the requirements of a Clean Water Act Section 404/401 Permit will be identified in the contract documents. The Contractor shall comply with the following requirements in order to meet the general conditions of Clean Water Act Section 404/401 Permits.

1. Historic or Archaeological Remains.
The Contractor shall comply with Article 2102.03, J.

2. Inspection.
The Contractor shall allow representatives from the Iowa Department of Natural Resources or U.S. Army Corps of Engineers to inspect the work any time deemed necessary to ensure that the work is being accomplished in accordance with the terms and conditions of the contract documents and permit.

3. Timing.
The Contractor is encouraged to conduct construction activities during a period of low flow unless otherwise agreed upon by the Engineer.

4. Vegetation Clearing.
Clearing of vegetation, including trees located in or immediately adjacent to waters of the state, shall be limited to that which is absolutely necessary for construction of the project as indicated in the contract documents. Vegetative clearing material shall not be disposed of in wetlands unless otherwise indicated in the contract documents.

5. Disposal and Handling.
All construction debris shall be disposed of at upland, non-wetland locations so that it cannot enter a waterway or wetland. Construction equipment, activities, and materials shall be kept out of the water to the maximum extent possible. Equipment for handling and conveying materials during construction shall be operated to prevent dumping or spilling the materials into waterbodies, streams, or wetlands except as approved by the Engineer. Care shall be taken to prevent petroleum products, chemicals, or other deleterious materials from entering waterbodies, streams, or wetlands.

6. Erosion Control.
Erosion control features shall be installed by the Contractor in accordance with Sections 2601 and 2602.

7. Revegetation.
All disturbed areas not covered with revetment shall be seeded in accordance with Section 2601.

8. Temporary Fills.
If temporary crossings, causeways, or work pads are needed for the work, then temporary structures and fills shall be constructed in accordance with Section 2547.

9. Flowable Mortar.
Flowable mortar shall be installed in accordance with Section 2506.

10. Bridge Removal.
When bridge removal is identified in the contract documents, the bridge and piers shall be removed in accordance with Section 2401. Debris from bridge removal that falls into the water shall remain there only temporarily and shall be removed by the Contractor.

11. Revetment.
Revetment materials shall comply with Section 4130.

12. Indiana Bats.
Suitable habitat for the Indiana bat (Myotis sodalis), as identified by the Contracting Authority, shall be removed between September 15th and April 15th when Indiana bats are not expected to be using potentially suitable trees. The Contractor shall limit removal of forest cover to those areas which are absolutely necessary for the construction of the work. Questions regarding this condition shall be directed to the Engineer.

13. Navigation.
No activity shall cause more than a minimal adverse effect on navigation. Safety lights and signals required by the contract documents shall be installed on authorized facilities in navigable waters of the United States. Payment will be made in accordance with Article 1109.03.

14. Aquatic Life Movements.
When indigenous aquatic life has been identified in the contract documents, no activity shall substantially disrupt the necessary life cycle movements of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the area.

15. Spawning Areas.
When spawning areas and spawning seasons have been identified in the contract documents, the Contractor shall limit activities in spawning areas during spawning seasons and avoid these areas. Contractor's activities that result in physical destruction (e.g., through excavation, fill, or downstream smothering by substantial turbidity) of an important spawning area will be prohibited, unless otherwise indicated in the contract documents.

16. **Migratory Bird Breeding Areas.**
When migratory bird breeding areas have been identified in the contract documents, activities in waters of the United States that serve as breeding areas for migratory birds shall be avoided by the Contractor.

17. **Shellfish Beds.**
When shellfish beds have been identified in the contract documents, no construction activity shall occur in areas of concentrated shellfish populations.

18. **Suitable Material.**
No activity shall use undesirable material (e.g. trash, debris, car bodies, asphalt, etc.). Discharged material or material used for construction shall be free from toxic pollutants in toxic amounts in accordance with Section 307 of the Clean Water Act.

19. **Water Supply Intakes.**
Unless otherwise indicated in the contract documents, no activity shall occur in the proximity of a public water supply intake, except where the activity is for repair or improvement of public water supply intake structures or adjacent bank stabilization.

20. **Adverse Effects From Impoundments.**
If construction activity creates an impoundment of water, adverse effects to the aquatic system due to accelerating the passage of water, or restricting its flow shall be minimized.

21. **Management of Water Flows.**
To the maximum extent practical; the pre-construction course, condition, capacity, and location of open waters shall be maintained by the Contractor during construction, including stream channelization and storm water management activities.

22. **Equipment.**
Heavy equipment working in wetlands or mudflats shall be placed on mats, or other measures shall be taken to minimize soil disturbance.

23. **Endangered Species.**
No activity will be authorized which will jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Federal Endangered Species Act, or will destroy or adversely modify the critical habitat of such species.

24. **Historic Properties.**
No activity will be authorized which violates the requirements of Section 106 of the National Historic Preservation Act.

25. Mitigation.
The work shall be constructed to avoid and minimize adverse effects, both temporary and permanent, to waters of the United States at the project site (i.e., on site).

1105.15 VALUE ENGINEERING PROPOSAL.

A. The Contractor may submit written Value Engineering (VE) Proposals to the Engineer, for changing the plans, specifications, or other contract requirements. The purpose of this provision is to encourage the Contractor to suggest alternative lower cost or more efficient construction and to share with the Contractor any cost savings. The changes shall not impair the essential functions or characteristics of the project, including but not limited to service life, economy of operation, ease of maintenance, desired appearance, or design and safety standards.

B. VE Proposals shall contain the following information:

1. Existing requirements and proposed changes;

2. Contract requirements that must be changed if the VE proposal is adopted;

3. A detailed cost estimate of performing the work as stipulated and as proposed;

4. The time within which the Engineer must make a decision thereon;

5. The items of work affected by the proposed changes, including quantity variations;

6. A statement that the VE proposal is submitted pursuant to the provisions of Article 1105.15.

C. The provisions of this article do not require the Engineer to consider any VE proposal that is submitted. Proposed changes that involve the basic design of a bridge or pavement type, or involve the use of mechanical dowel bar inserters will not be considered an acceptable incentive proposal.

D. If a VE proposal is similar to a change in the contract documents under consideration by the Contracting Authority for the project at the time the VE proposal is submitted, or if the VE proposal is based on or similar to standard specifications, special provisions, or plans adopted by the Contracting Authority, the Engineer will not accept the VE proposal.

E. The Contractor shall continue to perform the work in accordance with contract requirements until a change order incorporating the VE proposal has been processed. If a change order has not been processed by the date on which the Contractor's VE proposal specifies that a decision thereon

should be made, or such other date as the Contractor may subsequently have specified in writing, the proposal shall be rejected.

F. The Contracting Authority will not be liable to the Contractor for failure to accept or act upon any VE Proposal submitted or for any delays to the work attributable to any such VE proposal.

G. The Engineer shall be the sole judge of the acceptability of a VE proposal and of the estimated net savings in construction costs from adoption of all or any part of such VE proposal. In determining the estimated net savings, the right is reserved to disregard the contract bid prices if, in the judgment of the Engineer, the prices do not represent a fair measure of the value of work to be performed or to be deleted.

H. The Contracting Authority reserves the right to require the Contractor to share in the Contracting Authority's costs of investigating a VE proposal. Where this condition is imposed, the Contractor shall indicate acceptance in writing, and acceptance may constitute authority for the Contracting Authority to deduct up to 50% of the investigation costs from any money due to the Contractor resulting from the change.

I. If the Contractor's VE proposal is accepted in whole or in part, such acceptance will be by change order. The change order will incorporate the changes in the contract documents which are necessary to permit the VE Proposal to be put into effect, and will include any conditions upon which the Contracting Authority's approval is based. The change order shall also set forth the estimated net savings in the cost of performing the work attributable to the VE proposal effectuated by the change order, and will further provide that the Contractor be paid 50% of the estimated net savings amount.

J. Acceptance of the VE proposal and performance of the work will not extend the time of completion of the contract, unless specifically provided for in the change order authorizing the proposal.

K. The amount specified to be paid to the Contractor in the change order for a VE proposal shall constitute full compensation to the Contractor for the proposal and performance of the work.

L. The Contracting Authority reserves the right to adopt a VE Proposal for general use on contracts administered by the Contracting Authority when it determines that a VE proposal is suitable for application to other contracts. When an accepted VE proposal is adopted for general use, only the Contractor who first submitted this VE proposal will be eligible for compensation according to this article, and in that case, only on those contracts awarded to the same Contractor prior to submission of the accepted VE proposal and on which such VE proposal is also submitted and accepted. VE proposals identical or similar to previously submitted VE proposals will be eligible for consideration and compensation under provisions of this article if those VE proposals were not adopted for general application to other contracts administered by the Contracting Authority.

Subject to the provisions contained herein, the State or any other public agency will have the right to use all or any part of any submitted VE proposal without obligation or compensation of any kind to the Contractor.

M. The Contractor is encouraged to include the provisions of this article in contracts with subcontractors. All VE proposals by subcontractors shall be submitted by the prime contractor.

Section 1106. Control of Materials

1106.01 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS.

A. Materials used in work shall meet all quality requirements of the contract. In order to expedite inspection and testing of materials, the Contractor shall notify the Contracting Authority in writing of the proposed sources of materials promptly after being awarded the contract. Any material shall be produced with a reasonably uniform quality and within requirements specified; the producer shall perform quality control tests and evaluations the producer believes necessary to control the product adequately. All materials for use in the project are subject to inspection and tests at any time prior to being incorporated into the work.

B. For the convenience of the Contractor and when convenient to the Contracting Authority, materials may be inspected at the site of production. Materials tested and found in compliance at the site of production may be later inspected for reasonable conformance and will be rejected for obvious mistakes, contamination, quality change, or mishandling. To avoid later rejection, materials which usually show an extreme change in character or quality prior to or during the process of incorporation into the work should be produced to more rigid limits than those required by the specifications. At the option of the Engineer, approval of the source, or approval of materials at the source prior to delivery, may be required. If it is found after examination that sources of supply for previously approved materials do not produce specified products or when conditions are such that use of unfit materials cannot be prevented except by extraordinary inspection methods, the Contractor shall furnish materials from other sources. Before delivery, and at any time during the process of preparation and use, materials shall be subject to the approval of the Engineer.

C. Materials which are not previously inspected will be inspected at the project site. Acceptance at this time will be based on sampling and testing, producer's certifications, visual inspection, or any combination of these at the discretion of the Engineer.

D. Use of materials on the basis of the producer's certification, quality control tests, and evaluations may be permitted or required. Contractor and supplier laboratories performing testing for all projects on Interstate and Primary routes shall be qualified laboratories in accordance with Materials I.M. 208. The Engineer may require specific data obtained by qualified persons and

procedures be provided with the material when delivered. Certified gradation testing by a certified aggregate technician will be required for all aggregates to be furnished by the Contractor, and this shall be done in accordance with Materials I.M. 209 and 213. This requirement shall apply to aggregate furnished in accordance with Article 1106.05 only when gradation of that aggregate is a contract requirement.

1106.02 SAMPLES AND TESTS.

A. Each consignment of material shall be tested or inspected before being incorporated into the project and shall be approved by the Engineer in charge of the contract before it is used. The Contractor shall afford such facilities for collecting and forwarding samples as the Engineer may require.

B. When not designated in the standard or supplemental specifications or Materials I.M.s, the inspection, sampling, testing, and basis of acceptance of materials shall be in accordance with the current AASHTO "Standard Specifications for Transportation Materials and Methods of Sampling and Testing," including published interim standards.

1106.03 STORAGE OF MATERIALS.

The Contractor shall be responsible for care and storage of materials delivered to the project site or purchased for use. Material that has been delivered to the project site and has become damaged or contaminated before actual incorporation in the work may be rejected by the Engineer even though it may have been previously acceptable. Stored materials shall be so located as to facilitate thorough inspections.

1106.04 UNACCEPTABLE MATERIALS.

All materials not conforming to requirements of the specifications at the time they are to be used shall be considered unacceptable, and these materials will be rejected and shall be removed immediately from the work site unless otherwise instructed by the Engineer. Rejected material shall not be used until the defects have been corrected and approval has been given.

1106.05 AGGREGATE FURNISHED BY COUNTY.

On some Secondary asphalt concrete paving or base construction projects, part or all of the aggregates may be furnished by the County in the pit, stockpile, or on the road, as stated in the contract documents. When the proposal states that the County will furnish the aggregate, the material will be furnished in the designated pit, stockpile, or on the road without cost to the Contractor, unless otherwise stated.

A. Aggregate Furnished by County in Pit.

1. When aggregate is furnished by the County in a pit, the Contractor will be required to do all work necessary, including stripping, pumping, processing, and hauling, to produce pit run material or material of the quality specified. The operation in any county owned or county controlled pit will be under the general direction of the County Engineer. All gravel aggregate produced for base construction or produced from

wet pits for any part of the construction shall be stockpiled for a period of not less than 24 hours before being used in the project.

2. In the operation of the pits, the Contractor will be required to conduct the work in such a manner that a uniform product is obtained. This may require working full faces, partial faces, and/or simultaneous operations from different locations in the pit, as directed by the Engineer. All oversize aggregate less than 8 inches (200 mm) in diameter shall be crushed to pass the 3/4 inch (19 mm) sieve.

B. Aggregate Furnished by County in Stockpile.
When aggregate is furnished in a stockpile or stockpiles at stated locations, the Contractor will not be responsible for quality of the aggregate unless designated, but the Contractor will be required to mix, blend, haul, compact the material, and do all other work necessary to incorporate this material into the project.

C. Aggregate Furnished by County on Road.
When aggregate is furnished on the road, the material will be deposited by dumping the required amount onto the road. The Contractor will not be responsible for quality of the aggregate unless designated, but the Contractor will be required to windrow, equalize, mix, blend, wet, compact the material, and do all other work necessary to incorporate this material into the project.

D. Filler.
When it is possible to predetermine, with a reasonable degree of accuracy, that the aggregate specified for use and furnished will require the addition of filler or another aggregate to produce a workable and satisfactory mixture, the contract documents will identify the filler or other aggregate and will include an estimate of the quantity and a basis of payment.

1106.06 REUSING HMA AND OTHER BITUMINOUS MATERIALS.

Unless specified otherwise, bituminous materials not specifically addressed in the contract documents shall become property of the Contractor. The Contractor may remove from the project according to the rules and regulations of the DNR or, with approval of the Engineer, use the material as allowed by the contract documents.

1106.07 WASTE.

The Contractor shall provide waste areas or disposal sites for excess material (excavated material or broken concrete) not desirable to be incorporated into the work. The Contractor shall ensure areas (including haul roads) selected for waste or disposal do not impact:

- Culturally sensitive sites or graves.
- Wetlands or “Waters of the U.S.”, including streams or stream banks below the “ordinary high water mark”, without an approved U.S. Army Corps of Engineers Section 404 Permit.

No payment for overhaul will be allowed for material hauled to these sites. Excess material shall not be placed within the right-of-way unless specifically stated on the plans.

Section 1107. Legal Relations and Responsibility to the Public

1107.01 LAWS TO BE OBSERVED.

A. The Contractor is presumed to be familiar with all laws, ordinances, and regulations that may in any manner affect those engaged or employed upon the work, or materials or equipment used in or upon the work, or that may in any way affect the conduct of the work. The Contractor shall so conduct the work that conflict with any such laws, ordinances, or regulations will be avoided, and the Contractor shall save harmless the Contracting Authority and its representatives against any claims arising from violation thereof.

B. The provisions of Chapter 73, Code of Iowa, concerning preference for Iowa products and labor shall not apply to contracts involving work financed wholly or in part by the Federal Government.

C. All contractors must register with the Labor Commissioner as required by the Code of Iowa, Chapter 91C. For State contracts, this registration must be on file prior to the award of contract.

D. Contractors shall indicate whether or not they are an "out of state contractor", as defined in Iowa Code Section 103A.3.

E. On non-Federal aid contracts, out-of-state contractors shall either file a surety bond, as provided in section 91C.7 of the Code of Iowa, with the Division of Labor Services in the amount of $25,000 for a one-year period or shall provide a statement to the Division of Labor Services that they are prequalified to bid on contracts with the Department.

1107.02 INSURANCE.

A. Liability Insurance for All Projects.

1. It shall be the Contractor's responsibility to have liability insurance covering all of the construction operations incident to contract completion and the Contractor must have on file with the Contracting Authority a current "Certificate of Insurance" prior to award of contract. The certificate shall identify the insurance company firm name and address, Contractor firm name, policy period, type of policy, limits of coverage, and scope of work covered (single contract or statewide). This requirement shall apply with equal force, whether the work is performed by persons employed directly by the Contractor including a subcontractor, persons employed by a subcontractor, or by an independent contractor.

2. In addition to the above, the Contracting Authority shall be included as an insured party, or a separate owner's protective policy shall be filed showing the Contracting Authority as an insured party.

3. The liability insurance shall be written by an insurance company (or companies) qualified to do business in Iowa. For independent contractors engaged solely in the transportation of materials, the minimum coverage provided by such insurance shall be not less than that required by Chapter 325A, Code of Iowa, for such truck operators or contract carriers as defined therein. For all other contractors, subcontractors, independent contractors, and the Contracting Authority, the minimum coverage by such insurance shall be as follows:

General Liability, Including:	BODILY INJURY	
Independent Contractors	$500,000	Each Occurrence
Contractual Liability,	$500,000	Aggregate
Products and Completed Operations	PROPERTY DAMAGE	
	$250,000	Each Occurrence
	$250,000	Aggregate
	or	
	BODILY INJURY AND PROPERTY DAMAGE - COMBINED SINGLE LIMIT*	
	$750,000	Each Occurrence
	$750,000	Aggregate

*A comprehensive Catastrophe Liability Policy (Umbrella) can be used to aid in achieving the minimum required limits.

4. Failure on the part of the Contractor to comply with the requirements of this article will be considered sufficient cause to suspend the work, withhold estimates, and to deny the Contractor from receiving further contract awards, as provided in Article 1103.01.

B. Insurance When Working In Railroad Right-of-Way.

1. General.
This section shall apply when specified in the proposal form. When work is to be performed within railroad right-of-way, this specification prescribes provisions for Public Liability and Property Damage Insurance obtained by the Contractor for their own operations; and on behalf of railroads on or about whose right-of-way the Contractor is required to work in during the construction of highway projects.

2. Applicability.
This specification applies to the following:

a. To Contractor's legal liability for bodily injury to or death of persons and for injury to or destruction of property.

b. To the liability which may attach to railroads for bodily injury to or death of persons and for injury to or destruction of property.

c. To damage of property owned by or in the care, custody, or control of the railroads, both as liability or damage may arise out of the

Contractor's operations, or may result from certain work, described in Article 1107.02, B, 5, that may be performed by railroads at or about railroad rights-of-way, in connection with the construction of highway projects.

3. Contractor's Public Liability and Property Damage Insurance.

a. The Contractor may be subject to liability with respect to bodily injury or death of persons, and damage or destruction of property, which may be suffered by persons other than their own employees as a result of their operations in connection with construction of highway projects located wholly or partly within railroad right-of-way. Protection to cover such liability of the Contractor shall be furnished under regular Public Liability and Property Damage Insurance policies issued in the name of the Contractor. These policies shall be written to furnish protection to the Contractor respecting their operations in performing work covered by their contract.

b. When the Contractor sublets a part of the work on any project to a subcontractor, the Contractor shall secure insurance protection in the Contractor's own behalf under the Contractor's Public Liability and Property Damage Insurance policies to cover any liability imposed on the Contractor by law for damages because of bodily injury or death of persons and damage or destruction of property as a result of work undertaken by these subcontractors. In addition, the Contractor shall provide for and on behalf of any such subcontractor's protection to cover like liability imposed upon the latter as a result of their operations by means of separate and individual Public Liability and Property Damage policies; or, in the alternative, each subcontractor shall provide satisfactory insurance on the subcontractor's own behalf to cover the subcontractor's individual operations.

c. The Contractor shall furnish to the Department evidence that the insurance coverages required herein have been provided. The Contractor shall also furnish a copy of this evidence to the railroad or railroads involved. The insurance specified shall be kept in force until all the work required to be performed shall have been satisfactorily completed and accepted in accordance with the contract under which the construction work is undertaken.

4. Railroad Protective Insurance.

In connection with highway projects for the elimination of hazards of railroad highway crossings and other highway construction projects wholly or partly within railroad right-of-way, railroad protective liability insurance shall be purchased on behalf of the railroad by the Contractor. The standards for railroad protective insurance established by this specification shall be adhered to insofar as the insurance laws of the State will permit.

5. Standards for Railroad Protective Insurance.

a. Coverage shall be limited to damage suffered by the railroad on account of occurrences arising out of the work of the Contractor on or about the railroad right-of-way, independent of the railroad's general supervision or control, except as noted in Paragraph b, 4, b below.

b. Coverage shall include:

1) The death of or bodily injury to passengers of the railroad and employees of the railroad not covered by State Workmen's Compensation laws,

2) Personal property owned by or in the care, custody or control of the railroads,

3) The Contractor, or any of the Contractor's agents or employees who suffer bodily injury or death as a result of acts of the railroad or its agents, regardless of the negligence of the railroad, and

4) Negligence of only the following classes of railroad employees:

a) Any supervisory employee of the railroad at the job site,

b) Any employee of the railroad while operating, attached to, or engaged on, work trains or other railroad equipment at the job site which are assigned exclusively to the Contractor, or

c) Any employee of the railroad not within a) or b) above who is specifically loaned or assigned to the work of the Contractor for prevention of accidents or protection of property, the cost of whose services is borne specifically by the Contractor.

c. The maximum dollar amounts of coverage with respect to bodily injury, death, and property damage is limited to a combined amount of $2 million per occurrence with an aggregate of $6 million applying separately to each annual period.

6. Form of Insurance Policy.

The policy forms and endorsements shall be those adopted by the companies for use in the State of Iowa.

7. Payment.

Payment to the Contractor for insurance required in the contract documents shall be considered as incidental to other items in the contract.

1107.03 PERMITS, LICENSES, AND TAXES.

The Contractor shall procure all necessary permits and licenses; pay all charges, fees, and taxes; and give all notices necessary and incident to the due and lawful prosecution of the contract.

1107.04 PATENTED DEVICES, MATERIALS, AND PROCESSES.

A. The Contractor and Contract Surety shall indemnify and save harmless the Department, any affected third party, or political subdivision from any and all

claims for infringement by reason of the use of any patented or copyright item.

B. The Contractor shall indemnify the Department for costs, expenses, and damages that may be obligated for payment by reason of an infringement during the prosecution of the work or after completion of the project.

1107.05 RESTORATION OF SURFACES OPENED BY PERMIT.

A. Prior to final acceptance, if any repairs to the roadway are necessary due to construction or repair of drains or sewers, laying or repairing of pipes or conduits for telegraph or electric wires, or from any other disturbance of the roadway under permission issued by the Contracting Authority, the Contractor shall, upon notification by the Engineer, immediately make necessary repairs in conformance with the contract documents. These repairs shall be paid for per Article 1109.03, B; however, compensation will not be allowed when these repairs are made necessary by the Contractor's negligence or carelessness.

B. The Contractor shall not authorize any person or persons to make an opening in the roadway unless a permit, duly authorized by the Contracting Authority, is presented.

1107.06 FEDERAL PARTICIPATION.

A. The attention of the Contractor is directed to the provisions of an act of Congress known as Title 23, United States Code, Section 1 and any other acts of Congress providing for road improvements. When the Federal Government is to pay all or any portion of the cost of an improvement or project, the construction work, although it is under the supervision of the Department and subject to laws of the State of Iowa, is also subject to the above mentioned acts of Congress and to all authorities. This construction work shall be subject to inspection by duly authorized agents of the Federal Government, but this inspection will not make the Federal Government a party to the contract.

B. On all contracts involving Federal-aid, all products of iron, steel, or a coating of steel which are incorporated into the work must have been manufactured in the United States. The Engineer may allow minimal amounts of these materials from foreign sources, provided the cost does not exceed 0.1% of the contract sum or $2,500, whichever is greater. The Contractor shall certify that these materials are of domestic origin.

1107.07 SAFETY, HEALTH, POLLUTION, AND SANITATION.

A. In the performance of the contract, the Contractor shall comply with all applicable laws, rules, regulations, and ordinances governing safety, health, pollution, sanitation, noise control, and disposal of waste materials. The Contractor shall also make available such additional safeguards, safety devices, protective equipment, and take such actions as are reasonably

necessary to protect the life and health of employees and the public. Violations of properly promulgated laws, rules, regulations, and ordinances reported to the Engineer by responsible agencies may result in the issuance of a suspension order until such time as the violation is corrected.

B. The Contractor shall make adequate provisions satisfactory to the Engineer for safety of inspectors, particularly at sampling locations. Provisions shall include guards for moving belts, pulleys, and wheels near the sampling point and a stable platform when sampling is to be done from an elevated location.

C. There shall be suitable retention dams in areas where approved liquid asphalt materials or asphalt binder are stored and used, to minimize pollution of nearby areas from effects of normal rains. The Contractor shall take other necessary precautions to prevent pollution of streams, lakes, ponds, reservoirs, and other areas with fuels, oil, bitumens, chemicals, or other harmful materials and to prevent pollution of the atmosphere from particulate and gaseous matter.

D. Machinery must be properly maintained at all times in order to limit engine noise as well as other extraneous noise.

E. When directed by the Engineer, and with no additional compensation, the Contractor shall apply water to the construction area and haul routes, as necessary, to prevent the spread of dust. On Primary Roads and Primary Road extensions, on temporary Primary Road haul roads, and when designated in the contract documents construction areas adjacent to Primary Roads on which traffic is maintained, the Contractor will be paid for watering ordered by the Engineer at the rate of $15 per thousand gallons ($4 per kL).

1107.08 PUBLIC CONVENIENCE AND SAFETY.

A. The schedule for removal of existing guardrail, warning devices, and other traffic control devices requires Engineer's approval. The Contractor may be required to place temporary warning devices at locations where replacement features are not installed the same day as removal takes place.

B. The Contractor shall conduct the work to assure the least possible obstruction to access by the residents along the project. The Contractor shall schedule and conduct the work in such a way as to provide for their safety and convenience. The Contractor shall submit a construction staging plan to the Engineer for local access required to remain open. Relocated accesses shall be completed prior to removal of existing accesses. If a permanent access cannot be completed prior to removal of an existing access, the Contractor shall provide and maintain an alternate access. Work and materials required by the Engineer for public convenience and safety in excess of that provided for in the contract documents will be paid for per Article 1109.03, B.

C. Whenever it is practical to do so, the Contracting Authority will close the portion of the road under construction, provide a detour, and cause suitable detour signs to be erected to mark such detour.

D. When it is not practical for the Contracting Authority to close the road for construction, the Contractor will be expected to perform the work under traffic. The contract documents will indicate this fact and provide instruction for handling traffic through the work. Unless otherwise stated in the contract documents, all work shall be performed by the Contractor between the hours of 30 minutes after sunrise to 30 minutes before sunset.

E. Except when the contract documents indicate the road is to be closed, during all pavement widening, base widening, and HMA resurfacing work, traffic will be permitted to use the routes involved at all times and shall not be delayed unnecessarily. Where a pavement or base is being widened, the machine depositing material shall operate within the designated work area. Construction equipment may be stored within the right-of-way, as far from the traveled way as is practical, but the roadbed shall be free of Contractor's equipment during non-working hours. The work shall be planned and conducted to cause a minimum delay or interference with traffic.

F. When work on a traveled way necessitates diverting traffic from a work lane to another lane, material, mobile equipment, and vehicles shall occupy the work lane to the minimum extent and for the minimum time necessary, and non-mobile equipment shall be removed from the work lane promptly after its operation is completed in that lane.

G. On two-lane roadways, a work area shall be established only on one side of the roadway and there shall be no parking of vehicles or equipment on the opposite shoulder within 500 feet (150 m) of the work area.

H. The location for storage of equipment by the Contractor during nonworking hours shall be as reviewed and approved by the Engineer prior to use.

I. Parking of private vehicles on Interstate right-of-way will not be allowed. Parking of unattended equipment within the median or storage of equipment within 50 feet (15 m) of the edge of pavement will not be allowed.

J. Materials stored within the highway right-of-way shall be placed to cause a minimum obstruction to traffic. Sidewalks, gutters, sewer inlets, and portions of highway adjoining the roadway under construction shall not be obstructed more than is necessary.

K. When the shoulder work is a part of the contract for work on a project open to public traffic during construction, the Contractor shall coordinate the operations so that the length and degree of pavement edge drop-off caused or partly caused by the operations are minimized.

L. Shoulder construction in conjunction with PCC overlay or HMA resurfacing shall meet the following:

1. Paved Shoulders (Partial or Full Width).
Construction shall be staged so no drop-offs exist at the pavement or shoulder edge when the adjacent lane is to be opened to traffic. The pavement edge drop-off requirement shall be satisfied with an HMA shoulder fillet. This fillet shall extend into the shoulder area a minimum of six times the thickness of the drop-off and shall be placed prior to the adjacent lane being opened to traffic. Compaction of the HMA fillet shall be a minimum of one coverage with a pneumatic tired roller per 1 inch (25 mm) of thickness. The fillet shall be removed prior to start of shoulder paving. The shoulder edge drop-off requirement shall be satisfied with a granular fillet, meeting the requirements of the following paragraph.

2. Granular Shoulders.
Construction shall be staged so no drop-offs exist at the pavement edge when the adjacent lane is to be opened to traffic. The drop-off requirements shall be satisfied with a shoulder fillet or full shoulder width of granular material according to Article 2121.03. The fillet shall extend into the shoulder area a minimum of six times the thickness of the drop-off and shall be placed prior to the adjacent lane being opened to traffic. Compaction of the fillet shall be a minimum of one coverage with a pneumatic tired roller per 1 inch (25 mm) of thickness.

M. When the Contractor works on a bridge spanning a roadway or passageway, the Contractor shall take all necessary steps to protect the public using the facility below the bridge from falling debris, material, or construction equipment. The Contractor shall submit a safety procedure written plan to the Engineer prior to starting work. The plan shall include the following:
Design of the means and methods used to provide protection.
All assumptions used in the design.

Evaluation of the plan and design may require its preparation by a Professional Engineer licensed in the State of Iowa. If so, the costs will be paid for in accordance with Article 1109.03, B.

1107.09 BARRICADES AND WARNING SIGNS.

A. Barricades, warning signs, and other aspects of traffic control shall be in accordance with the contract documents. In providing adequate and proper traffic control, both the Contracting Authority and the Contractor have certain responsibilities.

1. Responsibilities of the Contracting Authority.

a. Advance Notification.
Whether a road is closed for construction or traffic is to be maintained during construction, the Contracting Authority will furnish, erect, and maintain such suitable advance warning signs, warning lights, and barricades as it deems appropriate outside the project area, in addition to those barricades and signs required to

be erected by the Contractor. If necessary, where a road is closed for construction, a marked detour will be established.

b. Primary Road Intersections.
The Department will furnish, erect, and maintain such suitable advance warning signs, warning lights, and barricades as it deems appropriate where a Primary Road intersects a Primary project to provide a marked detour for through traffic using the intersecting Primary route or to provide advance notification to through traffic using the intersecting Primary Road and passing through the intersection. A marked detour may allow public traffic to use the intersection.

c. Secondary Projects.
Where a Secondary Road project requires work within a Primary Road right-of-way or extension of the right-of-way across the Secondary Road, the Primary Road shall be protected as a Primary project through which traffic is maintained. The Department will furnish, erect, and maintain such suitable advance warning signs, warning lights, and barricades as it deems appropriate. The County will notify the Department so this protection can be provided for Secondary projects.

d. Availability.
Except when there is an item for traffic control, all signs and traffic control devices (except pilot car signs and flagger signs) will be made available to the Contractor at a nearby site designated by the Engineer. They will be furnished by the Contracting Authority. Replacement materials will also be furnished as necessary.

e. Additional Notification.
Any additional signs, barricades, or notification beyond the project area deemed appropriate by the Engineer will be the responsibility of the Contracting Authority.

f. Regulatory and Warning Signs.
The Contracting Authority will erect prior to construction any additional special regulatory or warning signs required due to construction that are located outside of the project limits. This does not apply to warning and regulatory signs specifically required for traffic control zones necessary for construction activities defined in the contract documents.

g. Suspensions.
By agreement, the Contracting Authority will accept responsibility for maintenance of signs and barricades when work is suspended for 30 calendar days or more, or when such time of suspension is anticipated.

2. Responsibilities of the Contractor.

a. General.

1) The Contractor shall be responsible for placing and maintaining proper barricades, warning signs, and other traffic control devices on the project, and the Contractor shall take every reasonable precaution to prevent traffic from interfering with the work and to prevent the work from interfering with the

traffic; and shall take every reasonable precaution to provide for safety of the general public traveling to, through, within, along, and across the project. Where the road is closed for construction, the Contractor shall take every reasonable precaution to protect the work and equipment and to provide for safety of the public. When traffic is to be maintained through the construction, the Contractor shall erect and maintain all signs; furnish, erect, and maintain all other traffic control devices and other safeguards; provide all flaggers necessary to protect the traveling public. Payment for this work will be in accordance with Article 2528.05.

2) The Contractor shall furnish, erect, and maintain ROAD WORK AHEAD and END ROAD WORK signs at the mainline limits of individual work areas on highway construction or contract maintenance projects where traffic is maintained through a traffic control zone. The ROAD WORK AHEAD sign shall be placed to identify where traffic enters a traffic control zone. The END ROAD WORK sign shall be placed to identify where traffic leaves a traffic control zone and be located at least 500 feet (150 m) beyond the work area. Should more than one contractor be working on the project, the Engineer will assign the responsibility for these signs.

b. Intersecting Local Public Roads.

1) When a road closed for construction intersects other local public roads within a project, the Contractor shall erect and maintain barricades and warning signs in accordance with the contract documents. Payment for this work will be in accordance with Article 2528.05.

2) The responsibility described in the previous paragraph is intended to be in addition to actions of the Department described in Paragraph A, 1, b.

c. Entrance from Local Public Roads.

On local public roads open to traffic during construction, the Contractor shall erect and maintain signs in accordance with the contract documents. When scarification is part of the contract, ROUGH ROAD signs shall also be erected on the shoulder of the road under construction at local public road intersections. These signs shall be erected, moved when appropriate, and maintained by the Contractor until the scarified areas are covered with the new surface material. Payment for this work will be in accordance with Article 2528.05.

d. Shoulder Drop-Offs.

Drop-offs at paved and granular shoulders shall be treated as provided in Article 1107.08. All other drop-offs shall be handled in accordance with project plan requirements.

e. Sign Removal.

1) The Contractor shall not remove, move, or obstruct any regulatory, guide, or warning sign without approval of the Engineer. If these signs interfere with construction, approval of

the Engineer shall be obtained prior to removal; temporary re-erection, if appropriate; and re-erection by the Contractor.

2) The Contractor shall be responsible for erecting, moving, maintenance, and removal of all signs necessary to protect the work area and uncompleted work and signs required elsewhere by the contract documents.

3) If the Contractor inadvertently damages a regulatory, guide, or warning sign, or makes it ineffective, the Contractor shall correct it and promptly notify the Engineer.

f. Availability of Signs.
The Contractor shall pick up signs and barricades furnished by the Contracting Authority at the site designated and shall return them when the work is completed.

g. Traffic Control Item.
When there is a contract item for traffic control, the Contractor shall furnish all signs, barricades, channelizing devices, and other traffic control identified in the contract documents.

h. Commencement of Responsibility.
The Contractor shall assume the responsibility required by this article because of the operations concurrent with possession of the work site or right-of-way through moving of equipment, machinery, tools, or materials thereon and in all cases when the work is commenced.

i. Cleaning.
The reflective surfaces of signs and traffic control devices shall be washed, as described in Article 2528.03, L, and shall be clean at the time of initial installation on a project.

j. Traffic Control in Place.
At any time signs, barricades, or other traffic control devices are in place, for which the Contractor is responsible, the Contractor provide the Engineer the following information at the preconstruction conference or before work commences:

1) The name and telephone number of a 24 hour emergency response person for traffic control (answering services are not acceptable); so that repair or maintenance of these devices can occur promptly, within 2 hours and

2) The name and telephone number of the traffic control technician in responsible charge of the traffic control for the project per Article 2528.01, C.

B. The contract documents may require placement, maintenance, and removal of temporary and permanent pavement marking and temporary delineators. This work shall be in accordance with requirements of Section 2527.

C. An additional flagger shall be stationed at public road intersections or crossings within the work area, if necessary, to prevent vehicles from entering the work area against the flow of traffic. When traffic control is incidental, additional flaggers will not be paid for separately.

D. The Engineer may require additional flaggers or other safeguards because of unusual or changed conditions, including suspensions and delays. Except when the need arises from the Contractor's actions or inactions, this will be paid for in accordance with Article 1109.03.

1107.10 USE OF EXPLOSIVES.

A. When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be responsible for all damage resulting from use of explosives.

B. All explosives shall be stored in a secure manner in compliance with all laws and ordinances and in quantities maintained at a practical minimum. Storage places shall be clearly marked. Where no local laws or ordinances apply, storage shall be provided satisfactory to the Engineer and, in general, not closer than 1000 feet (300 m) from the road, building, camping area, or place of human occupancy.

C. The Contractor shall notify each public utility company having structures in proximity to the site of the work of the Contractor's intention to use explosives. This notice shall be given sufficiently in advance to enable the companies to take such steps as may be necessary to protect their property from damage.

1107.11 PROTECTION AND RESTORATION OF PROPERTY.

A. The Contractor shall replace or renew fences, sidewalks, or other property damaged by performance of the work or the negligence of the Contractor's employees.

B. The Contractor shall take suitable precautions to prevent damage to telephone, telegraph, and electric transmission lines along the highway and to pipes, conduits, and other underground structures.

C. Unnecessary breaks in tile lines due to the Contractor’s operations shall be replaced at no additional cost to the Contracting Authority.

D. The Contractor shall be responsible for damage to property resulting from the performance of the work; however, this responsibility shall not extend to damage to fences, telephone, telegraph, or electric lines occupying the right-of-way unlawfully, provided due caution has been used in removing them.

E. The Contractor shall carefully protect from disturbance all land monuments and property marks until an authorized agent has witnessed or otherwise referenced their location, and the Contractor shall not remove them until so directed.

F. The Contractor's responsibility shall not be released until the work under the Contractor's contract is completed and accepted.

1107.12 RESPONSIBILITY FOR DAMAGE CLAIMS.

A. The parties agree that it is their intent that there be no third-party beneficiaries to this contract. No provision of this contract; or of any addendum, materials instructional memorandums, plan, proposal, special provision, standard specification, developmental specification, supplemental specification, or general supplemental specification; shall be construed as creating any third-party beneficiaries.

B. The Contractor shall indemnify and save harmless the Contracting Authority and other agencies which have concurred in the award of the contract, as well as their officers and employees, from all suits, actions, or claims of any character, except as provided in the next sentence. Indemnity shall not, however, extend to acts or omissions for which the Contracting Authority is solely responsible, though it shall extend to those claims, actions, or suits in which the Contractor, Subcontractor, or either's employee or agent, and the Contracting Authority are alleged to be, or could be, jointly or concurrently liable. Any funds due said Contractor under the Contractor's contract as may be considered reasonable and necessary by the Contracting Authority for such purpose may be retained for the use of the Contracting Authority; in case no money is due, the Contractor's surety may be held until such suit or suits, action or actions, claim or claims have been settled and suitable evidence to that effect furnished to the Contracting authority, except that money due the Contractor will not be withheld when the Contractor produces satisfactory evidence of insurance covering the claim, action, or suit.

C. The Contractor's responsibility for providing warning devices required by Article 1107.09 to avoid damages or injuries to the traveling public on any portion of the road covered by the contract shall not cease until the work on such portion has been released by the Engineer. A "release" in this context means a written statement by the Engineer stating that the Contractor may cease to maintain barriers and lights, that the road may be opened to traffic, and that the Contractor is relieved of further maintenance of that portion of the road. This release shall not constitute an acceptance of the work.

D. The Contractor's responsibility for maintenance of lights on any individual structure will cease upon final acceptance of such structure, or when released in writing by the Engineer.

1107.13 OPENING OF SECTIONS OF HIGHWAY TO TRAFFIC.

A. When any substantial portion, part, or feature of a contract is completed to the extent that its stability and integrity is not dependent upon completion of other items or work required in the contract, that portion, part, or feature may be released by the Engineer, after conferring with the Contractor, and opened to traffic or received for public usage prior to final approval and acceptance of all work involved in the contract. The Contractor will not be

responsible for damages due to the elements or the general wear of traffic to those portions, parts, or features of the road which have been released by the Engineer. The Contractor will be responsible for any damages which may be caused by defective work or failure to comply with the contract documents.

B. The above provisions relating to a release by the Engineer will be applicable only to those portions, parts, or features of a contract for which the Engineer has furnished to the Contractor a written release.

1107.14 CONTRACTOR'S RESPONSIBILITY FOR WORK.

The Contractor will be responsible for care and maintenance of partially completed work and finished work on any portion of the road until the Contractor has been released by the Engineer from this responsibility. It shall be the Contractor's responsibility to adjust the operation or method of operation to prevent any damage of any nature to any portion of partially completed or completed work, except for damage to work in officially designated disaster areas where the damage results from Acts of God for which the designation is made. Repair work shall be done promptly upon being so ordered by the Engineer.

1107.15 CONTRACTOR'S RESPONSIBILITY FOR UTILITY FACILITY AND SERVICES.

A. The Contracting Authority will endeavor to have all necessary adjustments made to public or private utilities within or adjacent to the limits of construction prior to construction activities, except those requiring coordination with the Contractor. Utility facilities have been plotted from available surveys and records, and shall be considered approximate. Other utilities may exist and their location may not be presently known or identified on the plans. The Contractor shall notify Iowa One-Call at 1.800.292.8989 to identify the location of all underground utility facilities within the construction area.

B. The Contractor shall determine the exact location of all public and private utility facilities located within the construction area to avoid damage in accordance with Section 480.4, Code of Iowa. The Contractor shall have considered in their bid all permanent and temporary utility appurtenances in their present or adjusted positions as shown in the contract documents. For projects not developed under 761 IAC, Chapter 115.25 and not designated as POINT 25 projects in the contract documents, additional compensation will not be allowed for any delays, inconvenience, or damage sustained by the Contractor due to any interference from the utility appurtenances or their operation or relocation.

C. Where existing utility facilities are shown in the contract documents or encountered within the construction area, the Contractor shall notify the utility company prior to beginning construction activities. The Contractor shall be responsible for notifying utilities and conducting work near utility facilities, required by Iowa Code 480.4.

D. Any system for supplying water, gas, power, or communications; a storm sewer, sanitary sewer, drainage tile, or other system for transmitting liquids; a pipeline system; traffic signalization system; and lighting systems within the limits of the proposed construction, which are to be adjusted, are to be moved by the utility company at their expense, except as otherwise provided for in the contract documents.

E. The Contractor shall cooperate with utility companies in their adjustment operations so that these operations may progress, the duplication of adjustment work may be reduced, and that services rendered by those parties will not be interrupted.

F. Where the Contractor's operations are adjacent to properties of railway, communication, or power companies, or are adjacent to other utility facilities where damage might result in considerable expense, loss, or inconvenience, work shall not begin until all arrangements necessary for protection of the facilities have been made.

G. In the event of interruption to utility services as a result of accidental breakage or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the authority in restoration of service. If a utility service is interrupted, repair work shall be continuous until service is restored.

H. Primary projects developed under 761 IAC 115.25 and designated as POINT 25 projects in the contract documents, where the utility company's adjustment is dependent on work by the Contractor, the Contractor shall provide the Contracting Authority and the utility company a good faith notice 14 calendar days and a confirmation notice not less than 3 working days before the Contractor's work will be complete and ready for the utility company to begin its work. If the utility fails to complete the adjustment of its facilities and fails to submit or comply with its accepted work plan as referenced in the Utility Status Report in the contract documents, and these failures result in a delay to the Contractor or causes damages to be incurred by the Department or Contractor, the utility may be liable for costs and damages incurred as a result of its failure to perform.

1107.16 PERSONAL LIABILITY OF PUBLIC OFFICIALS.

In carrying out any of the provisions of the contract, or in exercising any power or authority granted to any agent or representative of the Contracting Authority thereby, there shall be no liability upon such agent or representative, including the Engineer or authorized assistants, either personally or as an official of the Contracting Authority, it being understood that in such matters the Engineer acts as the agent and representative of the Contracting Authority.

1107.17 NO WAIVER OF LEGAL RIGHTS.

A. The Contracting Authority shall not be prevented by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefore from showing the true

amount and character of the work performed and materials furnished by the Contractor, or from showing that any such measurement, estimate, or certificate is untrue or incorrectly made, or that the work or materials do not, in fact, conform to the contract.

B. The Contracting Authority shall not be prevented, notwithstanding any such measurement, estimate, or certificate and payment in accordance therewith, from recovering from the Contractor and the Contractor's sureties such damages as it may sustain by reason of the Contractor's failure to comply with the terms of the contract. Neither acceptance by the Contracting Authority, or any representative of the Contracting Authority, nor any payment for or acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Contracting Authority, shall operate as a waiver of any portion of the contract, or for any power herein reserved, or any right to damages herein provided. A waiver of any breach of contract shall not be held to be a waiver of any other or subsequent breach.

Section 1108. Prosecution and Progress

1108.01 SUBLETTING OF CONTRACT.

A. The Contractor's own organization shall perform work amounting to not less than 30% of the total contract cost unless otherwise specified in the contract documents. The percent total contract subcontracted will be computed on Contract Unit Prices for the work performed by the subcontractor, unless the subcontractor is only doing partial work on the contract item. In order to meet this 30% requirement, the Contractor shall not purchase any materials for a subcontracted item nor shall they place other contractor's employees on their payroll. Employees must be hired in accordance with the AA hiring process as detailed elsewhere in the contract documents. Any item designated as a specialty item may be performed by subcontract, and the cost of any such specialty item as performed by subcontract may be deducted from the total cost before computing the amount of work required by the Contractor's organization. Any items that have been selected as specialty items for the contract are listed as such in the contract documents.

B. Except for the furnishing and transportation of materials, no portion of the contract shall be sublet, assigned, or otherwise disposed of except with written consent of the Contracting Authority. Where a subcontract has been approved, the approved subcontractor shall be responsible to complete that portion of the contract with its own organization.

C. Where a subcontract does not exist, but a DBE firm is manufacturing, supplying, or trucking materials to the job site; terms of the agreement shall be described and documented on the Subcontract Request and Approval form (Form 830231). This will assure the Engineer that a Contractor is meeting commitments previously stated on the Statement of DBE Commitments form (Form 102115). This dollar value will not be used to

determine the percent subcontracted as specified previously. Where Davis/Bacon wage requirements apply, the Contractor shall be responsible for collecting and submitting certified payrolls for all drivers. Owner/operators shall be listed on the certified payrolls as owner/operators.

D. Request for permission to subcontract, assign, or otherwise dispose of any portion of any contract shall be submitted in writing with the Contractor's signed contract to the Office of Contracts, on a Subcontract Request and Approval form (Form 830231). For contracts that exceed $600,000, the Contractor shall submit the Subcontract Request and Approval form electronically using the software furnished by the Department. In certain situations, with approval of the Department, the Contractor may request an extension of up to 30 calendar days to submit the Subcontract Request and Approval forms.

E. Either the Contractor or approved subcontracts (e.g. contractors) can use leased employees from a firm that does not perform highway construction with its own organization. Work performed by a DBE firm using leased employees will not count towards meeting the Department's annual DBE goal.

When used, leased employees will be considered part of the Contractor's "own organization" if:

- The use of the employee leasing company is documented with the submittal of a Request to Subcontract.
- The Contractor maintains supervisory control over day-to-day activities of leased employees.
- The Contractor remains responsible for the quality of work of leased employees.
- The leasing company is responsible for customary employer responsibilities including EEO/AA in hiring, training, promotions, and submittal of required employee information to the Department and other governmental agencies.
- The Contractor retains power to accept or exclude individual employees from work on the project.
- The employee leasing company prepares and submits required certified payrolls. The Contractor remains ultimately responsible for payment of predetermined minimum wages and submission of payrolls.
- The Contractor retains responsibility for compliance with contract requirements.

1108.02 PROSECUTION OF WORK.

A. General.

1. The proposal form may designate the contract period by either a Specified Start Date, Approximate Start Date, or Late Start Date. The proposal form may also indicate the contract period by a Completion Date for non-highway type contracts (e.g. buildings, furnishing

materials, etc.). The number of working days will be designated for the three types of start dates. Working days will not apply for a Completion Date contract period.

2. The return of the signed and executed contract to the Contractor shall serve as notice that the contract bond is acceptable, that the contract is in force, and that the Contractor may complete arrangements for materials and other work in accordance with the contract documents.

3. Should a delay become apparent before or after the work is started, the Engineer will immediately notify the Contractor in writing that work on the contract will be delayed, and if possible, the approximate duration of the delay.

B. Completion Date Contracts.

The Contractor shall complete the contract on or before the Completion Date. Unless noted otherwise in the proposal form, the Contractor may commence work any time after receipt of the signed contract, specifications permitting. Articles 1108.02, E, Charging of Working Days and 1108.02, F, Winter Work will not apply. Liquidated damages will be assessed in accordance with Article 1108.08 for each calendar day beyond the Completion Date that the contract remains uncompleted.

C. Working Day Contracts.

The three types of start dates are as follows:

1. Specified Start Date.

Working days will be charged to the Contractor starting on the Specified Start Date, but not prior to 15 calendar days after the contract has been signed by the Contracting Authority. Starting work prior to the Specified Start Date will be considered upon request, and working days will be charged when work starts.

2. Approximate Start Date.

It is expected the site will be available by the Approximate Start Date. If it appears the site will not be available by the Approximate Start Date, the Engineer will inform the Contractor of the delay and if possible the duration of the delay. The Contractor may commence work, weather and specifications permitting, any time after execution of the contract and on or after the Approximate Start Date provided the site has become available. If work is started under these conditions, working days will be charged. Starting work before the Approximate Start Date and before the site is available, will be considered only after the Contractor has submitted a signed waiver of any right to claim extra compensation for damages due to delays from any cause related to early commencement. If approved, working days will not be charged when working prior to the date of site availability. If the Contractor is working on the project when the site becomes available, working days will be first charged on the following day.

3. Late Start Date.

a. Unless noted otherwise in the proposal form, the Contractor may commence work any time after receipt of the signed contract, weather and specifications permitting. Except as noted in Article 1108.02, F, working days will begin to be charged whenever the Contractor starts work. Charging of working days will begin on the Late Start Date if the Contractor has not started work prior to this date.

b. If the Contractor wishes to start preliminary work prior to the Late Start Date and move out intending to return at a later date to complete the project, the Contractor shall request approval from the Engineer for temporary suspension of work in accordance with Article 1108.06. Approval of suspension of work in this circumstance will be based on if the road is open to traffic and the roadway is in a condition that is at least as safe as it was before the start of the preliminary work. The Engineer will submit in writing to the Contractor approval for suspension of work and a computed revised Late Start Date. The revised Late Start Date will be computed by adding the working days used for the preliminary work to the Late Start Date listed on the proposal form. The charging of the remainder of the working days will resume on the revised Late Start Date or when the Contractor recommences work prior to the revised Late Start Date.

D. Intermediate Contract Periods.

Intermediate contract periods may be designated for construction of certain portions of the contract. The intermediate contract period may be the same type as listed in Articles 1108.02, B and 1108.02, C. The intermediate contract period, description, working days (if applicable), and liquidated damages will be shown as a site number on the proposal form.

E. Charging of Working Days.

1. The Contractor will be charged working days as defined in Article 1101.03 and this article. For multiple site contracts, working day charges for each site will be charged independently based on the controlling operation for the site.

2. Working days will be charged beginning with the following circumstances:

a. On the date specified for projects with a Specified Start Date.

b. On the date that has been agreed to at the preconstruction conference for projects with an Approximate Start Date.

c. On the start date indicated in the Notice to Proceed for projects with an Approximate Start Date.

d. On the day following the date the site becomes available if the Contractor is already working on the site for projects with an Approximate Start Date.

e. On the date the Contractor begins work prior to the Late Start Date.

f. On the date specified for projects with a Late Start Date and the Contractor has not begun work prior to that date. However, working days will not be charged prior to 15 calendar days after the contract has been signed by the Contracting Authority, as long as the Contractor furnished the signed contract, performance bond, and proof of insurance within the time allowed by Article 1103.07; and has not begun work on the contract.

3. The Contractor will be charged 1/2 working day when weather or other conditions beyond the control of the Contractor permits work for at least 1/2 but less than 3/4 of a working day. The Contractor will not be charged a working day when weather or other conditions beyond the control of the Contractor work for less than 1/2 of a working day. In the event of adverse weather when work on a project is ready to be started or resumed and the Contractor is not on the project, working days will not be charged during the inclement weather period provided the Contractor starts work as soon as weather and ground conditions permit work to be started or resumed.

4. Working days will not be charged for Sundays and recognized legal holidays the Contractor does not work. Working days will be charged for Sundays and recognized legal holidays the Contractor does work.

5. Working days will not be charged for Saturdays the Contractor does work, unless a 6 day work week is specified in the contract documents.

6. Working days will be charged for cure time of pavement and structural concrete when it is the controlling item of work.

F. Winter Work.

1. Winter work is work done at the project site between November 15 and April 1. The proposal form may require winter work on all or portions of the project. If winter work is required on a project, the proposal form will indicate how the working days will be counted. When winter work is not required in the contract documents, the following shall apply:

a. The Contractor may start or resume work before April 1. Working days will not be charged if the proposal form does not indicate that working days will be charged during winter work. Working days will be charged if the proposal form indicates that working days will be charged during winter work.

b. For projects started prior to November 15, the Contractor may work between November 15 and April 1 with no working days charged if working days remain on November 15.

2. If the number of working days specified on the contract has been exceeded, the Engineer may require the Contractor to continue work after November 15 if it is in the best interest of the Contracting Authority. These working days will be charged.

G. Notice to Proceed.

1. A notice to proceed will be issued when, in the opinion of the Engineer, considering the approximate starting date, site availability, and working days allowed, failure of the Contractor to commence work places the timely completion of the project in jeopardy. The starting date in the notice to proceed will not be less than 15 calendar days after the date of the issuance of the notice.

2. Working days will be charged beginning with the starting date established by the notice or when the Contractor starts work if prior to that date.

H. Weekly Report of Working Days.
Whenever the Contractor is subject to being charged with working days, the Engineer will furnish the Contractor a weekly statement indicating the working days to be charged to the Contractor for that period. Should the Contractor believe the statement to be inaccurate, the Contractor shall submit to the Engineer, in writing, an objection and reasons within 10 calendar days after receipt of the statement.

I. Work Progress.

1. The progress of the work shall be at a rate sufficient to complete the contract within the time allowed. If it appears that the rate of progress is such that the contract will not be completed within the time allowed, or if the work is not being executed in a satisfactory manner, the Engineer may order the Contractor to take such steps as necessary to complete the contract within the period of time specified or to prosecute the work in a satisfactory manner. If the Contractor fails to comply with such order within 14 calendar days after receipt of the order, the Contractor may be disqualified from receiving any additional bidding proposals, and the Contracting Authority will have the right to declare the contract in default and to complete the work in accordance with Article 1108.11. Failure of the Contracting Authority to issue such order shall not alter the Contractor's responsibility under the contract.

2. The Contractor's sequence of operations shall be such as to cause as little inconvenience to the general public as possible.

J. Schedule of Staging.
On any project, or part of a project, on an existing road where the work may prohibit or restrict public or private access that has been previously available, the Contractor may be required to submit a schedule of staging for the Engineer's approval before work is started. Preliminary work may be required in stage construction, even though the work involved in these operations is similar, in order to minimize the inconvenience to the public and those to whom access has been previously available. This requirement will apply equally to work that is subcontracted.

K. Accelerated Work Schedule.

1. An accelerated work schedule may be required by a note on the proposal. When required, the Contractor shall marshal the necessary forces, including but not limited to, extra crews, subcontractors, extra work hours, or other acceptable methods to insure completion of the project, or various stages of the project, within the contract period and in compliance with the specifications.

2. A work plan shall be submitted to the Engineer for review prior to commencement of work. Work will be permitted on a 24 hour day basis and on Sundays and holiday, though work may be restricted as identified in the contract documents. Credit will not be allowed for delayed or slow delivery of materials.

3. The proposal form may specify a completion bonus. An accelerated work schedule, as provided in this article, is allowed for work necessary to earn the bonus.

L. Preconstruction Conference.
The Engineer may schedule and conduct a preconstruction conference. The Contractor and the intended subcontractors, if known, shall participate in this conference. The Engineer will invite representatives of railroads and utilities and others having responsibilities or interest in the work.

M. Notification of Traffic Impacts.
The Contractor shall provide the Engineer with 10 calendar days notice before commencing or resuming work on a Primary or Interstate road or bridge open to traffic. This notification is needed to suspend the issuance of permits for oversized loads when width or vertical clearance restrictions occur during construction.

1108.03 LIMITATIONS OF OPERATIONS.

A. The Contractor shall conduct the work so as to create a minimum amount of inconvenience to traffic. At any time, when in the judgment of the Engineer, the Contractor has obstructed or closed, or is conducting operations on, a greater portion of the road than is necessary for the proper prosecution of the work, the Engineer may require the Contractor to finish the sections on which work is in progress before work is started on any additional sections.

B. Whenever work which is being done by other contractors or subcontractors is contiguous to, or a part of, the work included in this contract, the Engineer will, in case of dispute, determine and define the respective rights of the various interests involved, in order to secure the completion of all parts of the work in general harmony and with satisfactory results.

C. Except when an accelerated work schedule is required, no work requiring inspection will be permitted on Sundays or holidays observed by the Department except with permission of the Engineer. The Contractor should

request a determination of the holidays to be observed at the beginning of each calendar year.

D. Work on Primary Roads where traffic is maintained through the project and work on all Interstate highways will not be permitted during the times identified below without approval of the Engineer:

1. **Memorial Day and Labor Day weekends** - No work will be allowed the preceding Friday and all day Saturday.

2. **Independence Day** – When Independence Day is observed as a State Holiday on Monday, no work will be allowed beginning the preceding Friday through the holiday. When Independence Day is observed as a State Holiday on Friday, no work will be allowed the preceding Thursday through the following Saturday**.**

E. If the Contractor requests permission to work for the times identified above and the Engineer approves this request, working days will be charged for the times requested.

1108.04 METHODS AND EQUIPMENT.

A. The methods and equipment used shall produce a satisfactory quality of work and shall be adequate to maintain the schedule of progress specified. Equipment used on any portion of the project shall be such and its use so regulated that no serious or irreparable damage to the roadway, adjacent property, or other highways will result from its use. If damage does occur to the highway, suitable repairs shall be made.

B. When the methods and equipment to be used by the Contractor in accomplishing the construction are not prescribed in the contract documents, the Contractor is free to use any methods or equipment that will accomplish the contract work in conformity with the requirements of the contract documents, as demonstrated to the satisfaction of the Engineer.

C. When the contract documents specify that the construction be performed by use of certain methods and equipment, these methods and equipment shall be used unless others are authorized by the Engineer.

D. If the Contractor desires to use a method or type of equipment other than specified in the contract documents, the Contractor may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the method and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor shall be fully responsible for producing construction work in conformity with contract requirements. If after trial use of the substituted methods or equipment the Engineer determines that the work produced does not meet the requirements of the contract documents, the Contractor shall discontinue use of the substitute method or equipment and shall complete the remaining construction with the

specified methods and equipment. The Contractor shall remove the defective work and replace it with work of specified quality, or take such other corrective action as the Engineer may direct. Change will not be made in basis of payment for the construction items involved or in contract time as a result of authorizing a change in methods or equipment under these provisions.

1108.05 CHARACTER OF WORKERS.

Any employee of the Contractor who is careless, incompetent, or disorderly, or who refuses or neglects to perform the work in accordance with the contract documents or who shall commit trespass upon any public or private property in the vicinity of the work, shall be discharged upon the written request of the Engineer and shall not be re-employed on any of the work unless written permission is given by the Engineer.

1108.06 TEMPORARY SUSPENSION OF WORK.

A. Work shall be suspended wholly or in part when, in the opinion of the Engineer, weather or other conditions are unfavorable to its satisfactory prosecution. Work shall also be suspended at the direction of the Engineer pending settlement of disputes arising out of failure of the Contractor to comply with provisions of the contract.

B. The start of work may be delayed or work may be suspended upon request of the Contractor and with approval of the Engineer. The Engineer may require the request to be in writing and also may require the Contractor to include with the request a schedule for satisfactory completion of the work. Prior to temporary suspension of work, all obstructions or hazards that prevent safe travel by public traffic shall be removed from the project.

C. The Engineer will notify the Contractor in writing of directed or approved temporary suspension of work. Working days will not be charged during periods of suspension of work directed or approved by the Engineer except when the suspension is a result of a violation of terms of the contract.

1108.07 EXTENSION OF CONTRACT PERIOD.

An extension of the contract period will be granted by the Engineer for additional work requiring additional construction time that adds additional work to the controlling item of work.

1108.08 LIQUIDATED DAMAGES.

A. Liquidated damages will be assessed as follows:

1. Completion Date Contracts.

The amount of liquidated damages specified in the proposal form will be assessed, not as a penalty but as predetermined and agreed liquidated damages, for each calendar day that any work remains uncompleted beyond the Completion Date or any extension granted under Article 1108.07. Assessment of liquidated damages will be based only on the

number of calendar days required to complete the contract beyond the completion date, plus authorized extensions.

2. Working Day Contracts.
The amount of liquidated damages specified in the proposal form will be assessed, not as a penalty but as predetermined and agreed liquidated damages, for each working day that any work remains uncompleted beyond the number of working days allowed or any extension granted under Article 1108.07. If work remains uncompleted on more than one portion for which working days and liquidated damages have been specified, the liquidated damages assessed will be the total of the damages per day listed for each uncompleted portion. Assessment of liquidated damages will be based only on the number of working days required to complete the contract in excess of the specified working days allowed, plus authorized extensions.

B. The final payment will be withheld until the amount of liquidated damages are agreed upon.

C. This provision for the assessment of liquidated damages for failure to complete work within the contract period does not constitute a waiver of the Contracting Authority's right to collect any additional damages other than time delays which the Contracting Authority may sustain by failure of the Contractor to carry out the terms of the contract.

1108.09 FAILURE TO COMPLETE WORK WITHIN CONTRACT PERIOD.

A. If the Contractor fails to complete the work within the contract period, or any extension thereof, as provided in Article 1108.07, upon written notice to the Contractor and surety, said contract shall be in default. The Contracting Authority may, at its option, permit the Contractor or the Contractor's surety to complete the work included in the contract, or may proceed to complete the work in accordance with Article 1108.11. In either event, the Contractor or the Contractor's surety shall be responsible for all costs incident to the completion of the work, and also for the liquidated damages stipulated in the proposal form.

B. The Contracting Authority may waive such portion of the liquidated damages as may accrue after all of the following conditions are met:

1. Traffic must have complete use of the roadways, shoulder to shoulder, with no delays or one way traffic and no obstructions except for signs warning of construction work ahead.

2. The remaining work to be completed is confined to the areas outside the shoulder edge.

3. Only minor work is left for completion such as clean up or erosion control work if it is a small item, not part of an erosion control contract,

and the erosion control work is completed during the first available seeding period.

4. The remaining work is completed without excessive delay on the part of the Contractor.

1108.10 CONTRACTS IN DEFAULT.

The Contracting Authority may declare a contract in default for any one of the following reasons:

A. Failure to complete the work within the contract period or any extension thereof;

B. Failure or refusal to comply with an order of the Engineer within a reasonable time;

C. Failure or refusal to remove rejected materials;

D. Failure or refusal to correct any defective or unacceptable work;

E. Bankruptcy or insolvency, or the making of an assignment for the benefit of creditors;

F. Failure to carry on the work in an acceptable manner.

1108.11 COMPLETION OF CONTRACTS IN DEFAULT.

A. If for any reason a contract is declared in default, the Contracting Authority shall have the right, without process or action at law, to take over all or any portion of the contract and complete it, at its option, either by day labor or by reletting the work. Written notice will be given the Contractor by the Contracting Authority that the Contractor's contract has been declared in default, and upon receiving this notice, the Contractor shall relinquish possession of the project site or the parts of the project specified in the notice.

B. The Contracting Authority may, at its option and at a rental which it considers reasonable, retain all material, equipment, and tools on the project site until the work has been completed.

C. Neither the Contracting Authority nor any member or employee thereof shall be in any way liable or accountable to the Contractor or the Contractor's surety for the method by which the completion of the contract, or any portion thereof, may be accomplished, or for the price paid therefor. Should the cost of completing work be in excess of the original contract price, the Contractor and the Contractor's surety will be held responsible for such excess cost. Should the cost of such completion, including all proper charges, be less than the original contract price, the amount so saved shall be paid to the Contractor. Neither by taking over the portions of the contract nor by declaring the contract in default will the Contracting Authority forfeit the right

to recover damages from the Contractor or the Contractor's surety for failure to complete the entire contract.

1108.12 TERMINATION OF CONTRACTOR'S RESPONSIBILITY.
The contract will be considered completed when the work has been accepted in writing by the Engineer. Such acceptance will release the Contractor from all further obligation with respect thereto, except to conditions and requirements set forth in the bond.

Section 1109. Measurement and Payment and Metric Conversion

1109.01 MEASUREMENT OF QUANTITIES.
The work completed under the contract will be measured in accordance with the contract documents. The standards of the U.S. DOT, FHWA, and ASTM SI-10 will be used.

A. Methods of Measurement.

1. Payment will be based on the actual quantity of work performed under the various classifications of work in the contract unless otherwise provided below or in the method of measurement for the various classes of work.

2. For items to be paid for by plan quantity by specification or plan quantity agreement, by written agreement between the Contractor and the Engineer, final settlement may be made on the basis of contract quantities without final field measurements. This agreement may be made before work is started or after work has been completed, if no material deviation from the original plans is involved. Except for those items for which quantities cannot be accurately predetermined, the contract quantities have been accurately and properly estimated, but adjustments will be made for obvious errors or authorized changes. The Engineer will exercise such controls and make such measurements as are necessary to assure that each item of work is done in substantial compliance with the contract documents. The use of this agreement for payment shall not be considered as a change in the contract.

3. When a contract item or quantity for any granular material is in tons (Mg), the quantity may be measured by volume.

B. Metrication.
Project specific documents provided by the Contractor on English unit contracts shall be expressed in English units and on metric unit contracts shall be expressed in metric units. Manual conversion of metric units to English units is acceptable on contracts expressed in English units. Manual conversion of English units to metric units will be acceptable on metric unit contracts. The Contractor shall be responsible for the conversion of units. The following tables provide common metric units and symbols, prefixes, and conversions:

Table 1109.01-1: Common Prefixes Used with Metric Units

Prefix	Symbol	Multiplication Factor
giga	G	1,000,000,000
mega	M	1,000,000
kilo	k	1,000
hecto	h	100
deka	da	10
base unit	_	1
deci	d	0.1
centi	c	0.01
milli	m	0.001
micro	µ	0.000001

Table 1109.01-2: Common Metric Units and Symbols

Measurement	Unit	Symbol
Length	kilometer	km
	meter	m
	centimeter	cm
	millimeter	mm
	micrometer	µm
Area	hectare	ha
	square meter	m^2
	square centimeter	cm^2
	square millimeter	mm^2
Volume	cubic meter	m^3
	cubic centimeter	cm^3
	cubic millimeter	mm^3
	kiloliter	kL
	liter	L
	milliliter	mL
Mass	megagram	Mg
	kilogram	kg
	gram	g
Temperature	degrees Celsius	ºC
Pressure	pascal	Pa
	kilopascal	kPa
	megapascal	MPa
Force	newton	N
	kilonewton	kN

Table 1109.01-3: Other Metric Units Which Might be Encountered and the Symbol for Each

Electric current	ampere	A
Luminous Intensity	candela	cd
Frequency	hertz	Hz
Energy, Work	joule gigajoule	J GJ
Luminous flux	lumen	lm
Electric Potential	volt	V
Power	watt kilowatt	W kW

Table 1109.01-4: English and Metric Unit Conversion (Referenced from ASTM SI-10, except those marked with asterisks)

Measurement	English Units (Muliply)	Metric Units (To Find)	Conversion Factor (By)
Length	mile yard foot (U.S. Survey) inch station* station*	kilometer meter meter millimeter meter metric station	1.609347 0.9144 0.3048006 25.4 30.48006 0.3048006
Area	acre square yard square foot square inch square mile square*	hectare square meter square meter square millimeter square kilometer square meter	0.4046873 0.8361274 0.09290304 645.16 2.589998 9.290304
Volume	cubic yard cubic foot cubic inch gallon fluid ounce board foot	cubic meter cubic meter cubic millimeter liter milliliter cubic meter	0.7645549 0.02831685 16,387.06 3.785412 29.57353 0.00236
Mass	ton (2000 lb.) pound ounce	megagram kilogram gram	0.9071847 0.4535924 28.34952
Pressure	pounds per sq. in. (psi) pounds per sq. ft.	kilopascals Pascal	6.894757 47.880263
Overhaul	station yard*	station meter	0.2330368

Other	lbs./cu. ft. lbs. force gal./cu. yd. lbs./gal. oz./cu yd. oz./100 lbs.	kg/m^3 Newton L/m^3 kg/L mL/m^3 mL/kg	16.01846 4.448222 4.9511316 0.1198264 38.680714 0.6519846
	(To Find)	**(Divide)**	**(By)**
Temperature: **(ºC x 1.8) + 32 = ºF** (Take the temperature in ºC and multiply by 1.8; then add this number to 32 to get the temperature in ºF.)			

1. Exceptions.

The Engineer may approve exceptions to construction based on plan dimensions, on a project-by-project basis, provided the request does not adversely affect the intended design. Exceptions shall be at no additional cost to the Contracting Authority.

a. Reinforced Concrete Box (RCB) Culvert.

1) The Contractor, as an option, may construct a comparable size single or twin box culvert in metric units using the MRCB-G1-95 or MTWRCB-G1-95 culvert standards in lieu of the English culvert standards specified on the letting plans. Exceptions/substitutions on special designs that are not covered by the MRCB-G1-95 or MTWRCB-G1-95 standards will not be allowed.

2) After being awarded the contract, if the Contractor intends to exercise this option, the Contractor shall submit to the Engineer an amended copy of the letting plan showing the alternate units for all the appropriate dimensions. These shall include the fill height, the culvert span and rise, all longitudinal (along the culvert) dimensions and a list of the MRCB-G1-95 or MTWRCB-G1-95 culvert standard sheets required to build the RCB, including headwall sheets and bell joint sheets if required.

3) A list of comparable metric culvert opening sizes that can be constructed in lieu of a specified English culvert opening is as follows:

Table 1109.01-5: Comparable Metric Culvert Opening Sizes

English (feet)	Comparable Metric (millimeters)	English (feet)	Comparable Metric (millimeters)
3 x 3	900 x 900	8 x 6	2400 x 1800
4 x 4	1200 x 1200	8 x 10	2400 x 3000
5 x 3	1500 x 900	10 x 4	3000 x 1200
5 x 4	1500 x 1200	10 x 5	3000 x 1500
5 x 5	1500 x 1500	10 x 6	3000 x 1800
5 x 6	1500 x 1800	10 x 8	3000 x 2400
6 x 3	1800 x 900	10 x 10	3000 x 3000
6 x 4	1800 x 1200	10 x 12	3000 x 3600

6 x 5	1800 x 1500	12 x 6	3600 x 1800
6 x 6	1800 x 1800	12 x 8	3600 x 2400
6 x 8	1800 x 2400	12 x 10	3600 x 3000
8 x 4	2400 x 1200	12 x 12	3600 x 3600
8 x 5	2400 x 1500		

b. Construction Materials.

1) The following exceptions in Division 41, Construction Materials are approved, and will be allowed:

a) Section 4151, Steel Reinforcement.

All English Reinforcing steel may be substituted with metric reinforcing steel as follows:

Table 1109.01-6: Metric Reinforcing Steel

English	Hard Converted* Metric Size	Soft Converted* Metric Size
4	15	13
5	15	16
6	20	19
7	25	22
8	25	25
9	30	29
10	35	32
11	35	36

* Hard Converted metric size reinforcing steel refers to bars referenced in ASTM A 615/A 615 M - 95b using the following sizes: 10, 15, 20, 25, 30, 35, 45, and 55. Soft Converted metric size reinforcing steel refers to bars referenced in ASTM A 615/A 615 M - 96a using the following sizes: 10, 13, 16, 19, 22, 25, 29, 32, 36, 43, and 57.

b) Plant Operations.

Batching of materials may be performed with English or metric units, but all reports on English unit contracts shall be prepared in English units, and all reports on metric unit contracts shall be prepared in metric units.

c) Delivery Tickets.

Delivery tickets for materials such as aggregates, HMA mixes, asphalt binder, etc. may be converted at the end of the day, or at the end of a process for the day, in lieu of individual ticket conversion; but all reports on English unit contracts shall be prepared in English units and all reports on metric unit contracts shall be prepared in metric units.

2) All hard converted metric reinforcing steel (bar size matrix shown on plans) may be substituted with English reinforcing steel or soft converted metric steel as follows:

Table 1109.01-7: Hard Converted and Soft Converted Metric Sizes

English	Hard Converted* Metric Size	Soft Converted* Metric Size
4	10	13
5	15	16
6	20	19
8	25	25
10	30	32
11	35	36

* Hard Converted metric size reinforcing steel refers to bars referenced in ASTM A 615/A 615 M - 95b using the following sizes: 10, 15, 20, 25, 30, 35, 45, and 55. Soft Converted metric size reinforcing steel refers to bars referenced in ASTM A 615/A 615 M - 96a using the following sizes: 10, 13, 16, 19, 22, 25, 29, 32, 36, 43, and 57.

3) The spacing or pattern of bar placement shall be as shown in the contract documents, and no changes in the spacing or the pattern will be allowed with the substitution.

2. Method of Measurement and Basis of Payment.
The cost of all equipment, labor, and materials necessary for metric conversion shall not be paid separately, but shall be considered incidental to the price bid for the item for which the conversion was necessary. The cost of exception of construction materials as specified above shall not be paid separately, but shall be considered incidental to the price bid for the item for which the substitution is made.

1109.02 SCOPE OF PAYMENT.

A. The Contractor shall accept the compensation herein provided as full payment for furnishing all material, labor, tools, and equipment and for performing all work under the contract or any extension thereof allowed under Article 1108.07; also, for all cost arising from the action of the elements or other natural causes, agreements, and performances, non-performances, or delays involving other contractors and third parties, or injunctions or lawsuits resulting therefrom, or from any unforeseen difficulties not otherwise provided for in the specifications and which may be encountered during prosecution of the work and up to the time of acceptance thereof, except damage to the work due to acts of war. Nothing herein shall in and of itself be construed to prejudice or deny any claim filed under provisions of Article 1109.11.

B. The contract price for any item shall be full compensation for acceptable work and for materials, equipment, tools, and labor for performance of all work necessary to complete the item in accordance with the contract documents, except as specifically exempt in the clauses covering the basis of payment for the item.

1109.03 PAYMENT FOR WORK PERFORMED.

The Contractor shall receive and accept payment for work performed under the contract as follows:

A. Items of Work Performed Which Are Covered by Definite Prices Stipulated in the Contract.

1. For all items of acceptable work performed which are covered by definite unit prices or lump sum amounts specified in the contract, the Contractor shall receive and accept compensation at the rate specified in the contract, except for items identified as that of significant change as provided in Article 1109.16.

2. In making contract adjustments, consideration will be given to the portion of the cost of the work that can be classified as fixed costs, independent of the exact quantity of work performed, such as transportation and installation costs on equipment, overhead cost, etc. Any price adjustment will be arrived at from the standpoint that neither party to the contract shall be penalized by the increase or decrease in quantities which occasioned the price adjustment.

B. Extra Work.

Extra work ordered by the Engineer, of a quality or class not covered by the contract, will be paid for either at an agreed price or on a force account basis.

1. Agreed Price Basis.

For extra work ordered by the Engineer and performed on an agreed price basis, the Engineer and the Contractor shall enter into a written agreement before the work is undertaken. This written agreement shall describe the extra work that is to be done and shall specify the agreed price or prices therefore.

2. Force Account Basis.

a. For extra work performed on a force account basis, the Contractor shall receive the rate of wage (or scale) agreed to in writing with the Engineer before beginning work for each and every hour that laborers, timekeepers, supervisors, and superintendents are actually engaged in work.

b. The Contractor shall receive the actual costs paid to, or in behalf of, workers by reason of subsistence and travel allowances, health and welfare benefits, pension fund benefits, or other benefits, when the amounts are required by a collective bargaining agreement or other employment contract generally applicable to the classes of labor employed on the work.

c. An amount equal to 35% of the sum of the above items will also be paid to the Contractor. The 35% shall cover compensation for furnishing the necessary small tools for work, together with all other overhead items of expense.

d. For property damage, liability, and worker's compensation insurance premiums, unemployment insurance contributions, and social security taxes on the force account work, the Contractor shall receive the actual cost, to which 10% will be added. The Contractor shall furnish evidence of the rate or rates paid for such bond, insurance, and tax.

e. The wage of the superintendent, timekeeper, or supervisor who is employed partly on force account work and partly on other work shall be prorated between two classes of work according to the number of persons shown by the payrolls as employed on each class of work.

f. For materials used on force account work, the Contractor shall receive the actual cost of materials delivered on the work, including the freight and handling charges as shown by original receipted bills, to which cost will be added a sum equal to 15% thereof.

g. Rental rate for machinery, tools, or equipment (except small hand tools which may be used) and fuel and lubricants shall be based on the average monthly rental rate published in the RENTAL RATE BLUE BOOK by Primedia Information, Inc. The Engineer and the Contractor shall agree on a rental rate in writing before extra work on force account basis is performed. Profit percentage shall not be added to the rental rate.

h. Compensation as herein provided shall be accepted by the Contractor as payment in full for extra work done on a force account basis. It will be assumed that such payment includes the use of tools and equipment for which no rate is allowed, overhead, and profit.

i. At the end of each day, the Contractor shall prepare payrolls in duplicate for labor furnished on a force account basis, using the Contracting Authority's standard force account forms. Both copies shall be signed by the inspector and Contractor's representative. One copy shall be furnished to the Engineer and one to the Contractor. Claims for extra work performed on a force account basis shall be submitted to the Engineer in triplicate. To the claims shall be attached such receipts or statements as the Engineer may require in support of such claims. Such claims shall be filed not later than the tenth day of the month following that in which the work was actually performed, and shall include all labor charges, rental charges on machinery, tools, and equipment, and all material charges insofar as they are available.

3. Extra Work Performed by the Subcontractor.

The percentage markup to be allowed to the Contractor for extra work, including force account work, performed by a Subcontractor shall be in accordance with the following:

- 10% on the first $50,000 with a $100 minimum.
- 5% on the portion over $50,000.

C. Deficient Work.

1. Payment for work judged by the Engineer to be deficient work will be made at the reduced rate specified in the contract documents or, if no such rate is specified, at a modification of the contract price, as determined by the Engineer.

2. All contract price adjustments will be subject to the concurrence of the Contracting Authority.

1109.04 CANCELLED WORK.

A. The Contracting Authority will have the right to cancel any or all items from the contract when unforeseen circumstances, unanticipated design changes, or other reasons beyond the control of the Contractor prevent or unreasonably delay completion of the contract or certain items of the contract, or when the Contracting Authority determines that cancellation is in the public or national interest.

B. The Contractor may be prevented from starting work on a contract or an identified phase of a contract as a result of a delay caused by the Contracting Authority or others.

C. When the contract period is defined by the Approximate Starting Date and the delay prevents the Contractor's starting work on the contract or an identified phase of the contract for 30 calendar days beyond such date, the Contractor may request cancellation by written notice to the Engineer, stating the reasons therefore.

D. When the contract period is defined by the Late Start Date and the delay prevents the Contractor's starting for more than 30 calendar days after the date of award of contract and at least 30 calendar days beyond the date which, by notice to the Engineer, the Contractor proposed to start work, the Contractor may request cancellation by written notice to the Engineer, stating the reasons therefore.

E. In either case, within 30 calendar days from the date of the request, the Engineer will eliminate or minimize, if possible, the cause for the delay and issue a notice to proceed, redefine the basis on which the work is to proceed, or cancel the contract or phase of the contract.

F. The Contractor shall not use delays that occur prior to starting work or an identified phase of the work as a basis of a claim against the Contracting Authority except for an extension of contract period.

G. Notices described in this article should be transmitted by certified mail.

H. For finished portions of non-major items canceled, the Contractor will be paid at the contract unit prices, in accordance with the provisions of Article 1109.03. For finished portions of major items canceled, the Contractor will

be paid as provided in Article 1109.16. For all items, materials ordered and delivered for the unfinished portion of such canceled or omitted items, the Contracting Authority will pay cost plus 10% as an overhead charge. The Contractor's expense for work of handling or transporting this material shall be included in computing the cost. The Contracting Authority will also pay any actual expenses sustained by the Contractor by reason of such cancellation or omission and not represented by work completed or material delivered. In computation of material cost or expenses sustained, no anticipated profit will be included. Material paid for shall become the property of the Contracting Authority and shall be disposed of as directed by the Engineer.

1109.05 PARTIAL PAYMENTS.

A. Progress Payments.

1. For work extending over a period of more than one month, the Contractor will receive monthly progress estimate payments based on the amount of work completed. For Primary and Secondary projects in which the Contracting Authority is the Department or a county Board of Supervisors, these progress payments will be bi-weekly if requested by the Contractor. For late payment, the Contracting Authority will pay a penalty of 1.0% per month (or part of a month), or a minimum of $250, whichever is the greater amount, on any work completed but not processed for payment within 14 calendar days after completion of the work. Completion of the work includes physical completion of the work and submittal of all paperwork required by the contract.

2. On contracts for which the contract sum is $10,000 or more, payments may be allowed based on value of processed or fabricated materials or rolled steel products which have been delivered on the work or 90% of the value of processed or fabricated material, or rolled steel products, reserved for the project and stored elsewhere within Iowa or in other locations where there is routine inspection by Departmental personnel, provided the materials are of acceptable quality and the manner of storage is satisfactory to the Engineer.

3. Should a reasonable doubt arise as to the integrity of any part of the completed work, the payment for that portion will not be allowed until the cause for such doubt has been removed. The Engineer's estimates of work completed will result in partial payments on the contract sum, and the allowance of a progress payment by the Contracting Authority does not constitute final acceptance of the work upon which the payments are based.

4. The Contractor shall sign the final voucher certifying the quantities are just and unpaid.

B. Prompt Payment to Subcontractors.

1. The Contractor shall promptly pay each subcontractor. Any delay or postponement of payment among the parties may take place only for good cause, with written notification to the subcontractor. A payment, excluding retainage, to a subcontractor for satisfactory performance of the subcontractor's work shall be made by the Contractor no later than one of the following, as applicable:

a. 7 calendar days after the Contractor receives payment for the subcontractor's work.

b. 7 calendar days after the Contractor could have received payment for the subcontractor's work, if the reason for nonpayment is not the subcontractor's fault.

2. The Contractor may withhold up to 5% of each progress estimate on work performed by subcontractors.

3. Retained funds due a subcontractor shall be payable by the Contractor within 30 calendar days after satisfactory completion of the work by the subcontractor. Subcontractor’s work is satisfactorily completed when all requirements called for in the subcontract have been accomplished and required documentation provided by subcontractor. Non-bonded subcontractors may be required to submit proof of payment for all material bills and wages to the Contractor before the Contractor is required to pay the retainage.

4. The use of joint checks for payment to subcontractors for their materials is acceptable under the following conditions:

a. The request for a joint check from the prime contractor is made by the materials supplier.

b. The joint check issued by the prime contractor is for an amount not to exceed the cost of unpaid invoice(s) from the materials supplier to a subcontractor on that contract.

c. The joint check is given to the subcontractor and the subcontractor must release the joint check to the material supplier.

d. The use of a joint check by the prime contractor is applicable to all their subcontractors.

C. Retainage.

1. Three percent of each progress estimate will be deducted and held as retainage on the first $1,000,000 paid on a contract. Additional retainage will be withheld to a maximum of $30,000 following retainage release if subsequent work is performed. This retainage is held exclusively for claims filed in accordance with Iowa Code 573 and shall not be considered as an encumbrance on work performed by a subcontractor.

2. The retained funds held by the Contracting Authority for the contract will not be due and payable prior to 30 calendar days after the date of final

acceptance of the entire contract or following the release or adjudication of claims that may have been filed, or until the Contractor has filed the signed final voucher with the Contracting Authority.

D. Complaints.

1. Compliance with prompt payment is the responsibility of both the Contracting Authority and Contractor.

2. If the Contractor feels the Contracting Authority has not complied with the prompt payment provisions, the initial attempt to resolve the issue shall be with the Project Engineer, stating the project number, items of work, quantities, unit prices, dates work was performed, total amount owed, and signature of a representative of the Contractor.

3. If a subcontractor feels the Contractor has not complied with the prompt payment provisions, the initial attempt to resolve the issue shall occur with the Contractor. The attempt to resolve the issue shall include at least one written request to the Contractor, stating the project number, items of work, quantities, unit prices, dates work was performed, total amount owed, and signature of a representative of the subcontractor.

4. If the initial attempt to resolve the issue does not result in satisfactory payment for completed work, the Contractor or subcontractor shall submit a written complaint to OES-Civil Rights. The written complaint shall include copies of the correspondence with the Project Engineer or Contractor that provides the details stated above. The Department will investigate and provide written response to the complainant within 15 business days of receipt of the complaint.

E. Required Records.

The Contractor shall maintain a system for tracking the status of subcontractor work and payments. The Contractor shall retain records that document the date of field completion, date of satisfactory completion of the work and the date of final payment (including funds retained in accordance with Article 1109.05, B, 2) to each subcontractor. Copies of the records to verify compliance with Article 1109.05, B shall be provided to the Contracting Authority, if requested.

Prior to receiving final payment, the Contractor shall provide to the Engineer the "Certification of Subcontractor Payments" (Form 518002). This form shall include the names of each approved subcontractor, the date of field completion, the date of satisfactory completion of the work, the date of final payment, the number of days between satisfactory completion and final payment, and the date of payment by the Contracting Authority. Explanations for any final payments made after the 30 calendar day period following field completion shall be included with Form 518002.

Failure to comply with Article 1109.05, B may result in price adjustment credits, loss of Annual Good Faith Effort points, or suspension of bidding qualification in accord with Article 1102.03, A, 2.

1109.06 PAYMENT OF RETAINED FUNDS.

Retained funds may be released by one of two methods. On contracts where the progress and final payment vouchers are paid by the Department the retainage will be released according to Paragraph A. On all other contracts the retainage may be released by either Paragraph A or Paragraph B below.

A. Retainage Release.

When 95% of the original contract amount has been completed to the satisfaction of the Engineer, and it is apparent that conditions beyond the control of the Contractor will delay completion of the contract for more than 60 calendar days, the Contractor may request payment of retained funds. If the Contracting Authority agrees, payment of the retained funds will be made no sooner than 30 calendar days after approval.

B. Supplemental Contract.

1. When 95% of the work has been performed to the satisfaction of the Engineer, including consideration of the contract period, and it is apparent that conditions beyond the control of the Contractor will delay the completion of the contract for more than 60 calendar days, the Contractor may request a supplemental contract for the uncompleted portion of work on the same terms as those of the original contract. If the Contracting Authority agrees, and the surety for the Contractor consents to the extension of the bond for the time required to complete the supplemental contract, the supplemental contract will be issued. After the contract has been entered into, full payment will be made for the work completed except under circumstances which would prejudice the rights of those who have filed claims pursuant to Chapter 573, Code of Iowa.

2. The unpaid moneys held by the Contracting Authority as a retainer of the original contract price will be due and payable to the Contractor 30 calendar days after the date of the Contracting Authority's approval of the supplemental contract, except as provided for the release and adjudication of claims in Article 1109.05.

1109.07 CERTIFIED STATEMENT OF SALES TAX AND USE TAX PAID.

Contractors and approved subcontractors will be provided a Sales Tax Exemption Certification to purchase building materials, supplies, or equipment in the performance of construction contracts let by the Department.

1109.08 RESERVED.

1109.09 FINAL ACCEPTANCE AND PAYMENT.

A. Final acceptance is a written acceptance by the Contracting Authority. The Contracting Authority will make final acceptance promptly upon the satisfactory completion of the work. Final payment will be made as soon as possible following the expiration of statutory time for filing claims, or following adjudication or release of claims against the amount withheld.

B. On all Interstate and Primary System contracts, interest shall be paid in accordance with IAC Chapter 27 and Chapter 573.12, Code of Iowa. Interest shall begin to accrue on retained funds on the date of the first progress payment until the date final payment is issued. Interest shall be paid on retained funds only if the accrued interest on those funds is greater than $25. The interest payment will be issued by a separate warrant within 2 weeks after issuance of final payment. Interest will cease to accrue on retained funds if:

- After 90 calendar days following contract acceptance if the Contractor has failed to submit to the Contracting Authority documentation necessary for final payment or,
- Upon payment of retained funds by a retention release voucher.

C. On county or city administered contracts, failure to make final payment within 50 calendar days after final acceptance of the work, and if all requirements of the contract are complete, will cause interest to accrue and additional payment to be made in accordance with provision of Chapter 573, Code of Iowa.

D. Completion of the work will be considered as the date of approval and work acceptance on "Statement of Completion and Final Acceptance of Work" (Form 830435) by the Engineer. When interest is to be paid, the date from which interest is to be calculated will be the 31st calendar day after all required materials, certifications, and other documentation required to be submitted by the Contractor are received by the Engineer; however, the Contractor will be paid no interest if final payment is made within 50 calendar days from the final acceptance. The signed final voucher is not required documentation, but if not returned to the Engineer within 50 calendar days, it will be considered required documentation.

E. Signing of the final voucher, or acceptance of payment based thereon, shall not waive any rights of either party in the resolution of any claim filed in accordance with Article 1109.11.

F. The Engineer must be satisfied as to the completion of each part of the work, and may reject any portion found to be inconsistent with the terms of the contract documents.

1109.10 RESPONSIBILITY FOR PAYMENT.

Payment for work will be made by the Contracting Authority by warrants drawn against funds which are legally available for such work.

1109.11 DISPUTED CLAIMS FOR EXTRA COMPENSATION.

A. In any case where the Contractor deems that extra compensation is due for work or material not clearly covered in the contract and not ordered by the Engineer as extra work as defined herein, the Contractor shall notify the Engineer in writing to make claim for this extra compensation before work begins on which the claim is based.

B. The Contracting Authority will be responsible for damages attributable to the performance, nonperformance, or delay, of any other contractor, governmental agency, utility, firm, corporation, or individual authorized to do work on the project, only when these damages result from negligence on the part of the Contracting Authority, its Engineer, or any of its officers or employees. In any case where the Contractor deems that extra compensation is due from the Contracting Authority as damages resulting from these performances, non-performances, or delays, the Contractor shall notify the Engineer in writing at the time the delay occurs.

C. In all cases, if this notification is not given, or if after the notification is given, the Engineer is not afforded facilities for keeping strict account of actual costs as defined for force account construction, the Contractor thereby agrees to waive the claim for extra compensation for this work. This notice by the Contractor, and the fact that the Engineer has kept account of the cost as aforesaid, shall not be construed as establishing the validity of the claim. The claim, when filed, shall be in writing and in sufficient detail to permit auditing and an intelligent evaluation by the Engineer. The claim shall be supported by such documentary evidence as the claimant has available and shall be verified by affidavit of the claimant or other persons having knowledge of the facts. If the claimant wishes an opportunity to present the claim in person, then the claim shall be accompanied by a written request to do so. Where the claimant asks an opportunity to present the claim in person, the Engineer, within 30 calendar days of the filing of the claim, will fix a time and place for a meeting between the claimant and the Engineer. The Engineer will, within a reasonable time from the filing of the claim or the meeting above referred to, whichever is later, rule upon the validity of the claim and notify the claimant, in writing, of the ruling together with the reasons therefore. In case the claim is found to be just, in whole or in part, it will be allowed and paid to the extent so found.

D. The Contractor shall not institute any court action against the Contracting Authority for the adjudication of any claims until the claim has been first presented to the Engineer, pursuant to this article, and either submitted to arbitration or a request for arbitration is denied pursuant to Article 1109.12.

1109.12 ARBITRATION.

A. If a Contractor's claim as outlined in Article 1109.11 has been disallowed in whole or in part, then the Contractor may, within 30 calendar days from the date the ruling of the Engineer is mailed, make a written request to the Engineer that the claim or claims be submitted to a board of arbitration. The

Engineer will decide whether the matter is one which is subject to arbitration and will, within 30 calendar days of the receipt of the request for arbitration, grant or deny the same. The Engineer's decisions will be final.

B. The board of arbitration will consist of three persons; one to be chosen by the Engineer, one by the Contractor, and the third by the two arbitrators thus chosen.

C. The arbitrators selected will be persons experienced and familiar with construction or engineering practices in the general type of work involved in the contract, but will not have been a regular employee or an individual retained by either party at the time involved in the controversy, or at the time of arbitration.

D. The board of arbitration will make its own rules of procedure and will have authority to examine records kept by the Engineer and the Contractor. If the desired records are not produced within 14 calendar days after they are requested, the board of arbitration will proceed without them as best it may. In determining the findings or award, or both, the majority vote of the board will govern. Copies of the findings or award, or both, signed by the arbitrators will be filed with the Engineer and the Contractor. A unanimous report or minority report may be filed. The board of arbitration will fix the cost of the proceedings, including a reasonable compensation to the arbitrators, and will determine how the total cost shall be borne.

E. The board of arbitration will have jurisdiction to pass upon questions involving compensation to the Contractor for work actually performed or materials furnished and upon claims for extra compensation which have not been allowed by the Engineer. Jurisdiction of the board will not extend to a determination of quality of work or materials furnished or to an interpretation of the intent of the plans and specifications except as to matters of compensation. Jurisdiction of the board will not extend to setting aside or modifying the terms or requirements of the contract.

F. The findings or award, or both, of the arbitration board, if acceptable to both parties to the contract, may become a basis for final payment.

G. If the findings of the arbitration board are unacceptable to either party to the contract, said findings may become the basis for further negotiations between the parties. If a solution agreeable to both parties has not been reached through the filing of a claim, through arbitration, or if arbitration has been denied, either party may resort to whatever other methods for resolving the claim are available.

1109.13 CLAIMS AGAINST CONTRACTOR.

A. The Contractor guarantees the payment of all just claims against the Contractor or any of the Contractor's subcontractors in connection with the work. If another contractor on the project submits a claim for alleged damages caused by delay due to the Contractor not having completed the

work in a timely manner, the Contractor's bond shall remain in effect until payment of such claim is made or until litigation is concluded, at which time the bond will be released.

B. Claims may be filed against the Contractor as provided in Chapter 573, Code of Iowa. The claims shall be submitted on forms provided by the Contracting authority. The amount of retainage held by the Contracting Authority is described in Article 1109.05, C.

C. For public improvement projects let and paid by the Department, the claims shall be submitted to the Project Accounting and Payables Section, Office of Finance, Iowa Department of Transportation. For public improvements let by the County, claims shall be filed with the county auditor. For public improvements let by the City, claims shall be filed with the officer, board, or commission authorized by law to let contracts for such improvements.

D. The contract bond required by Article 1103.05 stipulates that the principal and sureties agree to pay to all persons, firms, or corporations having contracts directly with the principal or with subcontractors, all just claims due them for labor performed or materials furnished, in the performance of the contract on account of which the bond is given, when the same are not satisfied out of the portion of the contract price which the public corporation is required to retain until completion of the public improvements, but the principal and sureties shall not be liable to said persons, firms, or corporations unless the claims of said claimants against said portion of the contract price shall have been established as provided by law.

1109.14 TIME LIMITS FOR FINAL ADJUSTMENT.

The Contractor shall understand that the Contracting Authority will not be bound to consider applications for correction of estimates and payments after the Contractor has signed the final estimate, or after 30 calendar days from the date when the final estimate is submitted to the Contractor for approval. Should an error be discovered as a result of the Contractor's annual audit, an application for correction, promptly made, will be considered.

1109.15 NATIONAL EMERGENCY PROVISIONS.

A. The Contracting Authority may, by written notice, with the approval of the FHWA where applicable, terminate the contract or a portion thereof when the Contractor is prevented from proceeding with the construction contract as a direct result of an Executive Order of the President with respect to the prosecution of war or in the interest of national defense, as provided in Chapter 573A, Code of Iowa.

B. When contracts, or any portion thereof, are terminated before completion of all items of work in the contract, payment will be made for the actual number of units or items of work completed at the contract unit price, or as mutually agreed for items of work partially completed or not started. Claim for loss of anticipated profits will not be considered. Reimbursement for organization of the work (when not otherwise included in the contract) and moving equipment to and from the job will be considered where the volume of work

completed is too small to compensate the Contractor for these expenses under the contract unit prices, the intent being that an equitable settlement will be made with the Contractor.

C. Acceptable materials, obtained by the Contractor for the work, which have been inspected, tested, and approved by the Engineer, and which are not incorporated into the work, will be purchased from the Contractor at actual cost as shown by receipted bills and actual cost records at such points of delivery as may be designated by the Engineer.

D. Termination of a Contract or a portion thereof shall not relieve the Contractor of responsibilities for the completed work, nor shall it relieve the Contractor's surety of its obligation for and concerning any just claims arising out of the work performed.

1109.16 STANDARDIZED CONTRACT CLAUSES.

A. Differing Site Conditions.

1. During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.

2. Upon written notification, the Engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding anticipated profits, will be made and the contract modified in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the contract is warranted.

3. No contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

4. No contract adjustment will be allowed under this clause for any effects caused on unchanged work.

B. Suspensions of Work Ordered by the Engineer.

1. If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation

and/or contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer, in writing, a request for adjustment within 7 calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

2. Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the cost and/or time required for the performance of the contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or Subcontractors at any approved tier, and not caused by weather, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The Contractor will be notified of the Engineer's determination whether or not an adjustment of the contract is warranted.

3. No contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.

4. No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided or excluded under any other term or condition of this contract.

C. Significant Changes in the Character of Work.

1. The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the contract nor release the surety, and the Contractor agrees to perform the work as altered.

2. If the alterations or changes in quantities significantly change the character of the work under the contract, whether such alterations or changes are in themselves significant changes to the character of the work or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding anticipated profit, will be made to the contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

3. If the alterations or changes in quantities do not significantly change the character of the work to be performed under the contract, the altered work will be paid for as provided elsewhere in the contract.

4. The term "significant change" shall be construed to apply only to the following circumstances:

a. When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction; or

b. When a major item of work, as defined elsewhere in the contract, is increased in excess of 125% or decreased below 75% of the original contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125% of original contract item quantity. The adjustment in unit price for an underrun in excess of 25% will be computed on the difference between the actual quantity and 75% of the original contract quantity.

Section 1110. Progress Scheduling

1110.01 GENERAL.

A. When specified in the contract documents, the Contractor shall submit a progress schedule of construction activities based on the CPM by the principles defined in the most current issue of THE USE OF CPM IN CONSTRUCTION published by the AGC. The CPM progress schedule may be hand or computer developed.

B. The CPM progress schedule shall be used for coordination and monitoring of all work under the contract including all activity of subcontractors, vendors and suppliers. The CPM progress schedule shall include provisions for traffic control, any staging, and other events to complete a project or tied projects. This schedule shall be the Contractor's intended working schedule and shall be used to plan, organize and execute the work; record and report actual performance and progress; and forecast remaining work.

1110.02 SUBMITTAL OF A CPM PROGRESS SCHEDULE.

A. Submitting a CPM Progress Schedule.
When a submittal of a CPM progress schedule is specified in the proposal form, the successful bidder for the project must submit 5 copies of a satisfactory CPM progress schedule to the Contracts Engineer with the signed contract. Failure to submit a CPM progress schedule may result in suspension of bidder qualifications in accordance with Article 1102.03, A.

B. Compliance with Intended Work.
Upon receipt of the CPM progress schedule, the schedule will be reviewed for compliance with the intended work. The Contracting Authority will notify the Contractor within 10 calendar days after receiving the CPM progress schedule if the schedule is approved or if any corrections or revisions are needed. If corrections or revisions are required for the initial CPM progress schedule, the Contractor shall submit 3 copies of the revised CPM progress schedule to the Engineer 10 or more calendar days before the preconstruction conference. If the Contractor fails to submit a revised CPM progress schedule as stated above, the Contractor's bidder qualification may

be suspended according to Article 1102.03, A, and the contract may be declared in default according to Article 1108.10.

1110.03 REQUIREMENTS FOR THE CPM PROGRESS SCHEDULE.
The CPM progress schedule submitted shall be a network diagram with a numerical tabulation for each activity.

A. Network Diagram.

1. The network diagram shall show a logical sequence and quantities of the required work. The network diagram shall also show the order and interdependence of activities. The Contractor shall prepare the network diagram making use of the crew hour estimates and material delivery schedules so that the project or tied projects are completed within the specified contract period. The Contractor shall take account in the network diagram for any critical closure periods and limitations of operations specified in Article 1108.03, the contract proposal, or the plans.

2. The basic concept of network scheduling shall be followed to show how the start of a given activity is dependent on the completion of preceding activities and how its completion may affect the start of following activities. The network diagram shall include the following:

- activity description
- activity duration (work days)
- intended production rates
- any activity done by a subcontractor noted (the subcontractor identified)
- location of activity
- critical path noted
- event nodes numbered
- all restraints noted
- slack "or float" for each activity (work days)
- work days calendar which extends for the length of the contract plus 25% additional time
- dummy paths noted
- start/completion dates

B. Numerical Tabulation.

1. The Contractor shall include a numerical tabulation for each activity shown on the detailed network diagram. The following information shall be furnished as a minimum for each activity on this tabulation:

- event nodes numbered
- activity description
- activity location
- if activity done by a subcontractor (identify the subcontractor)
- estimated duration (work days)
- earliest start date (calendar date)

- earliest completion date (calendar date)
- latest start date (calendar date)
- latest completion date (calendar date)
- contractor's intended start date (calendar date)
- contractor's intended completion date (calendar date)
- slack or float for each activity (work days)
- quantities involved on each activity based on the Contractor's intended start and completion date

2. This numerical tabulation may be either a computer printout or prepared manually. There shall be a column for each of the above requirements.

C. Other Specific Requirements.

1. The construction time, as determined by the CPM progress schedule, for the entire project or any milestone shall not exceed the specified contract period. No individual activity duration shall be longer than 20 working days unless specified in the contract proposal or by the Contracting Authority. A unique activity numbering system shall be used to identify activities by bid items, work items, areas, procurements, or subcontractors. If subnetworks are used, no two activities shall bear the same activity number or description.

2. There shall be a legend with the CPM progress schedule defining all abbreviations, terms, or symbols used.

1110.04 USE OF CPM PROGRESS SCHEDULE IN CONSTRUCTION OPERATIONS.

A. No contract work shall be done without a CPM progress schedule approved by the Engineer. The items in the activities for the denoted critical path will determine the controlling operations of the work for the charging of working days.

B. During the life of the project, the Contractor shall review the CPM progress schedule with the Engineer biweekly unless otherwise specified. The Contractor shall submit a revised CPM progress schedule within 5 working days of the review meeting if the Contractor is behind schedule or if the schedule has been modified. All revised CPM progress schedules must be approved by the Engineer. For each revised CPM progress schedule, the Contractor shall submit three copies to the Engineer.

C. If the Contractor deviates from the current approved CPM progress schedule by not following the logical sequence of the critical path, payment will be withheld for the pay items for the affected activities until the Contractor submits a revised CPM progress schedule and this schedule is approved by the Engineer.

D. A revised CPM progress schedule will be required if the controlling operation falls 10 working days behind schedule, the Engineer then may take steps

specified in Article 1108.02, K, to insure satisfactory completion of the project. If the controlling operation falls 20 working days behind schedule and it appears that the completion of the project in the specified time is in jeopardy, the Contracting Authority may take action described in Article 1102.03, B, and Article 1103.01 and may take further action described in Article 1108.02, K.

1110.05 METHOD OF MEASUREMENT AND BASIS OF PAYMENT.
The cost of preparing and revising the CPM Progress Schedule shall be included in the bid item for Mobilization.

Section 1111. Incentive/Disincentive for Early Completion

1111.01 GENERAL.

A. I/D provisions for early completion of specific highway construction projects with critical closure activities may be assigned by the Department. Early completion may be specified for an entire project or for designated portions of a project.

B. Projects on which I/D provisions will apply have the I/D daily rates, the critical closure activity, the number of closure days allowed, the total working days for the project, and the maximum incentive payment shown on the proposal form.

1111.02 DEFINITIONS.

A. Critical Closure Activity.
Critical closure activities on highway construction projects are those activities specified in the contract documents where traffic movements are adversely affected causing undue delay and operating costs.

B. Closure Day.
A closure day is a calendar day during the critical closure activity. A closure day will be counted for each calendar day or portion of a day during the critical closure activity. The number of closure days given will assume some delay caused by weather. The Contractor may work any days and hours within the critical closure activity.

C. I/D Daily Rate.
The I/D Daily Rate is the incentive or disincentive dollar amount per day assigned by the Contracting Authority, that will be applied to the contract for incentive payment or disincentive assessment.

1111.03 CONSIDERATION FOR EXTRA WORK OR DELAYS DURING THE CRITICAL CLOSURE ACTIVITY.

A. The duration of a critical closure activity will be in closure days. Closure day credits will not be given within the assigned critical closure activity.

B. Additional closure days may be added when approved by the Engineer for extra work, overruns of contract items, or extraordinary circumstances.

C. Approved extra work or overruns of contract items that will delay the Contractor during the critical closure activity must be documented and included in the critical path of the project on a revised critical path diagram which is subject to the approval of the Engineer. An additional closure day may be added for each additional closure day caused by the approved extra work or overruns of contract items as shown on the revised critical path diagram and approved by the Engineer.

D. Non-weather related extraordinary circumstances that delay the Contractor during the critical closure activity must be documented by the Contractor and a written request for additional closure days must be submitted to the Engineer within 10 calendar days of the beginning of the delay. The Engineer will approve or deny all requests for additional closure days resulting from non-weather related extraordinary circumstances. Non-weather related extraordinary circumstances shall be limited to the following:

1. Strikes.
Strikes which are not directed against the Contractor.

2. Legal Stoppages.
Legal Stoppages will be allowed if they result from legal action against the Contracting Authority or against the Contractor if not based on a specification violation.

3. Late Delivery of Material.
Procurement of material for a project is the sole responsibility of the Contractor. Late delivery will be considered an extraordinary circumstance only when the Contractor can show that orders were placed with a reliable supplier in sufficient time for materials to be delivered when needed and only when there is:

- **a.** A nationwide shortage; or
- **b.** An industry wide strike; or
- **c.** Transportation strike which delays the delivery of material; or
- **d.** Delays due to a change in material commitments when caused by a Federal emergency or order.

4. Natural Disaster.
A suspension order may be issued on any project in a declared disaster area, if the disaster causes conditions that do not allow productive work.

E. Adverse weather including rain, snow, wind, flood, extreme heat, and the results thereof, such as inaccessibility or non-workability of materials, is only considered as extraordinary circumstance if the Contractor is working or ready to work on the contract and the adverse weather conditions do not allow productive work on the critical path. Adverse weather that delays the Contractor during the critical closure activity must be documented by the Contractor and a written request for additional closure days must be

submitted to the Engineer within 10 calendar days of the beginning of the delay. Some delays for weather have been included in the number of closure days allowed. Therefore, additional closure days for adverse weather will not be allowed for the first 5 consecutive closure days of each delay.

1111.04 WORK OUTSIDE THE CRITICAL CLOSURE ACTIVITY.

A. The contract period may specify a number of working days. These days are provided to complete work prior to and/or following the critical closure activity. Working days will not be charged on any calendar day that a closure day is charged.

B. The liquidated damage rate shown on the proposal will be assessed for each working day used in excess of the number of working days specified.

1111.05 I/D PAYMENT OR ASSESSMENT.

A. Incentive Payment.
For the number of closure days remaining after completion of the critical closure activity, the Contractor will be paid the I/D daily rate as an incentive payment. Maximum incentive payment will not exceed that amount shown on the proposal. Incentive payments will be made in accordance with Article 1109.09.

B. Disincentive Assessment.
For the number of closure days used to complete the work required in a critical closure activity in excess of the specified closure days, the Contractor will be assessed the I/D daily rate. There will be no maximum amount for the disincentive assessment.

Section 1112. A + B Bidding

1112.01 GENERAL.
A + B Bidding may be assigned by the Department. If so, the determination of the low bidder will involve a combination of the contract sum and the bidder's proposed time to complete all work designated in the A + B portion of the proposal form.

1112.02 DEFINITION.

A. Critical Closure Activity.
Critical closure activities are those activities specified in the contract documents where traffic movements are adversely affected causing undue delay and operating costs. The Critical Closure Activity will be defined in the proposal form.

B. Closure Day.
A closure day is a calendar day during the critical closure activity. A closure day will be counted for each calendar day or portion of a day during the

critical closure activity. The Contractor may work any days and hours within the critical closure activity.

C. Daily Road User Cost.
The amount which represents the average daily cost of interference and inconvenience to the road user. The daily road user cost will be shown on the proposal form.

1112.03 PREPARATION OF PROPOSAL.
The bidder shall establish the number of calendar days to be used to complete the work required under the A + B portion of this contract as identified in the proposal form. The proposal may state a maximum number of calendar days allowable. Bids showing time for completion in excess of this maximum amount will be considered non-responsive and will be rejected.

1112.04 CONSIDERATION OF BIDS.

A. Each bid submitted shall consist of two parts:

(A) The contract sum.
(B) Total number of calendar days proposed by the bidder to complete all work defined as the Critical Closure Activity in the proposal form. The bidder shall enter the number of calendar days on the proposal form.

B. The bid amount for award consideration will be determined by the following formula:

(A) + [(B) x (Daily Road User Cost)] = Bid amount for award consideration.

1112.05 WORK OUTSIDE THE CRITICAL CLOSURE ACTIVITY.

A. Work performed on any calendar day prior to and/or following the critical closure activity will have working days charged according to Article 1108.02, D, of the Standard Specifications. Working days will not be charged on any calendar day that a closure day is charged.

B. The liquidated damage rate shown on the proposal will be assessed for each working day used in excess of the number of working days specified.

1112.06 I/D PAYMENT OR ASSESMENT.

A. Incentive Payment.
For the number of closure days remaining after completion of the critical closure activity, the Contractor will be paid the I/D daily rate as an incentive payment. Incentive payments will be made in accordance with Article 1109.09 of the Standard Specifications.

B. Disincentive Assessment.
For the number of closure days used to complete the work required in a critical closure activity in excess of the specified closure days, the Contractor

will be assessed the I/D daily rate. There will be no maximum amount for the disincentive assessment.

1112.07 CONSIDERATION FOR EXTRA WORK OR DELAYS DURING THE CRITICAL CLOSURE ACTIVITY.

Article 1111.03 applies.

1112.08 DETERMINATION OF DBE GOOD FAITH EFFORT.

The percentage of DBE Commitment for each bidder will be computed by dividing their DBE Commitment by their bid for the Contract Sum (A). This percentage will used in the Contract Award Procedures listed Article 1102.17.

DIVISION 20. EQUIPMENT REQUIREMENTS

This Division consists of requirements for equipment used on various types of construction and maintenance work.

Section 2001. General Equipment Requirements

2001.01 GENERAL.

A. Obtain Engineer's approval for equipment. Maintain equipment in working condition.

B. Except as provided in Article 1105.12, G, do not operate equipment that exceeds the legal axle load, as defined herein, on pavement or on primed or unprimed subgrade, subbase, or base course.

C. Do not use tractors with lugs for manipulating or spreading subbase or base material except when traveling on uncompacted material deposited by spreaders or spreader boxes.

D. Keep equipment that comes in contact with bituminous materials or bituminous mixtures clean by heating, scraping, or by the use of an approved release agent described in Materials I.M. 491.15. When kerosene, distillates, or other solvents are used, allow the equipment to drain for a minimum of 5 hours after cleaning. Collect the cleaning agents and dispose of according to Federal and State regulations.

2001.02 FIELD LABORATORY.

Comply with requirements of Section 2520.

2001.03 TRUCKS FOR TRANSPORTING BITUMINOUS MIXTURES.

A. Transport bituminous mixtures using motor trucks with tight metal or metal lined dump bodies. For hot mixes on unusually long hauls or for work after October 1, the Engineer may require the truck bodies to be insulated adequately to retain heat in the mixture.

B. Transport hot mixes in trucks having a cover of canvas or other suitable material. Covering normally will not be required between May 15 and October 1.

2001.04 MECHANICAL TAMPERS.

A. In areas inaccessible to rollers where compaction is required and hand tamping is not permitted, use a suitably sized mechanical tamper.

B. Do not operate pneumatic tampers at pressures lower than the manufacturer's recommendations.

2001.05 ROLLERS.

Use rollers that comply with the restrictions imposed in the specifications for the various types of construction. Use rollers in good repair and designed to do the work required. Use rollers that are approved by the Engineer and comply with the following requirements:

A. Soil Compaction Rollers.

1. Use sheepsfoot type rollers consisting of one or more drums having studs or feet projecting no less than 6 1/2 inches (165 mm) from the surface of the drum.

2. Load the roller so that no less than 200 psi (1380 kPa) is exerted on a single row of feet parallel to the axle of the drum.

B. Self Propelled, Smooth, Steel Tired Rollers.

1. Self propelled, smooth, steel tired rollers may be of the 3 wheel type, 2 axle tandem type, or 3 axle tandem type.

2. For natural subgrade, use rollers no less than the 3 ton (2.7 Mg) weight class.

3. For hot asphalt mixtures, use a driving drum no less than 60 inches (1500 mm) in diameter.

4. On tandem type rollers used for hot asphalt mixtures, use a driving drum capable of being filled with liquid ballast. The Engineer may require that it be partially or entirely filled.

5. For all other types of work, use rollers of a weight class no less than 8 tons (7.3 Mg). Load the driving drum to produce a compactive effort not less than 200 pounds per inch (3.5 kg/mm) of width of the roller. When the Engineer requires, weight the steering drum to 200 pounds per inch (3.5 kg/mm) of width of the steering drum.

C. Self Propelled, Pneumatic Tired Rollers.

1. Use tires no smaller than a 7.50 by 15 size.

2. For hot asphalt mixtures, use rollers capable of producing contact pressures of 80 psi (550 kPa). Operate when specified or directed by the Engineer. Ensure the 80 psi (550 kPa) contact pressure is obtainable with a legal axle load.

3. For all other types of work, use rollers loaded to produce a compactive effort no less than 200 pounds per inch (3.5 kg/mm) of width of the roller, based on the maximum ground contact width. Use a tire inflation pressure no less than 60 psi (410 kPa). Rollers complying with the requirements for HMA may also be used.

4. Ensure tire pressures vary no more than 5 psi (35 kPa).

5. Attach an information plate to each roller showing the tire size and ply and the correlation of wheel load and tire pressure with contact pressure. Equip the roller with wheel sprinklers, scrapers, or mats, and during cooler weather, protective skirting around the tires.

D. Pull Type, Pneumatic Tired Rollers.

1. Use tires no smaller than a 7.50 by 15 size.

2. Load the rollers to produce a compactive effort no less than 200 pounds per inch (3.5 kg/mm) of width of the roller, based on the maximum ground contact width.

3. Use a tire inflation pressure no less than 60 psi (410 kPa).

E. Trench Rollers.

1. For trench operations, use trench rollers with a compacting roller of a width no less than 15 inches (380 mm). Equip the rollers with a leveling mechanism to maintain the compacting surface of the roller in the desired plane while compacting surfaces below the edge of the old pavement. If used only to compact the bottom of a trench for widening, the leveling mechanism will not be required, provided the roller is built to fit the slope of the trench bottom.

2. The Engineer may require the roller loaded to produce the compactive effort best adapted to the work, to a maximum of 250 pounds per inch (4.5 kg/mm) of width of the tire.

3. Operate pneumatic tired rollers at an inflation pressure no less than 60 psi (410 kPa).

F. Self Propelled Vibratory Rollers.

1. Use self propelled vibratory rollers suitable for the use intended. The manufacturer's handbook shall be available to the operator.

2. Control the speed of the roller so there is a minimum of 10 impacts per linear foot (35 impacts per meter).

3. The Engineer will consider other types of rollers for approval.

2001.06 MATERIAL BINS.

A. For the purpose of this article, the word "bin" is defined as any structure in which materials are stored. The requirements apply to any bin that an inspector, while performing sampling or inspection duties, might work upon or beneath.

B. Ensure each part of each bin, including foundations and connections, has adequate strength to withstand any stress to which it might be subjected while in use.

C. The Engineer may inspect each portable bin each time it is erected. The Engineer may reject the use of any bin that does not perform as intended, or otherwise exhibits any unsafe condition.

2001.07 WEIGHING EQUIPMENT AND PROCEDURES.

This article describes equipment capability and procedures to be used when payment for an item is based on weight (mass).

A. Weighing Equipment.

1. Use weighing equipment meeting the requirements of the Iowa Department of Agriculture for measuring pay items. Ensure truck weighing equipment is of sufficient length to weigh, at one time, the maximum truck and trailer combination, or situate separate equipment so that both truck and trailer can be weighed at the same time. Make available upon request, at least 10 standard 50 pound (22.68 kg) test weights and suitable cradles and platforms for the purpose of testing weighing equipment.

2. Ensure weighing equipment is:

- Accurate to 2 pounds per 1000 pounds of weight (2 kg per 1000 kg), and
- Sensitive to a weight (mass) equal to 0.1% of the quantity being weighed but no less than 20 pounds (9 kg) and no less than a weight (mass) equal to one of the minimum graduations on a beam or dial scale.

3. When electronic devices such as load cells, computers, and printers are a part of the weighing equipment, ensure they are sealed or otherwise protected to prevent any unauthorized adjustment. Weighing systems which have been tampered with may be rejected from further use until the system has been checked and/or recalibrated. Furnish a copy of the manufacturer's detailed step by step instructions for adjusting and/or checking for accuracy, sensitivity, and tolerance of the equipment.

4. Tare all trucks to be weighed before loading. Tare these trucks daily thereafter, preferably on a random time basis. Use the previous day’s tare until a new tare is determined.

5. Provide a scale ticket to the Engineer with each load. Also, provide a scale ticket when tares are determined for verification and check weighing. “Verification weighing” is a second weighing of the same load on the same equipment. “Check weighing” is a second weighing of the same load on different weighing equipment. Perform check weighing on a certified truck scale. Ensure scale tickets, as a minimum, identify project number, date, truck number, type of material, and total net weight (mass).

6. Except for automatic weighing, use a weighmaster, as defined in Chapter 214, Code of Iowa, to weigh all loads or load increments. Ensure the weighmaster, or operator for automatic weighing, signs the first scale ticket of each day and initials all subsequent tickets, or prints them using automatic equipment.

7. Check weighing and verification weighing may be made at any time as directed by the Engineer. The Engineer may check the operation of the equipment at any time. The verification weight (mass) shall not be different from the initial weight (mass) by more than 0.1%. When check weighing on a platform scale, the check weight (mass) shall not be different from the initial weight (mass) by more than 0.3%.

8. When the material is not weighed in the truck, (for example, weighing in a weigh hopper or determining weight from initial and final weighing of a weigh silo) perform check weighing on a certified truck scale. The net check weight (mass) shall not be different from the initial net weight (mass) by more than 100 pounds (45 kg). A suitable fuel adjustment may be made.

9. If the weight (mass) is not within the tolerances stated above, the Engineer may adjust the weight (mass) of loads previously weighed on the weighing equipment that day, and the previous day, by the difference greater than the specified tolerance. Perform verification and check weighings at no additional cost to the Contracting Authority.

B. Special Procedures for Asphalt Mixtures, Aggregates, and Binders.

1. Use automatic or semi automatic weighing on projects with contract quantities of asphalt mixtures totaling 10,000 tons (10,000 Mg) or more, or aggregates totaling 10,000 tons (10,000 Mg) or more from a single source.

a. Automatic Weighing.
Use weighing equipment that is self balancing and includes an automatic weight (mass) recorder. Have all tickets printed automatically with net weight (mass) and all weights (mass) needed to determine total net weight (mass).

b. Semi Automatic Weighing.

1) The weighing equipment may be self balancing or manually balanced. Use equipment that includes an automatic weight (mass) recorder that:

- Will not print until the equipment is balanced, and
- Prints the gross weight (mass) or the batch weights (mass) and number of batches.

2) For weigh hoppers, ensure the printout includes the empty weight (mass) after each discharge.

2. For measurement of asphalt binders by tank stick or in-line flow meter, meet the requirements of Materials I.M. 509 for calibration and measurement.

3. For asphalt mixtures, provide daily totals to the Engineer for all mixture quantities produced and used in the project. Provide daily totals to the Engineer for all mixture quantities produced and not incorporated into the project. Ensure this total identifies the quantity of asphalt binder used, but not incorporated.

2001.08 EQUIPMENT FOR PREWETTING AGGREGATES AND AGGREGATE MIXTURES.

Use equipment complying with one of the following:

A. Standard Mixer.
Use equipment that provides accurate control of the proportions of water and aggregate, as well as positive, thorough mixing of the materials. Dow boxes will be approved as a Standard Mixer.

B. Pugmill Mixer.

1. When this equipment is specified, ensure it:
- Provides accurate control of the proportions of water and aggregate, and
- Is designed so that the material can be retained in the mixing chamber under vigorous mixing action for at least 15 seconds.

2. If using continuous flow type mixers, use ones that:
- Have twin mixing shafts, and
- Are equipped with a hopper or bin at the discharge end of the mixer designed to minimize segregation of the mixed materials.

2001.09 WATER DISTRIBUTORS.

A. To apply water to the roadway, use a distributor mounted on a truck or trailer equipped with pneumatic tires.

B. Use a distributor equipped with an adequate pressure pump and spray bars to distribute water evenly over the intended area.

C. Use distributors that have a:
- Spray bar with correct size and pattern of nozzles,
- Means to maintain uniform nozzle pressure,
- Means to control application rates between 0.05 to 0.50 gallon per square yard (0.20 to 2.50 L/m^2), and
- Positive sprayer shutoff mechanism.

D. For trench operations, use distributors that have an offset spray bar with replaceable nozzles so the width to which water is applied can be adjusted to the work.

2001.10 WATER SUPPLY EQUIPMENT.

A. Use water supply equipment, including pipe lines and water trucks, of a capacity and nature to ensure an ample supply and sufficient pressure for all the requirements of the work.

B. When pumping is necessary, backup pumping equipment may be required.

2001.11 EQUIPMENT FOR HEATING BITUMINOUS MATERIALS.

A. Use equipment for heating bituminous material that:

- Has adequate capacity to heat the material to the temperatures specified,
- Is equipped with an accurate thermometer which will indicate the temperature of the bituminous material in the unit in which heat is being applied,
- Will not damage the bituminous material by local overheating or by contamination with the material used for the transfer of heat, and
- Will ensure continuous circulation between the storage tank and the mixer during the operating period.

B. Heat the material under control by:

- Using circulating steam or a liquid through coils in the car or tank,
- Electric heat,
- Circulating the bituminous material through a separate heating unit, or
- Other means so that no flame is applied to metal with which the bituminous material comes in contact.

C. Jacket or insulate all pipe lines to prevent heat loss.

2001.12 EQUIPMENT FOR DISTRIBUTING BITUMEN.

A. Mount distributors on motor trucks or trailers. Ensure distributors comply with the restrictions imposed in the specifications for the various types of construction. Use only those distributors which are in good repair and are designed to do the work. Use distributors and trucks that are approved by the Engineer.

B. Equip distributors with adequately sized burners and flues for heating the bituminous material. Ensure they have a means for circulating the material in the tank when the burners are in operation. Equip distributors with adequate and safe catwalks or ladders for use in making stick measurements.

C. Equip each unit with the following:

1. An accurate thermometer for indicating the temperature of the bitumen in the tank.

2. A tachometer operated by a wheel independent of the truck wheels.

3. A calibrated or verified measuring stick.

4. A quick opening gate in the dome of the distributor tank.

5. Quick cutoff valves at the nozzles or other means for reversing the direction of flow through the nozzles.

D. Use separate power supplies for the pressure pump and the distributor drive train. Pressure equipment which depends on the drive train power for the distributor may be approved provided special devices are installed to ensure that variation from the designated rates of application will not exceed 0.02 gallon per square yard (0.10 L/m^2). Use a pressure system with sufficient capacity to produce a uniform, fine, even spray from all the nozzles for the maximum width of the spray bar used. Ensure it is capable of distributing bitumen at rates varying from 0.03 to 0.50 gallon per square yard (0.15 to 2.50 L/m^2). Use nozzles of a size such that bitumen may be spread in a uniform coating without the forward speed exceeding 20 mph (30 km/h).

E. Use spray bars that are adjustable for the widths of application required by the work. Equip them with a means of shifting at least 6 inches (150 mm) laterally from the center position during bitumen application. Use spray bars that are also adjustable vertically to ensure uniform transverse application of the bitumen. Equip distributors used for applying bituminous seal coat binder bitumen with a positive means for maintaining a constant nozzle height (within ± 1/2 inch (15 mm)) during discharge of the load. If dollies are used for maintaining the constant nozzle height, use a spray bar mounting that adjusts vertically.

F. With each distributor, provide the manufacturer's instructions for use, including specific recommendations for the following:

1. Spray bar height above road surface.

2. Nozzle size and angle of spray fan with spray bar axis.

3. Tables showing rates of distribution in gallons per square yard (liters per square meter) for tachometer readings, spray bar pressure, or pump revolutions, and for various widths of spray bars.

G. Calibrate or verify the tanks of all distributors that have not been previously checked:

- Before being initially used, and
- After any damage or alteration which may affect the calibration.

H. Calibrate distributors initially at the Iowa DOT Materials Laboratory. Verification of a manufacturer's calibration may be made by the Iowa DOT Materials Laboratory or by a District Materials Office. Have distributor calibrations certified annually by either the Iowa DOT Materials Laboratory or District materials personnel. If distributors are found to have inaccurate calibrations, have distributors recalibrated by the Iowa DOT Materials Laboratory before further use.

2001.13 SPREADERS.

This article applies to equipment used for distribution of certain materials, other than liquids, where it is required that the material be distributed on a roadbed at a specified uniform rate.

A. Non-Self-Propelled Cover Aggregate Spreaders.
Comply with the following:

1. Equipped with a mechanical feed of a length at least equal to the width to which aggregate is spread with a single pass of the spreader.

2. Capable of depositing aggregate from the transporting vehicle directly upon freshly applied bitumen in a smooth, uniform layer, at the rate required and in a manner that equipment will not come in contact with the bitumen until the bitumen is covered with a layer of aggregate.

3. Equipped so that they may be filled and moved without discharging aggregate.

B. Self-Propelled Cover Aggregate Spreaders.
Comply with the requirements of Article 2001.13, A, and the following:

1. Are mounted on pneumatic tires.

2. Have a width of spread no less than 13 feet (3.9 m).

3. Provide cutoff plates to permit the width of spread to be reduced in increments of 1 foot (0.3 m) from the maximum to 4 feet (1.2 m).

4. Are capable of spreading aggregate of 1 inch (25 mm) maximum size at any rate desired from 3 to 50 pounds per square yard (1.5 to 27 kg/m^2) of surface covered.

5. Provide a hopper with the following qualifications (conveyers are suitable for conveying the aggregate from the hopper to the spreading element):
- **a.** Has a capacity of no less than 5 tons (4.5 Mg).
- **b.** Is integral with the spreader unit.
- **c.** Can receive aggregate from transporting vehicles without the wheels of such vehicles coming in contact with uncovered bitumen on the road surface.
- **d.** Augers or agitators distribute aggregate uniformly to the spreading element without segregating aggregate particles.

6. Have adequate power to propel the spreader at uniform speed on gradients up to 6%.

C. Sand Spreader.
For spreading sand cover for tack and seal coat, use a spreader that has one (or more) horizontal rotating disk fed by a conveyor and driven by power takeoff or by a separate unit.

D. Materials Spreader for Base Widening Work.

1. Place the material used in base widening by machine without dumping on the pavement.

2. Use a machine that will spread the base materials in a uniform layer of the desired thickness and width in a uniformly loose condition.

3. Locate the wheels of the spreader so they do not operate on the 1 foot (0.3 m) width of pavement adjacent to the edge of the base widening.

2001.14 BROOMS.
Use a rotary type broom driven by an auxiliary motor or by a power takeoff from the power plant of the unit propelling the broom.

2001.15 MOTOR GRADERS.
Equip motor graders used in trimming edges of subbases or bases with an offset blade with supplementary cutting edge designed so the wheels of the motor grader will be operated entirely on the surface of the base or subbase.

2001.16 SCARIFYING EQUIPMENT.
Use scarifying equipment designed and operated to loosen the material to the depth specified.

2001.17 PULVERIZING EQUIPMENT.
Use pulverizing equipment designed and operated to pulverize the material to the degree specified.

2001.18 TRENCH EXCAVATING MACHINES.

A. Use a machine designed for the required purpose.

B. Use equipment capable of excavating the material to the full, normal design depth and suitable width.

2001.19 ASPHALT MIXTURE PAVING MACHINE.

A. Spread all asphalt mixtures to be placed 8 feet (2.4 m) wide or more in width using a self- propelled finishing machine which will receive the hot mixture and spread the mixture in a layer of uniform density to the desired thickness.

B. Use a finishing machine consisting of a tractor unit and a screed unit.

1. Use a tractor unit with dual controls to permit operation of the finishing machine from either side. The tractor unit will provide the motive power and may be mounted on crawler treads or pneumatic tires. If mounted on pneumatic tires, maintain sufficient inflation pressure to keep vertical movement to a minimum. Ensure the length of crawler treads or distance between axles, if mounted on pneumatic tires, is sufficient to allow the tractor unit to pass over small irregularities in the base without abrupt vertical movement.

2. Attach the screed unit to the tractor unit so that it is free floating on the mixtures being placed. Equip the screed with vibrators or tampers for giving the initial consolidation to the material. Operate this equipment at the frequency the manufacturer recommends. Ensure the screed unit operation produces a smooth surface, free from surface tears or voids, and within the permissible variation specified for the type of work involved.

3. Use a screed unit that is adjustable to the crown of the finished surface. Ensure it is equipped with an approved device which will indicate the slope of crown. Provide a minimum 2 foot (0.6 m) long straightedge for checking the installation of screed extensions.

4. A screed extension may be used, provided it has a screed plate with vibration. If the extension exceeds 1 foot (0.3 m), extend the auger as well. Other extensions will be allowed only for use in placing fillets or short or irregular tapers.

C. Do not use finishing machines which operate with rollers on the freshly placed mixture.

D. Unless otherwise specified, use a finishing machine that has automatic screed controls, except for the following uses:

1. Wedge courses.

2. Curb fill resurfacing.

3. Urban type sections containing fixtures or other permanent grade control features.

4. Surface layers 1 inch (25 mm) or less in thickness.

5. Special leveling course (scratch course) in which the screed rests entirely on the high spots of the underlying base during the paving procedure.

6. Single course resurfacing on Secondary projects.

E. Ensure automatic controls:

1. Have grade and slope control systems which operate with an approved grade reference system.

2. Work in conjunction with a ski type device, traveling stringline, or other approved, self contained grade referencing system.

F. Use a self contained grade referencing system no less than 30 feet (9 m) long. Verify both the grade and slope controls are adequately sensitive and in proper working order at all times. During malfunctions the Engineer may permit the completion of the day's work using manual controls.

G. A special commercial joint matching shoe may be used when constructing longitudinal joints on surface courses:
- When placing a single lift only, with a thickness of 1 1/2 inches (40 mm) or less, or
- For placement in conjunction with heater scarification work.

H. For placing the final lift of paved shoulders, use finishing machines or pavement widening machines that have an automatic grade and slope control system approved by the Engineer. The joint matching shoe may be used when placing any paved shoulder.

I. Obtain the Engineer's approval for machines used for spreading mixtures on areas less than 8 feet (2.4 m) wide. Do not use machines which are less than standard size for highway work without the Engineer's permission.

J. Obtain the Engineer's approval for use of material transfer vehicles. The Engineer will base approval on bridge and pavement structural evaluation of resultant axle and wheel loads.

K. When using a windrow pick-up process, control the process to produce a windrow that is uniform and does not extend more than two truck dumps ahead of the paver. Pick up all hot mix material from the windrow and deposit it in the paver. Balance windrow placement to maintain a uniform quantity of material in the paver hopper.

2001.20 EQUIPMENT FOR WEIGHING AND PROPORTIONING PORTLAND CEMENT CONCRETE MATERIALS.

A. General.

1. Use weighing and proportioning equipment that meets the requirements of this article. Allow the Engineer every opportunity to witness calibration of the equipment during the Engineer's normal working hours, or at a mutually agreeable time. This schedule limitation will be modified, if necessary, for work to be done according to an accelerated work schedule. The Engineer may consider a report concerning equipment and its calibration certified by a Professional Engineer licensed in the State of Iowa in lieu of this calibration. The Engineer may, at any time, perform such tests or checks as necessary to verify a report or to assure continued compliance.

2. Coarse aggregate sampling facilities which permit collecting representative portions of a ribbon or stream will be required at the proportioning plant site. The Engineer will designate a sampling point:
- Prior to individual material identity loss in the proportioning mixing process, and
- After delivery to the plant or after delivery to a site stockpile, whichever is nearest the mixer.

3. Furnish personnel, test weights, and equipment for calibration of the plant and for verifying accuracy of proportions. Arrange for weighing water to calibrate the water meter.

B. Proportioning Equipment.

1. Use proportioning equipment complying with the following requirements:
- **a.** Accurate to 0.5% of the batch weight (mass).
- **b.** Sufficiently sensitive so that 0.1% of the batch weight (mass) or 2 pounds (1 kilogram), whichever is greater, will be detectable.
- **c.** Weighs each individual material within ± 1.0% of the batch weight (mass) and returns to zero within ± 0.5% of the batch weight (mass).
- **d.** Is protected from air currents, vibration, and so forth which may affect the accuracy of weighing. Keep all fulcrums, clevises, and similar working parts clean and in proper working condition.
- **e.** Has available upon request, at the plant site, standard test weights for calibrating weight equipment according to Table 2001.20-1. Have suitable devices available for conveniently applying test loads.

Table 2001.20-1: Standard Test Weights

Nominal Scale Capacity lb (kg)	Minimum Test Weights (Mass) Required Total lb (kg)
0 to 500 (0 to 225)	2 @ 50 lbs. ea. (2 @ 22.68 kg ea.)
Over 500 to 5000 (Over 225 to 2250)	500 (225)
Over 5000 to 10,000 (Over 2250 to 4500)	1000 (450)
Over 10,000 (Over 4500)	2000 (900)

- **f.** Weighs cement in an independent hopper.
  - **1)** Use a weigh hopper that has:
    - **a)** A dust tight seal between the charging mechanism and the batching hopper which will not affect the accuracy of weighing.
    - **b)** A discharge hose or device which will prevent the loss of cement during discharge.
  - **2)** Do not allow any part of the discharge device which comes in contact with the receiving equipment to be supported by the weigh hopper. Ensure cement hoppers are equipped with a vibrator and with a vent which will adequately release air pressure which may affect weighing.
- **g.** Will weigh fly ash and GGBFS according to the requirements of weighing cement. Fly ash and GGBFS may be weighed in the same hopper as the cement, provided the cement is introduced into and weighed in the hopper first.
- **h.** Sets and operates automatic weighing equipment, if used, with the following interlocks:

1) The charging mechanism cannot be opened until the equipment has returned to zero balance within ± 0.5% of the batch weight (mass).
2) The charging mechanism cannot be opened if the discharge mechanism is open.
3) The discharge mechanism cannot be opened if the amount in the hopper is over or under by more than 1.0% of the batch weight (mass).

2. When automatic weighing equipment is required:
a. Manual controls may be used for emergencies. Manual controls will not be permitted longer than 1 working day after automatic batching equipment failure.
b. Weigh fly ash according to the requirements for cement.

C. Water Measuring Equipment.

1. Measure water using equipment that will clearly indicate the volume or weight (mass) being measured with an accuracy of 2 pounds (1 kg) or ± 1.0%, whichever is greater. Arrange the equipment so the accuracy of the measurement will not be affected by variations in pressure of the water supply line. Unless water is measured by weight (mass), provide containers in which the entire quantity of water required for one batch of concrete may be weighed for calibration purposes.

2. Equipment that measures moisture in the fine aggregate and adjusts the batch amounts of fine aggregate and batch water on a continuous basis will be allowed provided satisfactory calibration and correlation procedures are met.

D. Equipment for Admixtures.

1. Use equipment for dispensing liquid admixtures that is accurate within ± 3.0% of the quantity required. The visual inspecting chamber requirement may be waived in lieu of admixture dispensing systems using positive electronic flow metering and computer controlled delivery that prevents improper admixture incorporation into the mix. Ensure dispensing equipment has a means for routine diversion of a measured quantity into a suitable vessel for calibration and for periodic verification of the batch quantity.

2. When liquid admixtures are proportioned and introduced into the mix, use equipment and procedures that meet the following requirements:
a. Measures and automatically introduces separately each individual admixture into the mixer with the mixing water.
b. Uses a dispenser equipped with a measuring chamber which provides a means of determining the batch quantity by visual inspection.

E. Equipment for Volumetric Proportioning.

1. Use volumetric proportioning equipment meeting the applicable requirements of ASTM C 685, Sections 5, 6, 7, and 8 and the applicable requirements of Article 2413.03, A, 3.

2. Calibrate each time, when in the Engineer's opinion, material or condition changes may affect the calibration.

3. It is not intended that this equipment be used in place of conventional drum mixing equipment normally used for structures and paving applications.

4. This equipment may be used on miscellaneous pours, described in Materials I. M. 534, less than 50 cubic yards (50 cubic meters) per day.

5. Equipment used on miscellaneous pours shall be equipped with a batch ticket printer to include the cement, coarse and fine aggregate, and water count. Equipment used in accordance with Section 2413 shall be equipped with a batch ticket printer for the cement count.

2001.21 PORTLAND CEMENT CONCRETE MIXING EQUIPMENT.

A. General.

1. Use mixing equipment that meets the requirements of this article for the type specified.

2. Allow the Engineer every opportunity to witness the calibration of the equipment during the Engineer's normal working hours, or at a mutually agreeable time. This schedule limitation will be modified, if necessary, for work to be done under an accelerated work schedule.

B. Construction or Stationary Mixer.

1. Use only batch type mixers.

2. Do not allow the total volume of the batch to exceed the designated size of the mixer or the rated capacity as shown on the manufacturer's rating plate.

3. After all solid materials are assembled in the drum, mix for a minimum of 60 seconds and a maximum of 5 minutes. The Engineer may increase the mixing if the mixer efficiency tests show that the concrete is not satisfactory for uniformity or strength. Use an accurate timing device that:
- **a.** Indicates minimum mixing time.
- **b.** Starts automatically when the mixer is fully charged.
- **c.** When applicable, locks the discharge chute until the expiration of the required time.

4. Operate mixers at the manufacturer's recommended mixing speed. Charge the batch into the mixer so that:
- Some water will enter in advance of cement and aggregates, and
- All water is in the mixing chamber by the end of the first 25% of the specified mixing time.

5. Operate mixing drums of tilting drum mixers at an angle no steeper than the mixer manufacturer's recommendation. Do not use a mixer if the drum is not clean or if the mixing blades are damaged or badly worn.

6. When a construction or stationary mixer is used for mixing pavement concrete, have the quantities of fine aggregate, coarse aggregate, cement, mineral admixture, liquid admixture and water for each batch automatically documented on individual batch tickets or on a daily summary. Have the time of discharge for each batch recorded automatically as well. These proportioning documents will become property of the Contracting Authority.

C. Truck Mixer and Agitator.

1. The equipment shall have a metal plate or plates attached with the following information:
- Gross volume of the drum
- Mixed concrete capacity
- Maximum and minimum mixing speed

The plate may be issued by the Truck Mixer Manufacturers Bureau, if not, have an independent laboratory meeting the requirements of ASTM C 1077 perform the proof tests described in Annex A1 of ASTM C 94. The test report of the proof test results may be required.

2. Do not exceed mixer or agitator capacity. Keep mixing and agitator speeds within the designated limits. Equip truck mixers with reliable reset revolution counters. If truck mixers are used for mixing while in transit, the revolution counter is to register the number of revolutions at mixing speed.

3. Have an authorized representative of the concrete producer certify that:
- **a.** The interior of the mixer drum is clean and free of hardened concrete,
- **b.** The fins or paddles are not broken or worn excessively,
- **c.** The other parts are in proper working order,
- **d.** The unit has been checked by the representative within the previous 30 calendar day period to substantiate this certification.

4. Keep the current, signed certification with the unit at all times.

5. For bridge floor concrete, ensure mixing is between 70 and 90 revolutions. For other structural concrete and pavement concrete, ensure mixing is between 60 and 90 revolutions with satisfactory

preblending of the materials, or between 70 and 90 revolutions without preblending. Use the manufacturer's designated mixing rate. Keep the mixing rate duration between the limits stated above to produce uniform, thoroughly mixed concrete.

6. The Engineer may inspect mixer units at any time to assure compliance with certification requirements. Removal of inspection ports may be required. Should the Engineer question the quality of mixing, the Engineer may check the slump variation within the batch. Should the slump variation between two samples taken, one after approximately 20% discharge and one after approximately 90% discharge of the batch, show a variation greater than 3/4 inch (20 mm) or 25% of the average of the two, whichever is greater, the Engineer may require:

- The mixing to be increased,
- The batch size reduced, or
- The unit removed from the work.

D. Continuous Mixer.

A continuous mixer used in conjunction with volumetric proportioning may be approved as provided in Article 2001.20, E.

2001.22 PLANT EQUIPMENT FOR HOT MIX ASPHALT MIXTURES.

Ensure plant equipment will proportion each aggregate, dry and heat the aggregate (except mineral filler), proportion the aggregate and hot asphalt, and mix all materials. The plant may be of a batch type, continuous type, or drum mixing type. Ensure the plant is equipped to produce uniform mixtures of required composition, heated to the desired temperature.

A. Aggregate Feeders for Dryer Drum or Drum Mixer.

1. Ensure the following:

a. The feeder uses mechanical means to accurately feed each aggregate (except for mineral filler added without heating) to a central elevator or conveyor in the proportion prescribed by the approved design mix.

b. The feeders are belt type feeders equipped with adjustable gates or adjustable drive systems that can be calibrated and controlled.

c. The feeder throats are of sufficient size to ensure positive and continuous flow.

d. All feeders mechanically or electronically interlocked during operation.

e. On some types of feeders, revolution counters capable of registering to a tenth of a revolution may be necessary (and may be required) for accurate calibration and control.

2. When drum mixing plants are used, ensure:

a. The central conveyor is equipped with a continuous weighing system with a recorder that can be monitored by the plant operator.

b. The aggregate weighing system interlocks with the asphalt control unit.

3. If a drum mixing plant is adding RAP, ensure the following:
- **a.** A dual weigh belt system is used to control delivery of virgin aggregates and recycled material to the dryer.
- **b.** The belt system is equipped with interlocking control mechanisms in a manner that will assure positive and accurate delivery of recycled and virgin materials in proper proportions at all times.
- **c.** The belt system includes recorders that will record the total amount of material being delivered by each belt system separately.
- **d.** The belt weighing controls are connected to a totalizer which is interlocked with the asphalt delivery system in a manner which will ensure that asphalt delivered to the mix is at all times within ± 0.3% of the intended amount. Obtain the Engineer's approval for the system.
- **e.** The Engineer is provided a schematic diagram of the control system prior to plant calibration.

B. Dryer Drum and Drum Mixer.
Ensure the following:

1. The plant is equipped with means for drying and heating the aggregate and/or mixture.

2. Heating is controlled to avoid damage to the aggregate and asphalt.

3. Operation of the equipment is controlled so the specified temperature is maintained.

C. Screens.
Ensure the plant is equipped with adequate means to remove objectionable oversize and foreign material from the aggregate before entering into the hot aggregate bin dryer drum, or drum mixer.

D. Aggregate Bins.
Ensure the following:

1. The plant has aggregate bins of sufficient capacity to ensure uniform and continuous operation.

2. The heated aggregate storage is provided with sufficient ventilation by means of a stack or connection to the dust collection system so that moisture from the hot aggregate will be removed before condensing in the aggregate storage.

3. When mineral filler is added without heating, adequate additional dry storage is provided for the mineral filler, and provisions are made for proportioning the filler uniformly in the desired proportion for the mixture.

E. Equipment for Heating and Storing Asphalt Binder.
Apply Article 2001.11 for heating asphalt binder. Comply with the following:

1. Provide duplicate storage facilities of sufficient capacity to permit complete unloading of a tank car or truck transport in a single operation, unless the asphalt binder is supplied to the project from transports measured by weight (mass).

2. Fill and withdraw storage material from each tank as a separate, definite operation which will permit the Engineer to measure the quantity of asphalt binder used from each storage tank.

3. Install and maintain each storage tank in a level position.

4. Furnish measurement devices and gauging tables so accurate determinations of quantities used and stored can be made at regular intervals.

5. Provide suitable means for maintaining the specified temperature of the asphalt binder in the pipe lines, meters, weighing buckets, spray bars, and other containers and flow lines.

6. Include a spigot for removing asphalt samples from the delivery line to the mixer before the asphalt binder is metered into the mixer or weighed.

F. Asphalt Binder Control Unit.
Provide satisfactory means, by weighing, metering, or volumetric measurements, to add the proper amount of asphalt binder to the aggregate. Operate all measuring devices within a delivery tolerance of 1.5% by weight of binder.

1. Batch Plants.
- **a.** Measure the quantity of asphalt binder for each batch on equipment meeting the appropriate requirements of Article 2001.07, A, or by an approved automatic batch metering system.
- **b.** When used for proportioning only, meet the appropriate equipment requirements of Article 2001.20.
- **c.** Use a sufficiently flexible means of heating that will not affect the weighing.
- **d.** Arrange the container so that it will deliver the asphalt binder in a thin, uniform sheet or in multiple streams the full width of the mixer, except in the case of a mixer into which the asphalt binder is sprayed. If the binder is deposited on a flow or spreader sheet, use a heated sheet with sufficient slope to discharge promptly into the mixer.

2. Continuous Plants.
- **a.** Comply with the following:
  - **1)** To supply asphalt binder to the mixer, use a pump constructed to be under a positive pressure sufficient to maintain uniform delivery from the pump. The pressure is to be maintained within ± 0.5 psi (5 kPa) of the recommended operating pressure.

2) Install accurate pressure gauges in readily accessible locations in lines feeding the metering pump and the mixer spray bars. Install gauges of such size that the normal operating pressure can be easily read to the nearest 1.0 psi (10 kPa).

b. For the mixer unit, comply with the following:

1) Equip with a surge tank or a deaeration chamber for supplying a constant pressure flow of asphalt binder to the metering pump.

2) The surge tank or the deaeration chamber is to be of dimensions and capacity to provide the pressure specified. The capacity is to be at least a 6 minute supply of asphalt binder at the normal mixing rate of the mixer unit.

3) The surge tank or the deaeration chamber is to be fitted with baffles and other appurtenances necessary to prevent the incorporation of air bubbles into the asphalt binder as the tank is being filled.

4) When the surge tank system is used, the pressure at the spray bar is to be no greater than 20 psi (140 kPa).

5) When a deaeration chamber system is used, the pressure difference between the return line and the spray bar is to be no greater than 20 psi (140 kPa).

6) Separate return lines are to be provided for each tank.

7) Obtain the Engineer's approval for the surge tank or the deaeration chamber.

3. Drum Mixing Plants.

Ensure the following:

a. The plant uses a pump to supply asphalt binder to the mixer, which is constructed to be under positive pressure sufficient to maintain uniform delivery from the pump.

b. A totalizing flow meter is placed in the line between the metering pump and mixer unit.

c. The asphalt control unit is interlocked with the aggregate weighing system specified in Article 2001.22, A, and is equipped to automatically adjust for variation in aggregate delivery.

d. The plant is operated with automatic controls, except when approved by the Engineer.

e. The asphalt control unit is equipped so the plant operator can monitor and adjust the flow rate of aggregate or asphalt binder.

G. Thermometer Equipment.

Install an accurate, registering pyrometer or other approved thermometric instrument in the discharge chute of the dryer drum or drum mixer in a manner so the temperature of the heated aggregate or mixture is continuously measured. Locate this instrument where it is in clear view of the plant or dryer operator and readily accessible to the Engineer.

H. Control of Mixer Capacity and Mixing Time.

Equip the plant with positive means to govern and maintain mixing time.

I. Dust Collector.

1. Install and properly maintain proper housings, mixer covers, and dust collecting systems and returns.

2. Obtain the Engineer's approval for the method of returning dust collected by dry type collection systems to the hot aggregate mixture. If not required in the mixture, remove the bag house fines from the project and plant site.

3. When wet type collection systems are used, remove all wet material from the project and plant site.

J. Hot Aggregate Proportioning.
Apply the requirements of this article only to batch plants.

1. Accurately weigh the mineral filler and dried aggregate from each bin in a weighing hopper that is of ample size to hold a full batch without hand raking or running over.

2. Support the weighing hopper so it will not be easily thrown out of alignment or adjustment.

3. Construct gates on bins and hoppers to prevent leakage when closed.

4. Separately proportion mineral filler which is added cold from a hopper and feed uniformly into the heated aggregate before delivery to the pugmill.

5. Weigh the quantity of aggregate for each batch on equipment meeting the appropriate requirements of Article 2001.07, A. When this equipment is used for proportioning only, meet the appropriate requirements of Article 2001.20.

K. Mixer.

1. Batch Mixer.
- **a.** Use twin shaft pugmills capable of producing a uniform mixture within the job mix or other specified limits.
- **b.** Do not exceed 3/4 inch (20 mm) clearance of the blades from all fixed and moving parts. Orient the blades according to the manufacturer's recommendation.
- **c.** If the pugmill is not enclosed, equip it with a dust hood to prevent loss of dust by dispersion.
- **d.** Construct the mixer to prevent leakage of contents until the batch is to be discharged.
- **e.** Use an accurate time lock to control the operation of a complete mixing cycle by:
  - **1)** Locking the weighing hopper gate when the mixer is charged and until the mixer gate is closed at the completion of the cycle.

2) Locking the outlet of the asphalt binder delivery system throughout the dry mixing period.

3) Locking the mixer gate throughout the dry and wet mixing periods.

f. The dry mixing period is the interval of time between the opening of the weighing hopper gate and the application of asphalt binder. The wet mixing period is the interval of time between the application of asphalt binder and the opening of the mixer gate. Ensure control of the timing is flexible and capable of being set at intervals of no more than 5 seconds. Install a mechanical batch counter as part of the timing device and design it to register only completely mixed batches.

g. When adding RAP:

1) Modify batch plant equipment to provide for accurate proportioning of the recycled material and for adding it directly into the weigh hopper, with weighing as a separate increment of the total batch.

2) The RAP may be added to the hot elevator with no preheating. In any method where preheating is being done, the equipment must be specifically designed for this purpose.

3) For RAP proportioning systems, meet the requirements of Article 2001.22, A.

4) When the heat transfer method is used, superheat the new aggregate so that, when combined with the RAP, the temperature of the resultant mixture will meet all requirements for mixing and placing the hot mixture.

5) Obtain the Engineer's approval for each plant modified for recycling mixtures.

6) For each job mix formula within a project, provide daily printouts identifying weight of RAP separately from total batch as recorded by a totalizer.

2. Continuous Mixer.

a. Use an approved twin shaft pugmill capable of producing uniform mixtures within the job mix or other specified limits.

b. Ensure paddles are of a type adjustable for angular position on the shafts and reversible to retard the flow of mix.

c. Equip the mixer with a discharge hopper holding approximately 1 ton (1 Mg) and discharging intermittently by means of quick acting gates.

d. Regulate the distance to the receiving vehicle to minimize segregation.

e. Provide satisfactory means to afford positive interlocking control between the flow of aggregate from the bins and the flow of asphalt binder from the meter or other proportioning source. Accomplish control by interlocking mechanical means or by any positive method for accurate control.

f. Include an accurate revolution counter, operating continuously during production.

g. Equip the plant with positive means to govern and maintain a constant time of mixing.

3. Drum Mixer.

a. Comply with the following:

1) Use equipment capable of producing uniform mixtures within the job mix or other specified limits.

2) Introduce the aggregate, asphalt binder, and additives, when furnished, continuously and uniformly. This is to be controlled by the plant operator.

3) Discharge the mixture continuously and uniformly onto an elevator or conveyor that discharges into a hot mixture storage unit meeting requirements of Article 2001.22, L.

4) Continue the mixing until the asphalt binder is uniformly distributed and the aggregate particles are uniformly coated.

b. The plant may be modified with a pugmill coater. The coater shall be inclined and positioned as an integral built-in unit, located between the drum and the hot elevator of the plant setup. Introduce the asphalt binder, and additives when furnished, continuously and uniformly at the lower end of the coater. This shall be controlled by the plant operator. Obtain the Engineer's approval for each plant modified.

c. When adding RAP, modify drum mixing equipment to process RAP according to Article 2001.22, A.

L. Hot Mixture Storage.

1. Provide suitable hot mixture storage when the hot mixture is not hauled immediately to the project and placed.

2. Use hot mixture storage bins that are either 1) surge bins to balance production capacity with hauling and placing capacity; or 2) storage bins which are heated and/or insulated and have a controlled atmosphere around the mixture. Use hot mixture storage bins that:

a. Are round or octagonal in shape and designed for the intended use.

b. Fill using an enclosed system, unless skip conveyors are used.

c. Dump material directly into trucks through quick opening and quick closing gates.

d. Do not result in significant segregation, damage, or cooling.

3. To each bin, affix an indicating or control device which:

- Is visible to the loading operator, and
- Allows control of material remaining in the bin.

4. Limit the holding time to 4 hours in storage bins.

5. Use hot mixture placed in storage bins within 24 hours of production, unless the Engineer approves otherwise.

M. Safety Requirements.

1. Place adequate and safe stairways, platforms, and guarded ladders to plant units at points required for accessibility to sampling locations and other plant operations.

2. Guard and protect all gears, pulleys, chains, sprockets, and other moving parts.

3. Maintain ample and unobstructed passage for personnel at all times in and around the truck loading area. Protect this area from falling material.

4. Ensure bins comply with the requirements of Article 2001.06.

N. Plant Calibrations.

1. Provide personnel, weighing devices, test weights, and equipment for calibration of the plant and verifying accuracy of proportions.

2. Provide sufficient space between aggregate feeds and elevators to permit taking of samples of the discharge for accurate calibration and control of rate of feed.

3. Weigh samples of sufficient size for calibration and checking of proportions.

4. Ensure truck sampling and weighing is acceptable.

5. Allow the Engineer every opportunity to witness calibration of the equipment during the Engineer's normal working hours, or at a mutually agreeable time. This schedule limitation will be modified, if necessary, for work to be done under an accelerated work schedule.

6. Ensure the Engineer's representative indicates witnessing the calibration by signing the calibration documents and charts.

DIVISION 21. EARTHWORK, SUBGRADES, AND SUBBASES

This work consists of grading and construction of subgrades and subbases as required for the various types of work in the following sections. Complete the work in conformance with the lines, grades, thicknesses, and typical cross sections shown in the contract documents or as established by the Engineer.

2101. Clearing and Grubbing.
2102. Roadway and Borrow Excavation.
2103. Presplitting and Production Blasting of Rock Slope Cuts.
2104. Channel Excavation.
2105. Stripping, Salvaging, and Spreading Topsoil.
2106. Settlement Plates.
2107. Embankments.
2108. Overhaul.
2109. Natural Subgrade.
2110. Soil Aggregate Subbase.
2111. Granular Subbase.
2112. Wick Drains.
2113. Subgrade Stabilization Material.
2115. Modified Subbase.
2116. Full Depth Reclamation.
2120. Fuel Adjustment.
2121. Granular Shoulders.
2122. Paved Shoulders.
2123. Earth Shoulders for Pavements and Bases.
2125. Reshaping Ditches.
2126. Reclaiming Present Surfacing Material.
2127. Reconstruction of Roadbed.
2128. Furnish and Apply Granular Shoulder Material.

Section 2101. Clearing and Grubbing

2101.01 DESCRIPTION.

A. Clearing: Cut and remove trees 3 inches (75 mm) or more in diameter.

B. Grubbing: Remove stumps, including roots, to a depth of at least 12 inches (300 mm).

C. Removal of Logs and Down Timber: Remove logs and down timber encountered on the work.

D. Hedge Removal: Pull or grub hedge fences of Osage Orange or shrubs planted close together in rows. If any individual tree, of those composing a hedge, has a diameter greater than 6 inches (150 mm), it will be measured separately as a tree.

E. Brush and Shrub Removal: Pull or grub trees and shrubs less than 3 inches (75 mm) in diameter, including roots, which are not classified as hedge.

F. Removal of Growing Corn: Cut stalks to a maximum height of 5 inches (125 mm) above the ground, remove the stalks, and thoroughly disk the corn stubble.

G. Vegetation and Rubbish Removal: Remove vegetation and all rubbish encountered on the right-of-way.

H. Field Fence: Remove field fence from the project.

2101.02 MATERIALS.
None.

2101.03 CONSTRUCTION.

A. Remove woody and other herbaceous vegetation, field fences, and rubbish from the right-of-way and from borrow pits furnished by the Contracting Authority. Do not remove field fences, trees, shrubs, and grasses that are to be preserved as indicated in the contract documents or as designated by the Engineer.

B. Unless shown otherwise in the contract documents or ordered by the Engineer, clear and grub the area within the need line, or the entire right-of-way including borrow pits and the area covered by embankments. All of this material which is removed from the project remains the property of the Contractor.

C. Material from clearing and grubbing may be burned according to IAC 567-23.2 and additional local ordinances. The unburned materials may be buried on State of Iowa right of way at locations approved by the Engineer.

D. Material from clearing and grubbing may be processed by such means as chipping of logs, down timber, or brush, for mulching material, or salvaging of logs and down timber for firewood. Other vegetation including corn stubble may be disked into the existing ground surface.

E. Haul the materials from clearing and grubbing (other than field fence) that are not handled on the project to a "yard waste" landfill.

F. Remove field fence from the project. Field fence may be deposited in an appropriate landfill.

2101.04 METHOD OF MEASUREMENT.
Measurement for Clearing and Grubbing, removal, and clean-up of other material in units (calculated to the nearest 0.1 unit) or by area will be as follows:

A. Units.

1. Clearing and Grubbing will be the quantity shown in the contract documents.

- **a.** Trees 3 inches (75 mm) in diameter or greater will be counted and the circumference will be measured at a height of 18 inches (450 mm) above the ground. The diameter will be calculated by measuring the circumference to the nearest inch (10 mm) and dividing by 3.14. See Table 2101.04-1 for identification of units per tree for clearing, grubbing, and clearing and grubbing.
- **b.** Stumps 3 inches (75 mm) in diameter or greater will be counted and the diameter, in inches (millimeters), calculated by determining the average diameter at cutoff. See Table 2101.04-1 for identification of units per stump for grubbing.
- **c.** Logs and down timber 3 inches (75 mm) in diameter or greater will be measured in a manner similar to that used for trees (Item a above). Measurement will be at a point 18 inches (450 mm) from the end of the log with greatest diameter or 18 inches (450 mm) from the base of the tree for down timber for clearing. See Table 2101.04-1 for identification of units per log and down timber for clearing.
- **d.** Hedge rows will be measured in linear feet (meters) and converted to units using a rate of 30 units per station1 unit per meter of hedge row.
- **e.** Brush will be measured in square feet (square meters) and converted to units by using a rate of 0.8 units per 100 square feet (0.1 unit per square meter) of brush.
- **f.** Growing corn will be measured in square feet (square meter) and converted to units by using a rate of 0.2 units per 100 square feet (0.02 units per square meter) of growing corn.
- **g.** Vegetation removal will not be measured for payment.
- **h.** Field fence removal, included in clearing and grubbing, will be measured in stations (meters) and converted to units at a rate of 6.0 units per station (0.2 units per meter) of fence.

2. For each tree or stump counted as identified in Items a, b, and c in Paragraph 1 above, units will be determined as identified in Table 2101.04-1.

Table 2101.04-1: Clearing and Grubbing Units

	Unit		
Size Diameter	**Clearing**	**Grubbing**	**Clearing and Grubbing**
3 in. to 6 in. inclusive (75 mm to 150 mm inclusive)	0.5	1.1	1.6
Over 6 in. to 9 in. inclusive (Over 150 mm to 225 mm inclusive)	1.1	2.8	3.9

Over 9 in. to 12 in. inclusive (Over 225 mm to 300 mm inclusive)	1.9	4.8	6.7
Over 12 in. to 15 in. inclusive (Over 300 mm to 375 mm inclusive)	2.8	6.6	9.4
Over 15 in. to 18 in. inclusive (Over 375 mm to 450 mm inclusive)	4.7	8.8	13.5
Over 18 in. to 24 in. inclusive (Over 450 mm to 600 mm inclusive)	8.4	13.6	22.0
Over 24 in. to 30 in. inclusive (Over 600 mm to 750 mm inclusive)	11.4	17.6	29.0
Over 30 in. to 36 in. inclusive (Over 750 mm to 1000 mm inclusive)	22.0	28.0	50.0
Over 36 in. to 42 in. inclusive (Over 1000 mm to 1150 mm inclusive)	30.0	50.0	80.0
Over 42 in. to 48 in. inclusive (Over 1150 mm to 1300 mm inclusive)	40.0	80.0	120.0
Over 48 in. to 60 in. inclusive (Over 1300 mm to 1600 mm inclusive)	60.0	100.0	160.0
Over 60 in. to 72 in. inclusive (Over 1600 mm to 2000 mm inclusive)	80.0	120.0	200.0
Over 72 in. (Over 2000 mm)	120.0	160.0	280.0

B. Area.

1. The area in acres (hectares) will be based on that shown in the contract documents, computed from a need line, or computed from a right-of-way line if the limits are not shown for this item in the contract documents.

2. Within these limits, an item for clearing and grubbing in units will not be measured for payment.

2101.05 BASIS OF PAYMENT.

Payment for Clearing and Grubbing, removal of trees, stumps, logs and down timber, hedge rows, brush, field fence, and growing corn will be made at the contract unit price per unit or per acre (hectare) as indicated below. If the Contractor is required to save material less than 6 inches (150 mm) in diameter or to process material saved to an extent greater than is necessary to produce neat piles, this extra saving and processing is considered extra work and payment will be as provided in Article 1109.03, B. Removal and disposal of household rubbish and other nonhazardous rubbish is considered extra work and payment will be as provided in Article 1109.03, B.

A. Units.
Number of units satisfactorily completed.

B. Area.
Number of acres (hectares) satisfactorily completed.

Section 2102. Roadway and Borrow Excavation

2102.01 DESCRIPTION.
Excavate, haul, place, compact, and shape construction materials.

2102.02 MATERIALS.

A. Class 10.
Includes:
- Normal earth materials such as loam, silt, gumbo, peat, clay, soft shale, sand, and gravel.
- Fragmentary rock or boulders handled in the manner normal to this class of excavation.
- Any combination of the above described materials and any other material not classified as Class 12 or Class 13.

B. Class 12.
Includes:
- Granite, trap, quartzite, chert, limestone, sandstone, hard shale, or slate in natural ledges or displaced masses.
- Rock fragments or boulders which occur on the surface or in subsurface deposits mixed with earth, sand, or gravel when their size, number, or location prevents them from being handled in a manner normal to Class 10 excavation.

C. Class 13.
Includes all materials included under the definitions of Classes 10 and 12 and any other material encountered, regardless of its nature.

D. Borrow.

1. Select Treatment Material.

a. Cohesive Soils.
Meet all of the following requirements:
1) 45% or less silt size fraction.
2) 110 pcf (1750 kg/m^3) or greater density (AASHTO T 99 Proctor Density).
3) Plasticity index greater than 10.
4) A-6 or A-7-6 soils of glacial origin.

b. Granular Soils.
Meet all of the following requirements:
1) 15% or less silt and clay.

2) 110 pcf (1750 kg/m^3) or greater density (AASHTO T 99 Proctor Density).
3) Plasticity index, 3 or less.
4) A-1, A-2, or A-3 (0).

c. Special Backfill Material Material.
Meet the requirements of Section 4132

2. Suitable Soils.

a. Ensure all soils provided for the construction of embankments meet the requirements below. They are suitable when moisture control or moisture and density control is designated.
1) 95 pounds per cubic foot (1500 kg/m^3) or greater density (AASHTO T 99 Proctor Density).
2) AASHTO M 145-91 index of less than 30.

b. Soils not meeting these requirements are considered unsuitable soils.

c. When placing soil below water, use clean granular material.

3. Unsuitable Soils.
Unsuitable soils shall be placed in the work only as specified by Standard Road Plan RL-1B or shall be removed as directed by the Engineer. Use in the work will be according to the definitions in Table 2102.02-1:

Table 2102.02-1: Uses for Unsuitable Soils

Definition	Use
1. Peat or Muck. **2.** Soils with a plasticity index of 35 or greater. **3.** A-7-5 or A-5 having a density less than 85 pcf (1350 kg/m^3) (AASHTO T 99 Proctor Density).	Slope Dressing Only.
1. All soils other than A-7-5 or A-5 having a density of 95 pcf (1500 kg/m^3) or less (AASHTO T 99 Proctor Density). **2.** All soils other than A-7-5 or A-5 containing 3.0% or more carbon.	Type C placement placed 3 feet (1 m) below top of subgrade in fills.
1. A-7-6 (30 or greater). **2.** Residual clays (overlaying bedrock) regardless of classification.	Type B placement placed 5 feet (1.5 m) below top of subgrade in fills.
1. Shale. **2.** A-7-5 or A-5 soils having a density greater than 86 pcf (1351 kg/m^3) but less than 95 pcf (1500 kg/m^3) (AASHTO T 99 Proctor Density).	Type A placement placed in layers 5 feet (1.5 m) below top of subgrade in fills (Alternate layers to consist of suitable soils or Type C placement soils).

E. Selected Backfill Material.
Shown in the contract documents.

F. Special Backfill Material.
Meet the requirements of Section 4132.

2102.03 CONSTRUCTION.

A. General.

1. Prepare the site and construct the embankment according to Section 2107.

2. Remove materials as indicated in the contract documents and from borrow pits, exclusive of that designated as channel excavation.

3. Remove material necessary to provide suitable approaches from intersecting highways and private entrances.

4. Shape and slope materials for construction of the roadbed, slopes, gutters, and inlet and outlet ditches according to these specifications and the alignment, grade, and cross sections shown in the contract documents or established by the Engineer.

5. Before beginning construction, remove grass, weeds, other herbaceous vegetation, and rubbish as provided in Article 2102.03, G.

6. Work around utility poles if it is impractical to remove them before excavation or embankment construction.

B. Classification of Excavation.

1. Class 10 Excavation.
Excavate Class 10 material.

2. Class 12 Excavation.
Excavate Class 12 material.

3. Class 13 Excavation.
- **a.** Excavate Class 13 material. This classification covers work commonly referred to as "Unclassified Excavation". Use or remove Class 13 material as provided for in the contract documents.
- **b.** The contract documents will specify the limits for Class 13 excavation. Excavation within these limits will not be classified as Class 10 or Class 12 excavation.

C. Removal and Placement of Boulders.

1. Remove or bury boulders. Remove, where necessary, surface collections of boulders within the limits of the work for satisfactory completion of the work.

2. After completion of excavation operations, collect loose boulders and rocks. Also collect pieces of broken PCC that have a vertical projection 4 inches (100 mm) or more above the surface or the ground, or have a minimum diameter of 6 inches (150 mm) and that appear during the finishing operation.

3. Boulders, except those handled in a way normal to Class 10 excavation, will be classified as Class 12 excavation. Unless otherwise specified, place boulders in any of the following ways:

- **a.** Boulders too large to be loaded and hauled with available equipment may be buried in locations where they will not be exposed by erosion. Ensure that boulders buried this way are covered with at least 1 foot (0.3 m) of earth. Excavation made for the purpose of burying boulders will not be measured or paid for.
- **b.** Boulders or rock fragments may be used in construction of embankments provided they are covered with at least 1 foot (0.3 m) of earth and they do not interfere with specified compaction of the embankment. If boulders delivered to the embankment in combination with finer material interfere with compaction, remove and place them as provided in this article.
- **c.** If the quantity of boulders or rock fragments available at any one time is more than 100 cubic yards (100 m^3), the material may be placed in the embankment no less than 2 feet (0.6 m) below the finished grade line according to Article 2107.03, J. Cover with at least 2 feet (0.6 m) of earth on slopes.

4. Boulders not placed as provided above may, with approval of the Engineer, be:

- **a.** Used for filling gullies.
- **b.** Racked in neat compact piles at locations the Engineer designates within the right-of-way and accessible from the traveled way.
- **c.** Buried within the right-of-way at locations the Engineer designates.

D. Removal of Unsuitable or Unstable Soil and Placement of Selected or Special Backfill Material.

1. Removal of unsuitable or unstable soil or placement of selected or special backfill material, or both, may be required in the contract documents or by the Engineer.

2. If the finished grade line leaves a subgrade of unsuitable or unstable soil, the Engineer may require the Contractor to remove that soil as below grade excavation and place backfill material to the finished grade line. Material encountered above the elevation of finished subgrade which cannot be properly consolidated in the embankment may be designated as unstable soil by the Engineer. If the surface on which the plans indicate that selected or special backfill material is to be placed is such that it will be seriously distorted by hauling equipment, the Engineer may designate this material as unstable.

3. Remove unsuitable or unstable soil and place selected or special backfill material according to the following requirements:

a. Removal of Unsuitable or Unstable Soil.

1) Remove these soils to the elevation shown in the contracts documents or as directed by the Engineer. Remove and place them as directed in the contract documents or by the Engineer and, in the case of unsuitable soils, according to Article 2107.03, N.

2) Conduct operations so that the Engineer is given the opportunity to take cross sectional measurements required before the backfill material is placed.

b. Backfill Materials.

1) Obtain selected backfill materials from locations shown in the contract documents or as directed by the Engineer.

2) Furnish special backfill material that meets the requirements of Article 2102.02, F. Place salvaged materials used as special backfill material in uniform lifts no more than 6 inches (150 mm) thick. Place salvaged composite material used as special backfill material in uniform lifts of no more than 6 inches (150 mm) thick.

c. Placement of Backfill Material.

1) Place special or selected backfill material in areas shown in the contract documents or as directed by the Engineer. Place and compact as provided in Section 2107 with the following modifications:

a) Where compaction with moisture and density control or with moisture control is required, ensure the moisture content of special backfill material is within the limits specified.

b) When select backfill material is placed for subgrade treatment purposes, compact using moisture control.

2) Ensure the moisture content of backfill material is uniform. If necessary, adjust by processing in an approved pugmill or by adding water and road mixing in place prior to spreading and compacting.

a) Use selected backfill material that at the time of spreading and compacting is no drier than 2.5 percentage points below the optimum moisture shown in the contract documents. If not shown, the Engineer will determine the optimum moisture.

b) Use special backfill material that at the time of spreading and rolling is no drier than 2 percentage points below, and does not exceed, the maximum amount that will permit obtaining required compaction without rutting.

3) When 2 feet (0.6 m) or more of selected or special backfill material is placed in areas where unstable soils have been excavated, the condition of the underlying soil may limit the amount of compaction to be done in the bottom 1 foot (0.3 m) of subgrade treatment. In exceptionally wet or unstable areas, the Contractor may be permitted to end dump the first 1 foot

(0.3 m) of treatment material and doze it into position with only partial compaction, as directed by the Engineer. Compact the material above the bottom 1 foot (0.3 m) as provided above.

4) When less than 2 feet (0.6 m) of selected or special backfill material is placed in areas of exceptionally wet or unstable soils, the Engineer may require a tamping type roller to be used for compaction of the material placed in the first foot (0.3 m) of thickness.

E. Rock Cuts.

1. When excavation to the finished grade line results in a roadbed surface consisting of loose or solid rock, excavate 1 foot (0.3 m) below the finished grade of the roadbed. Place backfill material to the required grade with suitable earth. Subject to the Engineer's approval, the earth backfill material may be obtained from any point within the right-of-way where suitable backfill material material is available. Conduct operations so that the Engineer is given the opportunity to take cross section measurements required before backfill material is placed.

2. When presplitting of rock cuts is required, refer to Section 2103.

3. The contract documents may require that part or all of the Class 12 Excavation be crushed. When crushing is required, crush the rock to the size or gradation, or both, specified in the contract documents. Stockpile or use the crushed materials as specified in the contract documents.

F. Borrow.

1. General.

a. Unless provided otherwise in the contract documents, when the quantity of material required for embankments is not available within the limits of the roadway cross sections or specific borrow areas as indicated, make up the deficiency from borrow areas the Contracting Authority provides and defines on the plans or furnish equivalent material from alternate borrow areas (in lieu of plan borrows) or Contractor furnished borrow.

b. The following definitions apply to this specification:

1) Designated Borrow Areas.
A general term for borrow areas the Contracting Authority provides; including mandatory and optional borrow areas.

a) Mandatory Borrow Areas.
An area provided by the Contracting Authority from which the Contractor is expected to obtain borrow material and to operate in the area according to the contract documents. Mandatory borrow areas will be designated in the contract documents.

b) Optional Borrow Area.
An area provided by the Contracting Authority from which the Contractor may obtain borrow material. If so obtained,

the Contractor is expected to operate in the area according to the contract documents. Borrow areas are optional borrow areas unless specifically designated as mandatory borrow areas.

2) Alternate Borrow Areas.
An area outside the highway right-of-way provided by the Contractor from which the Contractor may obtain borrow material in lieu of designated borrow areas and to be used according to the contract documents.

3) Contractor Furnished Borrow.
A general term for borrow material provided by the Contractor. The type of material shall be as specified in the contract documents. If the type of material is not specified, provide Suitable Soils. Contractor may elect to provide Select Treatment Material in lieu of Suitable Soils.

c. Upon completion, excavate borrow areas that are sufficiently regular in cross section to permit accurate measurement. Carefully blend to natural land forms and avoid unnecessary damage to the land. Do not turn natural drainage of surface water on to adjoining owners. Use diligence in draining the surface water in its natural course or channel. Complete excavation consistent with the existing natural drainage conditions or as shown in the contract documents.

d. Where a mandatory borrow area is designated in the contract documents, it is mandatory that borrow material be obtained from the borrow location designated and in accordance with the borrow design on the contract documents, unless permission is obtained from the Engineer to obtain borrow from another location.

e. Unless the contract documents designate borrow areas as mandatory borrow areas, borrow areas will be considered optional borrow areas. The Contractor has the option of either using the optional borrow areas or proposing to furnish equivalent material from alternate borrow areas.

2. Contactor's Plan.

a. Submit a plan to the Engineer for use of proposed alternate or designated borrow intended to be used in a manner different from that shown in the contract documents. Also, sample the proposed alternate borrow areas by core drilling or test pits. When the Contracting Authority determines it is necessary, sample in the presence of the Engineer. Test samples and ₽provide results and verification samples to the Contracting Authority

b. The submission for use of alternate borrow areas shall include all such areas necessary or contemplated for completion of the planned work.

c. Approval of materials and their use will be based on AASHTO M 145-91 and includes the following:

1) Select Treatment Materials.

a) The Engineer's approval is required for all soils required for select subgrade treatments. The Contractor may elect

to substitute with special backfill material or modified subbase material at one-half the required rate at no additional cost to the Contracting Authority. If special backfill material or modified subbase material is used in lieu of select material, the Contractor shall provide for suitable surface and subsurface drainage of this material and provide suitable soils in lower portion of original subgrade treatment layer at no additional cost to the Contracting Authority.

(1) Cohesive Soils.
Meet the requirements of Article 2102.02, D, 1, a.

(2) Granular Soils.
Meet the requirements of Article 2102.02, D, 1, b.

(3) Special Backfill Material.
Meet the requirements of Section 4132.

(4) Modified Subbase Material.
Meet the requirements of Section 4123.

b) Use select treatment sources with sufficient uniformity and size to assure that complete individual treatment areas will be constructed with similar material. Substitution of treatment types (cohesive, granular, special backfill, or modified subbase material) will be allowed only with the Engineer's permission.

2) Suitable Soils.
Meet the requirements of Article 2102.02, D, 2.

3) Unsuitable Soils.
Meet the requirements of Article 2102.02, D, 3.

4) Other Materials.
Place materials not covered above as required by Standard Specifications.

d. The Engineer may decline approval of an alternate borrow area when:

1) Necessary clearances cannot be obtained prior to the time scheduled for commencement of work.

2) Restrictions attached to clearances will delay or interfere with scheduled completion of work or may result in less than necessary quantities of required borrow materials.

3) Contractor's plan for use of borrow areas, including Contractor's verification of quantity and quality of required material, is not sufficient to assure availability of required material.

4) Contractor's proposed plans fail to meet requirements of the contract documents.

e. The Engineer will be allowed time to evaluate each alternate borrow area. If the clearance is not obtained within 30 calendar days, the proposed use of that borrow area may be rejected. During this evaluation period, the Contractor will not be charged for working days the Contractor does not work because the Contractor cannot use the borrow area.

f. The maximum allowance for each contract is not to exceed 30 working days. This allowance will not apply to work for which an intermediate completion time is specified. It will be given only when the delay will not interfere with others authorized to work on the project. It does not increase the Engineer's responsibility to provide coordination.

g. The Contracting Authority will not be responsible for damages due to a delay in approval of an alternate borrow area or when approval of an alternate borrow area is declined.

3. Contractor Provided Clearances.

Obtain and provide Engineer necessary environmental, archaeological, and historic preservation clearances and comply with all restrictions attached to these clearances for alternate borrow areas and sites where Contractor furnished borrow is obtained. Obtain other licenses and permits involved in the proposed use of these areas.

4. Restoration.

a. Optional borrow areas shown on the Contractor's plan shall be left in at least as good a condition as that required by the contract documents for designated borrow areas. This applies whether all or only a part of the site or the material is used for borrow.

b. Use and rehabilitate optional borrow areas andalternate borrow areas (unless Contractor and landowner have agreed to the final design of the alternate borrow area) so that:

1) The sites can continue to be used for the purpose for which they were used prior to removal of borrow.

2) The sites may still be used for those higher and more profitable or better potential uses to which the site might have been put to prior to removal of borrow material.

c. The Engineer will require restoration according to 314.12, Code of Iowa, to meet the above requirement. The overall Contractor's plan shall neither detract from nor interfere with the air, light, and view of motorists nor of adjacent landowners.

5. Obligations and Payment.

Use of an alternate borrow area shall not increase future obligations or total cost to the Contracting Authority. Complete all excavation from the roadway and the mandatory borrow areas.

6. Starting Work.

Except for exploratory purposes, do not start work and take material from an alternate borrow or a Contractor furnished borrow area until after:

- The Engineer approves the borrow proposal in writing, and
- Providing the Engineer with a written release executed by the property owner and the Contractor relieving the Contracting Authority of any and all obligations to the property owner and saving the Contracting Authority harmless from all claims for injury

to persons or damage to property resulting from the Contractor's operations.

7. Material Verification.
Material supplied from alternate borrow areas or Contractor furnished borrow may be verified by the Contracting Authority for compliance with these requirements. When testing by the Contracting Authority is required, a minimum of 10 working days is necessary for testing. When the Engineer orders, remove and replace material verified not in close compliance with these requirements, at no additional cost to the Contracting Authority.

G. Placement of Surplus Material.
Place excavated surplus material as directed by the Engineer. Use to widen adjacent embankments, flatten sideslopes, or construct berms according to Article 2107.03, L.

H. Provisions for Drainage.

1. Construct intercepting ditches as shown in the contract documents.

2. In cuts alongside hills where there is a possibility of surface water causing damage to the backslope of the cut, construct intercepting ditches with appropriate flume outlets to intercept surface water. Where surface water or water from side ditches would otherwise follow the toe of the embankment slope, direct the water away from the toe of the slope with runout ditches.

3. When the Engineer requires locating tile of lines, construct trenches and place backfill material at locations shown in the contract documents or as directed by the Engineer. Construct a continuous trench having a minimum depth of 5 feet (1.5 m) and a minimum width of 4 inches (100 mm). Construct trenches outside the limits of the embankment. The Engineer will examine the trench and excavated material to locate tile lines. Do not start placing backfill material without the Engineer's approval. Place backfill material in all trenches.

4. If, during the course of the work, the natural flow of surface waters or artificial drains is interrupted, provide temporary drainage facilities needed to prevent damage to public or private property. Restore the original drainage facilities as soon as the work will permit. The Contractor is fully liable for all damages arising from action or inaction in providing for temporary drainage.

I. Protection of Trees and Shrubs.
Ensure trees and shrubs to be preserved are protected from injury during grading operations. The Engineer may require barricades or fences for this purpose.

J. Archaeological Salvage.
Temporarily discontinue operations at sites whenever remains of prehistoric people's dwelling sites, burial sites, or artifacts of historical or archaeological significance are encountered. The Engineer, in conjunction with proper archaeological authorities of the State of Iowa, will promptly examine the exposure and determine the disposition.

K. Finishing.

1. Finish excavation and embankment, including borrow pits, in a high quality manner to the specified or designed grade and cross section. On projects which do not involve a surface course other than a traffic compacted surface, the Engineer may waive setting finishing stakes if grade and cross section are within compliance and appearance and riding qualities are satisfactory. Keep backslopes neatly finished as construction progresses.

2. Keep finishing work as close as possible to construction operations. Ensure stream pollution by soil erosion does not occur. When erosion control items are a part of the contract, the contract documents may specify a completion date for specific areas. When these dates are not specified, complete erosion control work on finished areas within 5 working days after completion of finishing. Keep finishing operations current with other construction operations.

3. Maintain partly finished work. If partly finished work is not maintained in a manner satisfactory to the Engineer, the Engineer may order, in writing, that all other work be discontinued until all finishing and maintenance work is in a satisfactory condition. Before the final acceptance, finish the roadway to the specified or designed line, grade, and cross section.

4. Grade slopes, shoulders, and ditches to the degree obtainable using power equipment operating under favorable conditions and operated by skilled workers. Hand methods of finishing will be required only when satisfactory results are not otherwise obtained.

5. Finish backslopes and foreslopes to conform to the cross section. Remove bulges and fill sags. Unless specifically excluded, roughen backslopes and foreslopes as a final finishing operation, except those which contain sufficient sand or rock to make roughening impractical. Roughen to a minimum depth of 3 inches (75 mm) by scarification, use of a heavy disk, or other suitable means.

6. Operate surface roughening equipment parallel with the toe of the slope. If an objectionable amount of material being roughened rolls down the slope, start the roughening operation at the toe of the slope and proceed in parallel strips up the slope.

7. Construct temporary water pollution control according to Section 2602.

L. Grading for Paving.

1. When grading work is done immediately prior to paving work covered by a separate contract, build the rough grade to the full width of the roadbed. Build with a crown to provide sufficient surface drainage. Construct the roadbed so that the surface is:
   a. Not lower at any point than the elevation of the corresponding pavement subgrade.
   b. Not above this elevation by more than 3 inches (75 mm), except at structures or when required by the contract documents.

2. Earth moving equipment with legal axle loads will be permitted to operate on new pavements or resurfaced roads if the road is not open to general traffic. Earth moving equipment will not be permitted to operate on pavements or resurfaced roads open to general traffic.

3. The above restrictions will not be construed to:
   a. Prevent the Contractor from hauling across pavement with legal loads at locations the Engineer designates.
   b. Prohibit the Contractor from turning across pavement to the opposite shoulder when embankment height or ditch depth prevents turning in the opposite direction.

4. Furnish flaggers as necessary for safe operations, at no additional cost to the Contracting Authority.

2102.04 METHOD OF MEASUREMENT.

A. Measurement for Roadway and Borrow Excavation will be as follows:

1. Excavation.
   a. Cubic yards (cubic meters), as determined by the Engineer, for the quantity of Class 10, Class 12, or Class 13 material excavated from:
      - The roadway,
      - Borrow pits,
      - Areas where unsuitable or unstable soil is shown in the contract documents or designated by the Engineer, and
      - Drainage channels, other than intercepting ditches and flumes.
   b. Except as provided in this article, measurements will be made by cross sectioning of the area excavated before and after excavation. Quantities will be computed from the cross section measurements by the average end area method, which may be generated from aerial photography. The volume of topsoil stripped and salvaged as provided in Section 2105 will be excluded from quantities measured as provided above.
   c. Payment will be made for the quantity of Class 10 excavation shown in the contract documents, adjusted by an increase or decrease in borrow excavation or change in backslope. Should the Contractor or the Engineer desire actual measurement, written

notice shall be given to the other party at any time during the construction period. If actual measurement is requested, the preliminary cross sections and the balance points shown in the contract documents will be used. This method shall be used in conjunction with the quantities shown in the contract documents related to work as provided for in Articles 2107.04 and 2108.04.

d. When embankment-in-place is specified, the Engineer will determine the quantity of materials placed using cross section and end area methods. The quantity for which payment is made will not exceed that necessary to construct the embankment to the neat cross section shown in the contract documents, adjusted for settlement. The Engineer may elect to measure the embankment after selected backfill material and topsoil have been spread and deduct the computed quantities of selected backfill material and topsoils from the quantities of total embankment.

e. Overhaul will not be measured or paid for when excavation is paid for as embankment-in-place. Prior to computation of embankment quantities, the original ground profile and original ground elevations shown on the cross sections will be adjusted to conform as nearly as practical to information obtained from taking elevations on settlement plates.

f. Measurement for boulders or rock fragments classified as Class 12 excavation will be as follows:

1) Boulders buried near the site: individually.

2) Boulders or rock fragments deposited in piles: by the volume of the pile.

3) Boulders or rock fragments handled separately from fine material and placed in embankments or in gullies: in the transporting vehicle.

4) All boulders, rocks, or PCC collected as part of the finishing operations: in the transporting vehicle or in piles.

5) When boulders or rock fragments are mixed with earth, sand, gravel, or other fine material and cannot be handled in a way normal to Class 10 excavation, the total volume of the mixture of rock and fine material will be determined by cross sectional measurements, if practical. If not, the Engineer will estimate total volume. The quantity thus determined will be considered as Class 12 excavation.

6) Boulders or rock fragments handled and deposited in final position in a manner normal to Class 10 excavation will not be measured as Class 12 excavation.

2. Intercepting Ditches and Flumes.
Feet (meters) along their center lines.

3. Selected Backfill Material.
Quantity shown in the contract documents.

4. Special Backfill Material.
- **a.** Tons (megagrams) or cubic yards (cubic meters) of material placed.
- **b.** If measurement by weight (mass) is impractical, the material may be measured by volume in the transporting vehicle. This volume will be converted to tons (megagrams) using a conversion factor the Engineer determines.

5. Water for Embankment Construction.
- **a.** Water for Embankment Construction required by the Engineer: thousands of gallons (kiloliters) by gauging the contents of the transporting vehicle or by metering the supply.
- **b.** Water used in connection with specified compaction with moisture and density control or with moisture control: not measured for payment.

6. Locating Tile Lines.
Distance in stations (meters) of constructing trenches and placing backfill material.

7. Crushing of Class 12 Excavation.
- **a.** Cubic yards (cubic meters) shown in the contract documents.
- **b.** Prior to the start of this work, if either the Engineer or the Contractor desires actual measurement, the Engineer will determine in cubic yards (cubic meters) the quantity of Class 12 Excavation that will be crushed computed from the cross section measurements by the average end area method based on soil borings.

B. Removal of pipe culverts that are not encased in concrete are incidental to excavation and will not be measured or paid for.

2102.05 BASIS OF PAYMENT.

A. Payment for Roadway and Borrow Excavation will be the contract unit price as follows:

1. Roadway and Borrow Excavation.
- **a.** Class 10, Class 12, and Class 13 excavation or embankment-in-place:
  - **1)** Per cubic yard (cubic meter).
  - **2)** Payments are full compensation for:
    - Material excavated in the manner prescribed in these specifications, the preparation of the site for embankment, and the formation and compaction of embankment.
    - Finishing the earth roadway, side ditches, and slopes.
    - Repairing and replacing fences that have been unnecessarily damaged or removed by the Contractor.
    - Incidental work required to make the grading work complete.

b. Excavation work done prior to the staking and cross sectioning of the work by the Engineer: no payment will be made.

c. Below grade excavation:

1) When the contract contains a separate unit price for below grade excavation, all excavation made below grade according to the contract documents or on order of the Engineer will be paid for at the contract unit price for the class of excavation involved.

2) When the contract does not contain a unit price for below grade excavation, the Engineer orders below grade excavation, and the contract documents do not indicate that below grade excavation will be required, it will be paid for:

- At double the contract unit price for Class 10 and Class 13 excavation to a maximum depth of 3 feet (1 m).
- As extra work as provided in Article 1109.03, B, if the depth of Class 10 or Class 13 excavation exceeds 3 feet (1 m).
- At the contract unit price for Class 12 excavation.

d. Excavation involved in rebuilding embankments: by class of excavation involved.

e. Excavation for runout ditches to divert the flow of water from side ditches away from the toe of embankments: paid for at the contract unit price for Class 10, Class 12, or Class 13 excavation, as the case may be.

f. When the contract contains a unit price for Class 10 excavation only and the contract documents do not indicate that Class 12 excavation is to be expected, any necessary Class 12 excavation, either above or below grade, will be paid for at 10 times the contract unit price for Class 10 excavation.

2. Intercepting Ditches and Flumes.

For removal of surface water from side hill cuts into side ditches: per linear foot (meter).

3. Selected Backfill Material.

a. Per cubic yard (cubic meter).

b. Except for water added, payment is full compensation for all work involved in excavating, hauling, and incorporating this material into the roadway.

4. Special Backfill Material.

a. Per ton (megagram) or cubic yard (cubic meter) including water naturally present in the material.

b. Except for water added, payment is full compensation for all work involved in:

- Furnishing material,
- Excavating material,
- Processing material, when the source is designated in the contract documents,
- Hauling this material, and

- Incorporating material into the roadway.

c. If furnished by the Contractor and processed in an approved pugmill to a moisture content satisfactory to the Engineer: per ton (megagram) based on scale weights, including water. If payment is made in the above manner, no separate payment will be allowed for water or its incorporation into the mixture.

d. The contract will have a separate item for Special Backfill, Place Only, in tons (Mg) or cubic yards (m^3), when the Contracting Authority is providing the material or if the material is available from mandatory crushing of pavement or pavement scarification on the contract. The cost of crushing or pavement scarification should be included in the Contractor's price for special backfill material if recycling is not required but the Contractor chooses to crush the pavement removed or scarify the HMA surfacing for special backfill material.

5. Water for Embankment Construction.

a. Water for Embankment Construction added by order of the Engineer: per 1000 gallons (kiloliter).

b. Payment is full compensation for furnishing, transporting, and manipulation to incorporate the water ordered by the Engineer to be applied.

c. If the contract does not contain a unit price for water, and moistening of the material is authorized or ordered, water will be paid for as extra work at the rate of $12.00 per 1000 gallons ($3.20 per kiloliter).

d. Payment will not be made for water used in connection with specified compaction with moisture and density control or with moisture control.

6. Locating Tile Lines.

Per station (meter).

7. Crushing of Class 12 Excavation.

Per cubic yard (cubic meter).

B. When Type B compaction is specified, work performed at the Engineer's direction to dry the material in excess of that obtained by the maximum number of diskings specified in Article 2107.03, F shall be performed as extra work as provided in Article 1109.03, B.

C. Extra compensation will not be allowed for working around utilities.

D. Work performed in connection with preservation of archaeological salvage will be paid for as provided in Article 1109.03, B.

E. If the contract does not include an item for Stripping, Salvaging, and Spreading Topsoil (Section 2105), such work the Engineer orders will be paid for at 1.5 times the contract unit price for Class 10 excavation.

Section 2103. Presplitting and Production Blasting of Rock Slope Cuts

2103.01 DESCRIPTION.

A. These specifications cover the work of presplitting a rock slope cut by establishing a free surface in the rock by the controlled use of explosives placed in properly aligned and spaced drill holes. The contract documents may specify more than one elevation level of pre-split holes.

B. These specifications also cover the work of production blasting an area to be excavated by the controlled use of explosives placed in properly aligned and spaced drill holes.

2103.02 MATERIALS.

A. Furnish blasting material for presplitting complying with the explosive manufacturer's instructions.

B. Furnish granular stemming material specified by the explosive manufacturer.

2103.03 CONSTRUCTION.

A. Removal of Material above the Top Pre-Split Hole Line Elevation. Remove all material above the top elevation of the first level of pre-split drill holes according to Section 2102.

B. Presplitting.

1. For each elevation level of pre-split holes, align the pre-split holes so that a finish slope is cut within reasonably close conformity with the design slope specified in the contract documents. Space a line of pre-split holes so that uniform shear occurs between holes with minimum disturbance of the rock cut face. Use a maximum spacing between pre-split holes of 48 inches (1.2 m).

2. For each elevation level of pre-split holes, drill each hole with a maximum length of 40 feet (10.5 m). Drill each pre-split hole with a maximum diameter of 3.5 inches (90 mm).

3. Use blasting procedures for presplitting complying with the explosive manufacturer's instructions. Before placing the explosive charge, determine that the hole is free of obstructions for the depth of the required cut. Do not use explosives for which the maximum diameter is greater than one-half the diameter of the hole.

4. After explosive charges have been placed in the pre-split holes and prior to detonation, place backfill consisting of granular stemming material in the holes to contain the explosion. Ensure backfill consisting of stemming material is placed in all voids that may be present in the pre-split holes. If it is not possible to place this backfill material in a void,

place the explosive charges in the hole so that detonation does not occur within the void area.

5. For each elevation level of pre-split holes, the Contractor may set or detonate explosive charges the full length of the pre-split line or sections of the pre-split line. If detonation is by sections, extend the detonation for each section of pre-split line at least 50 feet (15 m) past each production blast area or to the end of the pre-split line. Simultaneously detonate all explosive charges within the pre-split line or section.

C. Production Blasting.

1. For each elevation level of pre-split holes, place production blasting holes in a pattern so that material suitable for excavation will be produced adjacent to the pre-split hole lines. Do not place production holes within 8 feet (2.4 m) of the pre-split hole line, except when otherwise approved by the Engineer. For each elevation level of pre-split holes, drill production blasting holes no deeper than the minimum depth pre-split hole.

2. Use blasting materials and procedures for production blasting that comply with the explosive manufacturer's instructions. Contain the explosion by placing backfill material consisting of granular stemming material (or use another suitable method), as specified by the explosive manufacturer and as approved by the Engineer, in the production blasting holes after placing the explosive charges and prior to detonation.

3. Detonate the explosive charges in a production blast area separately from the detonation of explosive charges of an adjacent pre-split line section. The Contractor may use appropriate time delays when detonating the explosive charges of the production blast area and an adjacent pre-split line section if:

- The pre-split line section is fired first, and
- Production blasting progresses so that the holes nearest the pre-split line are fired last.

4. After detonation, excavate material in the production blast area as Class 12 Excavation according to Section 2102.

2103.04 METHOD OF MEASURMENT.

A. Measurement for Presplitting of Rock Cuts will be square yards (square meters) determined by calculating the area of the pre-split face.

B. Measurement for the work of removing material above the top elevation of the first level of pre-split holes will be for the specified class of excavation according to Article 2102.04, A.

C. Production blasting (including drilling holes, setting and detonating explosive charges, and removing material from the production blast area) will not be measured separately, but will be measured as part of the Class 12 Excavation according to Article 2102.04, A.

2103.05 BASIS OF PAYMENT.

A. Payment for Presplitting of Rock Cuts will be the contract unit price per square yard (square meter) as determined according to Article 2103.04 of this specification.

B. Payment is full compensation for:
- All labor, equipment, and materials necessary to drill the pre-split holes,
- Placing explosive charges, and
- Detonating explosive charges to produce a finished acceptable slope cut for each elevation level of pre-split holes.

C. Payment for the work of removing material above the top elevation of the first level of pre-split holes will be for the class of excavation specified in the contract documents according to Article 2102.05, A, 1.

D. Payment for the work of production blasting, including drilling holes, setting and detonating explosive charges, and removing material from the production blast area, will be as part of Class 12 Excavation according to Article 2102.05, A, 1.

Section 2104. Channel Excavation

2104.01 DESCRIPTION.
Excavate channels or remove and place material involved in channel changes, or similar excavation not normal to Class 10, Class 12, or Class 13 excavation.

2104.02 MATERIALS.
Specified in the contract documents or designated by the Engineer.

2104.03 CONSTRUCTION.

A. Excavate channels or remove and place material involved in channel changes, or similar excavation not normal to Class 10, Class 12, or Class 13 excavation, as shown in the contract documents. Place this material as shown in the contract documents or as directed by the Engineer.

B. Channel excavation is classified as follows:

1. Class 10 Channel Excavation: refer to Article 2102.03, B, 1.

2. Class 12 Channel Excavation: refer to Article 2102.03, B, 2.

3. Class 13 Channel Excavation: refer to Article 2102.03, B, 3.

2104.04 METHOD OF MEASUREMENT.
Measurement for Class 10, Class 12, and Class 13 Channel Excavation will be the number of cubic yards (cubic meters) determined as prescribed in Article 2102.04.

2104.05 BASIS OF PAYMENT.

A. Payment for Class 10, Class 12, and Class 13 Channel Excavation will be the contract unit price per cubic yard (cubic meter).

B. Payment is full compensation for excavating and placement of the material within the free haul limit of 1000 feet (300 m), and for furnishing all equipment, tools, labor, and incidentals necessary to complete the work.

Section 2105. Stripping, Salvaging, and Spreading Topsoil

2105.01 DESCRIPTION.

A. Strip topsoil and prepare sod.

B. Haul, deposit, and spread topsoil.

2105.02 MATERIALS.
None.

2105.03 CONSTRUCTION.
Remove topsoil from borrow pits, cuts, or areas to be covered by embankments. Prepare sod. Haul, deposit, and spread topsoil on shoulders, slopes, excavated areas, borrow pits, and other designated areas according to the contract documents.

A. Sod Preparation.
Mow, burn, or remove, weeds, grass and growing crops or other herbaceous vegetation close to the ground as directed by the Engineer. Shred sod by shallow plowing or blading and thoroughly disking. Shred sod thoroughly enough to permit the soil to be easily spread in a thin layer over areas to be covered.

B. Topsoil Excavation.
After existing sod has been prepared, remove the topsoil to the depth specified. If not otherwise specified, the depth shall be 12 inches (0.3 m). The topsoil may be moved directly to an area where it will be used or may be stockpiled for future use.

C. Placing Topsoil.
Spread topsoil uniformly over the area to be covered. Smooth the surface of the topsoil and leave in a finished condition so that it will drain properly.

2105.04 METHOD OF MEASUREMENT.

A. The number of cubic yards (cubic meters) of topsoil moved will be computed on the basis of a uniform 12 inch (0.3 m) cut, or the depth as specified in the contract documents, over the area involved. Sufficient field measurements will be taken to assure reasonable conformity with the required depth of cut.

B. Topsoil salvaged from excavated areas and paid for as topsoil will not be included in excavation quantities for which payment is made.

2105.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price per cubic yard (cubic meter).

B. Payment is full compensation for preparing, stripping, transporting, and placing the topsoil according to the contract documents.

C. Overhaul will not be paid for this item.

Section 2106. Settlement Plates

2106.01 DESCRIPTION.

Furnish and install settlement plates consisting of a base plate, steel bar, steel riser pipe sections, PVC casing, inspection cover, and additional hardware and couplers which may be required as shown in the contract documents. The number of settlement plates will be shown in the contract documents.

2106.02 MATERIALS.

Meet the requirements of Division 41.

A. Base Plate and Steel Bar.
Apply Section 4153.

B. PVC Casing.
Apply Section 4149.

2106.03 CONSTRUCTION.

A. General.

1. Furnish and install settlement plates at the locations specified in the contract documents.

2. Obtain the Engineer's approval for settlement plates before beginning embankment construction.

B. Initial Installation.

1. Install the base plate at least 6 inches (150 mm) below natural ground, firmly seated on a level surface. Place the PVC casing on the base plate, centered on the steel bar attached to the base plate. Fill the void between the casing and bar with commercial grade oakum, tightly packed, in order to keep the casing centered on the bar.

2. Construct an inspection cover as shown in the contract documents and place over the top of the casing. Leave the cover in place at all times, except when inspecting or monitoring the riser pipe.

C. Adding Extensions.

1. Add riser pipe extensions and couplers, as necessary, in 3 foot (1 m) increments as construction of the embankment progresses. Install extensions in a plumb line.

2. Add sections of PVC casing and couplers, as necessary, in order to prevent fill material from coming into contact with the steel pipe extensions.

D. Final Cleanup.

1. After all embankment construction and monitoring has been completed, adjust the tops of the riser pipe and PVC casing so they terminate below the final elevation of the embankment.

2. Remove riser pipe sections protruding above the surface of the embankment. Then cut the PVC casing at a point below the surface of the embankment. Cover with a PVC cap, solvent welded to the casing, in order to prevent the intrusion of soil and water.

E. Monitoring.
The Engineer will determine elevations of settlement plates in accordance with Article 2526.03, G.

F. Limitations.

1. Take all necessary precautions to keep the alignment of the riser pipe and PVC casing in a plumb position.

2. Operate equipment so that the riser pipe and PVC casing are not damaged, displaced, or tilted out of plumb. Repair or replace all pipes that are damaged, displaced, or tilted out of plumb, at the discretion of the Engineer (at no additional cost to the Contracting Authority.)

2106.04 METHOD OF MEASUREMENT.
Settlement plates will not be measured directly for payment.

2106.05 BASIS OF PAYMENT.
Furnishing, installing, and extending settlement plates is incidental to embankment or excavation.

Section 2107. Embankments

2107.01 DESCRIPTION.

A. Prepare the site.

B. Place and compact excavated materials.

2107.02 MATERIALS.
Specified in the contract documents.

2107.03 CONSTRUCTION.

A. General.

1. Prepare the site, and place and compact excavated materials to the required elevation and cross section shown in the contract documents.

2. If the type of compaction is not specified, Type A compaction will be required.

B. Equipment.
Use equipment that meets the requirements of Section 2001 and the following:

1. Compaction Equipment.
- **a.** When compaction with moisture and density control is not specified, use equipment that meets the requirements of Article 2001.05, A. Other types of compacting equipment may be used as provided in Article 2107.03, G.
- **b.** For compaction of sand or other granular material, use either a:
  - Self propelled pneumatic roller meeting the requirements of Article 2001.05, C, or
  - Self propelled vibratory roller meeting the requirements of Article 2001.05, F.
- **c.** Compact special backfill material with equipment meeting the requirements of Article 2001.05, Paragraphs B, C, D, F, or other types of compacting equipment as provided in Article 2107.03, G.
- **d.** When compaction with moisture and density control is specified, any type of equipment which will produce the desired results may be used for compaction.

2. Equipment for Applying Water.
Apply Article 2001.09.

C. Preparation of the Site.

1. Where the height of proposed embankment at the center line is 5 feet (1.5 m) or less, remove sod (after thorough disking) from the area. Place the sod on the area to be occupied by the outer portion of the embankment as provided in Article 2107.03, D.

2. When an embankment is placed on or against an existing slope which is generally steeper than 3 horizontal to 1 vertical and is more than 10 feet (3 m) high, cut the slope into steps as the construction of the new embankment progresses. Assure that sod or other potential sliding surfaces are removed. Cut each step or series of steps to approximate horizontal planes with vertical slope cut dimensions of no less than 3 feet (1 m).

D. Depositing Embankment Material.

1. Comply with the following:
- **a.** Except for rock fills and granular blankets, deposit embankments in horizontal layers not over 8 inches (200 mm) in loose thickness.
- **b.** Keep the outer portion lower than its center.
- **c.** When construction will be suspended for a period during which rain is likely to occur, smooth the surface to produce a smooth and compact surface to shed water.
- **d.** Deposit soils containing quantities of roots, sod, or other vegetable matter outside of the shoulder line and within the outer 3 feet (1 m) of the embankment.
- **e.** Do not deposit tree stumps and other large woody objects in embankments.
- **f.** Alternate layers of drier soils with wetter soils whenever it is practical to do so without an increase in average haul.
- **g.** Do not construct embankments on frozen ground. Do not use frozen material to construct embankments.

2. Apply the following where Type A or Type B compaction operations are to be used:
- **a.** When the width at the attained height is 30 feet (10 m) or more, divide the area upon which the layer is to be placed into separate and distinct dump areas having widths no less than 15 feet (5 m). If hauling equipment is operated within a dump area, disk the area with a least one pass of a tandem axle disk or two passes with a single axle disk prior to compaction.
- **b.** During compacting operations, keep hauling equipment off dump areas of embankments 36 feet (11 m) wide or more. Empty hauling units may travel on the dump area during compaction operations as necessary to pass loaded hauling units if:
  - Within 36 feet (11 m) of a bridge or other limiting structure.
  - The width of the embankment is less than 36 feet (11 m) at the attained height.

c. If the design width of embankment is less than 30 feet (10 m) at the attained height, hauling units will be allowed to travel through areas where compaction operations are in progress. Ensure hauling equipment passing through compaction operations does not force water, disking, and compacting equipment to deviate from their intended paths.

d. Deposit the material over the dump area as a separate and distinct operation. If the material, as deposited, contains an average of more than 1 lump per square yard (square meter) large enough to have at least one dimension greater than 12 inches (0.3 m), disk the area with at least one pass of a tandem axle disk or two passes of a single axle disk. Use a disk designed and operated to cut and stir to the full depth of the layer.

3. After depositing and disking (if required), smooth the material to a uniform depth using a suitable motor patrol, bulldozer, or self propelled sheepsfoot type roller with a blade attachment. In addition to the initial smoothing, continue smoothing and leveling during compaction as necessary to provide a surface area free from ruts and other objectionable irregularities. The self propelled, sheepsfoot type roller with blade attachment may be used under the following conditions:

a. Leveling is completed according to the prescribed rolling pattern.

b. Compaction is the major function of this unit.

c. Power drums are prevented from spinning.

4. When, in the Engineer's opinion, the unit cannot satisfactorily accomplish both leveling and rolling, use a separate dozer or motor patrol for the leveling operation prior to initiation of compaction.

E. Type A Compaction.

1. Type A compaction refers to compaction requiring a minimum of one rolling per inch (25 mm) depth of each lift. A further requirement is that the roller continues operation until it is supported on its feet, or the equivalent.

2. After smoothing the surface of the layer and before depositing material for the next layer, compact the layer with at least one pass of the sheepsfoot type roller for each inch (25 mm) of loose thickness of the layer. Compact until the roller is supported entirely on its feet. This occurs when the tamping feet penetrate no more than 3 inches (75 mm) into an 8 inch (200 mm) lift or 33% of the depth of the layer being placed.

3. Determine if the moisture content of the material is excessive or suitable for satisfactory compaction. The Contractor may elect to start rolling operations immediately after the smoothing operation, or may elect to delay rolling operations, and instead, aerate the material in preparation for rolling. Proceed with aeration and compaction operations in an orderly fashion without unreasonable and unnecessary delay. Rolling

operations made prior to any aeration operations for a lift will not be counted as any of the required coverages.

4. Should the material be dry to the extent that it is likely to fail to be satisfactorily compacted by rolling, the Contractor may moisten the material. The Engineer may order the material to be moistened uniformly before compacting. Authorization may be given for the use of water in the final finishing of the roadbed.

5. Compensation will not be allowed for delays occasioned by the ordering of moistening or by drying.

6. The Contractor may request approval of other methods and equipment according to Article 2107.03, G.

F. Type B Compaction.

1. Type B compaction refers to compaction requiring a specified number of diskings and roller coverages, or the equivalent.

2. After smoothing the surface of the layer and before depositing the next layer, compact or smooth and compact the layer.

3. If the entire weight (mass) of the roller is supported on its feet after one pass of the roller for each inch (25 mm) of loose thickness of the layer, no further compacting is necessary. A roller will be considered to be supported entirely on its feet when the feet penetrate no more than 3 inches (75 mm) into an 8 inch (200 mm) lift or 33% of the depth of the layer being placed.

4. If the soil in the layer is too wet when it is deposited to compact to the degree that the entire weight (mass) of the roller is supported on its feet, the Engineer may require one disking per 2 inches (50 mm) of loose thickness of the layer in addition to the disking required in the smoothing operation. A disking consists of a complete coverage of the layer with either a tandem axle disk or a single axle disk. Use a disk designed and operated to cut and stir to the full depth of the layer. The Engineer may require an interval no longer than 2 hours between successive diskings. After the disking has been completed, compact the layer with one pass of a sheepsfoot type roller per inch (25 mm) of loose thickness of the layer.

5. The manipulation and compaction specified above is incidental to Class 10 or Class 13 excavation. The Engineer may require additional manipulation and compaction as extra work. If the soil is so dry that it will fail to be satisfactorily compacted by rolling, the Engineer may require the Contractor to moisten the material uniformly before it is compacted.

6. Compensation will not be allowed for delays caused by the ordering of moistening or by disking.

7. The Contractor may substitute Type A compaction at no additional cost to the Contracting Authority where Type B compaction is specified, by written notification to the Engineer, or the Contractor may request approval of other methods and equipment according to Article 2107.03, G.

G. Compaction by Other Methods and Equipment.

1. Other methods of compaction may be used. Demonstrate they will obtain suitable compaction of a variety of soil types and moistures normally encountered. Compaction will be considered suitable if the resulting density, with adequate moisture, is both:

- Reasonably uniform throughout the compacted lift.
- At least 95% of maximum density, determined according to Materials Laboratory Test Method No. Iowa 103.

2. Other types of compacting equipment may be used. Demonstrate they will obtain equivalent compaction results using a variety of soil types and moistures normally encountered. Demonstrations are to be such that results can be compared.

3. For Type A compaction, equivalent compaction must be recognizable by roller penetration or other significant characteristic.

4. For other methods or other equipment, a definite approval will be necessary, including any limitations the Engineer deems advisable.

5. Use of other methods and equipment prior to approval, except for demonstration tests, must provide 6 inch (150 mm) compacted lifts at 95% of maximum density, during which moisture is maintained no drier than 3 percentage points below optimum moisture.

H. Compaction with Moisture and Density Control.

1. The contract documents will show areas in which embankments shall be constructed with moisture and density control. The contract documents will also show the distance below the elevation of the completed grading work to which such methods are to be applied.

2. Where construction with moisture and density control is indicated in cut sections:

a. Excavate the roadbed below proposed subgrade elevation to a plane 6 inches (150 mm) above the elevation shown for the bottom of the moisture and density control section.

b. Thoroughly scarify the remaining 6 inch (150 mm) layer.

c. Increase or reduce the moisture content as necessary to bring the moisture throughout this 6 inch (150 mm) layer within the moisture limits specified.
d. Compact this 6 inch (150 mm) layer to no less than 90% of maximum density determined according to Materials Laboratory Test Method No. Iowa 03.
e. Deposit the remainder of the cut section to the completed grade elevation in layers according to Article 2107.03, D.
f. Uniformly moisten each layer as necessary to bring to within the specified moisture limits.
g. Compact each layer to no less than 95% of maximum density.

3. Where construction with moisture and density control is indicated in embankment sections outside cuts:
a. Deposit in layers, according to Article 2107.03, D, all material in fill above the designated elevation for compaction with moisture and density control.
b. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.
c. Compact the first layer placed with moisture and density control to no less than 90% of maximum determined according to Materials Laboratory Test Method No. Iowa 103.
d. Compact each succeeding layer to no less than 95% of maximum density.

4. Prior to compaction, bring the moisture content of each layer of earth to be compacted with controlled moisture and density to within the specified limits of the optimum moisture content. After field tests determine that a layer is within the specified moisture limits, begin compaction and continue until the required density is obtained. If compaction is interrupted or delayed on a layer, bring the moisture of the layer to within the specified limits before resuming compaction.

I. Compaction with Moisture Control.

1. The contract documents will show:
a. Areas in which embankments are to be constructed with moisture control.
b. The distance below the elevation of the completed grading work to which such methods are to be applied.
c. The moisture limits.

2. Where construction with moisture control is indicated in cut sections:
a. Excavate the roadbed below proposed subgrade elevation to a plane 6 inches (150 mm) above the elevation shown for the bottom of the moisture control section.
b. Thoroughly scarify the remaining 6 inch (150 mm) layer.
c. Increase or reduce the moisture content as necessary to bring the moisture throughout this 6 inch (150 mm) layer within the moisture limits specified.

d. Compact this 6 inch (150 mm) layer as specified in Article 2107.03, E.
e. Deposit the remainder of the cut section in layers according to Article 2107.03, D.
f. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.
g. Compact each succeeding layer as specified in Article 2107.03, E.

3. Where construction with moisture control is indicated in embankment sections outside cuts:
a. Deposit in layers, according to Article 2107.03, D, all material in fill above the designated elevation for compaction with moisture control.
b. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.
c. Compact layers placed with moisture control as specified in Article 2107.03, E.

4. Prior to compaction, bring the moisture content of each layer of earth to be compacted with controlled moisture within the specified limits of the optimum moisture content. After field tests determine that a layer is within the specified moisture limits, begin compaction and continue unit the requirements of Article 2107.03, E, are obtained. If compaction is interrupted or delayed for more than 1 hour on a layer, bring the layer within the specified moisture limits before resuming compaction.

J. Rock Fills.

1. When the excavated material consists of rock fragments too large to be placed in layers of the thickness prescribed without further breaking them down, it may be placed in the embankment in horizontal layers 4 feet (1.2 m) or less in thickness. Place each layer to avoid future water entrapment. In most cases, this will require placement to full embankment width, except for topsoil on the foreslope. Level each layer with a suitable dozer. Smooth each layer by choking the surface of the rock with spalls and finer fragments or earth.

2. Do not construct the 4 foot (1.2 m) lifts above an elevation 2 feet (0.6 m) below the finished grade line. The next foot (0.3 m) of embankment height may be placed in one layer using rock spalls and finer fragments which may be satisfactorily consolidated by the dozer and tractor. For the last foot (0.3 m) below the finished grade line, use either:
- Earth smoothed and placed in layers not exceeding 8 inches (200 mm) thickness and rolled as described above, or
- Special backfill material placed as shown in the contract documents.

3. Conduct operations in such a way that the Engineer is given the opportunity to take cross sectional measurements required before the earth cover is placed.

K. Granular Blankets.

1. Where a granular blanket is specified, spread material meeting the requirements of Section 4133 to the width and thickness shown in the contract documents. Do not use compaction equipment. The blanket may be constructed in several lifts. Do not incorporate foreign material from hauling equipment or other sources.

2. In areas requiring both granular blanket and subdrain backfill material, the sequence of operations will be the option of the Contractor. Ensure that contact areas between porous backfill material, granular material for subdrains, and granular blankets are free from clay or silt.

L. Rebuilding Embankments.

1. Do not place a pavement partly on an old and partly on a newly constructed embankment. Remove the part of the old embankment that would be under the pavement as below grade excavation to the natural ground line, or to a depth of 5 feet (1.5 m) below the proposed grade line, whichever is higher. Rebuild as prescribed for new embankments.

2. Rebuild embankments according to Article 2107.03, C, unless otherwise specified in the contract documents. Compact the material according to Article 2107.03, E.

3. At locations where the width of embankment widening is less than 4 feet (1.2 m), widening material may be placed and shaped to the bottom of pavement or base elevation without compaction other than that obtained with wheels of motor graders and hauling equipment. Placement and compaction may be accomplished in 8 inch (200 mm) lifts parallel to the finished slope, provided the existing slope has been roughened by disking or scarification.

4. In all cases of embankment widening, remove surface vegetation from slopes against which the widening material is to be placed. Deposit this material according to Article 2107.03, D.

M. Compacting Trench Bottom.

When designated in the contract documents, excavate the roadbed for the width shown to 1 foot (0.3 m) below subgrade elevation. Scarify the next 6 inch (150 mm) depth and compact as for Type B compaction, unless otherwise specified. When the bottom of the trench has been compacted, place suitable backfill material in the excavation and compact. If the type of compaction is not specified for this upper 1 foot (0.3 m), Type A compaction will be required on Primary projects and Type B compaction on Secondary projects.

N. Use of Unsuitable Soils.

1. Unsuitable soils may be used in embankments according to Standard Road Plan RL-1B, unless the Engineer directs otherwise.

2. Unless otherwise specified, when used in embankments, spread unsuitable material in uniform layers no more than 8 inches (200 mm) in loose thickness. Cover each layer with a layer or layers of suitable material.

O. Embankments Adjacent to Culverts and Structures.

1. When the contract documents require embankment construction adjacent to a bridge, culvert, or other structure, construct the compacted embankment to the height shown and to the full width of the roadway. Secure material for constructing these embankments from within the right-of-way or authorized borrow area as directed by the Engineer. Waste the material from within the waterway of bridges or culverts which is too wet to be suitable for compaction. Do not place this material in the embankment.

2. Place embankments adjacent to bridges, culverts, and structures with the same precautions and methods described in Article 2402.03, H. The contract documents may require moisture control.

3. Use mechanical or pneumatic tampers for compaction in areas occupied by embankments which are too narrow for the operation of rollers. The Contractor may elect to enlarge the area in which the embankment is to be constructed by cutting down the elevation of the old fill to permit rolling equipment to operate efficiently. When old fill is removed for this purpose, step it up to its original height such that each step has a horizontal dimension no less than 3 feet (1 m) with a vertical rise.

4. Flowable mortar may be placed as backfill material adjacent to bridges, culverts, and structures, at no additional cost to the Contracting Authority. Place this backfill material according to Section 2506.

2107.04 METHOD OF MEASUREMENT.

A. Measurement will be as provided in Article 2102.04. The following will be included in Class 10 excavation:

1. Excavation in preparation for constructing embankment by compaction with moisture control.

2. Excavation in preparation for constructing embankment by compaction with moisture and density control.

3. Excavation in preparation for compacting trench bottom.

4. Excavation in preparation for rebuilding embankment.

B. Embankment construction will not be measured separately for payment except as follows:

1. Compaction with Moisture and Density Control.
Cubic yards (cubic meters) shown on the contract documents as determined by the template fill volume. Shrinkage will not be included in moisture and density control quantity.

2. Compaction with Moisture Control.
a. Cubic yards (cubic meters) shown on the contract documents as determined by the template fill volume. Shrinkage will not be included in moisture control quantity.
b. When moisture control is required adjacent to culverts and stockpasses (Article 2107.03, O) the volume will be computed using the formula in Article 2107.04, B, 4. When moisture control is required adjacent to pipe culverts, the volume will be computed as provided in Article 2402.04.

3. Compacting Trench Bottom.
Stations (meters) shown on the contract documents as determined along the center line of the roadbed.

4. Compacting Backfill Adjacent to Bridges, Culverts, or Structures.
The quantity of backfill material placed and compacted by the grading contractor adjacent to bridges, box culverts, or structures or their extensions will be the quantity obtained by the following formula:

English

$$Q = \frac{(4 \text{ ft.} \times L \times H)}{27}$$

Metric

$$Q = (1.2 \text{ m} \times L \times H)$$

Where:
Q = quantity of compacted backfill material in cubic yards (cubic meters);
L = (1) length in feet (meters) of the culvert or stock pass from back to back of parapet, or
(2) length in feet (meters) from back of existing parapet to back of parapet of the extension;
H = nominal height of structure opening, feet (meters).

5. Granular Material for Blanket and Subdrain.
Cubic yards (cubic meters) according to Article 2312.04, A.

6. Water for Embankment Construction.
Except when compaction with control of moisture and density or moisture is specified, water for embankment construction required for moistening materials to be placed in embankment will be measured in

thousands of gallons (kiloliters) by gauging the contents of the transporting vehicle or by metering the supply. Authorized water for finishing the roadbed will not be measured for payment if a period in excess of 2 calendar days has elapsed between final compaction of a dump area and final finishing of the same area.

2107.05 BASIS OF PAYMENT.

A. Payment for embankment construction will be contract unit price as for Embankment-In-Place according to Article 2102.05, with the following additions:

1. Compaction with Moisture and Density Control.
- **a.** Per cubic yard (cubic meter).
- **b.** Payment is full compensation for the work of drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials to the specified density.

2. Compaction with Moisture Control.
- **a.** Per cubic yard (cubic meter).
- **b.** Payment is full compensation for the work of drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials, as specified.

3. Compacting Trench Bottom.
- **a.** Per station (meter).
- **b.** Payment is full compensation for the work of scarifying, drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials, as specified.

4. Compacting Backfill Adjacent to Bridges, Culverts, or Structures.
Per cubic yard (cubic meter).

5. Granular Material for Blanket and Subdrain.
Per cubic yard (cubic meter).

6. Water for Embankment Construction.
- **a.** Except when compaction with moisture and density control or moisture control is specified, payment for water for embankment construction added at the Engineer's direction will be the contract unit price per 1000 gallons (kiloliter).
- **b.** In case the contract does not contain a unit price for water, and moistening of the material is authorized or ordered, payment for water will be as extra work at the rate of $12.00 per 1000 gallons ($3.20 per kiloliter).
- **c.** When Type A compaction or compacting embankments with moisture and density control or moisture control is specified, manipulation necessary to incorporate water or work necessary to dry the material will be considered as incidental work and will not be paid for separately.

d. When Type B compaction is specified, manipulation necessary to incorporate water will be considered incidental to other work. Work performed at the Engineer's direction to dry or compact the material, in excess of that obtained by the maximum number of diskings and roller coverages specified for Type B compaction, will be paid for as extra work according to Article 1109.03, B.

B. Payment for Compaction with Moisture and Density Control, Compaction with Moisture Control, Compacting Trench Bottom, and Compacting Backfill Adjacent to Culverts and Stockpasses will be for plan quantities in conjunction with quantities shown in the contract documents described in Article 2102.04 and under the conditions described therein.

Section 2108. Overhaul

2108.01 DESCRIPTION.
Transport excavated material from roadway and borrow excavation, from channel excavation, and from excavation for structures a distance in excess of the free haul limit for the kind of excavation involved.

2108.02 MATERIALS.
Specified in the contract documents.

2108.03 CONSTRUCTION.
None.

2108.04 METHOD OF MEASUREMENT.

A. In determining what constitutes necessary haul, it will be assumed that material taken from excavation will be deposited in embankment after having been hauled the minimum possible distance. The haul distance for material moved from borrow outside the roadway will be measured from the center of mass along the shortest route the Engineer determines to be feasible and satisfactory. The haul distance for material obtained from the roadway, including interchanges and intersections, and placed inside the main roadway will be measured along the center line of the roadway.

B. If pavement equipment crossings are designated by the Contractor as provided in Article 1105.12, B, and the contract provides for payment of overhaul on the material involved, overhaul on the material obtained within the roadway will be computed and measured along the center line as described above. Overhaul will be computed and measured on the basis that material taken from excavation was deposited in adjacent embankment after having been hauled the minimum possible distance, irrespective of the number and location of equipment crossings designated by the Contractor. The haul distance for material moved from outside the roadway will be measured along the shortest route the Engineer determines feasible and

satisfactory. It will be assumed that an equipment crossing was designated opposite the point where the haul road enters the roadway.

C. The limits of free haul will be determined from a mass diagram by fixing two points on the volume curve, one on each side of the neutral grade point. One point is placed in excavation and the other in embankment so that the distance between them equals the free haul distance and the included quantity of excavation and embankment balance. Materials within the free haul limit will be eliminated from further consideration. The distance between the center of gravity of the remaining mass of excavation and the remaining mass of embankment, minus the free haul distance, will be the overhaul distance. The quantity of overhaul will be measured in station yards (station meter). A station yard (station meter) is defined as the product of an overhaul distance of 1 station (metric station) multiplied by 1 cubic yard (cubic meter) of material hauled a distance greater than the free haul distance.

D. Unless provided otherwise in the contract documents, the free haul distance will be 1000 feet (300 m).

E. Payment for Overhaul will be for quantities shown in the contract documents in conjunction with quantities shown in the contract documents described in Article 2102.04 and under the conditions described therein. If Class 10 excavation quantities are changed, overhaul quantities will also be subject to change. The Engineer will compute the overhaul change if it can be identified. If not, it will be adjusted by the ratio of adjusted quantities to original quantities shown in the contract documents of Class 10 excavation.

2108.05 BASIS OF PAYMENT.
Payment for the quantity of overhaul, measured as provided above, will be the contract unit price per station yard (station meter) with the following exceptions:

A. Overhaul will not be paid for selected backfill material if it can be secured and used as shown in the contract documents. Should changes from the contract documents cause an increase or decrease in necessary haul, payment will be adjusted for such increase or decrease at the contract unit price per station yard (station meter).

B. If no bid price appears in the contract for overhaul, increased overhaul will be paid for at a unit price agreed to by the Contractor and Engineer, but not to exceed $0.02 per station yard ($0.09 per station meter).

Section 2109. Natural Subgrade

2109.01 DESCRIPTION.
Shape and consolidate a prescribed portion of the subgrade in preparation for the placement of a pavement, pavement widening, base course, or subbase.

2109.02 MATERIALS.
Specified in the contract documents.

2109.03 CONSTRUCTION.

A. Natural Subgrade for Pavement, Pavement Widening, Base Course, or Subbase.

1. Construct the subgrade to have uniform stability for a width at least equal to that of the proposed pavement or base, plus 2 feet (1 m) on each side. Bring to an elevation such that after being rolled the surface is at the required elevation. Before preparing the subgrade, construct the roadbed to the full width and at least to the elevation of the finished subgrade.

2. When the composition or stability of the materials in the top 6 inches (150 mm) below the elevation of the subgrade is not reasonably uniform for the full width of the subgrade, scarify, mix and recompact, or otherwise treat the materials to produce a uniform condition. Meet the requirements of Article 2107.03, E, for recompaction on Primary projects and Article 2107.03, F, for recompaction on Secondary projects. Remove stones 4 inches (100 mm) or larger from the loosened portion of the subgrade. Remove the stones from the project as directed by the Engineer.

3. Fill depressions that develop during rolling with suitable material meeting the requirements of subgrade treatment as specified in the contract documents. Continue rolling until the subgrade is uniformly firm, properly shaped, and true to grade and cross section. Maintain the subgrade as constructed until the pavement is placed. Remove material, other than sand, which will not compact readily under the roller and replace with material which will compact readily. Roll that portion of the subgrade again. Use a roller that meets the requirements of Article 2001.05, B, except for work involving widening of such a width as to make use of a conventional roller impractical. Where a conventional roller is impractical, use a trench type roller meeting the requirements of Article 2001.05, E.

4. Extend rolling of the subgrade for at least 12 inches (0.3 m) outside each edge of the proposed pavement. Do not leave piles or ridges of earth or material on the shoulders that would seriously interfere with the operations of finishing pavement.

5. During the process of constructing subgrade, maintain the soil in a condition sufficiently moist to facilitate compaction and produce a firm, compact surface. Sprinkle or wet the finished subgrade as necessary to ensure a reasonable moisture content at the time pavement or base is placed upon it.

6. If, in preparation of subgrade, it becomes necessary to excavate below the elevation of the earth shoulders, provide ditches or drains at frequent intervals to permit ready drainage of surface water from subgrade to side ditches.

7. Maintain the completed subgrade during subsequent construction activities. Loads in excess of the legal axle load will not be allowed on the completed subgrade. If rutting or any other damage occurs to the subgrade as a result of hauling operations, immediately repair the subgrade. This repair will include, if necessary, scarifying to a depth of 6 inches (150 mm), aerating, and recompacting, all at no additional cost to the Contracting Authority. Meet the requirements of Article 2107.03, E, for recompacting on Primary projects and Article 2107.03, F, for recompacting on Secondary projects.

8. Should traffic by others authorized to do work on the project be specifically permitted by the Engineer to exceed the Contractor's self imposed limit, the Contracting Authority will pay a share of repair costs set by the Engineer representing an increase in cost of repair of damage, if any, caused by such traffic.

9. Complete subgrade preparation sufficiently in advance of pavement or base work so that normal progress can be maintained.

10. Before the final template shape is made, proof roll the subgrade with equipment meeting the requirements of Article 2001.05. Correct depressions that develop using the same procedure as in Article 2109.03, A, 3. If the subgrade is to be cut to the final grade elevation with an automatically controlled subgrade machine, grade the prepared subgrade to an elevation that will permit the machine to accomplish the final cut in one continuous forward pass. The elevation of the subgrade surface will be indicated by grade stakes. Correct the surface in both profile and cross section to within 0.05 foot (15 mm) of the desired elevation. In irregular or short sections, check the subgrade by the most accurate practical method, subject to the Engineer’s approval.

B. Treatment of Subgrade for Concrete Pavement.

Unless the Engineer orders otherwise, ensure the subgrade, at the time of placing concrete for Concrete Pavement (Section 2301) or Concrete Base (Section 2201), is either:

- In a uniform moist, but not muddy condition to a depth of not less than 1 inch (25 mm), or
- Covered with a single layer of plastic film meeting the requirements of Section 4107. Lap adjacent strips of plastic film by at least 12 inches (0.3 m). Do not stretch plastic film to the extent that its width is noticeably reduced. Plastic film which has been used for curing concrete, salvaged in usable condition, may be used for subgrade treatment.

C. Special Compaction of Subgrade.
When special compaction of subgrade is required in the contract documents, construct the portion of the roadbed to be covered by the pavement or base course, plus 3 feet (1 m) beyond the outer limits of the pavement or base course, in the following manner:

1. Expose a planed surface 6 inches (150 mm) below the finished grade line. Soil removed in the operation may be placed along the sides of the roadbed. Place the soil as backfill material in the excavation. Scarify the underlying exposed surface for a depth of 6 inches (150 mm).

2. Pulverize the scarified material to the extent that, when tested, no soil particles will remain on the 2 inch (50 mm) sieve. Uniformly dry or wet the scarified material to a moisture condition which will permit obtaining the required compaction without subsequent rutting from the batch trucks or other paving equipment in the paving area. Immediately stop construction of the pavement if rutting occurs to the extent that the thickness of the flexible or rigid pavement being spread does not conform to the design dimensions. Rework the rutted subgrade before resuming construction of the pavement.

3. Ensure the material at the time of compaction is not drier than 6 percentage points below its optimum moisture. Also ensure the density is not less than 95% of maximum density as determined by Materials Laboratory Test Method No. Iowa 103.

4. Place the material used to bring the subgrade to the required finished profile and cross section according to the above requirements for pulverization, moisture content, density, and stability.

2109.04 METHOD OF MEASUREMENT.

A. Unless provided otherwise, work connected with construction of natural subgrade for pavement, base course, pavement widening, or subbase will not be measured for payment.

B. Special Compaction of Subgrade, in stations (meters), will be the quantity shown on the contract documents. This quantity will be determined along the center line of the roadbed.

2109.05 BASIS OF PAYMENT.

A. Unless otherwise provided, work connected with construction of natural subgrade for pavement, base course, pavement widening, or subbase will not be paid for directly. It is considered as associated work and incidental to the contract unit price for construction of the pavement, base course, or widening.

B. Special Compaction of Subgrade:

1. Payment will be the contract unit price per station (meter).

2. Payment is full compensation for excavating, manipulating, replacing, and compacting the material, and for furnishing all water required for the work.

C. Excavation in excess of 3 inches (75 mm) for preparation of subgrade at locations other than structures or existing pavements will be paid for according to Article 2102.05, or, if no contract unit price is provided, Article 1109.03, B.

D. When adjustments to profile grades cannot be made, fill required for preparation of subgrade at locations other than structures or existing pavements will be paid for according to Article 2102.05, or, if no contract price is provided, Article 1109.03, B.

E. When grading of the subgrade is a part of the contract, additional payment will not be made for excavation or fill necessary for preparation of subgrade.

Section 2110. Soil Aggregate Subbase

2110.01 DESCRIPTION.

Construct soil aggregate subbase using soil from the subgrade combined with mineral aggregate present on the road surface, with the possible addition of aggregate.

2110.02 MATERIALS.

Use granular material that may be present on the roadbed plus the specified quantity of material meeting the requirements of Section 4120.

2110.03 CONSTRUCTION.

A. Soil Aggregate Subbase Equipment.
Use equipment that meets the requirements of Section 2001 and the following:

1. Weighing Equipment.
Apply Article 2001.07.

2. Compaction Equipment.
Apply Article 2001.05 except that other types of equipment may be used provided it is demonstrated they will consistently produce the specified density. Use equipment designed so that its operation will not distort the subgrade.

3. Equipment for Applying Water.
Apply Article 2001.09.

4. Field Laboratory.
Apply Section 2520.

B. Roadbed Correction.
Correct the portion of the roadbed to be used for soil aggregate subbase according to Article 2111.03, B.

C. Soil Aggregate Subbase Construction.

1. The Contractor may be required by the contract documents to furnish granular material for subbase construction in addition to that present on the existing roadbed. Uniformly distribute this additional material over the area to be occupied by the subbase at the rates specified.

2. Blade or scarify the roadbed to the depth necessary to:
- Produce a smooth subgrade matching the cross section shown in the contract documents, and
- Provide the quantity of material which, when combined with the granular material to be added, will produce a compacted subbase of the thickness designated.

3. Adapt the methods and sequence of operations to the width of roadbed and the quantity of granular material to be added in order to achieve the following results:
- **a.** Mix road surface materials and added granular material to the degree that there are no seams or streaks of separate material in evidence from visual inspection, and pulverize so that there are no soil particles larger than 2 inches (50 mm) in greatest dimension.
- **b.** The moisture content of the soil aggregate mixture will be approved on the basis of visual inspection. Uniformly wet or dry the material so that at the time it is spread and compacted it contains the amount of water necessary to obtain the required density, together with stability, with the field compaction process. Maintain the moisture content in the mixture until compaction is completed. Place wetted material in windrows prior to spreading for compaction. Smooth and roll to correct subgrade distortions greater than 1 inch (25 mm) above or below the intended plane of the bottom of the subbase.
- **c.** At railroad crossings, junctions with existing pavement, bridges, and similar structures, excavate the subgrade to permit the full thickness of subbase, base, and surface courses to be constructed to the proper elevation. Omit soil aggregate subbase for a distance of 50 feet (15 m) from railroad crossings, bridges, and existing intersection pavements. In these areas, thicken the specified base sufficiently to replace the omitted subbase.
- **d.** Sprinkle the surface on which the subbase is to be constructed with water as necessary to assure a moist condition to a depth of at least 1/2 inch (15 mm).

4. Spread and shape the prepared subbase material to assure conformance, after compaction, with the cross section shown in the contract documents. Compact the subbase at the moisture content specified in Article 2110.03, C, 3, b, to a density no less than 95% of maximum density as determined by Materials Laboratory Test Method No. Iowa 103. During compaction operations, perform additional shaping as necessary. Apply Article 2111.03, D, to the profile and cross-section.

D. Maintenance of Completed Subbase.
Apply Article 2111.03, E.

2110.04 METHOD OF MEASUREMENT.

Measurement for the quantities of the items associated with soil aggregate subbase will be as follows:

A. Construction of Soil Aggregate Subbase.
Miles (kilometers) shown on the contract documents. This will be determined along the center line of the subbase, including approaches to railroad crossings, bridges, and similar structures. At intersections, the length of subbase will not include that portion of centerline which overlaps previously determined pavement, base course, or subbase.

B. Granular Material.
Tons (megagrams) as computed by the Engineer from the weights (mass) of material delivered. No deduction will be made for moisture naturally occurring in the material.

2110.05 BASIS OF PAYMENT.

Payment will be the contract unit price for the items associated with soil aggregate subbase as follows:

A. Construction of Soil Aggregate Subbase.

1. Per mile (kilometer).

2. Payment is full compensation for:
- Roadbed correction.
- Furnishing and applying water.
- For doing all work necessary for completion of the soil aggregate subbase in compliance with the contract documents except for furnishing and hauling granular material.

B. Granular Material.

1. Per ton (megagram) for the granular material for soil aggregate subbase furnished and incorporated in the work.

2. Excavation or filling for roadbed correction in excess of 3 inches (75 mm) at locations other than structures or existing pavement will be paid

for according to Article 2102.05, or if no contract unit price is provided, as extra work.

Section 2111. Granular Subbase

2111.01 DESCRIPTION.
Construct a subbase consisting of a uniform mixture of granular material.

2111.02 MATERIALS.
Use either of the following:

A. Materials meeting the requirements of Section 4121, or

B. Recycled PCC material of the specified gradation. Use material reclaimed from an Interstate or Primary roadbed under the jurisdiction of the Department. Recycled PCC pavement, meeting the specified gradation, obtained from other sources may be used for granular subbase with the Engineer's approval.

2111.03 CONSTRUCTION.

A. Equipment.

1. Use equipment that meets the requirements of Section 2001.

2. Apply Article 2001.05, Paragraphs B, C, D, and F, to compaction equipment, except that other types of equipment may be used provided it is demonstrated they will consistently produce the required compaction.

B. Preparation of Subgrade.

1. Prepare subgrade for granular subbase according to Section 2109 with the following modifications:
- **a. Secondary and Local Projects.**
  - **1)** Check the cross section with an accurate template extending at least halfway across the width of the subgrade. Repair template deviations of more than 1 inch (25 mm). Prepare the subgrade to remove dips or humps from the general profile. Ensure the subgrade has a good riding surface after preparation is completed.
  - **2)** When PCC pavement is to be placed on the subbase, use the same preparation requirements as for Primary projects.
- **b. Interstate and Primary Projects, State Parks, and Institutions.**
  - **1)** Use grade stakes to indicate the elevation of the subgrade surface.

2) Correct the surface of the subgrade in both profile and cross section to within 0.05 foot (15 mm) of the desired elevation as indicated by the grade stakes.

2. Ensure the subgrade surface is in an undisturbed condition after final subgrade trimming. In areas where this condition does not exist, recompact according to Section 2109.

C. Delivery of Materials.

1. Operate trucks off the subgrade except in the area of unloading.

2. Maintain a clean aggregate interface between the granular subbase material and the porous backfill material of longitudinal subdrains.

D. Construction of Granular Subbase.

1. Ensure granular subbase material is uniformly moist prior to and during compaction. Place subbase material according to the contract documents.

2. Compact granular subbase with a maximum of three passes of a self propelled, non-vibratory steel or pneumatic roller. Use a roller with a compactive effort of 150 to 200 pounds per lineal inch (2.7 to 3.5 kg/mm) of contact surface.

3. Placing and compaction procedures will be evaluated on an initial trial section approximately 500 feet (150 m) long. This evaluation is to assess the extent of material degradation, consolidation, and permeability.

4. Profile and cross section tolerances for granular subbase are +0 to -0.05 foot (+0 mm to -15 mm).

5. At the Contractor's option, the subbase may be constructed to a general elevation higher than the required design elevation and cut back to design elevation. In this case, excess material removed may be salvaged. It may be processed as required and used for any purpose for which it can be approved under the specifications. The price paid for salvaged and reused material will be the contract unit price for the material as used. If the exposed portions of the subbase are damaged or disturbed, restore them to an acceptable condition (at no additional cost to the Contracting Authority) prior to any subsequent operation that will cover or conceal these portions of the subbase.

6. For sections of pavement more than 600 feet (180 m) long, complete the subbase no less than 600 feet (180 m) in advance of the concrete placing operation. Do not place granular subbase more than 2 months before the pavement is placed. The granular subbase may be placed in areas where the Engineer and the Contractor agree it is reasonable to

expect pavement construction can be accomplished prior to winter shutdown. Restrict granular subbase trimming to 1 mile (1.6 km) ahead of the paving operation when winter shutdown is eminent.

E. Maintenance of Completed Granular Subbase.
Do not operate hauling equipment and other traffic on the granular subbase material.

2111.04 METHOD OF MEASUREMENT.

A. Measurement for Granular Subbase material furnished and placed in accepted portions of work will be in square yards (square meters) for the specified design thickness. The measured area will be based on plan dimensions for the finished surface but will exclude fillets.

B. The design thickness of the placed material will be verified by spot checks of the grade.

2111.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price per square yard (square meter) for each specified design thickness of Granular Subbase as measured above.

B. The contract will have a separate item for Granular Subbase, Place Only, in square yards (square meters), when the Contracting Authority is providing the material or if the material is available from mandatory crushing on the contract. The cost of crushing shall be included in the Contractor's price bid for Granular Subbase if recycling is not required, but the Contractor chooses to crush the pavement removed for granular subbase.

C. Payment is full compensation for furnishing all materials, water, preparation of subgrade, and for doing all work necessary to complete the Granular Subbase in compliance with the contract documents.

Section 2112. Wick Drains

2112.01 DESCRIPTION.

A. Furnish all necessary labor, equipment, and materials and perform operations necessary for installation of prefabricated vertical drainage wicks (wick drains) according to the contract documents.

B. Wick drains consist of a band-shaped plastic case which permits continuous vertical drainage, wrapped in a filter material, installed in the subsoils by displacement methods, and spaced and arranged as shown on the plans.

2112.02 MATERIALS AND EQUIPMENT.
At least two weeks prior to construction, submit wick drain samples and certification indicating the source and material properties of the drain materials. At the

Preconstruction Conference, submit to the Engineer for review and approval details of the sequence and method of installation. Approval by the Engineer does not relieve the Contractor of the responsibility of installing the wick drains according to the contract documents.

A. Materials.

Install prefabricated wick drains consisting of a plastic drainage core encased in or integrated with a filter jacket. Ensure it is band-shaped with an aspect ratio (width divided by thickness) not exceeding 50. Prefabricated wick drains meeting this specification are listed in Materials I.M. 442.01.

1. Core

Meet the following requirements:

Provide continuous vertical drainage.

Continuous plastic material fabricated to promote drainage along the axis of the vertical drain.

2. Jacket.

a. Install a jacket that allows free passage of pore water to the core without loss of soil material or piping. Meet the following requirements for jacket material:

- Manufactured from a synthetic non-woven geotextile capable of resisting all bending, punching, and tensile forces imposed during installation and during the design life of the drain.
- Sufficiently rigid to withstand lateral earth pressures due to embedment and surcharge so that the vertical flow capacity through the core will not be adversely affected.
- Sufficiently flexible to bend smoothly during installation and induced consolidation settlement without damage.
- Comply with the following specifications:

Test Item	Designation	Minimum Roll Value*
Grab Tensile Strength	ASTM D 4632	80 lb. (355 N)
Trapezoidal Tear	ASTM D 4533	25 lb. (110 N)
Puncture Strength	ASTM D 4833	50 lb. (220 N)
Burst Strength	ASTM D 3796	130 psi (900 kPa)
Permittivity	ASTM D 4491	100 gal/min/ft^2 (4285 L/min/m^2)

*Ensure the jacket material is tested in saturated and dry conditions.

b. Do not allow the jacket material to be subject to localized damage (for example, punching through the filter by sand/gravel particles). Ensure the jacket material does not undergo cracking and peeling during installation of the drain.

3. Assembled Drain.

Meet the requirements below. The Engineer may reject material that is damaged during shipment, storage, or handling, or which does not meet the minimum requirements of the drain material.

- One single type of assembled drain used on the project, unless the Engineer approves otherwise.

- Mechanical properties (strength and modulus) of the assembled vertical drain equal to or greater than those specified for the component jacket and core.
- Resistant against wet rot, mildew, bacterial action, insects, salts in solution in the groundwater, acids, alkalis, solvents, and any other significant components in the site groundwater.
- Minimum discharge capacity of 3500 cubic feet per year (100 m^3/yr) when measured under a gradient of one at a lateral confining pressure of 25 psi (172 kPa).
- Minimum equivalent diameter of 2 inches (50 mm) using the following definition of equivalent diameter:
  dw = (a+b)/2.
  dw = diameter of a circular drain equivalent to the band shaped drain (inches (mm)).
  a = width of the band shaped drain (inches (mm)).
  b = thickness of the band shaped drain (inches (mm)).
- Drain material labeled or tagged in such a manner that the information for sample identification and other quality control purposes can be read from the label. Ensure, as a minimum, each roll is identified by the manufacturer as to lot or control numbers, individual roll number, date of manufacture, manufacturer, and product identification of the jacket and core.
- Ensure during shipment and storage the drain is wrapped in heavy paper, burlap, or similar heavy duty protective covering and according to the manufacturer's recommendations.

B. Equipment.

1. Install wick drains using equipment of a type that will cause minimum disturbance of the subsoil during the installation operation.

2. Install the wick drains using a mandrel. Push (in one continuous movement) the mandrel through the sand blanket and into the soil. Vibrating or driving are options if the Engineer approves. Ensure the mandrel:

- Protects the wick material from tears, cuts, and abrasions during installation,
- Is rectangular in shape and of a cross sectional area not to exceed 10 square inches (6500 mm^2), and
- Is provided with an "anchor" rod or plate at the bottom to prevent soil from entering the bottom of the mandrel during installation of the drain and to anchor the bottom of the drain at the required depth at the time of mandrel removal.

2112.03 CONSTRUCTION.

A. Familiarity with site conditions and the available geotechnical information is a necessity. Prior to installation of the wick drains, demonstrate the equipment, method, and materials produce a satisfactory drain installation. Drill at least two borings within the area designated on the plans in order to select the equipment, method, and materials: 1) suitable for the existing site conditions; and 2) capable of producing a satisfactory drain installation to the minimum elevation. Installation of up to ten trial drains may be required in each of two to four test locations designated by the Engineer. Compensation will be made for each trial drain if the installation satisfies the requirements of the contract documents. No compensation will be allowed for installing unsatisfactory trial drains.

B. The Engineer's approval of the method and equipment used to install the trial drains does not constitute acceptance of the method for the remainder of the project. If the Engineer considers that the method of installation does not produce a wick drain that satisfies the requirements of the contract documents, alter the method or equipment, or both, in order to achieve compliance.

C. Prior to installing the drains, grade the site sufficiently level (at no additional cost to the Contracting Authority) to allow vertical and proper drain installation.

D. Install the wick drains following placement of the sand blanket. Install a granular blanket of sufficiently coarse material and compact to provide a stable working surface.

E. Locate, number, and stake wick drains. Take all reasonable precautions to preserve the stakes. Ensure drain locations vary by no more than 3 inches (75 mm) from the locations indicated on the drawings. Two weeks prior to construction, submit drawings to the Engineer for approval showing the method of field locations, drain layout, and numbering plan.

F. Auguring or other methods may be used to loosen stiff upper soils prior to the installation of the drains, provided such operations do not extend more than 2 feet (600 mm) below the bottom of the sand blanket. After the wick drain has been satisfactorily installed, fill all holes or voids created by such operations with sand.

G. Check the installation equipment for plumbness prior to advancing each drain. Ensure the plumbness of the mandrel does not deviate more than 1/4 inch per foot (50 mm per meter) from vertical. Install the drains to the minimum elevation as shown on the plans. If the penetration shown on the plans is more than 1 foot (300 mm) into the underlying foundation layer and difficulties are encountered prior to achieving the indicated depths, install the drains to a depth of 1 foot (300 mm) below the bottom of the soil layer(s) being improved by wick drain installation as shown on the plans.

H. The Engineer will reject wick drains that vary from their proper location by more than 6 inches (150 mm) at the ground surface, drains that are damaged during installation or subsequent construction, or drains that are improperly completed. No compensation will be allowed for any materials furnished or for any work performed on such drains.

I. During installation, provide the Engineer with suitable means of measuring the vertical length of each wick drain installed at a given location and deriving a tip elevation for each drain.

J. Splices or connections in the wick drain material will not be allowed.

K. When obstructions that cannot be penetrated by the drain installation equipment are encountered below the working surface, notify the Engineer and complete the drain from the elevation of the obstruction to the working surface. At the direction of the Engineer, attempt to install a new drain (maximum of two attempts, as directed by the Engineer) within an 18 inch (450 mm) radius from the obstructed drain. The Contractor will be compensated for each obstructed drain unless the drain is improperly completed, in which case no compensation will be allowed.

L. After installation, cut each drain horizontally such that approximately 6 inches (150 mm) of drain material extends above the top of the sand blanket.

M. The Engineer will keep a daily log which lists for each drain the date of installation, top elevation, tip elevation, and pay length. A copy of each daily log will be provided to the Contractor.

2112.04 METHOD OF MEASUREMENT.

A. Measurement for Wick Drain (including trial wick drains) will be feet (meters) installed according to the contract documents, calculated from measurements taken from the top of the drain to the tip elevation of the drain.

B. In the case of obstructions, the Engineer will calculate the number of feet (meters) from measurements taken from the top of the drain to the elevation at which the obstruction was encountered.

2112.05 BASIS OF PAYMENT.

A. Payment for Wick Drain will be the contract unit price per foot (meter).

B. Payment includes:

- Field staking for the location of wick drains, and
- All labor, equipment, and materials necessary to complete the installation according to the contract documents.

C. No payment will be made for unacceptable drain or trial drain installations.

D. In instances where pre-auguring is permitted, the cost of pre-auguring and subsequent placing of sand backfill material is incidental to the price bid for Wick Drains.

E. The cost of borings drilled to select the equipment, method, and materials suitable for the existing site conditions to produce a satisfactory drain installation is incidental to the price bid for Wick Drains.

Section 2113. Subgrade Stabilization Material

2113.01 DESCRIPTION.

Place material to stabilize the subgrade under the pavement at locations specified in the contract documents.

2113.02 MATERIALS.

The type of subgrade stabilization material required will be specified in the contract documents. Use material that meets the requirements of Article 4196.01, B, 5.

2113.03 CONSTRUCTION.

A. Placement.
Place the subgrade stabilization material as shown in the contract documents (typically on subgrade with a specified backfill material placed on top). Overlap subgrade stabilization material sections a minimum of 2 feet (0.6 m) during placement operations. Place backfill material so the material remains in place or is not damaged.

B. Repair.
In the event of subgrade stabilization material failure or damage during construction:

1. Remove the damaged portion of material.

2. Replace the damaged portion with a patch of new material of the same type extending a minimum of 6 feet (2.0 m) in all directions beyond the edge of the failed area.

3. Replace the backfill material.

2113.04 METHOD OF MEASUREMENT.

Subgrade Stabilization Material of the type specified, in square yards (square meters), will be the quantity shown on the contract documents to the nearest square foot (0.1 m^2).

2113.05 BASIS OF PAYMENT.

A. Payment for the type of Subgrade Stabilization Material specified will be the contract unit price per square yard (square meter).

B. Payment is full compensation for all work, materials, equipment, and labor necessary to furnish, install, place, repair and maintain the subgrade stabilization material.

Section 2115. Modified Subbase

2115.01 DESCRIPTION.

Construct a subbase consisting of a uniform mixture of uniformly moistened granular materials.

2115.02 MATERIALS.

Apply Section 4123.

2115.03 CONSTRUCTION.

Place, shape and compact materials according to the contract documents.

A. Equipment.

1. Apply Article 2001.05, Paragraphs B, C, D, and F, except use rollers having a minimum compactive effort of 300 pounds per inch (5.25 kg/mm) width.

2. Other types of equipment may be used provided it is demonstrated they will consistently produce the required compaction without excessive aggregate breakdown. For all other equipment used, meet the other requirements of Section 2001.

B. Modified Subbase Construction.

1. Preparation of Subgrade.
Apply the requirements of Section 2109. In addition, disk the subgrade to a depth of 6 inches (150 mm), aerate, and recompact. Recompact to the requirements of Article 2107.03, E, on Primary projects and Article 2107.03, F, on Secondary projects. Proof roll after preparing subgrade.

2. Proof Rolling of Subgrade.
Proof roll with a truck loaded to the maximum single legal axle gross weight (mass) of 20,000 pounds (9.1 Mg) or the maximum tandem axle gross weight (mass) of 34,000 pounds (15.4 Mg). Operate the truck at a speed less than 10 mph (16 km/h). Make one pass on every lane. The subgrade will be considered unstable if, under the operation of the loaded truck, the surface shows yielding or rutting of more than 2.0 inches (50 mm) measured from the top to the bottom of the rut at the outside edges. Correct unstable subgrade according to Section 2109.

3. Delivery of Materials.
Maintain a clean aggregate interface between the granular subbase material and the porous backfill material of longitudinal subdrains.

4. **Placing and Compacting Modified Subbase.**
   - **a.** Ensure modified subbase material is uniformly moist prior to and during compaction.
   - **b.** Place modified subbase in uniform lifts no more than 6 inches (150 mm) thick.
   - **c.** Compact modified subbase with a minimum of six roller passes.
   - **d**. Profile and cross section tolerances for modified subbase are +0 feet to -0.05 feet (+0 mm to -15 mm).

2115.04 METHOD OF MEASUREMENT.

Modified Subbase will be the quantity shown in the contract documents.

2115.05 BASIS OF PAYMENT.

A. Payment for Modified Subbase will be the contract price per cubic yard (cubic meter).

B. Payment is full compensation for furnishing all materials, water, preparation of subgrade, and for all work necessary to complete the modified subbase in compliance with contract documents.

C. The contract will have a separate item for Modified Subbase, Place Only, in cubic yards (cubic meters), when the Contracting Authority is providing the material or if the material is available from mandatory crushing on the contract. The cost of crushing shall be included in the Contractor's price bid for modified subbase if recycling is not required, but the Contractor chooses to crush the pavement removed for modified subbase.

D. Excavation or filling in excess of 3 inches (75 mm) for preparation of subgrade at locations other than structures or existing pavements will be paid for according to Article 2102.05, or if no contract unit price is provided, it will be paid as extra work according to Article 1109.03, B, except where grading is a part of the contract.

E. Correction of subgrade after proof rolling will be paid as extra work according to Article 1109.03, B, except where grading is a part of the contract.

Section 2116. Full Depth Reclamation

2116.01 DESCRIPTION.

Reclaim existing asphalt pavement to the width and depth specified in the contract documents. Mix the reclaimed material in-place with an asphalt stabilizing agent, additional materials (when specified), and water (if required). Compact this mixture.

2116.02 MATERIALS.

A. Asphalt Stabilizing Agent.

1. Unless specified otherwise in the contract documents, the asphalt stabilizing agent may, at the Contractor's option, be either of the following:
   a. Emulsified Asphalt (HFMS-2s) meeting the requirements of Section 4140.
   b. Foamed Asphalt using PG 52 -34 or PG 46 -34 asphalt binder meeting the requirements of Section 4137.

2. Unless stated otherwise in the contract documents, use the residual asphalt application rate of 3.0%, by dry mass to determine the estimated plan quantity of asphalt stabilizing agent.

B. Pulverized Bituminous Material.

Ensure the reclaimed paving material conforms to the following gradation. The gradation may be revised with the Engineer's approval, but ensure the top size of the material does not exceed 25% of the depth of the compacted recycled mat.

Sieve Size	% Passing
1 1/2 inch (37.5 mm)	98 to 100
1 inch (25 mm)	90 to 100

C. Mineral Stabilizing Agents.

A mineral stabilizing agent may be required by the mix design. When specified, the agent may be from any locally available commercial source meeting the following criteria:

1. Portland cement meeting ASTM C 150, Type I.

2. Fly ash may come from any available source.

3. Hydrated lime meeting the requirements of Article 4193.

4. Limestone fines from limestone crushing operations.

D. Mix Design.

The contract documents will specify the mix design for the reclaimed mixture. The mix design establishes the depth of milling, the amount of added material, and the amount of residual asphalt to incorporate into the milled material and the optimum laboratory compaction moisture.

2116.03 CONSTRUCTION.

A. General.

1. Perform full depth reclamation between April 1 and November 1 unless otherwise specified in the contract documents.

2. Do not perform reclaiming operations when the weather conditions are such that proper mixing, shaping, and compacting the reclaiming material cannot be accomplished.

B. Equipment.

1. Furnish a self-propelled machine capable of reclaiming the existing paving material to the width and depth shown in the contract documents. Ensure the machine meets the following:
- **a.** Equipped with automatic depth control and maintain a constant cutting depth and width.
- **b.** Capable of pulverizing bituminous material to the required gradation.
- **c.** Capable of mixing the reclaimed material and asphalt stabilizing agent into a homogeneous mixture.
- **d.** Provides a positive means for accurately controlling the rate of flow and total delivery of the asphalt stabilizing agent into the mixture in relation to the speed and quantity of material being recycled.
- **e.** A delivery system meeting the requirements of Article 2001.22, F.

2. When foamed asphalt is used, use an asphalt foaming system that accurately and uniformly adds the specified percent of water to the hot asphalt binder. Use equipment fitted with a test nozzle to provide field samples of foamed asphalt. Equip tankers supplying the hot asphalt binder with a thermometer to continuously measure the temperature of the asphalt in the bottom third of the tank.

3. Use rollers meeting the requirements of Article 2001.05 for compacting the reclaimed material. As a minimum, have the following rollers available for use:
- **a.** Sheepsfoot roller.
- **b.** Double drum steel roller (may be used in the static or vibratory mode).
- **c.** 25 ton (22.5 Mg) or greater pneumatic tire roller.

C. Preparation.

Prior to initiating the reclaiming operation, clear all vegetation and debris within the width of pavement to be reclaimed. Remove of this vegetation and debris from the project according to Article 1104.08.

D. Reclaiming the Existing Pavement.

1. During reclaiming operations, apply the asphalt stabilizing agent to the pulverized material at a rate that will achieve the residual asphalt content established by the mix design. The Engineer may vary the application rate of asphalt stabilizing agent as required by existing pavement conditions.

2. Determine the amount of additional water needed to facilitate uniform mixing with the asphalt stabilizing agent and achieve a stable reclaimed layer above the minimum specified density. The water may be added prior to or concurrently with the asphalt stabilizing agent. Ensure adding water to facilitate uniform mixing does not adversely affect the asphalt stabilizing agent.

3. The mineral stabilizing agent may be added dry or in slurry form.

4. If multiple passes of the equipment are required to reclaim the pavement material to the desired width, use a minimum 6 inch (150 mm) overlap. Use an asphalt stabilizer application system capable of being adjusted for the width of reclaiming so that overlapped mixture maintains the designed residual asphalt content.

E. Compaction and Shaping.

1. Ensure the following:

- Field density for the reclaimed mat on Interstate and Primary roads is a minimum of 94% of laboratory density based on the dry weight of compacted material according to Materials I.M. 504.
- Field density for the reclaimed mat on shoulders and all other roads is a minimum of 92%.
- The surface density, based on the 2 inch depth nuclear probe density, is a minimum of 97% of the nuclear probe density measured at 75% of the reclaimed mat depth.

2. Perform initial rolling with a sheepsfoot roller until the roller pads walk out of the reclaimed mix. Shaping to achieve planned profile and cross slope should cut deep enough to remove the sheepsfoot roller marks.

3. Repeated reclaiming and rolling may be required within 2 calendar days after the initial processing and rolling to achieve the target density on the completed in-place recycled surface. Discontinue rolling that results in cracking, movement, or other types of distress until such time that the problem can be resolved. If there is a significant change in mix proportions, weather conditions, or other controlling factors, the Engineer may require construction of test strips to check target density.

F. Quality Control.

1. Control the residual asphalt content to be within ± 0.5% of the target establish by the design.

2. Control the mineral stabilizing agent to be within ± 0.5% of the target established by the design.

3. For foamed asphalt, ensure the asphalt binder is maintained at a temperature within ± 20ºF (10ºC) of the optimum temperature established by the design. The Engineer may verify the foaming characteristics of each new tanker load, by measuring a sample from the equipment's test nozzle.

4. Ensure the crown of the compacted reclaimed mat is within 6 inches (150 mm) of the centerline reestablished by construction survey, unless specified otherwise in the contract documents. Measure the profile along the center of each lane of the compacted reclaimed mat with a profilograph. Correct bumps and dips greater than 1 inch (25 mm). Ensure the cross-slope of the compacted reclaimed mat is within 1 inch (25 mm) of the designated slope.

5. Unless specified otherwise in the contract documents, perform nuclear gauge moisture and density tests every 500 feet (150 m) per lane at locations determined by the Engineer, according to Materials I.M. 504. The Quality Index for density will not apply. Remix and compact sections of reclaimed mat that do not achieve minimum density criteria.

2116.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Full Depth Reclamation.
Square yards (square meters) satisfactorily completed computed from the measured longitudinal length of pavement reclaimed to the nearest 0.1 foot (0.1 meter) and the width of pavement specified in the contract documents.

B. Asphalt Stabilizing Agent.
Tons (megagrams) or gallons (liters) measured through a calibrated pump used for metering the total delivery of the agent or by delivery tanker quantity.

C. Mineral Stabilizing Agent.
Dry tons (megagrams) by delivery tanker quantity.

2116.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Full Depth Reclamation.

1. Per square yard (square meter).

2. Payment is full compensation for all labor, equipment, and materials necessary for preparation, reclaiming, shaping, and compaction of the reclaimed material.

B. Asphalt Stabilizing Agent.

1. Per ton (megagram) or gallon (liter).

2. Payment is full compensation for all labor, equipment, and materials necessary for furnishing the agent and application of the agent into the reclaimed material.

C. Mineral Stabilizing Agent.

1. Per dry ton (megagram).

2. Payment is full compensation for all labor, equipment, and material necessary for furnishing the agent and application of the agent into the reclaimed material.

Section 2120. Fuel Adjustment

2120.01 DESCRIPTION.

Fuel Adjustment (FA) is an adjustment to monthly progress payments for cost changes in diesel fuel used on specific items of work identified.

2120.02 PRICE INDEX DEFINITION.

A. A Current Price Index (CPI) in dollars per gallon (liter) will be established by the Department of Transportation for each month. The CPI will be the price of No. 2 High Sulfur Diesel, as reported by the Oil Price Information Service, using the first weekday of the month and the average of all prices reported for Des Moines. This information will be available on the Departments' website.

B. The Base Price Index (BPI) for each contract will be the CPI in effect during the month previous to the month of letting of that contract.

2120.03 APPLICATION.

A. Applied as the work is done, according to this specification when indicated in the contract documents.

B. Fuel adjustment using a fuel adjustment factor (FUF) of 0.20 gallon per cubic yard (1.0 L/m^3) will be applied to:

1. Selected Backfill (including Stockpile)

2. Class 10 (Roadway & Borrow, Unsuitable, Waste, Stockpile, and Channel)

3. Class 12 (Roadway & Borrow, Channel, and Waste)

4. Class 13 (Roadway & Borrow, Channel, and Waste)

5. Topsoil, Furnish and Spread

6. Topsoil, Spread

7. Topsoil, Strip, Salvage, and Spread

8. Topsoil, Strip and Stockpile

C. Fuel adjustment using a FUF factor of 0.27 gallon per cubic yard (1.3 L/m^3) will be applied to Embankment-in-Place (non-dredge material).

D. Fuel adjustment will also be applied to Embankment-In-Place (dredge material). The fuel usage will be based on billed gallons (liters) of fuel used.

2120.04 METHOD OF MEASUREMENT.

A. Provide the Engineer with a monthly spreadsheet (the Engineer will provide the format) with quantities, and the fuel adjustment for the month (even if there will be no adjustment).

B. If the contract quantity for an item is in tons (megagrams), convert the quantity to cubic yards (cubic meters) using an appropriate conversion factor the Engineer approves. The total quantity of cubic yards (cubic meters) for each month (Y) is the sum of these quantities.

C. If the work is not completed within the contract period or authorized extensions thereof, the CPI to be used for work done after the contract period is to be the CPI that applied during the last working day within the contract period, including authorized extensions.

D. A fuel adjustment factor that accounts for the estimated amount of fuel used per cubic yard (cubic meter) of work covered by this specification will be applied to items of work covered in Article 2120.03, B or 2120.03, C.

E. A fuel adjustment will be made for items of work covered in this specification when the CPI for the month the work is performed is more than $0.15 per gallon ($0.04 per liter) different than the BPI established at the beginning of the project.

1. For items of work covered in Article 2120.03, B or 2120.03, C:

a. If the CPI is greater than the BPI plus $0.15, then the fuel adjustment will be positive which warrants additional payment to

the Contractor. The following formula will be used to calculate the additional payment:

(English) FA = FUF(CPI - (BPI + 0.15))Y
(Metric) FA = FUF(CPI - (BPI + 0.04))Y

b. If the CPI is less than the BPI minus $0.15, then the fuel adjustment will be negative and a credit will be due to the contracting authority. The following formula will be used to calculate the credit:

(English) FA = FUF(CPI - (BPI - 0.15))Y
(Metric) FA = FUF(CPI - (BPI - 0.04))Y

2. For the item of work covered in Article 2120.03, D:

a. If the CPI is greater than the BPI plus $0.15, then the fuel adjustment will be positive which warrants additional payment to the Contractor. The following formula will be used to calculate the additional payment:

(English) FA = (CPI - (BPI + 0.15)) x (billed gallons of fuel used per month)
(Metric) FA = (CPI - (BPI + 0.04)) x (billed liters of fuel used per month)

b. If the CPI is less than the BPI minus $0.15, then the fuel adjustment will be negative and a credit will be due to the contracting authority. The following formula will be used to calculate the credit:

(English) FA = (CPI - (BPI - 0.15)) x (billed gallons of fuel used per month)
(Metric) FA = (CPI - (BPI - 0.04)) x (billed liters of fuel used per month)

2120.05 BASIS OF PAYMENT.

A. Payment will be the Fuel Adjustment (FA) for each month, subject to the deduction for partial payments described in Article 1109.05. Should the Fuel Adjustment (FA) be negative, an equal amount will be deducted on payments made to the Contractor from sums otherwise due. This payment or deduction will be made by change order.

B. On completion of the work of the contract:

1. For all items covered in Article 2120.03, B or 2120.03, C, the sum of the total quantities (Y) for each monthly period will be adjusted, if necessary, to agree with the final quantities to be paid.

2. For the item covered in Article 2120.03, D, the sum of the total quantities for billed gallons (liters) of fuel used for each monthly period

will be adjusted, if necessary, to agree with the final quantities to be paid. This adjustment will be made by either:

- Subtracting the proper quantity from the last adjustment made, or
- Adding the proper quantity and computing the adjustment on the basis of the CPI in effect on the last working day any of this work was done.

C. On completion of the work of the contract, the monthly fuel adjustment will be revised by pro-rating any variance from the plan quantity.

D. Payment or deduction is full compensation for all fluctuations in fuel prices during the time the contract work is being done.

Section 2121. Granular Shoulders

2121.01 DESCRIPTION.

Prepare a shoulder area and furnish and place granular material as shown on the contract documents. This section may also apply to construction of paved shoulder fillets.

2121.02 MATERIALS.

A. For Type A and Type B shoulders, meet the following:

1. Crushed stone. Apply Article 4120.02.

2. Gravel/Limestone (if allowed in the contract documents). Apply Article 4120.02.

3. Crushed PCC, RAP, or crushed composite HMA and PCC. Apply Article 4120.02. Either salvaged or unclassified sources of material may be allowed. Other quality requirements of Section 4120 will not apply.

B. The Engineer may:

- Disallow short sections of material substitutions.
- Restrict the substitution to both sides of the pavement.

C. Use aggregate for paved shoulder fillets that meets the requirements of Article 4120.07.

D. Recycled crushed PCC, RAP, or crushed composite HMA and PCC shall be uniformly blended with crushed stone. Limit recycled materials to total no more than:

- 30% of the shoulder aggregate for new construction, and
- 50% of the total for existing granular shoulders.

2121.03 CONSTRUCTION.

A. Equipment.
Use equipment that meets the requirements of Section 2001 and the following:

1. Trench Machine.
Use a motor grader or other approved machinery to excavate for subgrade preparation.

2. Proportioning and Mixing Equipment.

a. Type A Granular Shoulders.

1) Prewetting will not be required when the quantity of Type A granular shoulders designated for the contract is less than 2000 tons (2000 Mg).

2) Use proportioning equipment that accurately proportions each material.

a) Mixing and Prewetting More Than One Aggregate: Apply Article 2001.08, B.

b) Prewetting One Aggregate: Apply Article 2001.08, A.

c) Prewetting One Premixed Aggregate: Apply Article 2001.08, A.

3) A traveling mixer may be used on a road that is closed to through traffic if it meets all of the following conditions:

a) Proportions water to a single or premixed aggregate.

b) Mixes the material in a single pass operation.

c) Achieves mixing equivalent to that required from a stationary mixer.

4) Ensure mixing plants include a means of calibrating and adjusting the proportioning equipment. Make provisions for a periodic check.

b. Type B Granular Shoulders.
Proportioning, mixing, and prewetting equipment is not specified.

3. Equipment for Applying Water.
Apply Article 2001.09.

4. Compaction Equipment.

a. Apply Article 2001.05, B and C, for compaction of granular shoulder material. Also apply Article 2001.05, D, when the road or adjacent lane is closed to public traffic. Vibratory rollers, described in Article 2001.05, F, may be substituted for compaction, provided equivalent compaction is obtained and demonstrated to the Engineer. This equipment may also be used for compaction of earth fill.

b. When the thickness of a Type B shoulder is 3 inches (80 mm) or less and the width is not more than 3 feet (1 m), the coverages may be with loaded truck tires having a weight (mass) not less than 200 pounds per inch (3.5 kg/mm) of tire width. Finish roll the surface of both types with one complete coverage by a steel tired roller.

5. Weighing Equipment.
Apply Article 2001.07.

B. Type A Granular Shoulders.

1. Proportioning and Mixing.
When more than one aggregate is to be combined, mix the aggregates before delivery to the road. Except as permitted in Article 2121.03, A, 2, a, premix aggregate with sufficient water, acceptable to the Engineer, so that all particles are uniformly wetted.

2. Surface Preparation.

a. Prepare the surface by one of the following methods:

1) Earth Shoulder Fill.

a) Construct a shoulder fill to an elevation below that of the pavement edge to allow for placement of granular shoulders as shown in the contract documents. Use select treatment materials of Article 2102.02, D, 1, if available and coordinated with the Engineer, or use suitable soils of Article 2102.02, D, 2. Do not use unsuitable soils of Article 2102.02, D, 3 or topsoil.

b) Spread and compact according to Articles 2107.03, D and E.

c) Shape, smooth, and finish the fill. Correct shoulder fill elevation deviations exceeding 0.05 foot (15 mm).

d) When unpaved side roads, drives, or entrances extend through the shoulder area, excavate them or fill them with earth as necessary, and as directed by the Engineer, to provide a suitable approach.

e.) Equivalent compaction with equipment specified in Article 2121.03, D, will be acceptable.

2) Trenching and Reshaping.

a) Remove the earth of the existing shoulder to the width and depth shown on the contract documents. Remove existing vegetation and deposit on the foreslope. Unless specified otherwise in the contract documents, remove excess excavated material from the project. Do not excavate for placement of shoulders at driveways and intersecting roads that have fillets or pavement of a higher type.

b) Correct shoulder fill elevation deviations exceeding 0.05 foot (15 mm). If placing earth backfill material is necessary in preparing the subgrade, thoroughly compact the earth backfill material by tamping or rolling in layers not exceeding 3 inches (80 mm) in depth.

c) For reshaping earth shoulders to the specified cross section adjacent to the granular shoulder, earth fill does not need to be rolled except for the 1 foot (0.3 m) adjacent to the granular shoulder.

b. If earth fill is expected, it will be designated in the contract documents along with provisions for payment.

3. Shoulder Construction.

a. Place granular shoulder material on the subgrade so no material is deposited on the adjacent pavement surface. Immediately remove material inadvertently spilled on the adjacent pavement using shovels and brooms.

b. Spread and compact the granular shoulder material so the finished elevation and width conform to the specified cross section.

c. Compact granular shoulder material with six complete coverages with a pneumatic tired roller or a steel vibratory roller, followed by at least one complete finish coverage with a steel tired roller. The Engineer may reduce the rolling when unstable subgrade is encountered, and may require additional finish rolling if needed to ensure a satisfactory surface finish. Shape concurrently with compaction. The tolerance for width of the completed shoulder is ± 0.2 foot (60 mm).

d. Maintain the required moisture content in the granular shoulder material until it has been satisfactorily spread, compacted, and finished to the required dimensions.

e. The Engineer will check the shoulder cross slope with a template furnished and used by the Contractor. Shoulder cross slope is not to be less than specified or more than 1% greater than specified.

4. Limitations.

a. When traffic is maintained on adjacent pavement, construct shoulders on one side of the pavement at a time. Conduct operations resulting in a minimum inconvenience to traffic. Fill the portion of the shoulder excavated with granular material and compact prior to opening to traffic. The Engineer may modify this requirement for unusual and justifiable conditions.

b. When construction of the pavement is staged, stage construction of the shoulder as well, according to Article 2121.03, C, 4. Place, and moisten if necessary, granular material for temporary fillets and compact according to Article 2121.03, C, 3.

c. Bring granular shoulder material up to the pavement edge for the full width of the shoulder, at the design cross slope, prior to winter shutdown.

C. Type B Granular Shoulders.

1. Proportioning and Mixing.

Use an aggregate in a moist condition so that it will readily compact. Do not apply Article 2001.08.

2. Surface Preparation.

a. Minimum surface preparation work is anticipated. Existing shoulders damaged by the Contractor’s operations shall be restored. Remove existing vegetation and deposit on the foreslope. Salvage bituminous edge rut material and existing aggregate from the fillet area and deposit on the outer shoulder area. The work shall assure a nearly vertical pavement edge.

b. If earth fill is expected, it will be designated in the contract documents along with provisions for payment.

3. Shoulder Construction.

a. Deposit, without dumping on the pavement, granular shoulder material directly on the shoulder for the width designated.

b. Thoroughly compact the moist aggregate with a minimum of four complete coverages of the entire exposed surface using a pneumatic tired roller or a steel vibratory roller. Follow this with at least one complete finish coverage using a steel tired roller. Moisten the aggregate if, in the opinion of the Engineer, it is so dry that it will not readily compact.

c. Shape the aggregate to produce a smooth surface flush with the pavement edge and tapered to meet the shoulders at the width shown in the contract documents.

4. Limitations.

a. When a drop-off is caused by the Contractor's operations and is adjacent to a lane open to public traffic, placement of granular shoulders shall be coordinated so they are brought up to the pavement operation before the adjacent lane is opened to traffic.

b. Use a fillet of granular material to temporarily correct a drop-off created by the resurfacing. If a fillet is placed, the minimum width of the fillet is to be 6 times the thickness of HMA resurfacing completed. Blade this material across the shoulder prior to placing the final layer of granular surfacing. The Engineer may modify this requirement for narrow shoulders and other justifiable conditions.

c. Bring granular shoulder material up to the pavement edge for the full width of the shoulder, at the design cross slope, prior to winter shutdown.

D. Paved Shoulder Fillet.

Place and compact aggregate for a fillet at the edge of a paved shoulder as provided in Article 1107.08.

2121.04 METHOD OF MEASUREMENT.

A. Measurement for Type A and Type B Granular Shoulders satisfactorily placed will be computed from the weights (mass) of individual truck loads, including moisture in the aggregate at time of delivery. Moisture added after delivery will not be measured for payment.

B. Trenching and Reshaping, in stations (meters), will be the quantity shown on the contract documents. The quantity of Trenching and Reshaping will be determined for each side of the pavement or base.

2121.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price as follows:

1. Type A Granular Shoulders.

a. Per ton (megagrams) for the tons (megagrams) placed on the shoulder.

b. Payment is full compensation for the following:
Furnishing materials, including aggregate and water.
Furnishing equipment, tools, and labor to place the material in accordance with the contract documents.

c. The earth shoulder fill required in the shoulder area under the granular shoulder will be paid for separately.

d. When traffic has not been routed through the work during paving or base construction, but all or a portion of the work must be done under traffic as provided in Article 2121.03, B, 4, no payment will be made for additional flagging, barricading, decreased production, or other items directly related to this traffic.

2. Type B Granular Shoulders.

a. Per ton (megagram) for the tons (megagrams) placed on the shoulder.

b. Payment is full compensation for the following:

- Furnishing materials, including aggregate and water.
- Furnishing equipment, tools, and labor to place the material in accordance with the contract documents.
- The minimum surface preparation work described in Article 2121.03, C, 2.

c. The earth shoulder fill required in the shoulder area under the granular shoulder will be paid for separately.

d. Furnishing and placing the paved shoulder fillet adjacent to paved shoulders is incidental and will not be paid for separately.

3. Trenching and Reshaping

Trenching and reshaping will be paid for at the contract unit price for per station (meter). Payment is full compensation for trenching, reshaping, and removing excess excavated material from the project.

B. The contract will have a separate item for Granular Shoulders, Place Only, of the type specified in tons (Mg), when the Contracting Authority is providing the material or if the material is available from mandatory crushing on the contract. The cost of crushing should be included in the Contractor's price for granular shoulders if recycling is not required but the Contractor chooses to crush the pavement removal for granular shoulder material.

Section 2122. Paved Shoulders

2122.01 DESCRIPTION.

A. Prepare the area adjacent to a pavement, as necessary, and furnish and place shoulder material on the prepared area. This work may include

construction of an earth fill and a special backfill material layer for new construction or surface preparation for resurfacing or overlay construction.

B. The type of shoulder material may be specified, or it may be an alternate on the proposal, and only one type will be bid and awarded.

2122.02 MATERIALS.

A. Hot Mix Asphalt Mixture (1,000,000 ESAL Base Mixture).
Use materials specified in Section 2303.

B. Portland Cement Concrete Base.
Use materials specified in Section 2201.

C. Special Backfill.
Use materials specified in Section 4132.

2122.03 CONSTRUCTION.

A. Equipment.
Use the type of equipment required or allowed for the type of paved shoulder to be placed. Adapt equipment to shoulder construction in a manner approved by the Engineer.

B. Preparation of Shoulder Area.

1. This work may involve construction of an earth fill and a special backfill material to allow placement of paved shoulders. Spread and compact earth fill according to the requirements of Section 2109.

2. Use select materials of Article 2102.02, D, 1, if available and coordinated with the Engineer, or suitable soils of Article 2102.02, D, 2. Do not use unsuitable soils of Article 2102.02, D, 3, or topsoil.

3. For shoulder construction in which PCC is placed over HMA, thoroughly clean the surface by brooming prior to placing concrete. When HMA is to be placed over HMA, prepare the surface according to Article 2303.03, C, 4.

C. Paved Shoulder Construction.
Construct paved shoulders as follows:

1. Hot Mix Asphalt Mixture.
- **a.** Prior to placement, tack coat the pavement edge.
- **b.** Proportion, mix, place, and compact HMA mixture to the width, thickness, grade, and slope shown in the contract documents, according to the requirements of Section 2303.

c. After finish rolling, visually inspect the paved shoulders to ensure:
Roller distortions have been smoothed.
Longitudinal and transverse joints have been smoothly constructed.
The general grade profile is satisfactory.

2. Portland Cement Concrete Base.

a. Proportion, mix, place, finish, and cure PCC base to the width and thickness shown in the contract documents. Except as modified herein, perform the work according to the requirements of Section 2201.

b. The shoulder may be placed separately, using either fixed forms or slip forms, after placement of the main line pavement. Place tie bars according to the contract documents, or use a method the Engineer approves, prior to the start of paving operations.

c. Finish and edge the concrete. Obtain the Engineer's approval for construction of surface corrugations.

d. Saw the transverse joints as shown in the contract documents. In addition, place expansion and contraction joints to coincide with similar joints in the abutting pavement. Seal transverse sawed joints according to Article 2301.03, P. Fill expansion joints in the same manner as for the main line.

3. Special Backfill Material.
Place special backfill material according to Article 2102.03, D, 3, c.

D. Finishing.
After completion of the paved shoulder, place the granular fillet as shown in the contract documents and according to Section 2121. Finish the foreslope according to Article 2123.03, C.

2122.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Paved Shoulders.

1. Hot Mix Asphalt Paved Shoulder.
Article 2303.04, A, 3, applies.

2. Portland Cement Concrete Paved Shoulder.
Article 2301.04, A, applies.

B. Special Backfill.
Contract quantity.

C. Resurfacing or Overlay of Existing Paved Shoulders.
Article 2303.04 applies.

2122.05 BASIS OF PAYMENT.

Payment for all work performed and measured as prescribed will be according to the following provisions:

A. Paved Shoulders.

1. Hot Mix Asphalt Paved Shoulder.
Article 2303.05 applies.

2. Portland Cement Concrete Paved Shoulder.
a. Article 2301.05, A, applies.
b. Payment for paved shoulders constructed is full compensation for:
- Preparing the area, including the earth fill, furnishing and placing the paved shoulder, and finishing the shoulder edge.
- Furnishing all the material, equipment, tools, and labor to complete the work according the contract documents and this specification.

c. Separate payment will not be made for:
- Construction of the earth fill.
- Asphalt binder.
- Tack coat bitumen.
- Placement, construction, or sawing and filling of joints for the PCC base.
- Finishing of the shoulder edge and furnishing granular material.

3. Furnish samples as specified in Section 2303 or 2301, with payment to be made as specified.

B. Special Backfill.
Article 2102.05, A, 4, applies.

C. Resurfacing or Overlay of Existing Paved Shoulders.
For HMA of the type, width, and thickness specified and satisfactorily constructed, payment will be according to Article 2303.05.

Section 2123. Earth Shoulders for Pavements and Bases

2123.01 DESCRIPTION.

A. Construct or finish earth shoulders. In general, earth shoulder construction for pavements and bases relates to the earthwork above subgrade elevation, adjacent to the sides of pavement or base. It may involve minor or major reshaping and replacement of embankment material.

B. This specification will not apply to Rebuilding Shoulders specified in Article 2213.03, J, or to Shoulders specified in Article 2302.03, F.

2123.02 MATERIALS.

A. For material deposited above an elevation 6 inches (150 mm) below subgrade elevation, use select treatment materials of Article 2102.02, D, 1, if

available and coordinated with the Engineer, or suitable soils of Article 2102.02, D, 2. Do not use unsuitable soils of Article 2102.02, D, 3, or topsoils.

B. Select earth for use that is reasonably free of roots, granular material, rocks with dimensions greater than approximately 2 inches (50 mm) in the top 3 inches (75 mm), or other materials which will not form a good seedbed.

2123.03 CONSTRUCTION.

A. General.

1. At elevations more than 6 inches (150 mm) below subgrade elevation, treat material placed during shoulder operations as embankment construction, unless specified otherwise.

2. Never deposit shoulder material on pavement or base.

B. Constructing Earth Shoulders.

1. Construct and finish earth shoulders by:
- **a.** Placing and consolidating suitable materials adjacent to a previously constructed pavement or base, as shown in the contract documents.
- **b.** Placing, in an acceptable condition, other sections of right-of-way disturbed by operations of the Contractor.

2. Spread the material more than 3 inches (80 mm) below the upper edge of the pavement or base in uniform layers no more than 6 inches (150 mm) in loose thickness. Roll at least three times. The final 3 inch (80 mm) layer need not be rolled except for 1 foot (0.3 m) adjacent to the pavement or base.

3. Where the width of shoulder will permit, use a roller meeting the requirements of Article 2001.05, C, or D. The Engineer may permit use of other rollers or other compactive methods that will produce equivalent results. Where the width of shoulder is less than 6 feet (1.8 m), wheels of pneumatic tired equipment may be used in lieu of the roller. Ensure thorough compaction against and adjacent to the edge of the base or pavement. Wheels of pneumatic tired equipment may be used for this purpose.

4. Where unpaved side roads, drives, or entrances extend through the shoulder area, excavate them, or fill them with earth, to the extent necessary to provide a suitable approach with the design shoulder slope, as directed by the Engineer. When the contract item for shoulders is Earth Shoulder Construction, carry the operations beyond the outside shoulder line for a distance of 1 foot (250 mm) for each 1/2 inch (10 mm) of the depth of pavement plus base (where base is used).

5. If the tool or machine used in finishing the shoulder produces a groove in the earth at the edge of the pavement or base, carefully fill the groove and thoroughly compact.

6. Refer to Articles 1105.12 and 2102.03, L, for restrictions on use of heavy equipment.

7. Commence shouldering operations when the pavement or base has attained the age requirements for opening to the Contractor, unless the Engineer specifically advises to delay starting, pending strength requirements or satisfactory surface conditions. Assign adequate equipment and organization so that the major portion of shouldering work may be completed within 6 working days after the Engineer releases the pavement for shoulder work.

8. The time for opening pavements and bases to the Contractor will be no less than that provided in Division 23. In addition to age requirements, Class A, C, or M Portland cement concrete must show a flexural strength of 500 psi (3.5 MPa) or more and Class B Portland cement concrete placed after September 15 must show a flexural strength of 400 psi (2.8 MPa) or more.

C. Finishing.

1. After earth shoulders have been compacted, shape to the specified cross section and smooth to a condition acceptable to the Engineer.

2. Smooth and finish earth surfaces which have been constructed under the contract.

3. Restore to an acceptable condition sections of right-of-way that have been disturbed by the operations.

2123.04 METHOD OF MEASUREMENT.

A. Contracts involving shoulder work will contain either items for both excavated material in cubic yards (cubic meters) and earth shoulder finishing, or a single item for earth shoulder construction. Measurement will be as follows:

1. Earth Shoulder Finishing.
- **a.** Stations (meters) shown in the contract documents along each edge of the pavement.
- **b.** The Engineer will measure material excavated involved with earthwork finishing and shoulders according to Article 2102.04.
- **c.** Unless provided otherwise in the contract documents, overhaul will be measured according to Article 2108.04.

2. Earth Shoulder Construction.
Stations (meters) shown in the contract documents along each edge of the pavement.

B. For shoulders built adjacent to paved, intersecting highways, measurement along the edge of pavement or base will terminate at the point where the intersecting highway shoulder merges with the shoulder of the road under construction. Measurement will then be continued from this merging point along the shoulder line of the intersecting highway and continued to a point where shoulder work under the current contract is terminated. There will be no overlapping or duplication in these measurements.

C. Shoulder work in connection with raised, unpaved medians will be measured and computed on the basis of a single measurement for the length of the median.

D. For work done in conjunction with shoulders adjacent to farm drives, approaches, and unpaved, intersecting roads, additional measurement will not be made for shoulders along the drive, approach, or intersecting road, nor will any deduction be made in the measurement along the edge of pavement or base.

E. Shoulder work in connection with unpaved islands will be considered incidental to island construction and will not be measured for payment.

F. For shoulder work completed in conjunction with paved driveways and entrances, additional measurements will not be made for shoulders built along the drive or entrance unless it is more than 25 feet (8 m) in length. If more than 25 feet (8 m) in length, measurements will be made from edge of pavement to the point of shoulder work termination. The width of drives or entrances along the pavement edge will not be measured for payment. Deductions or additional measurements will not be made for unpaved driveways or entrances.

G. When all or a portion of the work is done under general traffic, measurements or payment will not be made for traffic control, decreased production, or other items directly related to this traffic.

2123.05 BASIS OF PAYMENT.

A. Payment will be as follows:

1. Earth Shoulder Finishing.
- **a.** Payment will be the contract unit price for the following:
  - **1)** Earth Shoulder Finishing: per station (meter).
  - **2)** Excavation: per cubic yard (cubic meter), as provided in Article 2102.05, A, 1.
  - **3)** Overhaul: per station yard (cubic meter per metric station), unless the contract provides otherwise.
- **b.** Payments are full compensation for all work of building shoulders.

2. Earth Shoulder Construction.

a. Payment will be the contract unit price per station (meter).

b. Payment is full compensation for all costs including the cost of excavating, hauling, placing, compacting, rebuilding approaches, and finishing work.

B. Payment includes costs associated with work done under traffic.

Section 2125. Reshaping Ditches

2125.01 DESCRIPTION.

Remove excess earth material from side ditches according to the contract documents.

2125.02 MATERIALS.

See Article 2125.03.

2125.03 CONSTRUCTION.

A. Shape side ditches to produce smooth surfaces of the ditch and backslope which will conform to the typical section shown in the contract documents.

B. Use excavated materials to build shoulders or widen embankments, or remove excavated materials from the project as the Engineer directs. Do not deposit shoulder material on finished base or surface courses.

C. Place and compact material used for widening embankments according to Article 2107.03, L. Place, compact, and shape material used for earth shoulders as provided in Section 2123.

2125.04 METHOD OF MEASUREMENT.

Reshaping Ditches, in stations (meters), will be the quantity shown on the contract documents as determined along the bottom of the ditch.

2125.05 BASIS OF PAYMENT.

A. Payment for Reshaping Ditches will be the contract unit price per station (meter).

B. Payment is full compensation for the reshaping ditches, and for removal or placement of the excavated material.

Section 2126. Reclaiming Present Surfacing Material

2126.01 DESCRIPTION.
Scarify, windrow, load, stockpile, rehaul, and deposit granular material found on the present road surface.

2126.02 MATERIALS.
None.

2126.03 CONSTRUCTION.

A. Blade loose surfacing material from the shoulders to the central area of the roadway.

B. Scarify the old road surface to be reclaimed to a width and depth that will yield suitable surfacing material. The Engineer will determine what material is suitable for reclaiming. Pulverize the loosened material to the extent that 100% of the particles will pass a 3 inch (75 mm) sieve.

C. Haul and deposit reclaimed material in stockpiles and spread uniformly over the length of the project, or haul and spread the reclaimed material on specified sections of the project after grading is completed.

D. At the Contractor's option and without extra payment, the Contractor may substitute special backfill material, meeting requirements of Section 4132, for reclaimed surfacing in treatment areas. Obtain the Engineer’s approval for scarification and disposition of the surfacing material.

E. Reclaim surfacing material prior to installation of crossroad culvert pipe or grading operations. After surfacing material has been removed, satisfactorily blade and shape the roadway for local traffic.

2126.04 METHOD OF MEASUREMENT.
Measurement for Reclaiming Present Surfacing Material will be in cubic yards (cubic meters) in the transporting vehicle, and according to Article 2312.04, A. If such measurement is impractical, measurement may be made by the Engineer of the stockpile by the cross section method or by other feasible methods.

2126.05 BASIS OF PAYMENT.

A. Payment for Reclaiming Present Surface Material will be the contract unit price per cubic yard (cubic meter).

B. Payment is full compensation for reclaiming present surfacing material, scarifying, blading, loading, hauling, stockpiling, and spreading the reclaimed material as directed by the Engineer. No overhaul will be paid on this material.

Section 2127. Reconstruction of Roadbed

2127.01 DESCRIPTION.

A. Remove the upper portion of an existing roadbed to the depth specified in the contract documents.

B. Store removed material.

C. Recover stored material for reconstruction of roadbed.

2127.02 MATERIALS.

None.

2127.03 CONSTRUCTION.

A. Blading.

1. When indicated in the contract documents, blade road surfacing material into a windrow and reclaim according to the provisions of Section 2126. Store this reclaimed material at locations selected or designated for use as required for later construction. Remove and store the upper portion of existing roadbed (either in excavation or embankment) on the foreslope or at convenient locations adjacent to the work.

2. Lower the roadbed over the entire width from outside edge of shoulder to outside edge of shoulder to the elevation indicated in the contract documents. To the extent possible, place the material removed in this operation in its final location below subgrade elevation and compact as required. Excess material required for later building of shoulders may be stored on the foreslopes or in selected stockpile locations until construction of subgrade, subbase, base, or pavement is completed.

B. Widening.

1. Prior to the placement of material for the widening of embankments, remove all vegetation from the existing foreslope, and roughen or step the foreslope. Vegetation removal and foreslope roughening or stepping may be performed:

- As a complete operation on a given slope, or
- Just prior to placement of the material for a particular lift as the embankment is brought up.

2. Widening Less than 4 Feet (1.2 m).
If the width of the embankment widening at an attained elevation (measured horizontally between the existing foreslope and the proposed foreslope) is less than 4 feet (1.2 m), the widening material may be placed and shaped without specified compaction.

3. Widening 4 Feet (1.2 m) or More.

a. If the width of the embankment widening is 4 feet (1.2 m) or more, step or bench the existing foreslope:

- To the extent that the widening material can be placed in lifts of 8 inch (200 mm) loose thickness, and
- To a width sufficient to permit the operation of placing, leveling, and compaction equipment.

b. Depending the variance between the rate of slope of existing foreslope and the proposed foreslope, this may require compaction of widening material in the bottom nine or ten lifts of an embankment and not require a specified compaction in the top three or four lifts. Compact the materials used in embankment widening where the width is 4 feet (1.2 m) or more as provided in Article 2107.03, L.

C. When required by the contract documents, return reclaimed road surfacing material to the central portion of the roadbed. Spread the material uniformly over the area to be covered with a base or pavement, plus 1 foot (0.3 m) on each side.

D. When the base course or pavement has been completed, recover the material which has not already been used in required embankment. Use this material to build shoulders, flatten foreslopes, or to place otherwise as directed by the Engineer. If not utilized, remove the material from the project. This material becomes the property of the Contractor.

E. Build and finish earth shoulders as provided in Section 2123. When granular surface shoulder construction is a required part of the work, finish and compact the shoulders to the elevation of the granular surfacing bottom.

2127.04 METHOD OF MEASUREMENT.

A. Reconstruction of Roadbed.
The quantity, in stations (meters), will be shown in the contract documents as determined along the centerline.

B. Earth Shoulder Construction.
Article 2123.04, A, 2, applies.

C. Reclaiming Present Surfacing Material.
Article 2126.04 applies.

2127.05 BASIS OF PAYMENT.

A. Reconstruction of Roadbed.

1. Payment will be the contract unit price per station (meter).

2. Payment is full compensation for excavating, hauling, compacting, and recovering excavated material. This work will not include the cost of

reclaimed surfacing material or earth shoulder construction in the area of Reconstruction of Roadbed.

B. Earth Shoulder Construction.
Article 2123.05, B, applies.

C. Reclaiming Present Surfacing Material.
Article 2126.05 applies.

Section 2128. Furnish and Apply Granular Shoulder Material

2128.01 DESCRIPTION.

Furnish and apply granular material on the shoulder of an existing road for the purpose of shoulder repair. The quantity and rate will be specified for each site in the contract documents. Furnish the material to the locations shown in the contract documents. The Contracting Authority will prepare the surface, shape the material to the desired cross-section, and compact materials.

2128.02 MATERIAL AND EQUIPMENT.

A. Furnish material meeting the requirements of Section 2121 for Type B Granular Shoulders.

B. Use weighing equipment meeting the requirements of Article 2001.07.

C. The contract documents may require the Contractor to use an edge rut spreader that will be furnished by the Contracting Authority. The contract documents may require the Contactor to deposit the material directly into a shouldering machine furnished and operated by the Contracting Authority.

2128.03 CONSTRUCTION.

A. Traffic Control
The Contracting Authority will furnish traffic control. All material to be deposited onto a shoulder will be accessible from a closed lane.

B. Staging of Work
Provide the Engineer a minimum of one week notice prior to commencing delivery of materials at a particular site. The hours of delivery, delivery days of the week, delivery requirements, and contact person will be identified in the contract documents. The Contractor will be restricted to a single work site unless otherwise specified in the contract documents.

C. Placement
Spread the material to the width and depth specified in the contract documents. Place granular shoulder material on the subgrade in such manner that no material is deposited on the adjacent pavement surface. If material is inadvertently spilled on the pavement, immediately remove it.

D. Spreading
The Contracting Authority will perform the final spreading of the placed material to the final cross section.

E. Compaction
The Contracting Authority will compact the placed material.

2128.04 METHOD OF MEASUREMENT.

A. Measurement for Furnish and Apply Granular Shoulder Material satisfactorily placed will be computed from the weights (mass) of individual truckloads, including moisture in the aggregate at time of delivery.

B. Measurement may be converted from tons to cubic yards (megagrams to cubic meters) or cubic yards to tons (cubic meters to megagrams) with approval of the Engineer. The Engineer will determine the conversion factor.

C. When measurement is by the cubic yard (cubic meter), all loads shall be leveled and corners filled at the loading point. Measurement will be checked at the point of delivery. Deductions will not be made for natural settlement in transit. The tops of end gates on transporting vehicles shall not be lower than the adjacent sides. Weight (mass) measurements shall be taken on the Contractor's weighing equipment according to Article 2001.07. Load vehicles to ensure against loss of material between the scales and the point of delivery. Deduction will not be made for the weight (mass) of moisture naturally occurring in the material.

2128.05 BASIS OF PAYMENT.

A. Payment for Furnish and Apply Granular Shoulder Material will be the contract unit price per cubic yard or ton (cubic meter or megagram).

B. Payment is full compensation for:
- Furnishing, transporting, and depositing the material on the shoulder according to the contract documents,
- Furnishing all equipment, labor, and materials, and
- Performance of all work necessary to complete the work.

DIVISION 22. BASE COURSES

Construct base courses on prepared subgrades or subbases. Base courses consist of construction performed according to the requirements specified for the various types in the following sections. Comply with the lines, grades, thicknesses, and typical cross sections shown in the contract documents.

If a subbase or other prepared subgrade is not specifically required, prepare the subgrade as provided in Section 2109.

Section 2201. Portland Cement Concrete Base

2201.01 DESCRIPTION.
Construct PCC base course to the dimensions shown in the contract documents.

2201.02 MATERIALS.
Apply Article 2301.

2201.03 CONSTRUCTION.
Apply Section 2301 with the following exceptions:

A. Use Class A or Class C concrete, or the mixture used in the mainline paving.

B. The tolerance, when checked with a surface checker, shall be 0.25 inch in 10 feet (5 mm in 3 m).

C. If an asphalt surface is a part of the contract, a dark colored curing compound may be used.

D. The base may be opened to shouldering operations, traffic, or surfacing after it has attained an age of 72 hours and a flexural strength of 500 psi (3.5 MPa).

E. Saw and seal joints according to Section 2122 when constructing PCC paved shoulder. Joints need not be sealed for a PCC base course.

2201.04 METHOD OF MEASUREMENT.
Measurement for P.C. Concrete Base will be according to Article 2301.04, A.

2201.05 BASIS OF PAYMENT.
Payment for P.C. Concrete Base will be according to Article 2301.05, A.

Section 2203. Hot Mix Asphalt Base

2203.01 DESCRIPTION.
Construct an HMA base, as specified, upon a prepared or corrected subgrade or a previously constructed base or subbase.

2203.02 MATERIALS.
Apply Article 2303.02.

2203.03 CONSTRUCTION.
Construct HMA base to the dimensions shown in the contract documents and according to Section 2303.

2203.04 METHOD OF MEASUREMENT.
Measurement for the various items involved in the construction of a HMA base will be according to Article 2303.04.

2203.05 BASIS OF PAYMENT.
Payment for the various items involved in the construction of a HMA base will be as provided in Article 2303.05.

Section 2210. Macadam Stone Base

2210.01 DESCRIPTION.

A. Prior to placement of a surface course:

1. Prepare the subgrade,

2. Provide for a filter course,

3. Furnish, place, and compact a Macadam base course and a choke stone course, and

4. Apply a prime to the finished work.

B. Complete the above work according to the contract documents.

2210.02 MATERIALS.

A. Use aggregate that meets the requirements of Section 4122 for the base course and choke stone course.

B. For primer bitumen, use SS-1, SS-1H, CSS-1, or CSS-1H, meeting requirements of Section 4140. RC-70 and MC-70 may also be used after October 1, at the Contractor's option.

2210.03 CONSTRUCTION.

A. Equipment.
Use equipment meeting the requirements of Section 2001 and the following:

1. Weighing Equipment.
Apply Article 2001.07.

2. Compaction Equipment.
Apply Article 2001.05, F. In addition, a smooth faced, steel tired roller, meeting requirements of Article 2001.05, B, will be required for final rolling of the choke stone course.

3. Prewetting Equipment.
Apply Article 2001.08, A, if prewetting is to be done.

4. Spreading Equipment.
Use spreading equipment capable of spreading the base and choke stone course to the required thickness.

5. Broom.
Apply Article 2001.14.

6. Equipment for Heating and Distributing Bitumen.
Apply Articles 2001.11 and 2001.12.

7. Equipment for Applying Water.
Apply Article 2001.09.

8. Motor Graders.
Apply Article 2001.15.

B. Preparation of the Subgrade.
Correct and construct the subgrade with the provision for a filter course as required by the contract documents. Macadam stone base shall not be constructed on natural soil subgrade.

C. Macadam Base Course.

1. Spread base material to a width and depth so the base conforms to the desired profile and cross section. If spreading the base material in a single course, ensure the compaction equipment used will uniformly and satisfactorily compact the material for the full depth of the course. Spread the base material to maintain uniformity of the material. When a spreader does not spread to the full design width in one operation, the Engineer may require special handling of the center joint to avoid segregation.

2. Thoroughly and uniformly compact the base material immediately after it as been spread. Continue compacting until the base material is well seated and no appreciable displacement occurs when rolling.

D. Choke Stone Course.

1. The aggregate may be prewetted before delivery to the Macadam stone base. The Engineer may control the material delivery rate to reduce the time the material will remain on the base in an uncompacted condition to the practical minimum.

2. If the material is prewetted before delivery, or if water is added to the base after delivery, ensure the water is uniformly distributed throughout the material so that all particles are uniformly wet. Verify water is within 2.0% of the amount determined as field optimum to produce maximum density together with stability with the field compaction procedure. This moisture content will usually be 85 to 90% of the optimum determined according to Materials Laboratory Test Method No. Iowa 103. Maintain this moisture content in the material until base compaction is complete.

3. Spread the choke stone course as required for the Macadam base course.

4. Immediately after spreading the material, thoroughly and uniformly compact with three passes of a vibratory roller. During the compaction process, perform wetting, shaping, and edge trimming necessary to ensure proper compaction and to achieve the require profile, crown, cross section, and edge alignment. An additional final rolling with a smooth faced, steel tired roller will be required. Ensure the finished surface is free from irregularities and loose material and has a smooth riding surface.

E. Fillets for Intersecting Roads, Drives, and Turnouts.
Construct fillets according to the contract documents.

F. Priming Base Course.
Prime the surface of the choke stone course and adjacent subgrade according to the contract documents.

G. Maintenance of Completed Base.

1. The Contractor may choose how far in advance of the course to complete the base.

2. Prior to and during subsequent construction activities, maintain the completed base to the required density and cross section, and to a smooth condition free from loose material. Do not place hauling equipment or other traffic on the completed base.

3. If the Engineer permits traffic by others authorized to do work on the project that exceeds the Contractor’s self imposed limit during base

construction, the Contracting Authority will pay to repair the damage (if any) caused by this traffic. The Engineer will determine the cost for repair of the damage.

H. Winter Seal.

1. Prime (as specified) all base not covered with upper base or surface the same season which it is constructed. The Engineer may require an application of a winter seal. Except as modified by the Engineer, use a winter seal consisting of the bituminous material used as the primer or tack coat applied at 0.12 gallon per square yard (0.5L/m^2), and a sand cover applied at 10 to 15 pounds per square yard (5 to 8 kg/m^2). Spread bituminous material and aggregate according to Section 2307. Winter seal the Engineer requires will be paid for according to Article 1109.03, B.

2. Except where road closure is provided in the contract documents, traffic will be allowed to use the road from the time construction is stopped until work is resumed the following season. Make required repairs to the base when construction is resumed, at no additional cost to the Contracting Authority.

2210.04 METHOD OF MEASUREMENT.

Measurement for the quantities of the various classes of work involved in the construction of accepted portions of Macadam stone base will be as follows:

A. Macadam Stone Base.
Computed in tons (megagrams) from weights (mass) of individual truck loads.

B. Choke Stone Base.
Computed in tons (megagrams) from weights (mass) of individual truck loads, including free moisture in the material at the time of delivery. Moisture added after delivery of the material to the roadbed will not be measured for payment.

C. Primer Bitumen for Macadam Stone Base.
Apply Article 2307.04, B.

2210.05 BASIS OF PAYMENT.

For the performance of the various classes of work involved in construction of Macadam stone base, measured as provided above, payment will be the contract unit price as indicated below. Payments are full compensation for furnishing all materials, including water, and for all operations involved in the construction of the base.

A. Macadam Stone Base.
Per ton (megagram) for the number of tons (megagrams) placed.

B. Choke Stone Base.
Per ton (megagram) for the number of tons (megagrams) placed.

C. Primer Bitumen for Macadam Stone Base.
Per gallon (liter) for the number of gallons (liters) measured for payment.

Section 2212. Base Cleaning and Repair

2212.01 DESCRIPTION.
Clean and repair pavement in preparation for resurfacing with HMA.

2212.02 MATERIALS.
Meet the following requirements:

A. Hot Mix Asphalt.

1. Surface Patches.
Apply Article 2530.02, A. For patches on the Interstate system use a 1/2 inch or 3/4 inch (12.5 mm or 19 mm) mixture size.

2. Partial Depth Repair Patches.
Apply Article 2530.02, A. For patches on the Interstate system, use a 1/2 inch or 3/4 inch (12.5 mm or 19 mm) mixture size.

3. Full Depth Repair Patches.
Apply Article 2529.02.

B. Portland Cement Concrete.

1. Partial Depth Repair Patches.
Apply Article 2530.02.

2. Full Depth Repair Patches.
Apply Article 2529.02.

2212.03 CONSTRUCTION.

A. Equipment.
Use equipment meeting the requirements of Section 2001 and the following:

1. Bituminous Distributor.
Apply Article 2001.12.

2. Portland Cement Concrete Equipment.
Apply Section 2301.

3. Mechanical Tampers.
Apply Article 2001.04.

4. Sand Spreader.
Apply Article 2001.13, C.

5. Weighing Equipment.
Apply Article 2001.07.

6. Equipment for Heating Bituminous Materials.
Apply Article 2001.11.

7. Field Laboratory.
Apply Section 2520.

B. Preparation and Repair of Base.
Before any HMA surface patch, base, leveling, strengthening, wedge, intermediate, or surface course is placed, clean and repair the old pavement surface in the following manner:

1. Cleaning and Preparation of Base.

a. Remove spalled and scaled material, old patch and joint material, debris, and all other loose material that can be removed by hand tools, such as picks or air blast, as directed by the Engineer. Use mechanical hammers when required by the Engineer. On both concrete and bituminous surfaces, remove existing bituminous patch materials that are unstable to the degree that they have distorted under traffic or contain fractures or spalled particles.

b. Bituminous seal coats, or other bituminous layers that may not be as well cured or may be flushed at the surface but that lack sufficient thickness to cause instability to themselves or the new resurfacing, may be allowed to remain in place.

c. Clean cracks more than 3/4 inch (20 mm) wide to a depth of at least 1 inch (25 mm), and to a depth up to 3 inches (80 mm) if the material is readily removable. Use scrapers, air hoses, or brooms as necessary to ensure the base is free of foreign material at the time the resurfacing is spread.

d. All material removed from the pavement becomes the property of the Contractor. Remove the material from the work site according to Article 1104.08. Remove (by blading) portions of the earth shoulder that would interfere with placement of base, intermediate, or surface courses.

e. The Contractor may be required to mow grass on the shoulder, or otherwise prepare that surface, when a guide string line reference is to be positioned on the adjacent shoulder.

2. Base Repair.

a. General.

1) Repairing pavement for base repair consists of the following:
Surface Patches.
Partial Depth Repair Patches.
Full Depth Repair Patches.

2) The Engineer will identify the areas to be repaired.

3) When specified in the contract documents, full depth or partial depth repair patches may be PCC, HMA, or a combination. The Engineer may require HMA patches where sight distance is restricted.

4) For HMA repair patches, ensure the final surface of the patch is level with (or not more than 1/4 inch (5 mm) above) the surrounding pavement.

5) For PCC full depth and partial depth repair patches, finish the concrete to be level with (or not more than approximately 1/4 inch (5 mm) above) the existing surface for repair of PCC pavements that are to be resurfaced. For composite patches, finish the surface of the repair patch at approximately the level of the old PCC surface. Then finish the patch to the surface of the surrounding pavement with HMA at the direction of the Engineer.

6) Cure PCC full depth and partial depth repair patches according to Article 2529.03, H.

7) Curing compound will not be allowed on repair patches.

8) If sawed joints are required in repair patches, the curing protection may be removed from each patch immediately prior to sawing and must be replaced immediately after sawing joints in that patch. Do not seal joints on repair patches.

9) Allow PCC repair patches to cure a minimum of 5 hours, or as directed by the Engineer, prior to resurfacing with HMA. Prior to covering the patch with HMA, tack the patch area and edges.

10) For PCC patches when dowel bars are not required at the transverse edges, ensure the transverse edge of the existing pavement is vertical with a roughened face. The severance may be made at the patch edge using a wheel saw. Do not use a blade saw for a full depth severance at the patch edge.

11) A 10 inch (250 mm) severance will be considered full depth if the adjacent pavement exceeds that thickness. Perform all work in a manner that will not damage concrete that is to remain. Do not use heavy equipment adjacent to new concrete until the curing is completed. Remove material not designated for salvage according to Article 1104.08. Removed material becomes the property of the Contractor.

b. Full Depth Repair Patches.

1) Construct full depth repair patches according to Section 2529 with the following exceptions:

a) If the thickness of full depth repair patches is not shown in the contract documents, base the thickness on the existing pavement type.

b) Construct patches to be no less than:

(1) 6 inches (150 mm) for County Roads.

(2) 9 inches (230 mm) for Primary Roads.

(3) 12 inches (300 mm) for Interstate Roads.

2) Base maximum full depth repair patch thickness on the following:

a) Portland Cement Concrete Repair Patch.

(1) Rigid Pavement: Pavement thickness, but not more than 12 inches (300 mm).

(2) Rigid Pavement resurfaced with HMA (composite patch): Rigid pavement thickness and the patch covered with HMA surface.

(3) Flexible Pavement: Same as above for resurfaced rigid pavement.

b) Hot Mix Asphalt Repair Patch.

(1) Rigid Pavement: Pavement thickness, but not more than 12 inches (300 mm).

(2) Rigid Pavement resurfaced with HMA: Thickness of pavement, including resurfacing, but not more than 12 inches (300 mm).

(3) Flexible Pavement: Thickness of surface and base course, but not more than 12 inches (300 mm).

c. Surface Patches.

1) In areas where spalled concrete or old patching material is removed according to Article 2212.03, B, 1, for a depth greater than 1 inch (25 mm), but less than the total thickness of the old pavement:

a) Clean the depressions.

b) Apply a tack coat.

c) Fill depressions with hot HMA. Deposit the HMA in layers which, after compaction, will not exceed 3 inches (80 mm) in thickness.

2) Thoroughly compact each layer, while hot, by rolling with an adequately weighted pneumatic tire or by tamping with a mechanical tamper until it has attained a density satisfactory to the Engineer.

3) Succeeding layers may be placed as soon as the preceding layer has been properly compacted.

4) Ensure the final compacted surface is level with (or not in excess of 1/4 inch (5 mm) above) the surrounding surface.

d. Partial Depth Repair Patches.

Construct partial depth repair patches according to Section 2530, except patch edges do not need to be sawed with a blade saw.

C. Limitations of Operations.

1. Conduct work on only one lane at a time unless road is closed.

2. On two-way roadways, do not disturb the pavement for full depth or partial depth repair patches or surface patches unless the patch can be completed before the end of the working day.

3. Unless the road is closed, traffic shall be permitted to use the pavement during construction operations. Conduct operations to provide a minimum of inconvenience to traffic.

4. Adjust the work schedule so that excavating, placing backfill material, compacting, and finishing of each patch will be completed in 1 day for two lane roads. For roads with multiple lanes in each direction, the work area may include one lane in each direction or as allowed by the traffic

control details. If unforeseen conditions result in excavated section being left overnight, assign flaggers to warn and direct traffic from the time construction operations have stopped until they have resumed. No extra payment will be made for the necessary flaggers.

5. Apply Articles 1107.08, 1107.09, and 1108.03.

2212.04 METHOD OF MEASUREMENT.

Measurement for the various items involved in base repair will be according to the following:

A. Cleaning and Preparation of Base.
The length shown in the contract documents.

B. Full Depth Repair Patches.
Computed in square yards (square meters) to the nearest 0.1 square yards (0.1 m^2) from measurements of areas of concrete removed and replaced. Each patch less than 2 square yards (2 m^2) in area will be counted as 2 square yards (2 m^2).

C. Partial Depth Repair Patches.

1. PCC: The Engineer will calculate the area of each patch in square feet (square meters) from surface measurements. The area of each patch less than 1 square foot (0.1 m^2) will be counted as 1 square foot (0.1 m^2).

2. HMA: The Engineer will calculate the area of each patch in square yards (square meters) from surface measurements to the nearest 0.1 square yards (0.1 m^2).

3. If the patch area is increased by the Contractor to accommodate milling equipment, only the area designated by the Engineer will be measured for payment.

D. Patches by Count.
In addition to the measurements described in Paragraph B, the Engineer will count the total number of full depth patches placed. Patches in each traffic lane will be individually counted.

E. HMA Surface Patches.
Tons (megagrams) as provided in Article 2303.04, A.

F. Primer or Tack Coat Bitumen.
Not measured for payment.

G. Hot Mix Asphalt (Composite Section).
According to Article 2529.04, C.

H. CD and CT Joints.
According to Article 2529.04, B.

I. Hot Mix Asphalt Mixtures.
In addition to the measurement described in Paragraph C, the Engineer will measure the weight (mass) of HMA placed in partial depth patches according to Article 2303.04. If the patch area is increased to accommodate milling equipment, only the quantities for the area designated by the Engineer will be measured for payment. Asphalt binder and tack coat will not be measured separately for payment.

2212.05 BASIS OF PAYMENT.

Payment for construction of the various items involved in the base repair, measured as specified above, will be the contract unit price as follows:

A. Cleaning and Preparation of Base.
Per mile (kilometer).

B. Full Depth Repair Patches.

1. Per square yard (square meter).

2. Payment is full compensation for:
- Removal of the old pavement,
- Restoring the subgrade or subbase,
- Furnishing and installation of tie bars,
- Restoring longitudinal reinforcement for continuously reinforced patches,
- Furnishing and placing the patching material, including the asphalt binder,
- Tack coat, curing, and joint sealing, and
- Placing backfill material in the disturbed area.

3. Payment for overdepth patches will be made according to Article 2529.05, A, 2.

C. Partial Depth Repair Patches.

1. PCC: Per square foot (square meter).

2. HMA: Per square yard (square meter).

3. Payment is full compensation for removal of old pavement according to Article 1104.08 and for all materials and other items involved in construction of these patches.

D. Patches by Count.

1. Each, in addition to payment described in Paragraph B, for the number of individual full depth patches placed.

2. Payment is full compensation for sawing or cutting necessary, for furnishing and installation of dowel bars at patch edges, and for traffic control associated with that patch.

E. HMA Surface Patches.

1. Per ton (megagram).

2. Payment includes compensation for asphalt binder in the mixture and tack coat.

F. Primer or Tack Coat Bitumen.
Incidental to the work item.

G. Hot Mix Asphalt (Composite Section).
According to Article 2529.05, C.

H. CD and CT Joints.
According to Article 2529.05, B.

I. Hot Mix Asphalt Mixture.
In addition to the payment described in Paragraph C, HMA for partial depth repair patches will be paid for according to Article 2530.05, B, 1, c.

Section 2213. Base Widening

2213.01 DESCRIPTION.
Excavate shoulder material, remove existing curb and flumes, and construct widened portions of base prior to placement of a surface course, seal coat, or another base course as a part of the contract.

2213.02 MATERIALS.
Use materials meeting the following requirements:

A. Base Material.

1. HMA Base Widening.
a. Use mixture specified on the contract documents.
b. Meet requirements of Section 2303, as specified.

2. PCC Base Widening.
Apply Article 2201.03.

B. Primer or Tack Coat Bitumen.
Apply Article 2303.02, E.

2213.03 CONSTRUCTION.

A. Equipment, General.
Use equipment meeting requirements of Sections 2001, 2301, 2302, and 2303.

B. Widening Equipment.
Use widening equipment that complies with Section 2001 and the following:

1. **Trench Machine.**
   Use a machine which can be operated in a manner so that the depth and width can be accurately controlled.

2. **Compaction Equipment.**
   a. Apply Article 2001.05, E, except that other types of equipment may be used when it has been demonstrated that required compaction will be secured.
   b. On subgrade and the final layer of widening, use a self propelled finish roller that is smooth and steel wheeled.

C. Removal of Curb.

1. When specified in the contract documents or directed by the Engineer, remove integral curb by methods which will not damage the concrete that is to remain.

2. Remove curb by grinding (or other methods approved by the Engineer) to provide complete removal of curb extending above the pavement surface and a safe and smooth surface to accommodate traffic. Other curb removal methods may include sawing and breaking, or chipping. If removal is done by sawing and breaking, complete the work as shown in the contract documents and as follows:
   a. Make a vertical saw cut along the edge of the curb nearest the center line of pavement.
   b. At the end of the curb section, extend the saw cut to the extreme end of the curb.
   c. At this point, make a saw cut at a right angle extending to the pavement edge.
   d. Where flumes occur in curb sections, extend the saw cut across the throat of the flume.
   e. On resurfaced pavement, locate the saw cut 7 1/2 inches (190 mm) from the pavement edge. Cut to a depth of 3 inches (75 mm) below the surface of the resurfacing.
   f. Immediately before breaking the curb, clean the sawed groove and ensure it is free of dirt, stones, or foreign matter to a depth of at least 1 inch (25 mm) below the pavement surface.
   g. Remove concrete (including resurfacing concrete and concrete across the throats of flumes) to comply with the dimensions shown. Cut off loosened and exposed reinforcement.

3. Clean up broken concrete according to Article 1104.08. This broken concrete becomes the property of the Contractor.

D. Removal of Flumes.
Remove flumes according to Section 2514.

E. Preparation of Subgrade.
Prepare subgrade for base widening according to Article 2302.03, D, with the following exceptions:

1. Cut the trench to the width of the widening shown in the contract documents. If the existing pavement is HMA, saw or trim the edge of existing asphalt (if any) to a vertical line flush with the edge of the existing concrete. At the Contractors option, this trim line may be made at any uniform distance in from the edge of the existing concrete, but not to exceed 3 inches (75 mm).

2. For HMA base widening, tack coat the edge of the old pavement at a rate of 0.10 to 0.15 gallon per square yard (0.4 to 0.7 L/m^2) according to Article 2303.03, C, 2, b. A waiting period will not be required before placing the widening.

F. Base Widening Construction.

The contract documents will show the total thickness of base widening to be placed.

1. HMA Base Widening.

a. Limit the compacted thickness of the top layer to no more than 2 inches (50 mm). The maximum thickness of lower layers may exceed 3 inches (80 mm) if the Contractor demonstrates the thicker layers have compaction and riding characteristics within conformance to that expected from a 3 inch (80 mm) thick layer. Avoid dumping base material on the surface of the pavement. Immediately remove, by brooming, base material spilled on pavement.

b. Spread base material so that after compaction, the constructed width conforms to the design dimension.

c. Promptly and thoroughly compact each layer. Compact to the density specified in Article 2303.03, C, 5, for Class I compaction.

d. The percent of compaction will be based on the laboratory density obtained for that day's mixture.

e. Succeeding layers of base material may be placed as soon as the previous layer has been compacted. Take density samples from the compacted material and test according to Article 2303.03, D.

f. When the contract for base widening does not include resurfacing, ensure the final surface of the widening is flush with, or not more than 1/8 inch (3 mm) below, the surface of the old pavement.

g. Do not open the widening to traffic until it has cooled sufficiently to provide stability.

2. PCC Base Widening.

Prepare PCC base widening according to Article 2302.03, E, and the following exceptions:

a. Concrete Filler.

1) Clean depressed areas from which the curb has been removed. Clean using a stream of water or air under sufficient pressure to remove loose and foreign matter from the groove.

2) Fill with PCC of the same composition as the concrete used for widening. Immediately before concrete is placed, sprinkle the concrete surface with water and cover with a thin layer of dry Portland cement thoroughly broomed into the surface. Place

the filler at the same time the adjacent widening is placed. Thoroughly tamp the concrete for the filler into place.

3) Finish and cure the filler in the same manner as for the widening.

b. Curing.
If asphalt surface is a part of the contract, a dark colored curing compound may be used.

c. Joint.
Joints need not be sealed for PCC base widening.

G. Limitations of Operations.

1. When full depth repair patches are part of the contract, complete this work before base widening is placed.

2. Unless the road is closed, perform base widening construction on one side of the pavement at a time. Open widening to traffic on one side before removing the curb on the opposite side.

3. Allow traffic to use the pavement during construction operations. Conduct operations to minimize inconvenience to traffic.

4. Apply Articles 1107.08, 1107.09, and 2303.03, C, 4.

H. Maintenance of Base.
Maintain the completed base widening prior to and during subsequent construction activities.

I. Winter Seal.

1. Prime HMA base which is not covered with upper base or surface in the same construction season in which it is built. The Engineer may require an application of a winter seal consisting of:

- The bituminous material used as the primer or tack coat applied at 0.12 gallon per square yard (0.5 L/m^2), and
- A sand cover applied at 10 to 15 pounds per square yard (5 kg/m^2 to 8 kg/m^2), according to Section 2307.

2. Winter seal that the Engineer requires will be paid for as provided in Article 1109.03, B.

3. Except where road closure is provided in the contract documents, traffic will be allowed to use the road from the time construction is stopped until work is resumed the following season. Make required repairs to the base when construction is resumed, at no additional cost to the Contracting Authority.

J. Rebuilding Shoulders.
Apply Article 2302.03, F.

K. Samples.
Apply Article 2303.03, D, 5, c.

2213.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Removal of Curb.
Stations (meters) to the nearest foot (meter) shown in the contract documents.

B. Removal of Flumes.
Shown in the contract documents.

C. Excavation, Class 13, for Widening.
Shown in the contract documents.

D. Base Widening.

1. Hot Mix Asphalt Base Widening.

a. Measurement by Weight (Mass).
Determined according to Article 2303.04, A, 2.

b. Measurement by Area.
Determined according to Article 2303.04, A, 3.

2. Portland Cement Concrete Base Widening.
Shown in the contract documents for the depth specified.

E. Asphalt Binder.
Article 2303.04, B, applies when HMA is measured by weight.

F. Primer or Tack Coat Bitumen.
Will not be measured separately.

G. Samples.
Article 2303.04, H, applies for HMA base widening.

2213.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Removal of Curb.
Per station (meter).

B. Removal of Flumes.
Per unit.

C. Excavation, Class 13, for Widening.

1. Per cubic yard (cubic meter).

2. Payment includes removal of bituminous fragments, boulders, and broken concrete according to Article 1104.08.

D. Base Widening.

1. Hot Mix Asphalt Base Widening.

a. Measurement by Weight (Mass).
According to Article 2303.05.

b. Measurement by Area.
According to Article 2303.05 for the depth specified.

2. Portland Cement Concrete Base Widening.
Per square yard (square meter) for the depth specified.

E. Asphalt Binder.
Article 2303.05, B, applies when HMA is measured by weight.

F. Primer or Tack Coat Bitumen.
Incidental to HMA.

G. Samples.
HMA base widening samples: according to Article 2303.05, H.

Section 2214. Pavement Scarification

2214.01 DESCRIPTION.

A. Scarify asphalt or PCC pavement to improve surface profile and cross section in preparation for resurfacing.

B. For this specification, scarifying refers to removal of a pavement surface according to the contract documents using cold planning equipment.

2214.02 MATERIALS.

None.

2214.03 CONSTRUCTION.

A. Equipment.

1. Use scarifying equipment that is:
- Wide enough so no more than two passes will be necessary in each traffic lane, and
- Suitable for the method of operation.

2. Except for very short or irregular sections, use equipment controlled automatically by a two point control with a minimum distance between control points of 15 feet (4.5 m).

3. Use a rotary broom described in Article 2001.14 to clean the surface.

4. When complete removal of asphalt material to an underlying PCC surface is intended, the contract documents may allow this removal by other methods and equipment.

B. Pavement Scarification.

1. The contract documents will show the intended depth of scarification and/or the taper or cross section. Scarify the surface as required. Make scarification cuts in straight lines.

2. Continue scarification across bridges only if required in the contract documents.

3. Immediately remove scarification debris from the pavement surface and handle as specified in the contract documents

4. Use water to minimize airborne dust particles.

5. Promptly sweep the scarified surface with a rotary broom before opening to public traffic.

6. For resurfacing:

a. Scarify the entire area designated and leave a surface with a smooth profile. For extremely irregular areas or where channeling, corner breaks, or settlements have occurred, occasional skips will be allowed. However, at least 95% of each 100 feet (30 m) of traffic lane (or equivalent) must have a newly scarified surface.

b. When a cross section of the scarified surface is shown in the contract documents, scarify the surface accordingly. Control scarifying operations to provide a surface that is true within a nominal tolerance of 1/4 inch (5 mm), and 1/4 inch (5 mm) at longitudinal joints where adjacent passes meet. The profile may be inspected by checking with a 10 foot (3 m) surface checker placed parallel to the center line. Correct variations greater than 1/4 inch (5 mm).

c. When asphalt material is salvaged for recycling, comply with the following additional requirements:

1) Scarify the pavement to the depth designated. This is an approximate depth which may be adjusted to assure adequate salvaged material. When wire mesh is present in the asphalt pavement, as indicated in the contract documents, scarify without disturbing the wire mesh, unless complete removal of wire mesh is specifically indicated.

2) Perform scarification in a manner that minimizes aggregate degradation.

3) Furnish a scale meeting the requirements of Article 2001.07. Weigh the scarified and salvaged material. Determine the quantity stockpiled as directed by the Engineer.

4) Stockpile salvaged material according to Article 2303.02.

5) When Blading and Shaping of Shoulder Material is not required, blade the existing shoulder material away from the

pavement edge, if necessary to provide for safety and drainage. This material may be placed on the foreslope. This work is incidental, and no separate payment will be made.

C. Blading and Shaping of Shoulder Material.

1. At the locations shown in the contract documents, blade the existing shoulder material away from the pavement. Store the material in a windrow on the outer portion of the shoulder area. Make provisions for drainage through the windrow, satisfactory to the Engineer. Complete this before or in conjunction with removal of HMA surface in that area.

2. After the overlay is completed or as it progresses, return the windrowed aggregate adjacent to the pavement. Some additional granular surfacing of the shoulder material is anticipated. Shaping and compaction as specified for granular surfacing of shoulders will be required. Moistening may be required. If the total thickness of the combination of materials exceeds approximately 3 inches (80 mm), separately compact the material returned from the windrow. The finish rolling will only be required on the final surface.

D. Limitations.

1. Ensure persons and vehicles are protected from injury or damage that might occur during the construction period. During construction, provide the traffic control required by the contract documents. Apply Articles 1107.08, 1107.09, and 1108.03.

2. Keep the road open to traffic unless otherwise indicated. Do not allow equipment to extend into an open lane, except as allowed by the traffic control requirements in the contract documents.

3. Remove foamed material in existing pressure relief joints prior to removal of the HMA surface. Remove this material from the project location according to Article 1104.08.

4. Scarify to full lane width, with a runout at the end, before the lane is opened to public traffic.

5. Plan and complete scarification so no vertical drop-off at the center line or lane line is left overnight. Where an overnight drop-off results from unforeseen conditions, sign the approaches with a ROAD WORK AHEAD sign. Mark the drop-off with 42 inch (1050 mm) channelizers. Place the channelizers at 150 foot (45 meter) intervals in rural areas and at 50 foot (15 m) intervals in urban areas. Use a minimum of three channelizers at each drop-off location.

6. When resurfacing is part of the contract, sign the approaches to scarified areas on Primary Roads with ROUGH ROAD signs. Repeat the signs for traffic that may enter within the scarified area from

intersecting public roads. Erect, move (if appropriate), and maintain these signs until the scarified areas are covered with new mixture.

7. Preliminary scarifying may be done to obtain representative samples. Patch these areas after scarifying, when necessary. Patching should be done daily. Complete patching necessary to bring the scarified surface to the tolerance specified within 2 working days of the scarifying operation. Additional patching may be necessary to maintain this temporary surface.

8. Perform scarification following full-depth patching.

9. Commence HMA or PCC placement operations within 10 working days after completion of the scarification operation. Once started, continue placement operations each working day until the scarified surface is completely covered. Failure to comply with these requirements will result in the assessment of a price adjustment equal to the liquidated damages stated in the contract documents. Repair damage to the scarified surface during the time period for which liquidated damages are being assessed.

10. When HMA resurfacing is part of the contract, cover all scarified surfaces with at least one full lift of HMA prior to winter shutdown. Leave no vertical edges or fillets.

11. Take additional precautions necessary for safety during the operation. The Contractor shall hold the Contracting Authority harmless of damage or loss resulting from an accident, during the scarifying operation, caused by failure to fulfill the obligations as outlined in these requirements.

2214.04 METHOD OF MEASUREMENT.

A. Pavement Scarification.

1. Measurement by Weight (Mass).
Tons (megagrams) determined by the Engineer from the quantity of scale weights (mass) of the material salvaged.

2. Measurement by Area.
Square yards (square meters) shown in the contract documents.

B. Blading and Shaping Shoulder Material.
Stations (meters) shown in the contract documents along each edge of the pavement.

2214.05 BASIS OF PAYMENT.
Payment will be the contract unit price as indicated below. Payments are full compensation for furnishing materials, (including water), equipment, and labor necessary to complete the work according to the contract documents including salvaging, stockpiling, and removal of excess material and debris according to Article

1104.08. If the scarified pavement materials will become the property of the Contracting Authority, delivery and stockpiling of the material shall be according to Section 2555. Payment for scarifying will not include areas scarified to obtain preliminary samples. Patching of these areas, when necessary, will be considered incidental to Pavement Scarification.

A. Pavement Scarification.

1. Measurement by Weight (Mass).
Per ton (megagram).

2. Measurement by Area.
Per square yards (square meters).

B. Blading and Shaping Shoulder Material.
Per station (meter).

Section 2216. Cracking and Seating PCC Pavement

2216.01 DESCRIPTION.

A. Crack and seat existing PCC pavement prior to HMA resurfacing.

B. Associated work may include removal of an existing HMA overlay if present, subdrain construction, HMA resurfacing, and shoulder work.

2216.02 MATERIALS.
None.

2216.03 CONSTRUCTION.

A. Equipment.

1. Cracking Equipment.
Use equipment capable of producing the desired cracking pattern by providing a broad striking surface. Do not use equipment that punches holes in the pavement or results in excessive spalling of otherwise sound sections. A blade or spade type breaker is recommended and may be required.

2. Seating Equipment.

a. Use a pneumatic rubber tired roller meeting the following requirements:

1) Four rubber tires equally spaced across the full width.

a) The roller tires shall be mounted in line on a rigid steel frame such that all wheels carry equal loads regardless of surface irregularities.

b) The roller tires shall be capable of satisfactory operation at a minimum inflation pressure of 100 psi (700 kPa).

c) The roller tires shall be inflated to the pressure necessary to obtain proper surface contact pressure to satisfactorily seat pavement slabs.

d) At the Contractor's option, the roller tires may contain liquid.

2) Weight body suitable for ballasting to a gross load of 50 tons (45 Mg). The ballast shall allow gross roller weight (mass) to be readily determined and controlled to maintain a gross roller weight (mass) of 50 tons (45 Mg).

b. Tow the roller with a rubber tired prime mover.

3. Other Equipment.

a. Equipment that provides a means to dampen cracked pavement with water.

b. Equipment that provides compressed air with 100 psi (700 kPa).

c. Rotary broom described in Article 2001.14.

d. Various hand tools as needed.

B. Removal of Existing Asphalt Overlay.

1. Before cracking, remove all asphalt and other bituminous material existing on the pavement surface from the area to be cracked. Perform removal using a continuous operation. Remove to the underlying PCC pavement and according to the requirements of Section 2214, excluding Article 2214.03, D. Removal of full depth patches is not required.

2. Remove foamed material in existing pressure relief joints prior to removal of the HMA overlay.

3. Scarify to the full width of the lane, with a runout at the end, before the lane is opened to public traffic. Plan and complete scarification to leave no vertical drop-off at the center line or lane line overnight. Where an overnight drop-off results from unforeseen conditions, sign the approaches with a ROAD WORK AHEAD sign. Mark the drop-off with vertical panels. Place the panels at 150 foot (45 meter) intervals in rural areas and at 50 foot (15 m) intervals in urban areas. Use a minimum of three vertical panels at each drop-off location.

4. Additional scarification of the existing PCC pavement may be required at bridge approaches and other fixed objects, as designated in the contract documents.

C. Pavement Cracking.

1. Crack the existing PCC pavement to produce full depth, transverse hairline cracks at a nominal spacing designated in the contract documents. When not designated, use a spacing of 1 1/2 feet to 3 feet (0.5 m to 1 m). Avoid inducing cracking closer than 2 1/2 feet (0.8 m) from an existing crack or joint or deteriorated concrete. Prevent the formation of a continuous longitudinal crack.

2. When cracking operations begin, the Engineer will designate test sections of approximately 100 feet (30 m). Crack test sections using varying energy and striking patterns until a satisfactory cracking pattern is established. Use this energy and striking pattern for the remainder of the project, unless the Engineer determines that a satisfactory cracking pattern is no longer being produced. In this case, adjust the energy or striking pattern, or both, as necessary to re-establish a satisfactory cracking pattern.

3. Furnish and apply water to the test area to dampen the pavement following cracking to enhance visual determination of the cracking pattern. Furnish and supply water to check stations, as directed by the Engineer, to verify that the specified crack pattern is being maintained. This will normally be once a day. Furnishing and applying this water is incidental and will not be paid for separately.

4. Do not operate cracking equipment on a bridge. Do not crack areas in a bridge approach section or within 3 feet (1 m) of a fixed object.

5. Before opening to traffic, seat cracked pavement and then remove loose or spalled material by sweeping and by blowing joints and cracks with compressed air. Repeat cleaning as necessary until the HMA resurfacing is placed.

D. Pavement Seating.

1. Seat the cracked pavement as shown in the contract documents.

2. Roll the cracked pavement until seated to the Engineer's satisfaction. The intent is to:

- Load the roller so that satisfactory seating can be reasonably assured by one complete coverage by the roller, and
- Accomplish seating with a minimum damage to aggregate interlock at the cracks.

3. The Engineer will approve the weight (mass) of the roller and the rolling pattern, including laps, based on one or more initial test sections.

E. Limitations.

1. Ensure persons and vehicles are protected from injury or damage that might occur during the construction period. During construction, provide the traffic control required by the contract documents. Apply Articles 1107.08, 1107.09, and 1108.03.

2. Keep the road open to traffic unless otherwise indicated. Do not allow equipment to extend into an open lane, except as allowed by the traffic control requirements in the contract documents.

3. This work shall be carefully staged to minimize the time public traffic is to drive on pavement where the pavement work is only partially

completed. Do not start removing existing HMA overlay more than 14 calendar days before the succeeding operation is scheduled to begin. Do not start pavement cracking more than 14 calendar days before the overlay operation of the cracked and seated area is scheduled to begin.

4. Overlay cracked and seated areas with the full thickness of HMA, required by the contract, before a winter suspension.

5. Examine Article 1105.12. If the operation of the seating roller over a culvert is to be restricted according to Article 1105.12, G, this will be designated in the contract documents.

2216.04 METHOD OF MEASUREMENT.
The Engineer will calculate the area of Cracking and Seating of PCC Pavement, satisfactorily completed, from the length and the nominal width.

2216.05 BASIS OF PAYMENT.

A. Payment for Cracking and Seating of PCC Pavement will be the contract unit price per square yard (square meter).

B. Payment is full compensation for cracking and seating and for furnishing all materials, equipment, and labor.

Section 2217. Rubblizing Existing Portland Cement Concrete Pavement

2217.01 DESCRIPTION.
Rubblize and compact the PCC pavement as shown in the contract documents.

2217.02 MATERIALS.
None.

2217.03 CONSTRUCTION.

A. Equipment.

1. Use equipment capable of uniformly breaking the existing pavement without causing change to its cross slope or profile. Equip the unit with a water system to suppress dust generated by the operation.

2. Use a standard steel drum vibratory roller having a minimum gross weight (mass) of 10 tons (9 Mg) operated in the vibration mode to compact the rubblized pavement.

B. Rubblizing Existing PCC Pavement.

1. Saw to full depth at the beginning and end of the work. Sever tie bars on the mainline where the rubblizing abuts concrete which shall remain in place.

2. Operate the breaker unit at a speed such that the existing pavement is reduced into particles with a nominal maximum size of 4 inches (100 mm), based on a visual inspection of the rubblized pavement surface. Additional passes may be required if larger sizes remain after the initial rubblizing pass. Do not operate the breaker unit within 50 feet (15 m) of bridge abutments and other locations designated by the Contracting Authority.

3. Begin the rubblizing procecure at a free shoulder edge and work towards the centerline joint.

4. Operate the vibratory steel drum roller close behind the rubblizing operation at a speed not to exceed 6 feet (2 m) per second. Compact and seat with a minimum of 4 coverages. In addition, roll the surface immediately ahead of the paving equipment to remove distortion that may occur from batch trucks or other equipment.

5. Leave reinforcement in the rubblized pavement in place. However, cut off reinforcement exposed at the surface as a result of rubblizing operations or compaction operations, or both, and remove it from the project.

6. The roadway will be closed to thru traffic during construction, except at crossings designated in the contract documents. Keep all traffic to a minimum before the placement of the initial HMA course or the PCC pavement. Do not allow more than 2 working days to elapse between rubblizing pavement segments and placement of initial HMA course or PCC pavement. In the event of rain, this time limitation may be extended to allow sufficient time for the rubblized pavement to dry to the Engineer's satisfaction.

2217.04 METHOD OF MEASUREMENT.

The quantity of Rubblized Pavement, in square yards (square meters), will be the quantity shown in the contract documents.

2217.05 BASIS OF PAYMENT.

A. Payment for Rubblized Pavement will be the contract unit price per square yard (square meter).

B. Payment is full compensation for furnishing all equipment and materials, including water, and labor to rubblize the pavement, suppress dust, remove exposed reinforcement, and compact the rubblized pavement.

DIVISION 23. SURFACE COURSES

Construct surface courses on a prepared base, subbase, or subgrade according to the requirements specified for the various types in the following sections. Comply with the lines, grades, thicknesses, and typical cross sections shown in the contract documents or established by the Engineer.

Section 2301. Portland Cement Concrete Pavement

2301.01 DESCRIPTION.
A single course of PCC pavement of the type and class specified in the contract. If the class of concrete is not specified, Class C concrete shall be used.

A. Standard Concrete Pavement.
Standard concrete pavement may be reinforced or non-reinforced. Use the class of concrete specified in the contract documents. Reinforce as shown in the contract documents. Place within fixed forms, consolidate, and finish by equipment operating on forms.

B. Slip Form Pavement.
Slip form pavement may be reinforced or non-reinforced concrete of the class specified in the contract documents. Reinforce as shown in the contract documents. Place, consolidate, and finish without the use of fixed forms.

2301.02 MATERIALS.

A. General.

1. Meet the requirements for the respective items in Division 41. Unless specified otherwise, use coarse aggregate of the durability class required by Section 4115.

2. Ensure compatibility of all material combinations. If the concrete materials are not producing a workable concrete mixture, a change in the material may be required. Changes will be at no additional cost to the Contracting Authority.

B. Portland Cement Concrete Pavement.

1. **General.**
   - **a.** Proportion materials for pavement concrete in one of the mixtures identified in Materials I.M. 529 for the class of concrete specified in the contract documents. Any of the mixtures may be used, at the Contractor's option, provided the gradation of the separate aggregates complies with the gradation required for that mixture. Do not use C-5 and C-6 concrete mix proportions for pavements on Interstate or Primary highways.
   - **b.** After October 31, use Class A concrete to construct all items of concrete pavement specified to be constructed with Class B concrete. The Engineer will either require completion by continuing placement operations past October 31, or allow the Contractor the option of a winter shutdown. When completion is required, the Contracting Authority will pay the net increase in cost of materials resulting from the change in proportions for any pavement placed within the contract period or authorized extension of the contract period. Other increases shall be at no additional cost to the Contracting Authority.

2. **Combined Fine and Coarse Aggregate.**
   - **a.** If using an approved fine and coarse aggregate combination, fix the proportions on the basis of the relative amount of fine and coarse aggregate contained so as to be equivalent to one of the appropriate mixes specified for screened aggregates. These proportions are based on a specific gravity of 2.62 for Class V aggregate and 2.65 for other aggregates.
   - **b.** If the material furnished shows an average specific gravity other than the above values, adjust the proportions by the ratio of the actual average specific gravity to the above values.

3. **Water, Consistency, and Batch Yield.**
   - **a.** Use an amount of mixing water that will produce workable concrete of uniform consistency. Unless specifically modified by the Engineer, ensure slump, measured according to Materials I.M. 317, is no less than 1/2 inch (15 mm) or no more than 4 inches (100 mm). Slump requirements will not apply to slip form paving.

b. If it is not possible to produce concrete having the required consistency without exceeding the maximum allowable water cement ratio specified, the cement content may be increased or water reducing admixture may be added. Obtain the Engineer's approval. Do not exceed the maximum water cement ratio. Additional cement or water reducer will be considered incidental, with no additional cost to the Contracting Authority.

c. The basic absolute volume of water per unit volume of concrete is based on average conditions. If material characteristics require that the total quantity of water used to secure the required consistency reduces the batch yield (computed on the basis of absolute volumes of the batch quantities used) by more than 2.0%, the Engineer may adjust the proportions to correct the yield. This adjustment will not be a basis for adjustment of the contract unit price.

4. Entrained Air Content.

Use an approved air entraining agent. The target air content as determined by Materials I.M. 318 is 8.0%, with a tolerance of ± 2% when measured on the grade just prior to consolidation. Air content for non slip form paving is 7.0% ± 1.5%. The target air content may be adjusted by the Engineer based on random tests of the consolidated concrete behind the paving machine. These additional random tests will be used to consider the need for a target change, and will not be used in the acceptance decision.

5. Admixtures.

Approved admixtures complying with Section 4103 may be used with the Engineer's authorization.

6. Use of Supplementary Cementitious Materials.

The maximum allowable fly ash substitution rate is 20%. The GGBFS substitution rate shall not be more than 35% by weight (mass). The total mineral admixture substitution rate shall not exceed 40%. When Type IP or IS cement is used in the concrete mixture, only fly ash substitution will be permitted. Between October 16 and March 15, substitution of Type I/II cement with fly ash and GGBFS, or Type IP or IS cement with fly ash will be allowed only when maturity method is used to determine time of opening.

C. Proportioning and Mixing of Concrete Materials.

Proportion and mix materials according to the following requirements:

1. Storage and Handling of Aggregates.

a. Store and handle aggregates to avoid contamination and frequent variations in specific gravity, gradation, or moisture content of the materials used.

b. Keep fine and coarse aggregate stored in piles or bins entirely separate of one another.

c. When aggregates are trucked to the proportioning plant, the trucks must dump off a ramp or into a walled pit. In either case, they must

dump into a floored area. This floor shall consist of a substantial platform or a layer of similar aggregate at least 18 inches (0.5 m) thick placed entirely below the elevation of the surrounding ground.

d. Reduce, to a minimum the Engineer considers practical, the number of changes from one material to another having different frictional characteristics, class of durability, or average specific gravity.

e. At the time of proportioning or placing in proportioning bins, the moisture content of the aggregates shall be such that water will not drain or drip from a moisture sample. Handle aggregates in a manner that will prevent variations of more than 0.5% in moisture content of successive batches. Thoroughly wet coarse aggregates having an absorption greater than 0.5% and allow to drain for at least 1 hour before being used.

f. Drain fine aggregate at least 24 hours after washing and before batching.

g. Do not allow aggregates from two sources to commingle in stockpiles or in the finished pavement, except with the Engineer's approval.

2. Storage and Handling of Cement and Fly Ash.

a. Store cement in suitable weatherproof enclosures and handle to prevent loss.

b. Apply Section 4101 to cement which has developed lumps or which has been stored for extended periods.

c. Transport and store fly ash in suitable weatherproof enclosures in a manner to keep it dry.

d. Use proportioning equipment meeting the requirements of Article 2001.20, B.

3. Measurement of Materials.

Measurement of materials shall meet the requirements for the type of equipment used and the following additional requirements:

a. Operate cement scales within a delivery tolerance of 1.0% of the mass of cement per batch. When operated manually, balance scales to tare before each batch is weighed and after each batch is discharged.

b. Use cement and fly ash scales with automatic controls which meet the requirements of Article 2001.20, B, for all bid items involving more than 6000 square yards (5000 m^2) of pavement or base. Items made up of irregular areas, such as crossovers, turn lanes, and so forth, are excluded from this requirement.

c. Do not use manual controls for a period longer than 1 working day after a failure of the automatic controls, except with the Engineer's permission.

d. On work requiring automatic scales, the performance of the scale will be determined near the end of the first full day of production. Afterwards, performance of the scale will be determined at a frequency not to exceed 10,000 cubic yards (10,000 m^3) of concrete produced. Performance will be determined by comparing the accumulated mass of cement proportioned with the

corresponding accumulated mass of cement shipped to the project. The Contractor shall cooperate. Cement scale performance determinations are not required when a permanent, commercial ready mix plant is used to furnish less than 10,000 cubic yards (10,000 m^3) of concrete for a contract.

e. Determine the performance of fly ash scale, if present, as in Paragraph d above.

f. Operate aggregate scales within a delivery tolerance of 1.0% for each aggregate.

g. Measure water within a delivery tolerance of 1.0% of intended quantity.

h. Measure admixtures with approved equipment and procedures that assure the quantity measured is within a delivery tolerance of 3.0% of batch quantity. Clean and flush out mechanical dispensing equipment daily, and more frequently if necessary to ensure proper operation.

4. Mixing of Materials.

a. General.

1) Mix concrete materials either at the site of placement or in a construction or stationary mixer to be used for work on the project only. Concrete may also be ready mixed or transit mixed. During any one individual placement, use the same cement, aggregates, and admixtures throughout the placement unless the Engineer approves otherwise. With the Engineer's approval, concrete mixtures may be furnished from multiple plants provided the same materials are used in each mixture and mix consistency can be maintained.

2) Mix concrete material as provided in Article 2001.21 for the type of equipment used.

3) Do not use concrete transported without continuous agitation if the elapsed period between the time the concrete is mixed and the time it is placed is greater than 30 minutes. With the Engineer's approval, an approved retarding admixture may be used at the rate prescribed in Materials I.M. 403. Also with the Engineer's approval, the mixed-to-placed time period may be extended an additional 30 minutes.

4) Do not use concrete transported with agitation when the time between start of mixing and placement is more than 90 minutes.

5) Deliver and handle concrete in a manner that will:

- Prevent objectionable segregation or damage to the concrete, and
- Facilitate placing with a minimum of handling.

6) Thoroughly clean and flush the compartment in which the concrete is transported to the work at intervals necessary to ensure hardened concrete will not accumulate in the compartment. Discharge flushing water from the compartment before it is charged with the next batch.

7) Obtain Engineer's approval for plant equipment, operation, and procedures.

b. Concrete Mixed in a Construction or Stationary Mixer.

1) Use a method of handling batches and charging the mixer that ensures complete introduction of each batch separately without loss of materials.

2) Concrete discharged from the mixer is required to be uniform in composition and consistency. If this condition is not produced because of the size of the batch, the batch size may be reduced or the mixing time increased, or both, until this result is obtained.

c. Ready Mixed Concrete.

1) Ready mixed concrete is defined as concrete for which the required materials are as follows:

a) Proportioned in a central plant and mixed in a stationary mixer for transportation in trucks with or without agitation.

b) Proportioned and then mixed in a transit mixer prior to or during transit.

2) When additional mixing water is required at the site of placement, mix the batch for at least an additional 30 revolutions of the drum at mixing speed.

3) For main portions of the work designed to support public vehicular traffic:

a) Demonstrate to the Engineer before the work starts that each vehicle in which concrete will be delivered to the work is capable of discharging concrete having a slump not over 2 inches (50 mm) at an overall rate for its entire load of no less than 1.25 cubic yards (1 m^3) per minute.

b) Ensure concrete is delivered at a rate sufficient to maintain a sustained rate of progress no less than 100 feet (30 m) per hour for the width and depth of slab to be placed.

c) Ensure adequate and properly staffed dispatching system is utilized.

4) Ready mixed or transit mixed concrete may be used for other portions of the work under other restrictions specified for bid items involving 6000 square yards (5000 m^2) of pavement or less. Ready mixed or transit mixed concrete may also be used for irregular pavement areas such as crossovers and turn lanes.

2301.03 CONSTRUCTION.

When the contract allows for either standard or slip form pavement, the method used is the Contractor's option. When the contract allows only one type, use the type specified. When slip form is specified, small or irregular areas may be constructed with fixed forms. Irregularly shaped areas of either type of pavement may be formed and finished by hand methods.

A. Equipment.

1. General.

Provide sufficient equipment to perform all operations necessary to complete the work. Use equipment meeting the appropriate requirements of Section 2001 and the following provisions.

2. Proportioning and Mixing Equipment.
Use equipment that complies with the following:

a. Weighing and Proportioning Equipment.
Apply Article 2001.20.

b. Mixing Equipment.
Apply Article 2001.21.

c. Bins.
Apply Article 2001.06.

3. Construction Equipment for Portland Cement Concrete Pavement.
Use equipment that complies with the following requirements:

a. Equipment for Standard Concrete Pavement.

1) Side Forms.

a) General.

(1) Use side forms with a height (without horizontal joint) at least equal to the design thickness of the pavement at its edge. The additional height represented by integral curb may be secured by bolting extra forms on the top of the main form.

(2) Ensure the top face of a form does not vary from a true plane by more than 1/8 inch in 10 feet (3 mm in 3 m). Ensure the vertical face does not vary from a true plane by more than 1/4 inch in 10 feet (6 mm in 3 m).

(3) For curves having radii of 100 feet (30 m) or less, use flexible or curved forms.

b) Forms Required to Support Heavy Equipment.

(1) Use steel no thinner than U.S. standard 5 gauge (approximately 7/32 inch (5 mm)). Equip with a device that permits adjustment for horizontal and vertical curves for holding abutting sections firmly in alignment.

(2) If using forms having a height of 8 inches (200 mm) or more, ensure the base is no less than 8 inches (200 mm) wide. If using forms having a height less than 8 inches (200 mm), ensure their base width is no less than their height. Equip with no less than three staking points per each 10 feet (3 m) of length, with means for securely locking the form to each stake. Extend flange braces and staking pockets outward on the base no less than 65% of the height of the form.

c) Forms Not Required to Support Heavy Equipment.

(1) Forms not required to support heavy equipment may be made of wood or steel. Ensure forms have sufficient stiffness and are staked to remain vertical and true to line and grade during placing and finishing of concrete.

(2) Use nominal 2 inch (50 mm) stock straight wood forms.

(3) Use wood forms that are finished on the side supporting the concrete and on their upper edge.

2) Integral Curb Forms.

a) Use metal forms to form the back of all integral curbs, except where returns have a small radius or other special sections making the use of metal forms impractical.

b) Rigidly attach back forms for curb to the side forms for the pavement slab. Use all fastenings provided by the form manufacturer. Supply a sufficient length of curb forms and number of fastenings to make it possible to leave the forms in place for at least 6 hours after the curb is place.

c) At the time the curb form is placed, ensure the top of the pavement is free of all substances which prevent the rigid fastening or accurate alignment of the curb form. Ensure the curb form extends the plane of pavement form without a variation of more than 1/8 inch (3 mm). Set the top of the curb form at the elevation of top of curb being built, except at curb runouts.

d) Sloping faced curb not more than 4 inches (100 mm) in height may be shaped to the desired cross section with a curb mule without the use of face forms.

e) For straight sections of integral curb more than 4 inches (15 mm) high, the Contractor may use face forms or a slip form curb mule. If face forms are used, provide no less than 100 feet (30 m) for each curb being constructed. Properly secure face forms to maintain their shape and position during use. Ensure the face forms produce a curb cross section matching that of the details within the contract documents. Approved hand tools and methods may be used to supplement the forms in shaping the top roll and on returns and other special sections.

f) If a slip form curb mule is used, use a slip form curb mule that is no less than 6 feet (1.8 m) long, unless mounted on a machine. Obtain the Engineer's approval before using the slip form curb mule. Both back and face forms will be required when constructing barrier curbs or any curb having a top width of 8 inches (200 mm) or more.

3) Supplementary Rails.

a) Provide suitable metal rails capable of being securely attached to the top of the side forms to provide a track which will allow spreading, finishing, and curing equipment to back over the end of the previous day's run.

b) Ensure metal rail length is sufficient to accommodate all equipment which must be backed out of the way. Also ensure the rails are of such a height that all wheels and flanges of wheels will clear the previously placed concrete by at least 1/2 inch (15 mm).

4) Form Line Excavating Machine.

Excavate form lines for all forms supporting mechanical finishing equipment to line and grade by:

- A machine designed for this purpose and approved by the Engineer, or

- An approved machine which concurrently trims the subgrade or subbase to grade.

5) Subgrade Preparation.

Trim the subgrade or subbase to grade with a machine having electronic elevation controls. The Engineer's approval is required for other trimming methods.

6) Consolidating and Finishing Equipment.

For placing and finishing standard type pavement, the following equipment will be required:

a) Vibrators.

(1) Consolidate, with a single pass of an approved internal or surface vibrator, the full width and depth of concrete requiring a finishing machine. Operate internal vibrators within a frequency range of 4000 to 8000 vibrations per minute. The Engineer may authorize the minimum vibration frequency to be lowered to 3500 vibrations per minute for particular sections of paving, such as superelevations. Operate surface vibrators within a frequency range of 3500 to 6000 vibrations per minute.

(2) Avoid operating vibrators in a manner to cause a separation of mix ingredients, either a downward displacement of large aggregate particles or an accumulation of laitance on the surface of the concrete. When forward motion of the paver is reduced, vibrator frequency may need to be reduced to avoid separation of the mix.

(3) If a vibrator fails to operate within the specifications, repair or change the vibrator before paving begins:

- The following day, or
- The same day if the continuous paving that day is stopped at a header or the end of a session.

(4) If two adjacent vibrators fail to operate within specifications, stop paving operations and repair or replace the vibrators.

(5) Stop vibrators whenever forward motion of the paver is stopped.

(6) Use an electronic vibrator monitoring device displaying the operating frequency of each individual internal vibrator for all Interstate and Primary contracts with PCC paving quantities of mainline paving over 50,000 square yards (40,000 m^2) and other projects when specified in the contract documents. When required on a contract, the vibrator monitoring device will only be required in areas where mainline pavement length exceeds 600 feet (175 m). When project staging necessitates small mainline sections be paved separately from the majority of mainline paving, the Engineer may waive this requirement for those small sections.

(7) Use a vibrator monitoring device that meets all of the following:
- **(a)** Has a readout display near the operator's controls visible to the paver operator and the Engineer.
- **(b)** Operates continuously while paving.
- **(c)** Displays all vibrator frequencies with manual or automatic sequencing among all individual vibrators.
- **(d)** Records, at a minimum, the clock time, station location, paver track speed, and operating frequency of individual vibrators. Make recordings after each 25 feet (8 m) of paving or after each 5 minutes of time.

(8) Provide the Engineer with an electronic record daily for the first 3 days of paving and weekly thereafter. The Engineer may determine that more frequent submission is necessary, particularly if equipment malfunctions occur.

(9) If the electronic monitoring device fails to operate properly, manually check vibrators immediately. If vibrators are functioning properly, paving may continue, but correct the problem as soon as possible. If recording device fails to operate, paving may continue, but correct the malfunction within 3 paving days. The Engineer may allow additional time if circumstances are beyond the Contractor's control.

(10) Set the internal vibrator penetration depth into the concrete pavement slab to mid slab or as deep as possible while passing above reinforcing steel. Provide an operating position locking device so that no part of the vibrating unit can be lowered to the extent that it will come in contact with reinforcing steel or tie bars while paving.

(11) Do not exceed the manufacturer's recommendations for vibrator horizontal spacing. Do not exceed 16 inches (410 mm) from center to center.

(12) Mount longitudinal axis of vibrator body approximately parallel to direction of paving. Tilt trailing end of each vibrator downward to an approximate slope of 15 degrees below horizontal.

(13) Use vibrators that meet or exceed the following specifications at the manufacturer's design frequency of 10,000 vpm:
- **(a)** Amplitude (peak to peak) 0.070 inches (1.75 mm).
- **(b)** Centrifugal force 1200 pounds (5500 N).

b) Finishing Machine.

(1) Where side clearance is provided, a finishing machine designed for concrete paving will be required on all uniform width slabs 8 1/2 feet (2.6 m) or wider upon

which a continuous line of forms more than 600 feet (180 m) in length may be set. Obtain Engineer's approval before using this machine. Utility accesses, intakes, and other small fixtures will not be considered as an obstruction to the continuity of the form line. Railroad tracks, bridges, and existing paved intersections will be considered as obstructions in the continuity of the form line.

(2) Use a finishing machine that leaves the top of the concrete slab smooth with the desired crown and at the proper elevation. When the contract documents require the pavement to be laid partly with crown and partly without crown, equip the screed so that it can be adjusted to the change in shape at the required rate of change.

(3) If during the operation of subgrade or finishing equipment it is necessary to operate one or both sets of wheels or tracks on previously placed concrete, adjust or alter the wheels or tracks so that the bearing on the concrete will not be closer than 3 inches (75 mm) from the pavement edge. When operating with one side of the machine on pavement and the other side on forms, the wheels operating on the forms may be double flanged. Use flangeless, rubber faced wheels on the pavement. When operating over the edge of concrete less than 2 months old, support the ends of the finishing machine screeds with an approved device to provide from 1/16 to 1/8 inch (2 mm to 3 mm) clearance between the screed and previously placed pavement.

(4) Suspension resulting in a pendulum effect will not be approved.

(5) Sections of pavement not required to be finished with a finishing machine may be finished by hand equipment as provided in Article 2301.03, A, 3, d.

b. Equipment for Slip Form Concrete Pavement.

1) Form Line Excavating Machine.

When it is necessary to excavate to line and grade the path over which the pavement laying machine travels, use either:

- A machine designed for this purpose and approved by the Engineer, or
- A machine which operates concurrently with the trimming of the subgrade or subbase.

2) Subgrade Preparation.

Use an electronically controlled machine to trim the subgrade or subbase to grade to the Engineer's satisfaction.

3) Placing, Consolidating, and Finishing Equipment.

a) Use a slip form paving machine that meets all of the following:

(1) Is designed for the specific purpose of placing, consolidating, and finishing concrete pavement slabs without the use of fixed side forms.
(2) Leaves the edges of the slab vertical.
(3) Is self propelled and equipped with a means for spreading the concrete to a uniform depth before it enters the throat.
(4) Vibrates the concrete to the full width and depth being placed in a single passage. Accomplish vibration with vibrating tubes or arms working in the concrete or a vibrating pan operating on the surface of the concrete. Apply Article 2301.03, A, 3, a, for the amplitude, rate of vibration, monitoring, and locking device for depth.
(5) Produces a surface reasonably free of voids and tears.

b) When slip form paver is operated with one or both tracks on previously placed concrete, use tracks that are rubber faced, or travel on cushions of wood or belting, to prevent damage to the pavement surface.
c) Use a paver equipped with automatic horizontal and vertical grade controls.

4) False Forms.
With Engineer's approval, false forms may be used on slip form pavement work in areas that:
- Are to be subsequently abutted with other lanes of pavement in the 20 feet to 30 feet (5 m to 10 m) preceding a day's work joint, or
- Require vertical edge support.

c. Curing Equipment.
1) To apply liquid curing compounds (if used) on surfaces of pavements of uniform width for a continuous length of over 5000 feet (1500 m), use approved mechanical spraying equipment operating on the forms or outside the pavement edges. Use equipment with a shield provided to prevent undue loss of curing compound by wind action.
2) Hand spraying equipment may be used on vertical edges, hand finished sections, and all other pavement surfaces.

d. Finishing Equipment, Hand Method.
Apply the following for placing and finishing concrete by hand methods:
1) Vibrators.
Use:
- Vibration rate between 3500 to 6000 vibrations per minute, and
- Amplitude sufficient to be perceptible on the surface of the concrete more than 12 inches (0.3 m) from the vibrating unit.

2) Screed.
Use a screed that is:
- True to crown (may be of wood or metal), and

- Adjustable for crown (or furnish a separate screed for each variation in crown).

e. Finishing Tools.
Provide all finishing tools necessary for proper finishing of the concrete, including straight edges for checking and correcting finished concrete surfaces.

f. Washing Water.
Maintain an adequate supply of water suitable for washing testing equipment. Place at a convenient location near the site of concreting operations, as directed by the Engineer and at no additional cost to the Contracting Authority.

B. Subgrade Construction.

1. Unless a subbase is specified, prepare the subgrade for standard pavement according to Section 2109.

2. Comply with the following for subgrade construction for slip form pavement:

a. When the contract documents include a bid item for Class 10 excavation, perform all the work necessary for proper preparation of the subgrade.

b. When the contract documents do not include a bid item for Class 10 excavation, it may be assumed that the subgrade has been or will be shaped and compacted by others. Acceptable tolerance for that work is described in Article 2102.03, L, except that at approaches to existing improvements or structures, corrections will be based on a practical minimum cut and fill for the project.

3. Shape and compact subgrade according to the applicable following method:

a. Subbase Not Specified.
If no subbase is specified, prepare the subgrade according to the requirements of Section 2109.

b. Subbase Specified.
If a subbase under pavement is specified, prepare the subgrade according to the requirements for that type of subbase.

c. Proof Rolling Requirements.

1) Proof roll subgrades (with or without subbase) no more than 1 week prior to trimming of the final grade. Perform proof rolling with a minimum of one pass using equipment meeting the requirements of Article 2001.05.

2) Treat all areas not meeting the requirements of 2107.03, E, as specified in Section 2109.

C. Setting of Forms.

1. When side forms are used, set them accurately to the required grade and alignment. Found and secure them to maintain the required grade and alignment while concrete is being placed and finished and until it is

time for the forms to be removed. Set forms on properly compacted materials.

2. Set forms with:
- The base at the design elevation of the subgrade of the pavement at its edge, and
- The top at the design elevation of the surface of the pavement at its edge.

3. With the Engineer's approval, forms having a height greater than design thickness of the edge of the pavement may be used when set as follows:

a. Side Forms.
Side forms may be set with their tops at the design elevation of the finished surface of the pavement and their bases at an elevation lower than the design base, subbase, or subgrade elevation. However, base, subbase, or subgrade material shall be excavated to meet the lower edge of the form with a straight, lateral slope no steeper than one vertical to four horizontal. Additional excavation and concrete required by this method will be at no additional cost to the Contracting Authority.

b. Integral Curb Forms.
Forms for integral curb shall be rigidly attached to supporting side forms using all fastenings provided by the manufacturer. Take special care to remove all water and laitance from the edge of the pavement before the curb is placed.

4. After setting and locking forms, tamp on both sides throughout their entire length using a suitable tool. Ensure tamping forces suitable material into contact with the base of the form for its entire length and width. Tamp the forms that are to support mechanical finishing machines. Tamping of forms set on bases or subbases may be waived if the excavation and bedding of the forms meet the Engineer's approval. If rain or standing water softens the earth or subbase so that the form is not adequately supported, reset the form on suitable material before concrete is placed.

5. Clean forms before resetting. Coat with form oil before concrete is placed against them. Use an oil that will produce a film to prevent concrete from adhering to form.

D. Fixtures in Pavement Surface.

1. Adjust manholes, intakes, valve boxes, or other fixtures encountered within the area to be paved to conform to the finished surface of the pavement to be built. Payment for adjustment of manholes and intakes will be per Section 2435. Payment for adjustment of valve boxes and other fixtures will be per Section 2554. Prior to placing the concrete, clean foreign material from the outside of the fixtures for the depth of the concrete.

2. Construct fixtures as shown in the contract documents. Fixtures that fall in a form line may be boxed out if a finishing machine is being used. Do not cut or divide boxed out concrete on the original form line.

E. Placing Reinforcement and Placing Dowel Bars.

1. Placing Reinforcement.

a. Place reinforcement prior to vibration so it will be in its intended position in the completed concrete according to Article 2404.03, D. For slip form paving, tie bars may be installed after vibration, provided the concrete is consolidated around the bars. Reinforcing bars may be supported by approved chairs or be placed in position by a machine or method approved by the Engineer.

b. Use approved continuous bolsters with runners to support reinforcement for bridge approach sections. Place supports transversely across the approach and space them longitudinally no greater than 4 feet (1.2 m). For double reinforced approach sections the top layer of reinforcing may be chaired off the bottom layer of reinforcing using approved continuous high chairs with runners, provided they are positioned directly above the continuous bolsters with runners supporting the bottom layer of reinforcing. Hold epoxy coated reinforcing steel in place with epoxy or plastic coated bar supports and epoxy or plastic coated tie wires. Use continuous bolsters with runners and continuous high chairs with runners, either plastic or steel, meeting the requirements of Materials I.M. 451.01.

c. When welded wire fabric reinforcement is used (alternate methods of placing welded wire fabric reinforcement will be considered for approval):

1) Strike the concrete off at the elevation specified for fabric reinforcement.

2) Place the sheets as indicated in the contract documents. Handle and place the fabric carefully to ensure its installation in the proper position. Ensure the fabric is flat.

3) Deposit the balance of the concrete and vibrate in a manner that will not displace or distort the fabric. Sheets that have become bent or kinked may be rejected.

2. Placing Load Transfer Devices.

a. Load transfer devices may be required in the contract documents. Accurately place these assemblies as shown. To prevent their movement during subsequent concrete paving operations, securely stake or fasten to the base to line and grade. Do not use mechanical dowel bar inserters.

b. Do not use damaged assemblies. Ensure horizontal and vertical alignment of the load transfer bars does not exceed 1/4 inch (5 mm) from parallel to line and grade. Place each assembly so bars are in a horizontal plane at T/2 ± 1/2 inch (15 mm).

c. Check placement of each assembly and the position of the bars within the assembly using a suitable template or other device

approved by the Engineer. If assembly is found to be placed outside the above tolerances, correct the placement.

d. Cutting the tie wires of the load transfer assemblies is optional.

3. When dowels or tie bars or other articles are to be anchored in existing concrete, use a grout system listed in Materials I.M. 491.11 or 491.22 according to the manufacturer's instructions. Obtain Engineer's approval.

4. For horizontal installation of dowels or tie bars, use either a pressure injection system with mechanical proportioning and mixing, or encapsulated chemical anchors. Install as follows:

a. Ensure drilled or preformed holes to receive the grout match the dimensions and spacing shown in the contract documents. When not shown in the contract documents, the maximum nominal diameter of the hole must be 1/8 inch (3 mm) larger than the outside diameter of the dowel or bar, or as recommended by the manufacturer. Blow the hole clean with compressed air immediately prior to placing the grout.

b. Pressure inject the grout into the rear of the hole. Use sufficient grout so that when the bar, insert, or other article to be grouted is placed in position, excess grout will be forced out the front of the hole. Rotate the article to be grouted during the insertion process to ensure complete coating with the grouting material. Hand proportioning and mixing will not be allowed.

5. If using grout with approved encapsulated anchors, install according to the manufacturer's recommendations.

6. Use installation procedures for vertical or angled installations that are similar to those for horizontal installation. Pourable grouts may be used. Pourable grouts shall be mechanically mixed.

F. Placing Concrete.

1. The contract documents will show the width the pavement will be constructed. Unless otherwise shown, construct the pavement in a single pass.

2. Unless the Engineer permits otherwise, place pavement to be constructed using ready mix concrete in single lane widths only. Permission will be based on evaluation of type, quality, and quantity of equipment to be used and its anticipated rate of production.

3. At the Contractor's option, pavements may be placed in single traffic lane widths under the following conditions:

a. Submit a proposed plan of operation for approval of the Engineer.

b. Furnish (at no additional cost to the Contracting Authority) additional dowels, tie bars, or extra concrete required to conform to the approved, modified method of operation.

c. Deposit concrete upon the supporting surface in a manner which will minimize segregation and disturbance of reinforcement.

d. Except when welded wire fabric reinforcement is used, deposit concrete to the full depth of the pavement in a single operation. When welded wire fabric is used, apply Article 2301.03, E.

4. Operate vibrating units as recommended by the manufacturer and in a manner which complies with Article 2301.03, A, 3, a.

5. Concrete shall be placed and consolidated in a manner that prevents material retained in the grout box of the finishing machine from being incorporated into the pavement. At headers, concrete screeded over the header during finishing shall be removed.

6. Cure vertical edges of pavements and backs of curbs according to Article 2301.03, K.

7. Repair honeycombed areas on pavement edges immediately after removal of forms.

8. Place backfill material behind curbs, as directed by the Engineer, to prevent a flow of water in this area and subsequent undermining of pavement.

G. Multiple Lane Construction.

1. Construct all lanes and sections of pavement to the widths shown in the contract documents unless written approval has been secured for alternate methods described in Article 2301.03, F.

2. Construct expansion and contraction joints to be continuous across all lanes. Do not stagger expansion and contraction joints.

3. Edge the edge of the pavement adjacent to the steel form, or at any supplemental form or bulkhead that will be abutted by a subsequent slab, using a tool with a radius of 1/8 inch (3 mm) or less. Extend the cutting edge of the tool moving along the form downward beyond the rolled edge of the form to its vertical face. Tool the edge on abutting lanes in the same manner.

4. When keyed joints are required, fasten the keyway to the form by a method that will ensure construction of the keyed joint. Use fasteners that can remain in place until the concrete has been placed adjacent to and above the keyway.

H. Finishing and Texture.

Finish the concrete promptly after it has been placed and consolidated. Following the finishing operations, apply texture to the surface.

1. Finishing.

a. After the concrete has been consolidated, use the screed to strike off the surface to the true section. Finish the surface true to line and grade.

b. Ensure additional water is not added directly to the surface by spray wand, brush, or other methods. Burlap may be attached behind the screed and a small amount of water may be used to wet the burlap to facilitate finishing operations. Avoid wetting the surface to the extent a slurry is created.

c. Ensure the edge is true and uniform. Hand corrections may be needed if this is not accomplished by the paver.

d. When finishing by hand methods, consolidate concrete using vibrating units operating in the concrete. If the vibrating apparatus cannot consolidate the full width of the concrete in a single pass, use a definite system or pattern when operating the vibrator that ensures the full width of concrete in each linear foot (meter) of lane receives adequate and uniform consolidation. Obtain the Engineer's approval for the vibrating system and methods. Do not use vibrating equipment as a tool for moving concrete laterally on the grade.

e. The Contractor may use a float on the pavement surface.

2. Microtexture.

a. Microtexture is constructed to produce a roughened surface on the driving areas of the pavement.

b. Drag artificial turf, coarse carpet, or burlap longitudinally over the finished surface to produce a tight, uniform, textured surface. Burlap may be dampened to prevent adhesion of PCC mixture.

c. When, for any reason, the desired texture normally obtained by the drag is not secured, the Engineer may require that the final finish be a broom finish in lieu of, or in addition to, the drag finish. To obtain a broom finish, drag a suitable broom transversely across the surface of the plastic concrete.

3. Macrotexture.

a. General.

1) Macrotexture is constructed by placing grooves in the surface of a pavement, normally while the concrete is plastic. The Contractor may either transversely or longitudinally provide macrotexture tining.

2) When longitudinal grooving is used on mainline pavement, transverse grooving may be used on other pavement on the same project.

b. Application.

1) Where the speed limit is greater than 35 mph (60 km/h), place macrotexture on all mainline pavement, turn lanes, and the traveled portion of ramps. Macrotexturing is not required on radii, crossovers, paved medians, shoulders, and other irregular areas.

2) Transversely or longitudinally groove gapped sections of mainline pavement that utilize longitudinal texture. Hand methods may be used on these mainline sections.

3) When surface corrections are made in the hardened concrete, no macrotexture replacement is required.

4) Unless specified otherwise, groove or otherwise finish bridge approach sections in the same manner as either the adjacent bridge or pavement surface.

5) When finishing by hand methods, except for mainline pavement and ramps as described above, only microtexture will be required.

c. Operation.

1) General.

For grooving, use a mechanical device that:

- Has a single row of tines that are 1/8 inch ± 1/64 inch (3 mm ± 0.5 mm) wide, and
- Forms grooves in the plastic concrete that are1/8 inch (3 mm) deep as a target, with a ± 1/16 inch (± 1.5 mm) tolerance.

2) Transverse Grooving.

a) For transverse grooves, randomly space the tines from 3/8 inch to 1 5/8 inch (10 to 40 mm) with no more than 50% of the spacing exceeding 1 inch (25 mm).

b) At transverse joints, leave a 4 inch to 6 inch (100 to 150 mm) wide strip of pavement surface (centered along the joint) that is not grooved for the length of the joint.

3) Longitudinal Grooving.

a) For longitudinal grooves, uniformly space the tines at 3/4 inch (20 mm) intervals.

b) Accomplish longitudinal grooving using equipment with horizontal and vertical string line controls to ensure straight, uniform grooves.

c) At longitudinal joints, leave a 2 inch to 3 inch (50 to 75 mm) wide strip of pavement surface (centered along the joint) that is not grooved for the length of the joint.

d. Limitations.

1) Form grooves in a time and manner producing the desired surface texture while minimizing displacement of larger aggregate particles. Complete grooving before pavement surface permanently sets.

2) Where abutting pavement is to be placed, extend grooving as close as possible to the edge without damaging the edge. Where abutting pavement is not to be placed, do not groove the 6 inch (150 mm) area nearest the edge or 1 foot (300 mm) from the face of the curb.

3) Do not groove the outside 2 feet (0.6 meters) if placing structural rumble strips (rumble strips placed in the outside 2 feet (0.6 meters) of PCC pavements, as shown in the contract documents, to deter traffic).

4) Uniform width slabs of 20 feet (300 mm) or narrower and less than 600 feet (200 m) long may be grooved by hand methods.

Mainline and ramp pavement may also be grooved by hand methods during equipment breakdowns.

4. Smoothness.

a. Construct the pavement to have a smooth riding surface within the following tolerances:

1) Periodically check the pavement longitudinally with a 10 foot (3 m) straightedge. The surface is not to deviate from a straight line by more than 1/8 inch in 10 feet (3 mm in 3 m).

2) If slip form methods are used, the 6 inches (150 mm) nearest the edge may exceed the 1/8 inch (3 mm) tolerance, but is not to exceed 1/2 inch deviation in 10 feet (13 mm deviation in 3 m).

3) Where abutting pavement is to be placed adjacent to the pavement being checked, the surface is not to deviate by more than 1/4 inch (6 mm) when checked 1 inch (25 mm) from the edge with:
A 3 foot (1 m) straightedge used transversely, and
A 10 foot (3 m) straightedge used longitudinally.

b. Apply Section 2317 to all PCC Pavement bid items of a Primary project if any individual PCC Pavement bid item for that project is 5000 square yards (4200 m^2) or greater. Apply Section 2316 to all other Primary projects or when specifically required for other projects.

I. Integral Curb.

1. Before placing curb concrete, remove all free water, laitance, dust, leaves, or other foreign matter which may have collected on the edge of the slab.

2. Construct integral curbs before the initial set, but following the main paving slab finishing, except as provided for in Article 2301.03, J.

3. Do not use concrete which has dried, partially hardened, or requires retempering.

4. Construct integral curb as rapidly as paving slab finishing operations will permit. Complete integral curb construction the same day the slab is placed, except for the length of section required at the end of the day's run to accommodate the mechanical placing and finishing equipment. In the section left for subsequent curb placement, depress the paving slab surface along the line of the inside curb slope so that the new concrete placed for curb is no less than 1 1/2 inches (40 mm) thick. Tie this section of curb to the slab by using No. 3 (Size 10) hooked steel bars spaced at 1 foot (300 mm) intervals. Roughen the surface of the slab back of the key notch. Create a depression around each dowel so it will project at least 2 inches (50 mm) into the curb concrete.

5. Consolidate curb concrete to secure adequate bond with the paving slab and eliminate honeycomb in the curb. Avoid disturbing the alignment of forms or gutter flow line.

6. After removing face forms or shaping with the curb slip form, complete the final finish on curbs using hand methods, including the use of a 6 foot (1.8 m) straightedge. Check the resulting surfaces of both curb and gutter using the 10 foot (3 m) straightedge. Correct if necessary. When removing forms, avoid creating slumps and disturbing partially set concrete.

7. When curb is built on slabs traversed by headers or contraction or expansion joints, extend the joints through the curb directly over the joint in the slab at the same thickness as in the main slab.

8. Edge, protect, and cure all curbs the same as other parts of the paving slab.

J. End of Run.

1. General.

a. Install an approved header whenever 30 minutes or more have elapsed since the last concrete has been deposited on the subgrade, or if such a delay is anticipated.

b. Do not construct a header joint:

- Within 5 feet (1.5 m) of an intended or previously placed contraction joint.
- Opposite a contraction joint in multiple lane construction.

c. When a header joint is installed, wait a minimum of 6 hours to resume paving which abuts the header. When concrete delivery is resumed, place it adjacent to the exposed face of the header. Thoroughly consolidate the concrete and finish with an edging tool at the joint. Sawing and sealing of this joint is not required.

d. When the end of the day's run occurs in curb section, omit sufficient curb to accommodate equipment which must be backed out of the way. Construct the portion of the curb omitted as shown in the contract documents and according to Article 2301.03, I.

2. Headers Constructed in Plastic Concrete.

a. Construct the header true to line and grade with the face perpendicular to the surface and at right angles to the centerline of the pavement. Ensure tie bar reinforcement is level, true to line and grade, and normal to the header joint.

b. Concrete collected by a finishing machine during its first pass must not be used adjacent to the header board. Promptly remove concrete screeded over the header during finishing.

c. Consolidate concrete against the header and finish with an edging tool.

d. Remove the header board and all supports before paving is resumed.

3. Headers Constructed in Hardened Concrete.
The Contractor may pave past the location of the header. After the concrete has hardened, saw the pavement perpendicular to the centerline of the pavement, creating a vertical face. Drill holes for the tie bar reinforcement and grout the reinforcement into the holes according to Article 2301.03, E. Paving operations may begin adjacent to the header after a minimum of 1 hour following the placement of the reinforcement bars.

K. Curing and Protection of Pavement.

1. General.
- **a.** After finishing operations are complete, cure concrete pavement according to Article 2301.03, K, 2. Cure bridge approaches, medians, curbs, and ramps according to Article 2301.03, K, 2.
- **b.** Cure vertical edges of pavement and backs of curbs by the same method used for curing the surface.

2. Curing with White Pigmented Liquid Curing Compound.
- **a.** Apply curing compound in a fine spray to form a continuous, uniform film on the surface and vertical edges of the pavement slab.
- **b.** Apply curing compound as soon as the free water has appreciably disappeared, but no later than 30 minutes after finishing. With the Engineer's approval, cure application timing may be adjusted due to varying weather conditions and concrete mix properties to achieve acceptable macrotexturing.
- **c.** Use an application rate of no less than 0.067 gallon per square yard covering 15 square yards per gallon (0.3 L/m^2 covering 3 m^2/L).
- **d.** Ensure liquid curing materials are well agitated in the supply drum or tank immediately before transfer to the distributor. Keep curing materials well agitated during application.
- **e.** Apply using power spraying equipment capable of producing a fine spray which will not damage the surface of the concrete. Hand operated sprayers may be used for spraying the sides and irregular areas.
- **f.** If forms are used, coat vertical edges of the pavement within 30 minutes of form removal using curing material applied at the same rate as on the surface.
- **g.** If, due to other operations, the coating is damaged within 72 hours after being applied, immediately re-coat the affected areas. Coating of the sawed surface with curing compound will not be permitted on joints that are to be sealed. When pavement is opened to traffic prior to 72 hours after application of the curing coating, a re-coating will not be required.
- **h.** Apply a white pigmented curing compound meeting the requirements of Section 4105.

3. Cold Weather Protection.

a. Apply cure to all concrete pavement, including exposed edges of the slab, according to Article 2301.03, K, 2, prior to applying protection.

b. Protect concrete pavement less than 36 hours old as shown in Table 2301.03-1. Payment will be made as provided in Article 2301.05.

Table 2301.03-1: Concrete Pavement Protection Requirements

Night Temperature Forecast	Type of Protection[(a)]
35°F to 32°F (2°C to 0°C)	One layer of burlap for concrete.
31°F to 25°F (-1°C to -4°C)	Two layers of burlap or one layer of plastic on one layer of burlap.
Below 25°F (-4°C)	Four layers of burlap between layers of 4 mil (100 µm) plastic, insulation blankets meeting the requirements below, or equivalent commercial insulating material approved by the Engineer.

(a) The protection is to remain until one of the following conditions is met:
1. The pavement is 5 calendar days old.
2. Opening strength is attained.
3. Forecasted low temperatures exceed 35°F (2°C) for the next 48 hours.
4. Forecasted high temperatures exceed 55°F (13°C) in the next 24 hours and subgrade temperatures are above 40°F (4°C).

c. When insulation blankets are used, use blankets consisting of a layer of closed cell polystyrene foam protected by at least one layer of plastic film, rated by the manufacturer with a minimum R-value of 1.0 (0.1761 for metric units).

d. Shut down paving operations in time to comply with protection requirements outlined above. The cover may be temporarily removed to perform sawing or sealing. The Engineer may modify temperature restrictions and protection requirements.

4. Rain Protection.

a. Protect the pavement from rain damage.

b. To protect against the effects of rain on paving, have materials available near the worksite for proper protection of the edges and surface of concrete. Protective material may consist of sheets of burlap, paper, or plastic film. Keep planks (or other material with suitable stakes) on hand that can be used as temporary forms.

c. Failure to properly protect concrete may constitute cause for removal and replacement of defective pavement.

d. When pavement is placed directly on natural subgrade (Section 2109) construct earth check dams immediately after removing forms or after the slip form passes. This will prevent water from flowing along the edge of the pavement and undermining the slab. Space earth check dams and construct them wide enough such

that they do not provide an approach over which a vehicle may be driven onto the pavement.

L. Safety Fence for Pavement.

1. In addition to the requirements of Article 1107.09, install a safety fence for the full width of the slab near the end of each day's run.

2. Support the safety fence by setting posts near to the edge of the slab. Extend posts at least 2 feet (0.6 m) into the ground. Between the posts, stretch and secure a 48 inch (1.2 m) nominal height orange mesh safety fence meeting the requirements of Article 4188.03. Cut the twisted ends of the wire off flush with the twist so that a tool would be required to cut or otherwise release the fastening.

3. Support the fence span between the posts with no less than four equally spaced plastic drums weighted to make them stable and difficult to move. Use drums approved according to Materials I.M. 488.02.

4. On urban work where it is not feasible to set posts, steel drums or sand box supports may be substituted for the end posts.

5. Place a similar safety fence parallel to and within 50 feet (15 m) from the edge of the slab at public road and side street intersections. Construct these fences similar to the end of day's run safety fences.

6. To prevent traffic from entering on and damaging the pavement slab, install safety fences within 1 hour of the completion of finishing and curing operations at the fence location. Leave safety fences in place and maintain until the concrete has attained the strength and age requirements of Article 2301.03, U.

7. Intermediate safety fences may be required for the purpose of opening the slab for access to a side road, side street, or entrance.

M. Removal of Forms.

1. Leave side forms and curb forms in place for no less than 6 hours after the concrete is placed, unless earlier removal is required by Article 2301.03, N.

2. Exercise care when removing forms to prevent cracking, spalling, or over stressing the concrete.

3. Remove all stakes in any form before the form is raised.

4. If the method of form removal causes damage to the concrete, the Engineer may require forms to remain in place for more than 6 hours.

N. Sawing Joints.

1. Saw joints in a single cutting operation for a specific joint. Make saw cuts true to line and to the dimensions shown in the contract documents.

2. Begin joint sawing as soon as the concrete has hardened sufficiently to permit sawing without raveling or moving of aggregate. Saw joints before uncontrolled cracking takes place.

3. Control joints may be sawed by any saw designed for concrete sawing.

4. If necessary, use continuous sawing operations regardless of weather or daylight conditions.

5. Discontinue sawing a joint if a crack develops ahead of the saw.

6. A heavy span saw which is supported on the new pavement will not be allowed for sawing pavements and concrete overlays less than 7 inches (180 mm) deep.

7. If the pavement has been covered or protected due to cold weather, rain, or snow, saw joints by conventional saw equipment only.

8. Saw joints requiring compression sealant materials to be installed according to Article 2301.03, P, so that the compression sealant material can be installed and function correctly.

9. Repair uncontrolled cracking or random transverse cracking (at no additional cost to the Contracting Authority). Use repair methods approved by the Engineer.

10. When the normal pavement section is reduced by box-outs, such as for intakes, construct a contraction joint by sawing. Begin at one end of the box-out and extend to the pavement edge. Alternate types of transverse joints will be considered for approval. If box-out length exceeds 15 feet (4.5 m), construct a contraction joint at both ends.

O. Expansion Joints.

1. Install preformed joint material perpendicular to the pavement surface. Exercise care throughout pavement construction to ensure that the joint material remains in proper position.

2. Set reference stakes or markers showing exact joint location prior to placing concrete adjacent to the joint. After the mechanical finishing equipment has passed over the joint, check the joint for movement. If movement in excess of 1/2 inch (10 mm) has occurred, immediately correct the installation to its intended position.

3. After the surface finishing has been completed, edge the joint as shown in the contract documents with minimum disturbance to the adjacent concrete. Supplemental vibration equipment is required for proper consolidation of the concrete.

P. Sealing Joints.

1. Unless provided otherwise, seal joints as designated in the contract documents before any portion of the pavement is opened to the Contractor's forces or to general traffic. Saw or prepare joint openings to the designated dimensions. Clean and seal joint openings with one of the appropriate materials described in Section 4136.

2. Use joint sealer described in Article 4136.02, A, to seal sawed joints in PCC pavement, shoulders, medians, crossovers, and side road pavements, unless specified otherwise in the contract documents.

3. Within 3 hours after a joint has been wet sawed to the finished dimension, flush the wet sawing residue away from the sawed faces using a high pressure water blast operating with a minimum pressure of 1000 pounds per square inch (7000 kPa). Within 3 hours after the joint has been dry sawed to the finished dimension, blow the dry sawing residue from the joint. Use air compressors that provide moisture and oil free compressed air.

4. Immediately prior to installation of sealant, clean joints with an air blast. Do not perform sealing until visual examination verifies the joint surfaces appear dry, in addition to being clear of dust and contamination. Prepare joint sealer and install in the joint and to the proper level as shown in the contract documents and as recommended by the manufacturer. Heat hot poured sealers in a thermostatically controlled heating kettle. Heat the material to the temperature required for use, but not above that recommended by the manufacturer. After sealing, remove excess sealer from the pavement surface.

5. Place joint sealer only when the pavement and ambient air temperatures are 40°F (4°C) or above. When near this minimum, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the joint faces. When this sealer cannot be properly placed due to late fall work, submit a joint construction plan and sealing details to the Engineer for approval before commencing paving. Delay the cleaning, sealing, and, if required, resawing of joints until the following spring. This delay requires the Engineer's approval.

6. When surface correction is required, repair seals damaged from the corrective work. Joint preparation, cleaning, and sealing may be delayed until after corrective work, provided the pavement is not opened to traffic before corrective work is performed.

7. The Engineer may limit the wheel loads and axle loads of equipment operating on the pavement during preparation, cleaning, and sealing

operations, if prior to the age and strength specified in Article 2301.03, U. Additional tests to determine the modulus of rupture may be required.

8. If early pavement opening is specified, the cleaning, sealing, and, if required, resawing of joints shall be accomplished after the pavement is opened to traffic if hot pour sealing material is used.

Q. Concrete Median Strip.

Where the contract documents call for construction of concrete median strip between adjacent slabs, construct the median strip to conform to the dimensions shown and to the following provisions:

1. Construct the subgrade for the median strip to the elevation shown according to Article 2109.03, A.

2. Use the class of concrete specified for the pavement. Use placement and finishing methods that meet the requirements of this Section. Hand methods may be used and surface texturing will not be required.

3. Saw and seal joints as required for jointed pavement. When spacing is not designated, space joints as required for jointed pavement. Match median joints with joints in the abutting pavement.

4. Gore areas will be considered median strips. When constructed or reconstructed while the highway is open to public traffic, use Class M concrete.

R. Bridge Approach Sections, Reinforced Paved Shoulders, and Full-width Reinforcement for Pavements.

1. Construct bridge approach sections, reinforced paved shoulders, and full-width reinforcement for pavements as shown in the contract documents.

2. Use epoxy coated reinforcing according to Article 4151.03, except that cut or sheared ends need not be recoated.

3. Unless otherwise noted in the contract documents, use a clear distance of 2 inches (50 mm) between the face of concrete to near reinforcing steel.

4. Use Class C Concrete with coarse aggregate durability according to Section 4115.

S. Restriction of Operations Because of Weather.

1. Do not place concrete when stormy or inclement weather will prevent good quality work.

2. Do not use aggregates containing frozen lumps.

3. Do not place concrete on a frozen subgrade.

4. Concrete mixing and placement may be started, if weather conditions are favorable, when the air temperature is at least 34ºF (1ºC) and rising. At the time of placement, concrete shall have a temperature of at least 40ºF (4ºC).

5. Stop mixing and placing when the air temperature is 38ºF (3ºC) or less and falling.

6. During cold weather conditions, protect concrete less than 36 hours old in the manner specified in Article 2301.03, K, 3.

T. Night Operation.

Do not place concrete when darkness would prevent good quality work in placing and finishing operations. Unless shown in the contract documents or approved by the Engineer, placing and finishing operations under artificial light will not be permitted. Organize work accordingly.

U. Time for Opening Pavement for Use.

1. The time for opening pavement for use will be based on the restrictions listed in Table 2301.03-2, with flexural strength determined from beam specimens made during the progress of the work.

Table 2301.03-2: Minimum Flexural Strength

Strength Class of Concrete	Minimum Age	psi (MPa)
A	14 calendar days[(a)]	500 (3.45)
B	14 calendar days	400 (2.80)
C	7 calendar days[(b)]	500 (3.45)
M	48 hours	500 (3.45)

(a) 10 calendar days for concrete 8 inches (200 mm) thick or more.

(b) 5 calendar days for concrete 9 inches (230 mm) thick or more.

2. At the Contractor's option (unless specified otherwise in the contract documents), the time for opening pavement may be determined through the use of the maturity method as described in Materials I.M. 383.

3. Apply the following when the maturity method is used:

a. The time for opening pavement will be based on strength requirements only, as specified in Table 2301.03-2. Furnish all labor, equipment, and materials necessary for the development of the maturity-strength relationship as described in Materials I.M. 383.

b. The Engineer will determine if sufficient strength has been achieved for opening a section of pavement. The Contractor's maturity testing may be used as the basis for this determination. Provide

sufficient documentation of maturity testing before opening a section to traffic.

c. Should circumstances arise which are beyond the Contractor's or Engineer's control and strength cannot be determined by the maturity method, apply minimum age, minimum flexural strength, and fly ash restrictions.

d. Develop a new maturity curve for any change of a material source or proportion in the concrete mixture.

4. In cases where early opening of pavement is desirable, the Engineer may require the use of Class M concrete mixtures. Such sections of pavement may be opened to traffic in accordance with Table 2301.03-2.

5. At the Contractor's option, when Type I/II cements are used, Class C fly ash may be substituted for up to 10%, by weight (mass), of the cement in Class M concrete mixtures. Type IP and Type IS cements may be used in Class M concrete mixtures without fly ash substitution.

V. Shoulders.
Construct shoulders according to Section 2121, 2122, or 2123, as indicated in the contract documents.

W. Surfacing Approaches to Intersecting Roads, Driveways, and Turnouts.
Surface approaches to intersecting roads, driveways, and turnouts as provided in Section 2315.

2301.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Portland Cement Concrete Pavement.

1. Square yards (square meters), of the type specified, shown in the contract documents.

2. The coring requirements for thickness do not apply to detour pavements, paved drives, and temporary pavements. The thickness of pavement constructed will be determined from core depths as follows:

a. The division of sections, lots, and core locations will be according to Materials I.M. 346.

b. At locations determined by the Engineer, cut samples from the pavement, as directed above, by drilling with a core drill that will provide samples with a 4 inch (101.6 mm) outside diameter. Restore the surface by tamping low-slump concrete into the hole, finishing, and texturing. The Engineer will witness the core drilling, and identify and measure the cores immediately. The Engineer will measure the cores and determine the thickness index according to Materials I.M. 346. After measurement on the grade, deliver the cores to the Engineer’s office or field laboratory. When cores are not measured on the grade, the Engineer will take immediate possession of the cores.

c. Coring of pavement and other work for thickness determination may be waived by mutual agreement for sections of the same design thickness less than 5,000 square yards (4200 m^2).

d. Only sections which are cored will be included in the thickness index determination. Areas not cored will be paid for at the contract unit price.

B. Integral Curb.
Incidental to the other items of work. Not measured for payment.

C. Concrete Median.
Square yards (square meters) shown in the contract documents. This will be calculated to the nearest 0.1 foot (0.1 m) of the length along the surface and the overall width of median when no integral curb is involved, or the width from back to back of curb when integral curb is involved.

D. Bridge Approach Sections.
Square yards (square meters) shown in the contract documents.

E. Excavation.

1. When the contract provides a unit price per station (meter) for earth shoulder finishing and a price per cubic yard (cubic meter) for excavation, the excavation required for preparation of natural subgrade will be measured as provided in Article 2102.04. The volume measured for payment will include only the materials actually removed above the elevation of the pavement subgrade and between vertical planes 1 foot (0.3 m) outside the edge of the finished pavement.

2. Other work connected with preparation of natural subgrade will not be measured for payment.

3. When the contract provides a unit price for earth shoulder construction (whether or not a unit price per cubic yard (cubic meter) of excavation is provided in the contract), excavation required for preparation of natural subgrade will not be measured for payment. Unless otherwise provided in the contract documents, work connected with preparation of natural subgrade will not be measured for payment.

F. Driveway Surfacing Material.
Tons (megagrams) or cubic yards (cubic meters), as provided in the contract and in Section 2315, placed at intersecting roads, drives, and turnouts. Excavation required for placement of this material will not be measured for payment.

G. Portland Cement Concrete Pavement Samples.
Not individually counted for payment when furnished according to Article 2301.04, A, or when required in the contract documents.

H. Saw Cut and Joint Sealing.

1. Saw cut for constructing joints in new pavement will not be measured for payment.

2. Saw cut for cutting old existing pavement, which is to be abutted with new pavement, will not be measured for payment.

3. Joint sealing will not be measured for payment.

I. Safety Fence for Pavement.
Not measured for payment.

J. Rumble Strip Panel (PCC Surface)
By count for Rumble Strip Panels properly installed at locations designated in the contract documents.

2301.05 BASIS OF PAYMENT.

Payment will be as follows:

A. Portland Cement Concrete Pavement.

1. Contract unit price for Standard or Slip-Form Portland Cement Concrete Pavement of the type specified per square yard (square meter).

2. Payment for the quantities of pavement in square yards (square meters) will be at a percentage of the contract unit price according to Table 2301.05-1.

Table 2301.05-1: Payment Schedule for Quantities of Pavement

Thickness Index Range	Percent Payment	Thickness Index Range	Percent Payment
English (Metric)		English (Metric)	
0.00 or more (0.00 or more)	103	-0.56 to -0.60 (-13.98 to -15.24)	91
-0.01 to -0.05 (-0.01 to -1.27)	102	-0.61 to -0.65 (-15.25 to -16.51)	90
-0.06 to -0.10 (-1.28 to -2.54)	101	-0.66 to -0.70 (-16.52 to -17.78)	89
-0.11 to -0.15 (-2.55 to -3.81)	100	-0.71 to -0.75 (-17.79 to -19.05)	88
-0.16 to -0.20 (-3.82 to -5.08)	99	-0.76 to -0.80 (-19.06 to -20.32)	87
-0.21 to -0.25 (-5.09 to -6.35)	98	-0.81 to -0.85 (-20.33 to -21.59)	86

-0.26 to -0.30 (-6.36 to - 7.62)	97	-0.86 to -0.90 (-21.69 to -22.86)	85
-0.31 to -0.35 (-7.63 to -8.89)	96	-0.91 to -0.95 (-22.87 to -24.13)	84
-0.36 to -0.40 (-8.90 to -10.16)	95	-0.96 to -1.00 (-24.14 to -25.40)	83
-0.41 to -0.45 (-10.17 to -11.43)	94	-1.01 to -1.05 (-25.41 to -26.67)	82
-0.46 to -0.50 (-11.44 to -12.70)	93	-1.06 to -1.10 (-26.68 to - 27.94)	81
-0.51 to -0.55 (-12.71 to -13.97)	92	-1.11 or less (-27.95 or less)	80

3. Use the following formula to determine the thickness index for the section of pavement thickness:

Where: $TI = (\overline{X} - S) - T$

TI = thickness index for the section.
$\overline{X}$ = mean core length for the section.
T = design thickness.
S = core length standard deviation (of the sample) for the section.

4. Replace pavement represented by cores deficient from design thickness by 1 inch (25 mm) or greater. The deficient areas and the replacement of the deficient cores will be determined according to Materials I.M. 346.

5. At the Contractor's option, cores that are three standard deviations or greater than design thickness may be removed from analysis for thickness index determination. Do not remove more than 10% of the total cores in a section. Do not replace cores removed from the analysis.

6. Gaps in the pavement less than 500 feet (150 m), required by staging, will be considered irregular areas for analysis of pavement thickness determinations.

7. The percent payment for projects which have all core lengths greater than design thickness will be at least 100%.

B. Integral Curb.
Not paid for separately.

C. Concrete Median.
Contract unit price per square yard (square meter).

D. Bridge Approach Sections.

1. Contract unit price for bridge approach pavement per square yard (square meter).

2. Payment is full compensation for:

- Excavation for modified subbase and subdrain.
- Furnishing and installing subdrain.
- Furnishing and installing subdrain outlet.
- Furnishing and installing polymer grid.
- Furnishing and placing porous backfill material.
- Furnishing and placing modified subbase backfill material.
- Saw cutting.
- Furnishing and installing reinforcing steel, tie bars, and dowel assemblies.
- Placing, finishing, texturing, grooving, and curing.
- All joint construction.
- All other materials and labor to construct the Bridge Approach Section as shown in the contract documents.

E. Excavation.

1. When the contract provides a unit price per station (meter) for earth shoulder finishing and the contract also provides a price per cubic yard (cubic meter) for excavation, payment will be the contract unit price per cubic yard (cubic meter) for excavation in connection with subgrade preparation and building shoulders.

2. When the contract provides a unit price for earth shoulder construction, the excavation required for preparation of subgrade and construction of shoulders will not be paid for as a separate item. It is incidental to pavement construction and earth shoulder construction and is to be included in those contract prices.

3. When no price per cubic yard (cubic meter) for excavation is provided in the contract and no unit price is provided for earth shoulder finishing or earth shoulder construction, excavation necessary for subgrade preparation is incidental to pavement construction and is to be included in that contract unit price.

F. Driveway Surfacing Material.
Contract unit price as provided in Section 2315 for the quantity of driveway surfacing placed.

G. Portland Cement Concrete Pavement Samples.

1. Lump sum contract price for furnishing samples of finished pavement or other course according to Article 2301.04, A, or when required in the contract documents.

2. Payment is full compensation for furnishing all such samples for all courses or items of work.

H. Saw Cut and Joint Sealing
Incidental to the price for pavement.

I. Safety Fence for Pavement.
Incidental to the price for pavement.

J. Rumble Strip Panel (PCC Surface)
Each. Payment is full compensation for construction of the panels as detailed in the contract documents.

K. General.

1. Deduction will not be made from the area of pavement for fixtures with an area less than 9 square feet (1 m^2).

2. When any of the types of additional protection described in Article 2301.03, K, 3, is necessary, additional payment will be made as extra work at the rate of $1.00 per square yard ($1.20 per square meter) of surface protected. Payment will be limited to protection necessary within the contract period. Protection necessary after November 15 will be paid for only when the Engineer authorizes the work.

3. Furnish concrete for test specimens and transport the specimens and molds between the grade and plant as directed by the Engineer, at no additional cost to the Contracting Authority.

4. The above prices are full compensation for furnishing all tools, equipment, labor, and materials necessary for construction of the pavement in accordance with the contract documents.

5. The cost of furnishing, installing, and monitoring vibrators, as well as the vibrator monitoring device itself, is incidental to the contract unit price for PCC pavement.

Section 2302. Portland Cement Concrete Widening

2302.01 DESCRIPTION.
Widen existing pavement with PCC according to the contract documents. This work may also involve flume removal, curb removal, and shoulder construction. Apply the appropriate provisions of Section 2301.

2302.02 MATERIALS.

A. Meet the requirements of the appropriate sections of Division 41.

B. Meet requirements for Class A or Class C concrete in Materials I.M. 529.

2302.03 CONSTRUCTION.

A. Maintenance of Traffic.
Unless indicated otherwise in the contract documents, maintain traffic through the project.

B. Flume Removal.
Remove flumes according to Section 2514.

C. Curb Removal.
Remove curb according to Section 2514.

D. Subgrade Preparation.

1. Cut a trench for the widening that is no less than 6 inches (150 mm) greater than the base width of the widening shown in the contract documents. If fixed forms are used, adjust the trench width to accommodate the forms.

2. Bring the subgrade to an elevation and cross section such that, after being rolled, the surface will be at the required elevation.

3. Correct depressions that develop during rolling. Continue rolling until the subgrade is uniformly firm, properly shaped and true to grade and cross section.

4. Remove material (other than sand) which will not readily compact under the roller. Replace with material which will compact readily, and roll that portion of the subgrade again.

5. Use a roller meeting the requirements of Article 2001.05. Adapt the roller to conditions affecting the work. The Engineer may direct the weight (mass) of the roller be reduced to the minimum to provide a smooth, firm subgrade.

6. Treat subgrade or subbase according to Article 2109.03, A. When plastic film is used, size it to be no less than the nominal width of the widening being constructed.

7. Provide ditches or drains to allow water to drain from the widening trench.

8. Complete subgrade in advance of PCC placement. For sections more than 800 feet (250 m) long, complete the subgrade no less than 800 feet (250 m) in advance of PCC placement.

9. Check finished subgrade with a template supported on the adjacent pavement surface.

10. Clean edge of the old pavement.

E. Portland Cement Concrete Widening Construction.
Construct PCC widening as follows:

1. Placing and Finishing.

a. After preparing subgrade, deposit concrete directly on subgrade without being dumped on the pavement.

b. Concrete may be placed and finished by use of fixed forms or slipform paver.

c. When a slipform paver is used, control the concrete consistency and the amount of vibration so that the full width and depth of the section is consolidated. Ensure no slump occurs after the sliding form has passed. For the slipform paver, provide a metal strike off plate no less than 3 feet (0.9 m) long and extending no more than 3 inches (75 mm) into the pavement surface being widened. Use a sliding form made of metal. To assure alignment, provide the sliding side form with adjustable rigid braces at intervals of no more than 4 feet (1.2 m).

d. Use mechanical vibrators to consolidate the concrete. Provide a sufficient number of vibrators to ensure adequate consolidation. Operate vibrators at an appropriate frequency, according to Article 2301.03, A, 6, a, which is independent of the forward speed of the paver.

e. Finish the concrete widening to be flush with the adjacent pavement surface without either edging or sealing the joint. When voids wider than 1 1/2 inches (40 mm), measured at right angles to the pavement edge, occur in the edge of the old pavement, fill them with concrete. Separate them from the widening with preformed mastic dummy joint 1/8 inch thick by 2 inches wide (3 mm thick by 50 mm wide). Install the preformed mastic dummy joint directly over the edge of the old pavement. When checked, correct high spots in excess of 1/4 inch on a 10 foot (6 mm on a 3 m) straightedge. Produce texture on the new concrete using a burlap or carpet drag.

f. When concrete widening intersects an approach road or driveway to a dwelling or business establishment, make provisions for access as follows:

1. Construct widening only halfway through the roadway or driveway access on the initial construction. Provide a suitable approach through the unpaved portion of the access. In no less than 4 working days, and no more than 7 working days, fill gaps left open. A removable header board, equipped with keyway in lieu of dowel bars, may be used at these locations.

2. A temporary bridge, approved by the Engineer, may be provided for access from driveways to dwellings or to business establishments. This will permit the widening to be constructed continuously across the driveways. At the Contractor's option, concrete used to widen the pavement at driveways to dwellings or to business establishments may have 2 pounds (2 kg) of calcium chloride (solid form) per 100 pounds (100 kg) of cement added at the mixer for the full length of mixing cycle. When calcium chloride is used, the temporary bridges may be

removed after 24 hours when suitable approaches are provided for the driveway.

2. Contraction Joints.
Construct transverse contraction joints as shown in the contract documents. This work will be considered incidental and shall not be paid for separately.

3. Protection and Curing.
- **a.** Protect and cure freshly finished concrete as provided in Article 2301.03, K.
- **b.** Construct earth check dams within 0.5 calendar days after placing concrete. This is to prevent water from flowing along the edge of the pavement to the extent that the edge of the slab may be undermined. Space earth check dams and construct them wide enough such that they do not provide an approach over which a vehicle may be driven onto the pavement.

F. Shoulders.

1. Unless otherwise specified, consider shoulder construction adjacent to pavement widening to be Type A, B, C, or D.
- **a. Type A Shoulders.**
  Blade over the foreslope both the soil excavated from the trench and material of the shoulder lying above the proposed, finished shoulder line.
- **b. Types B and C Shoulders.**
  Excavate material lying above the proposed shoulder line and haul and deposit it at the Engineer's direction within a free haul limit of 1 mile (1.6 km).
- **c. Type D Shoulders.**
  Blade the soil excavated from the trench over the shoulder and shape the shoulders and slopes, the cost of which is included in the contract unit price for trench excavation.

2. Finish shoulders to a well defined shoulder line with uniformity in width, no abrupt changes in width, and smooth foreslopes.

G. Removal of Materials from Curbs and Flumes.

1. Unless provided otherwise, clean up all materials removed from curbs and flumes. Remove these materials according to Article 1104.08.

2. Deposit materials removed from curbs and flumes and designated for salvage in areas as designated in the contract documents. No overhaul will be allowed.

H. Limitations.

1. Unless the road is closed to traffic, construct pavement widening on only one side of the pavement at a time. Open the widened pavement on one side to traffic before removing the curb on the opposite side.

2. Place backfill material and compact the unfilled portion of trench excavation on one side of the pavement to provide a usable traffic surface before:
- Any work is done on the other side of the pavement, and
- Paving is opened to traffic.

3. Compaction required in this operation may be accomplished by rolling with a pneumatic tired roller which has a total weight (mass) of no less than 2000 pounds (900 kg).

4. At the end of the day, restore the shoulder disturbed in connection with curb removal to the general elevation of the pavement edge, unless protected by barricades.

5. Apply Articles 1107.08 and 1107.09.

I. Opening Widening to Traffic
Concrete widening may be opened to traffic as soon as the concrete has attained the age and flexural strength according to Article 2301.03, U and the shoulder backfill material has been placed.

2302.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Excavation, Class 13, for Widening.
Article 2213.04, C, applies.

B. Removal of Curb.
Article 2213.04, A, applies.

C. PCC Pavement Widening.
Square yards (square meters) shown in the contract documents. The thickness of the pavement will be determined as provided in Article 2301.04.

D. Shoulders.

1. Type A, B, and C Shoulders: stations (meters) shown in the contract documents.

2. Earth shoulder finishing: not measured separately, but will be incidental work included in construction of shoulders.

3. Type D shoulders: incidental to excavation and will not be measured for payment.

E. Removal of Flumes.
Article 2213.04, B, applies.

F. Portland Cement Concrete Pavement Samples.
Article 2301.04, G, applies.

2302.05 BASIS OF PAYMENT.
Payment will be contract unit price as follows:

A. Excavation, Class 13, for Widening.
Article 2213.05, C, applies.

B. Removal of Curb.
Article 2213.05, A, applies.

C. PCC Pavement Widening.

1. Per square yard (square meter) as provided in Article 2301.05.

2. Payment is full compensation for construction of the pavement widening and all other work not paid for under other items.

D. Shoulders.

1. Type A, B, and C Shoulders: per station (meter).

2. Type D shoulders: incidental to excavation and will not be measured for payment.

E. Removal of Flumes.
Article 2213.05, B, applies.

F. Portland Cement Concrete Pavement Samples.
Article 2301.05, G, applies.

Section 2303. Hot Mix Asphalt Mixtures

2303.01 DESCRIPTION.

A. Design, produce, place, and compact flexible paving (HMA and warm mix asphalt (WMA)) mixtures. Use proper quality control practices for the construction of surface, intermediate, or base course on a prepared subbase, base, or pavement to the dimensions specified in the contract documents.

B. A surface course is the upper lift for a wearing surface of a designated thickness. An intermediate course is the next lower lift or lifts of a designated thickness. Use intermediate course mixtures for leveling, strengthening, and wedge courses. A base course is the lift or lifts placed on a prepared subgrade or subbase.

C. WMA refers to asphalt concrete mixtures produced at temperatures approximately 50°F (28 °C) or more below those typically used in production of HMA but no higher than 280°F (135 °C). Temperature reductions may be achieved through additives or water injection systems approved by the Bituminous Engineer. The goal with WMA is to produce mixtures with similar or better strength, durability, and performance characteristics as HMA using substantially reduced production temperatures.

D. Unless explicitly stated, produce and place WMA mixtures meeting the same requirements established for HMA mixtures. Equivalent WMA mixtures may be substituted for HMA mixtures unless it is prohibited by the specifications.

2303.02 MATERIALS.

Use materials meeting the following requirements:

A. Asphalt Binder.
The Performance Graded asphalt binder, PG XX -XX, will be specified in the contract documents to meet the climate, traffic, and pavement conditions. Use asphalt binder meeting the requirements of Section 4137. Unless otherwise specified in the contract documents, use PG 58-28 for shoulder mixtures.

B. Aggregates.

1. Individual Aggregates.

a. Use virgin mineral aggregate as specified in Materials I.M. 510 and meeting the requirements of Section 4127.

b. When frictional classification of the coarse aggregate is required, the contract documents will specify the friction level and location. Furnish friction aggregate from sources identified in Materials I.M. T203. Limestone aggregate sources defined as containing less than 15% magnesium oxide (MgO) are identified in Materials I.M. T203.

1) Friction Classification L-2.

a) On Interstates and all mixtures designed for 30,000,000 ESALS and higher (cross-overs and detours with posted speeds below 60 mph excluded), if 40% or more of the total aggregate is a limestone, use a combined aggregate such that:

(1) At least 80% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 4 or better friction aggregate,

(2) At least 30% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 2 or better friction aggregate,

(3) At least 25% of the combined aggregate passing the No. 4 (4.75 mm) sieve is Type 2 or better friction aggregate, and

(4) The fineness modulus of the combined Type 2 aggregate is at least 1.0. Calculations for fineness modulus are shown in Materials I.M. 501.

b) For all other mixtures that do not satisfy Article 2303.02, B, 1, a, use a combined aggregate such that:
- **(1)** At least 80% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 4 or better friction aggregate, and
- **(2)** At least 25% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 2 or better friction aggregate, and
- **(3)** For Interstates and all mixtures designed for 30,000,000 ESALS and higher, the fineness modulus of the combined Type 2 aggregate is at least 1.0. Calculations for fineness modulus are shown in Materials I.M. 501.

2) Friction Classification L-3.
Use a combined aggregate such that:
- At least 80% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 4 or better friction aggregate, and
- At least 45% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 3 or better friction aggregate, or if Type 2 is used in place of Type 3, at least 25% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 2.

3) Friction Classification L-4.
Use a combined aggregate such that at least 50% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 4 or better friction aggregate.

2. Blended Aggregates.
- **a.** Use a blended aggregate meeting the combined aggregate requirements in Materials I.M. 510.
- **b.** When mixtures include RAP, use a blended mineral aggregate gradation consisting of a mixture of RAP aggregate combined with virgin aggregate.

C. Recycled Asphalt Materials.

1. Recycled Asphalt Materials (RAM) includes Recycled Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS). RAP is salvaged asphalt pavement. Use RAP from a source designated in the contract documents, or furnish Classified RAP, Certified RAP, or Unclassified RAP from the Contractor's stockpile. The designations Classified , Certified, and Unclassified are exclusively for the use of RAP in HMA.

2. Identify each RAP stockpile and document Classified and Certified RAP stockpiles as directed in Materials I.M. 505. Include the following information when documenting Classified RAP material in a stockpile for future use in HMA:
- Identification of the project from which the material was removed,
- Mix data from the original project including mixture type,

- Aggregate classification,
- Location and depth in the pavement structure,
- Extracted gradation information, if available, and
- Description of stockpile location and quantity.

Do not add material to a Classified or Certified RAP stockpile without the approval of the District Materials Engineer.

3. The Engineer may reject a RAP stockpile for non-uniformity based on visual inspection. Work the stockpiles in such a manner that the materials removed are representative of a cross section of the pile.

4. Place stockpiles of RAP on a base sufficient to prevent contamination, as directed in Materials I.M. 505. Do not use RAP stockpiles containing concrete chunks, grass, dirt, wood, metal, coal tar, or other foreign or environmentally restricted materials. RAP stockpiles may include PCC (not to exceed 10% of the stockpile) from patches or composite pavement that was milled as part of the asphalt pavement. Track equipment may operate on the stockpile during its construction.

5. When RAP is taken from a project, or is furnished by the Contracting Authority, the contract documents will indicate quantity of RAP expected to be available and test information, if known. Salvage this material. Unless otherwise specified in the contract documents, RAP not used in HMA becomes the property of the Contractor.

6. For mix design purposes, the Contracting Authority will test samples of the RAM. The aggregate gradation and amount of asphalt binder in the RAM will be based on the Contracting Authority's extraction tests. For mixtures containing RAM, adjust the contract binder grade as directed in Materials I.M. 510. No adjustments will be made to the contract unit price for required changes to the asphalt binder grade.

a. Classified RAP.

1) Classified RAP is from a documented source with the aggregate meeting the appropriate quality requirements in Materials I.M. 510, and properly stockpiled.

2) Classified RAP may be used in the base, intermediate, and surface mixtures for which the RAP aggregate qualifies. Classified RAP may be used in accordance with Table 2303.02-1.

3) Credit for frictional aggregate may be given for virgin aggregates used in the original pavement to be reclaimed. Types 4 and 5 frictional aggregate content in the RAP may be given full credit, while Types 2 and 3 content may be given credit for half the proportion in the original pavement. Credit may be used toward the total frictional aggregate requirement. No frictional credit shall be given beyond one generation of the RAP's service life.

4) Credit may be given for crushed particles in the original pavement to be reclaimed as determined in the paving history (or mix design when paving history is unavailable).

b. Certified RAP.
Any stockpiled RAP not meeting the requirements of Classified RAP or from an unknown source may be given a Certified status when meeting quality control sampling, testing, and reporting requirements in Materials I.M. 505. Certified RAP may be used in accordance with Table 2303.02-1.

c. Unclassified RAP.

1) Any stockpiled RAP not meeting the requirements of Classified RAP or Certified RAP shall be designated as Unclassified RAP. Unclassified RAP may be used in accordance with Table 2303.02-1. No frictional aggregate credit or aggregate crushed particles credit will be given for Unclassified RAP.

2) When an Unclassified RAP stockpile is characterized by sampling and testing for mix design, no material can be added to the stockpile until the project is completed.

Table 2303.02-1: Allowable RAP Usage

Mix Designation	Aggregate Quality Type	Maximum Allowance Usage[2]		
		Unclassified RAP	Certified RAP	Classified RAP
HMA 100K S	B	0%	10%	15% (min. 70% virgin binder)[1]
HMA 100K I	B	10%	20%	No Limit
HMA 100 K B	B	10%	20%	No Limit
HMA 300K S	B	0%	10%	15% (min. 70% virgin binder) [1]
HMA 300 K I	B	10%	20%	No Limit
HMA 300K B	B	10%	20%	No Limit
HMA 1M S L-4	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 1M S	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 1M I	B	10%	20%	No Limit
HMA 1M B	B	10%	20%	No Limit
HMA 1M B (shoulder)	B	10%	20%	No Limit
HMA 3M S L-4	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 3M S L-3	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 3M S	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 3M I	A	0%	0%	No Limit
HMA 3M B	B	10%	20%	No Limit
HMA 10M S L-3	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 10M I	A	0%	0%	No Limit
HMA 10M B	B	10%	20%	No Limit

HMA 30M S L-3	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 30M S L-2	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 30M I	A	0%	0%	No Limit
HMA 30M B	B	10%	20%	No Limit
HMA 100M S L-2	A	0%	0%	15% (min. 70% virgin binder) [1]
HMA 100M I	A	0%	0%	No Limit
HMA 100M B	B	10%	20%	No Limit

Note: 1. More than 15% of Classified RAP may be used for the surface course when there is quality control sampling, testing, and reporting of the RAP meeting the requirements in Materials I.M. 505. At least 70% of the total asphalt binder in the surface mix shall be virgin.
2. Maximum percentages shown are not to be combined.

7. Pre-consumer or post-consumer shingles that have been processed, sized, and ready for incorporation into an asphalt mixture constitute RAS material.

8. Up to 5% RAS by weight of total aggregate may be used in the design and production of an asphalt mixture. The percentage of RAS used is considered part of the maximum allowable RAP percentage. Unless explicitly stated otherwise in this specification or Materials I.M. 505, use RAS according to the same requirements as prescribed for RAP material.

9. RAS shall be certified from an approved supplier designated in Materials I.M. 506. Material processed prior to DOT source approval will not be certified.

D. Flexible Paving Mixture.

1. The job mix formula (JMF) is the percentage of each material, including the asphalt binder, to be used in the HMA mixture. Ensure the JMF gradation is within the control points specified for the particular mixture designated. Use the JMF to establish a single percentage of aggregate passing each required sieve size.

2. The basic asphalt binder content is the historical, nominal mixture asphalt binder content, expressed as percent by weight (mass) of the asphalt binder in the total mixture. Apply the values in Table 2303.03-1, based on mixture size and type.

3. If the asphalt binder demand for the combination of aggregates submitted for an acceptable mix design exceeds the basic asphalt binder content (see Table 2302.02-1) by more than 0.75%, include an economic evaluation with the mix design. Base this evaluation on past job mix history, possible aggregate proportion changes, and aggregate availability and haul costs for any changes or substitutions considered.

Table 2303.02-2: Basic Asphalt Binder Content (%)

Size	Aggregate Type	1 inch (25 mm)	3/4 inch (19 mm)	1/2 inch (12.5 mm)	3/8 inch (9.5 mm)
Intermediate and Surface	Type A	4.75	5.50	6.00	6.00
Intermediate and Surface	Type B	5.25	5.75	6.00	6.25
Base	Type B	5.25	6.00	6.00	6.25

4. Use a mixture design meeting gyratory design and mixture criteria corresponding to the design level specified in the contract documents. The Engineer may approve the substitution of any mixture which meets requirements for a higher mixture than specified in the contract documents, at no additional cost to the Contracting Authority. When a commercial mix is specified, use a 1/2 inch (12.5 mm) 300K surface mixture or higher for JMF approval.

5. Use 1,000,000 ESAL HMA base mixture for shoulders placed as a separate operation. For outside shoulders on Interstate projects, the Contractor has the option to substitute the mainline intermediate or surface mixture for a specified base mixture, at the Contractor's expense.

6. Prepare gyratory mixture designs for base, intermediate, and surface mixtures. Follow the procedure outlined in Materials I.M. 510. Submit a mixture design complying with Materials I.M. 510. Propose both a production and a compaction temperature between 215ºF (102ºC) and 280ºF (138ºC) for WMA mixture designs.

7. Use gyratory compacter for design and field control meeting the AASHTO protocol for Superpave gyratory compactors. Compactors for which compliance with this protocol is pending may be used at the discretion of the District Materials Engineer.

8. Unless otherwise indicated in the contract documents, do not use WMA on interstate travel lanes for surface, intermediate, or base courses.

E. Other Materials.

1. Tack Coat.

Tack coat may be SS-1, SS-1H, CSS-1, or CSS-1H. Do not mix CSS and SS grades. RC-70 and MC-70 may also be used after October 1, at the Contractor's option.

2. Anti-strip Agent.

a. Perform a moisture sensitivity evaluation of the proposed asphalt mixture design in accordance with Materials I.M. 507 for the following mixtures when placed in travelled lanes:

1) Mixtures for Interstate and Primary highways designed for 30,000,000 ESALS and higher

2) Mixtures for Interstate and Primary highways containing quartzite, granite, or other siliceous aggregate (not a limestone or dolomite) in at least 40% of the total aggregate (virgin and recycled) or at least 25% of the plus No. 4 (4.75 mm).

3) All WMA mixtures placed in travel lanes designed for 10,000,000 ESALS and higher. For the purpose of evaluating moisture sensitivity of proposed WMA mix designs which use water injection technologies, in lieu of a lab-scaled foaming device, the Contractor may test the proposed JMF from plant produced material placed off-site at no additional cost to the contracting authority.

b. Sample and test plant produced mixture for moisture susceptibility in accordance with Materials I.M. 204 and Materials I.M. 507 for bid item plan quantities of more than 1000 tons (1000 Mg) as follows:

1) For mixtures satisfying Article 2303.02, E, 2, a

2) For conditions satisfied in Article 2303.02, E, 2, g

c. Moisture susceptibility testing of plant produced mixture will not be required for base repair, patching, temporary pavement, or mixture bid items of 1000 tons (1000 Mg) or less.

d. A minimum tensile strength ratio (TSR) of 80.0% is required on plant produced mixture. When notified of non-compliant results, the Engineer may suspend paving operations until an approved "significant mix change" is implemented.

e. For mixture bid items of more than 1000 tons (1000 Mg), when the Contractor's mix design TSR results are greater than or equal to 80% and less than 90%, an anti-strip agent will be required until the Contracting Authority's TSR results on the plant produced mixture are equal to or exceeding 80%. Plant produced material without anti-strip shall be tested without penalty to confirm the need for an anti-strip agent. See Materials I.M. 510 Appendix C for additional information.

f. When the Contractor's mix design TSR results are below 80.0%, an anti-strip agent will be required. Plant produced material with anti-strip shall be tested to verify the minimum TSR is achieved. See Materials I.M. 510 Appendix C for additional information.

g. The Engineer may require an evaluation of the test method in Materials I.M. 507 for plant produced mixture as follows:

1) When there is a "significant mix change" to a mix satisfying Article 2303.02, E, 2, a.

2) When there is contamination and/or coating of the aggregate for any mixture placed in a travel lane.

3) When aggregates are inadequately dried during production of any mixtures placed in a travel lane.

h. The following anti-strip agents may be used:

1) **Hydrated Lime.**

Meet the requirements of AASHTO M 303, Type I or ASTM C 1097, Type S. Do not apply Section 4193. Hydrated lime will not be considered part of the aggregate when determining the job mix formula and the filler/bitumen ratio.

2) Liquid Anti-strip Additives.
For each JMF, obtain approval for liquid anti-strip additives blended into the binder. Approval will be based on the following conditions:

a) The asphalt binder supplier provides test results that the additive does not negatively impact the asphalt binder properties, including short term and long term aged properties.

b) The design is to establish the optimum additive rate when comparing the dry strength of specimens prepared with asphalt binder not containing the anti-strip additive to conditioned specimens prepared with asphalt binder containing the anti-strip additive. See Materials I.M. 510 Appendix C for additional information.

c) A dosage rate can be selected such that the conditioned indirect tensile strength can be improved by at least 10% while meeting all other requirements.

3) Polymer-based Liquid Aggregate Treatments.
For each JMF, obtain approval for polymer-based liquid aggregate treatments. Approval will be based on the design establishing the optimum additive rate when comparing the dry strength of specimens prepared without the anti-strip additive to conditioned specimens prepared with asphalt binder containing the anti-strip additive. See Materials I.M. 510 Appendix C for additional information.

3. Sand for Tack Coats.
Use sand meeting the requirements of Gradation No. 1 of the Aggregate Gradation Table in Article 4109.02.

4. Fabric Reinforcement.
Use fabric reinforcement meeting the requirements of Article 4196.01, B, 4.

5. WMA Technologies.
Chemical additives, organic additives, or water injection systems approved by the Bituminous Engineer may be used at the rate established by the mixture design in the production of WMA. Once production of a bid item has begun with a WMA technology, continue its use throughout the remainder of the bid item's production unless otherwise approved by the District Materials Engineer.

2303.03 CONSTRUCTION.

A. General.

1. The Contractor is responsible for all aspects of the project.

2. Provide quality control management and testing, and maintain the quality characteristics specified.

3. Apply Quality Management - Asphalt (QM-A) to asphalt mixture bid items when the plan quantity is greater than 1000 tons (1000 Mg) and all Interstate contracts. Follow the procedures and meet the criteria established in Articles 2303.02 and 2303.03, B; Section 2521; and Materials I.M. 510 and 511.

4. Apply Article 2303.03, E, for asphalt mixture bid items that have a plan quantity of 1000 tons (1000 Mg) or less as well as any patching bid items. For items bid in square yards (m^2), apply Article 2303.03, E when the plan quantity by weight (estimated with a unit weight of 145 pounds per cubic foot (2323 kg/m^3) unless otherwise stated on the plans) does not exceed 1000 tons (1000 Mg). Article 2303.03, E applies to Interstate patching as well as Interstate bid items of less than 1000 tons (1000 Mg), all of which are placed in a non-travel lane.

B. Equipment.

Provide sufficient equipment of the various types required to produce, place, and compact each layer of mixture as specified, such that the mixture is workable at the minimum placement and compaction temperature desired, regardless of storage or haul distance considerations.

Modify the asphalt mixing plant as required by the manufacturer when introducing a WMA technology. Plant modifications may include additional plant instrumentation, the installation of water injection systems and/or WMA additive delivery systems, tuning the plant burner and adjusting the flights in order to operate at lower production temperatures and/or reduced tonnage.

Use equipment meeting the requirements of Section 2001 with the following modifications:

1. Plant Calibration.

a. Calibrate each plant scale and metering system before work on a contract begins. Use calibration equipment meeting the manufacturer's guidelines and Materials I.M. 508.

b. The Engineer may waive calibration of permanent plant scales when a satisfactory operational history is available. The Engineer may require any scale or metering system to be recalibrated if operations indicate it is necessary.

c. Make calibration data available at the plant.

d. Calibrate each aggregate feed throughout an operating range wide enough to cover the proportion of that material required in the JMF. Make a new calibration each time there is a change in size or source of any aggregate being used.

e. For continuous and drum mixing plants, calibrate the asphalt metering pump at the operating temperature and with the outlet under pressure equal to that occurring in normal operations.

2. Paver.

Apply Article 2001.19. Spreaders described in Article 2001.13, D, may be used to place paved shoulders. Spreaders used to place the final lift

of paved shoulders shall meet additional requirements of Article 2001.19.

3. Rollers.

a. For initial and intermediate rolling, use self-propelled, steel tired, pneumatic tired, or vibratory rollers meeting the requirements of Article 2001.05, B, C, or F. Their weight (mass) or tire pressure may be adjusted when justified by conditions.

b. For finish rolling, use self-propelled, steel tired rollers or vibratory rollers in the static mode that meet the requirements of Article 2001.05, B, or F.

4. Scales.

Apply Article 2001.07, B, to paving operations regardless of the method of measurement.

C. HMA Construction.

1. Maintenance of the Subgrade and Subbase.

a. Maintain completed subgrade and subbase to the required density, true cross section, and smooth condition, prior to and during subsequent construction activities.

b. If rutting or any other damage occurs to the subgrade or subbase as a result of hauling operations, immediately repair the subgrade and subbase. Such repair will include, if necessary, removal and replacement, at no additional cost to the Contracting Authority.

c. Should traffic by others authorized to do work on the project be specifically permitted by the Engineer to use loads which exceed the Contractor's established limit, the Contracting Authority will pay repair costs for repairs directed by the Engineer.

2. Preparation of Existing Surfaces.

a. Cleaning.

Clean and prepare existing surface according to Article 2212.03, B, 1.

b. Tack Coats.

1) Apply tack coats when the entire surface area on which the coat is to be applied is free of moisture. Do not apply them when the temperature on the surface being covered is less than 25°F (-4°C).

2) Place a tack coat to form a continuous, uniform film on the area to be covered. Unless directed otherwise, spread the tack coat at an undiluted rate of 0.02 to 0.05 gallon per square yard (0.1 to 0.2 L/m^2). The tack coat may be diluted with water to improve application.

3) Allow tack coat to adequately cure prior to placement of HMA to assure bond to the underlying surface and avoid damage of the HMA being placed. If tack coat surface becomes dirty from weather or traffic, thoroughly clean and, if necessary, retack. A light application of sand cover may also be required, but this is

anticipated only for excessive application rates, breakdowns, and short sections remaining at the end of a day's run.

4) On highways being constructed under traffic, use procedures that provide safety and convenience to the public (without soiling their vehicles) as controlling factors. Limit tack coat application lengths to minimize inconvenience to the public. Keep applications within the hot mixture placing work area that is controlled by flaggers at each end. Plan applications so they will be covered with hot mixture when the work area is opened to traffic at the end of the day's work.

5) Tack the vertical face of exposed, longitudinal joints as a separate operation at a rate from 0.10 to 0.15 gallon per square yard (0.5 to 0.7 L/m^2). Tack before the adjoining lift is placed. Lightly paint or spray vertical surfaces of all fixtures, curbs, bridges, or cold mixture with which the hot mixture will come in contact to facilitate a tight joint with the fresh mixture.

c. Fabric Reinforcement.

1) When fabric reinforcement is required, the locations will be designated in the contract documents.

2) Do not place fabric on wet or damp surfaces, or when the road surface is less than 50°F (10°C).

3) Apply fiberglass fabric only with an adhesive recommended by the manufacturer.

4) Place fabrics with an adhesive backing according to the manufacturer's recommendations.

5) Place other fabrics with a heavy coat of asphalt binder at a rate of 0.20 to 0.25 gallons per square yard (0.9 to 1.1 L/m^2). Use the same binder grade used in the asphalt concrete mixture. For binders containing a WMA technology, place at a temperature between 260ºF and 315ºF (127ºC and 160ºC), otherwise place at a temperature between 295°F and 315°F (145°C and 160°C).

6) Place fabric reinforcement according to the contract documents (full width or individual crack or joint treatment). Place fabric immediately following the adhesive or asphalt binder placement under the fabric. Placement may be by hand or by a mechanical method designed for this purpose.

7) Take precautions to avoid wrinkles in the fabric and to ensure that air bubbles are removed without breaking the fabric. Cut and lap wrinkles or folds which cannot be removed by brushing in order to provide a smooth surface.

8) Additional adhesive or asphalt binder may be required to produce a tight, bonded surface. When applied full lane width, use a minimum 12 inch (300 mm) transverse and longitudinal lap.

9) Avoid applying tack coat over longitudinally placed fabric.

10) To avoid damage to fabric, do not allow traffic over fabric during placement and during curing of the adhesive material. A light application of HMA mix may be hand sprinkled on the fabric to prevent damage from necessary equipment traffic.

11) When directed by the Engineer, repair damaged or soiled fabric prior to HMA overlay, at no additional cost to the Contracting Authority. The Engineer may also require sanding during this period, at no additional cost to the Contracting Authority.

3. Handling, Production, and Delivery.

Ensure plant operation complies with the following requirements:

a. Handling Mineral Aggregate and RAP.

1) Keep various aggregate products used separate from one another. Make adequate provisions to prevent intermingling.

2) Handle stockpiling and processing in a manner to ensure uniform incorporation of the aggregate into the mix.

3) Feed various aggregates separately in their proper proportions using feeders to the cold elevator. Feed them at a rate to permit correct and uniform temperature control of heating and drying operations.

b. Handling Asphalt Binder.

Bring asphalt binder to a temperature of 260°F to 330°F (125°C to 165°C) before being measured for mixing with the aggregates. The temperature between these limits may be further regulated according to the characteristics of the mixture, method of proportioning, and viscosity of the asphalt binder. Heat modified asphalt binder according to the supplier's recommendations.

c. Handling Anti-strip Agents.

1) Hydrated Lime.

Accurately proportion lime using a method acceptable to the Engineer.

a) Added to a Drum Mixer.

(1) Add hydrated lime at the rate of 0.75% by weight (mass) of the total aggregate (virgin and RAP) for Interstate and Primary projects. Add hydrated lime to a drum mixer using one of the following methods:

(a) Add to virgin aggregate on the primary feed belt, as a lime water slurry.

(b) Thoroughly mix with the total combined aggregate if the aggregate contains at least 3% total moisture.

(c) Add to the outer drum of a double drum system away from heated gas flow and prior to the addition of the virgin asphalt binder.

(2) Alternative methods for mixing will be allowed only with the Engineer's approval. Do not introduce hydrated lime directly into a single drum mixer by blowing or by auger.

b) Added to a Batch Plant.

Add hydrated lime at the rate of 0.5% by weight (mass) of the total aggregate (virgin and RAP) for Interstate and Primary projects. Introduce it to a batch plant using one of the methods below. In any case, introduce the lime prior to the start of the dry mix cycle.

(1) Place on the recycle belt which leads directly into the weigh hopper.
(2) Add directly into the pugmill.
(3) Add directly into the hot aggregate elevator into the hot aggregate stream.

c) Added to the Aggregate Stockpile.
Add hydrated lime at a rate established by the AASHTO T 283 test. The instructions for establishing the rate are discussed in Materials I.M. 510. Add it to the source aggregates defined in Article 2303.02, E, 2, thoroughly mixed with sufficient moisture to achieve aggregate coating, and then place in the stockpile.

2) Liquid.

a) When liquid anti-strip additives are used, employ equipment complying with the anti-strip manufacturer's recommended practice to store, measure, and blend the additive with the binder.

b) The additive may be injected into the asphalt binder by the asphalt supplier or the Contractor. If the Contractor elects to add the liquid anti-strip agent, they assume the material certification responsibilities of the asphalt binder supplier. Ensure the shipping ticket reports the type and amount of additive and time of injection.

c) Ensure the asphalt supplier provides the Contactor and Engineer with the shelf life criteria defining when the anti-strip additive maintains its effectiveness. Do not use binder that has exceeded the shelf life criteria.

d) When using polymer-based aggregate treatment, comply with the manufacturer's recommended specifications and guidelines.

d. Production of Hot Mix Asphalt Mixtures.

1) Regulate the exact proportions of the various materials to be within the limits specified to produce a satisfactory bituminous coating and mixture. First dry mix the aggregates, then add the asphalt binder.

a) In batch plants, add the asphalt binder in an evenly spread sheet over the full length of the mixer box.

b) In continuous plants, spray the asphalt binder evenly into the aggregate within the first 30% of the length of the mixer box using a positive pressure spray.

c) In drum mixing plants, spray the asphalt binder evenly into the aggregate using a positive pressure spray.

2) Operate the mixer so that the mixture is of consistently uniform temperature, and when discharged from the mixer does not vary more than 20ºF (11ºC).

3) Do not allow the temperature of the mixtures to fall outside the following parameters:

a) Keep the production temperature of WMA mixtures between 215ºF (102ºC) and 280ºF (138ºC) until placed on the grade.

b) Do not produce WMA mixtures more than 10ºF (6°C) below the target temperature designated in the JMF without the approval of the Engineer.

c) Keep the production temperature of HMA mixtures between 225ºF (102ºC) and 330ºF (165ºC) until placed on the grade. Do not discharge HMA into the hopper when its temperature is less than:

(1) 245 ºF (118ºC) for a nominal layer thickness of 1 1/2 inches (40 mm) or less, or

(2) 225 ºF (102ºC) for a nominal layer thickness of more than 1 1/2 inches (40 mm).

d) Flexible paving mixtures not meeting these requirements will be rejected.

5) Use a rate of production that will not exceed the manufacturer's rated capacity for the mixer and will provide uniform coating. For batch mixers, use a dry mixing time of no less than 5 seconds and a wet mixing time of no less than 25 seconds. For continuous mixers, use a mixing time of no less than 30 seconds.

6) Control handling and manipulation of the hot mixture from the mixer to the final spread on the road in order to maintain uniform composition and minimize segregation of coarser particles. Minimize segregation to the extent that it cannot be visibly observed in the compacted surface. Apply only approved release agents to trucks and equipment, as specified in Article 2001.01.

7) Except for an unavoidable delay or breakdown, provide continuous and uniform delivery of hot HMA to any individual spreading unit. Deliver at a rate sufficient to provide as continuous an operation of the spreading unit as practical. Keep the paver hopper sufficiently full at all times to prevent non-uniform mixture flow to the screed.

4. Placement.

a. Clean the surface of each layer according to Article 2212.03, B, 1. If necessary, retack to provide bond with the succeeding course.

b. Prior to placing the final lift, correct bumps or other significant irregularities that appear or are evident in the intermediate course or other lower course.

c. Do not place HMA mixtures under the following circumstances:

1) On a wet or damp surface.

2) When road surface temperature is less than that shown in Tables 2303.03-1 and 2303.03-2.

Table 2303.03-1: Base and Intermediate Course Lifts of Asphalt Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, ºF (ºC)
1 1/2 (40)	40 (4)
2 - 3 (50 - 80)	35 (2)
Over 3 (Over 80)	35 (2)

Table 2303.03-2: Surface Course Lifts of Asphalt Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, ºF (ºC)
1 (30)	HMA: 50 (10) / WMA: 40 (4)
1 1/2 (40)	HMA: 45 (7) / WMA: 40 (4)
2 and greater (50 and greater)	40 (4)

3) After November 15, except with the Engineer's approval.

d. The Engineer may further limit placement if, in the Engineer's judgment, other conditions are detrimental to quality work.

e. When placing the mixture, maintain a finishing machine forward speed that will provide a continuous uniform operation. Minimize stopping.

f. Use a wire or string line to guide finishing machine and maintain alignment. Correct edge alignment irregularities immediately.

g. The contract documents will show the total thickness to be placed. Spread the mixture at a rate such that, when compacted, the layer(s) will be the required thickness.

h. Base the minimum layer thickness on Table 2303.03-3.

Table 2303.03-3: Minimum Lift Thickness

Design Mix Size - inches (mm)	Minimum Lift Thickness - inches (mm)
3/8 (9.5)	1 (25)
1/2 (12.5)	1 1/2 (40)
3/4 (19)	2 (50)
1 (25)	3 (75)

i. Ensure the compacted thickness of the top layer does not exceed 3 inches (75 mm). This restriction does not apply to HMA shoulders.

j. The maximum compacted thickness of lower layers may exceed 4 inches (100 mm) if it is demonstrated that the thicker layers have satisfactory density. The riding characteristics of the thicker layers must be within conformance to that expected from a 3 inch (75 mm) layer.

k. Complete each layer to full width before placing succeeding layers.

l. While operating on the road surface, do not use kerosene, distillate, other petroleum fractions, or other solvents, for cleaning hand tools or for spraying the paver hopper. Do not carry containers of cleaning solution on or near the paver. When a solvent is used, do not use the paver for at least 5 hours after cleaning. Collect and remove all cleaning materials and cleaning residue from the project and plant site. The cleaning material and residue becomes the property of the Contractor.

m. Whenever practical, spread mixtures using a finishing machine. Irregular areas may be spread by hand. Spread the hot mixture uniformly to the desired depth with hot shovels and rakes. Do not

dump loads faster than they can be spread properly. Do not allow workers to stand on the loose mixture while spreading.

n. After spreading, carefully smooth to remove all segregated coarse aggregate and rake marks. Use rakes and lutes designed for use on HMA mixtures.

o. Unless stated elsewhere in the contract documents, when placing two adjacent lanes, pave no more than 1 day of rated plant production before paving the adjacent lane(s). Place the adjacent lane to match the first lane during the next day of plant production.

p. Do not spread more mixture than can be compacted in the specified working hours of the same working day.

q. At the close of each working day, clear all construction equipment from the roadbed.

r. Prior to opening a lane to traffic, place fillets or full width granular shoulders according to Article 2121.03, C, 4. Place the material adjacent to and equal in thickness to the resurfacing. Fillet removal is incidental to the HMA mixture.

5. Compaction.

a. General.

1) Promptly and thoroughly compact each layer. Use mechanical tampers for areas inaccessible to the rollers.

2) Use a rolling procedure and compactive effort that will produce a surface free of ridges, marks, or bumps. Obtain the Engineer's approval for the rolling procedure and compactive effort.

b. Class I Compaction.

1) Applications.

a) Use Class I compaction for base, intermediate, and surface courses for the traffic lanes, ramps, and loops on all roadways.

b) For Class I compaction, the quality characteristic is in-place air void content and will be based on the theoretical maximum specific gravity (Gmm) obtained from the Quality Control Program for that day's mixture.

2) Test Strip Construction for Class I Compaction.

a) For the purpose of evaluating properties of the HMA mixtures and for evaluating an effective rolling pattern:

(1) Construct a test strip of the surface mixture prior to its placement on the surface course for Interstate highways, Primary highways, and ramps connecting Interstate and Primary highways.

(2) Construct a test strip of the intermediate mixture at the start of its placement on the intermediate course for Interstate highways, interstate-to-interstate ramps.

(3) Test strips for base mixtures may be constructed, but are not required.

b) When the contract documents specify both intermediate and surface courses and a test strip is required, place a surface course test strip in lieu of intermediate mixture in a

section of the intermediate course prior to actual surface course placement.

c) Test strips are not required when the entire production of the mixture bid item is placed in a single day.

d) The quantity of HMA mixture subject to the test strip production, will be pre-established with the Engineer and limited to a half day's production:

e) Only one test strip will be allowed for each mixture. The Engineer may require additional test strips if a complying HMA mixture or rolling pattern was not established.

f) Use procedures and documentation during test strip construction that allow the Engineer and Contractor to confirm mixture design properties and effectiveness of compaction procedures.

g) Use test strip production control that meets the requirements of Article 2303.03, D, 3, c. The test strip will be an independent lot. Determine sublots in accordance with Table 2303.03-4.

c. Class II Compaction.

Intended for paved shoulders, temporary crossovers, onsite detours, and other situations where Class I is not specified.

1) For all rollers, make initial contact with the hot mixture using the power driven wheels or drum.

2) Perform initial rolling at a temperature so the mixture will compact without excessive distortion. Except on longitudinal joints and super-elevated curves, begin rolling with the initial roller at the outer edges of the pavement. With each successive pass, progress inward toward the center. For each reverse trip, lap all but 4 to 6 inches (100 to 150 mm) of the previous track. When reversing direction, stop the initial roller at an angle with the longitudinal direction.

3) Following the initial rolling, give the layer an intermediate rolling with a pneumatic tired roller before the temperature falls below 225°F (110°C). Cover the area no less than six times with the intermediate roller.

4) Use a finish, steel tired roller to smooth out all marks and roughness in the surface.

5) For areas inaccessible to rollers, use mechanical tampers or other approved compaction methods.

6. Joints and Runouts.

a. Construct longitudinal joints for courses on resurfacing projects directly above the longitudinal joint in the existing pavement. Limit the offset distance between longitudinal joints in succeeding full depth HMA paving courses to 3 inches (75 mm) or less. Adjust hot mixture spreading along longitudinal joints to secure complete joint closure and full compression of the mixture with a smooth surface and joint after compaction.

b. Separate transverse construction joints in succeeding courses by at least 6 feet (1.6 m). Do not use wood or metal headers to form joint edge during rolling of the fresh mixture. Saw header to a straight

line at right angles to the center line to provide a full thickness vertical edge before continuing paving. Provide a 10 foot (3 m) straightedge for checking transverse construction joints for smoothness. Before compaction, use hand methods to correct surface variations at transverse construction joints indicated by the straightedge.

c. When a transverse construction joint is open to traffic, install a temporary runout 10 feet (3 m) long per 1 inch (25 mm) of lift thickness. Use suitable paper or burlap (not sand, dirt, or wood) under the taper to prevent adhesion.

d. When required to end paving for winter shutdown, locate runouts adjacent to each other. Install a winter shutdown runout 25 feet (8 m) long per 1 inch (25 mm) of lift thickness.

e. For temporary runouts open to traffic for periods greater than 4 weeks or winter shutdown runouts, the Contractor may reduce the amount of top size aggregate in the transition taper. Remove temporary runouts and winter shutdown runouts before commencing paving. Runout removal is incidental to the HMA mixture.

7. Miscellaneous Operations.

a. Leveling and Strengthening Courses.

1) The contract documents will show course thickness. Place strengthening and leveling courses as indicated in the contract documents. Use the same mixture specified for the base or intermediate course.

2) When the width of strengthening or leveling course is 8 feet (2.4 m) or more, spread using a finishing machine.

3) Compact leveling courses and intermediate mixtures placed as leveling/scratch courses (less than or equal to 1 inch (25mm) plan thickness) using Class II compaction, except make all passes with a pneumatic roller.

b. Wedge Courses.

1) Use the base or intermediate mixture to construct wedge courses used to secure desired curve super-elevation. When possible, spread using a finishing machine.

2) Place wedge courses in compacted layers no thicker than 3 inches (75 mm). Avoid crushing the coarse aggregate. Place wedge courses to the full width of the pavement.

3) On super-elevated curves which require wedge course placement, stage the shoulder construction. After completing each day's wedge placement operations and prior to suspending that day's construction activities, construct a full width shoulder on the high side up to the completed wedge course elevation. Shoulder construction staging will be considered incidental to shoulder construction.

4) The Engineer may waive field void sampling for wedge courses provided compaction has been thorough and effective.

c. Fixtures in the Pavement Surface.

1) Adjust manholes, intakes, valve boxes, or other fixtures encountered within the area to be covered by HMA to conform

to the final adjacent finished surface. Payment for adjustment of manholes or intakes will be per Section 2435. Payment for adjustment of valve boxes and other fixtures will be per Section 2554. Unless specified otherwise in the plans, adjust fixtures:

- Between placing the surface course and the layer preceding the surface course, or
- After placing the surface course using a composite patch or PCC patch.

2) Use PCC and HMA patch material complying with the requirements of Section 2529. Make patches large enough to accommodate the structure being adjusted.

3) Construct patches to be square. Orient them diagonally to the direction of traffic flow. Ensure the elevation of the adjusted fixture and patch does not differ from the elevation of the surrounding pavement surface by more than 1/4 inch (6 mm).

4) When shaping and compacting resurfacing near inlets to storm sewer intakes, shape to ensure maximum drainage into intakes.

d. Fillets for Intersecting Roads and Driveways.

1) Shape, clean of loose material, and tack coat the surface adjacent to the pavement being surfaced when fillets are designated in the contract documents for driveways to homesteads and commercial establishments and at intersecting roads. On the tack coated surface, place and compact the hot mixture in layers equal to the adjacent layer. Extend from the edge of the pavement as shown on the plans.

2) Place and compact fillets at intersecting roads at the same time as the adjacent layer.

3) Entrance fillets that are 8 feet (2.4 m) or wider may be placed as a separate operation. Pave fillets which are 8 feet (2.4 m) or wider with a self propelled finishing machine described in Article 2001.19.

4) The Engineer may approve other equipment for placement of fillets, based on a demonstration of satisfactory results.

e. Stop Sign Rumble Strips.

If the plans include the bid item Rumble Strip Panel (In Full Depth Patch), apply Section 2529. To meet the requirements of placing Stop Sign Rumble Strips before opening roadway sections to traffic, the Contractor may construct temporary rumble strip panels meeting the final pattern and location of the Stop Sign Rumble Strip indicated in the plans

f. Paved HMA Shoulders.

1) Compact paved HMA shoulders using one of the following methods:

a) Class II compaction (Article 2303.03, C, 5, c),

b) Rolling pattern established during the first day of shoulder placement to achieve Class I compaction (Article 2303.03, C, 5, b), or

c) Same rolling pattern established for adjoining mainline or ramp driving lane, as determined by density coring.

2) Shoulder area will not be included in Percent Within Limits (PWL) calculations for field voids on adjoining mainline or ramp driving lane. A price adjustment may be applied to shoulder areas that do not adhere to the established roller pattern.

D. Quality Assurance Program.

For interstate mixtures placed in a travel lane and each mixture bid item that has a plan quantity of more than 1000 tons (1000 Mg) (patching excluded) apply requirements of this article.

For items bid in square yards (m^2), apply the requirements of this article when the plan quantity by weight (estimated with a unit weight of 145 pounds per cubic foot (2323 kg/m^3) unless otherwise specified in the plans) exceeds 1000 tons (1000 Mg).

HMA mixture bid items with plan quantities of 1000 tons (1000 Mg) or less and patching bid items are both defined as small quantities. For those bid items, meet the requirements of Article 2303.03, E. For items bid in square yards (m^2), when the plan quantity by weight (estimated with a unit weight of 145 pounds per cubic foot (2323 kg/m^3) unless otherwise specified in the plans) does not exceed 1000 tons (1000 Mg), meet the requirements of Article 2303.03, E.

1. General.

Follow the procedures and meet the criteria established in Articles 2303.02 and 2303.03, B, Section 2521, and Materials I.M. 510 and 511.

2. Mix Design - Job Mix Formula.

a. The Contractor is responsible for the JMF for each mixture.

b. Submit a completed JMF, using the computer format of Form 956, for approval to the materials lab designated by the Contracting Authority. Submit supporting documentation demonstrating the design process was followed and how the recommended JMF was determined. Include an economic evaluation when required. Include trial and final proposed aggregate proportions (Form 955) and corresponding gyratory data. In addition, submit sufficient loose mixture and individual material samples for approval of the design.

c. Personnel preparing the JMF shall be Iowa DOT certified in bituminous mix design.

d. If the JMF is not satisfactory, submit another JMF for review. An approved JMF will be required prior to beginning plant production. The Contractor will be charged $1000 for each JMF approval requested and performed which exceeds two per mix size, type, and proposal item on any individual project or group of tied projects.

3. Plant Production.

a. General.

1) Perform sampling and testing to provide the quality control of the mixture during plant production. Certified Plant Inspection according to Section 2521 is required.

2) Personnel performing production quality control testing shall be Iowa DOT certified for the duties performed.

3) Provide easy and safe access for Iowa DOT staff to the location in the plant where samples are taken.

4) All of the following qualify as a "significant mix change":

- A single occurrence of an aggregate interchange of greater than 5%.
- A single occurrence of an asphalt content change greater than 0.2%.
- A deletion or introduction of a new material into the mix.
- A change of additive dosage rate.
- A change of binder, aggregate, or additive source.

b. Sampling and Testing.

Submit a testing plan meeting the requirements of Materials I.M. 511, Appendix D prior to the preconstruction meeting.

1) Asphalt Binder

Sample and test asphalt binder to verify the quality of the binder grade. Take asphalt binder samples at random times as directed and witnessed by the Engineer according to Materials I.M. 204.

2) Aggregate Gradation

a) Use cold feed gradation for aggregate gradation control to assure materials are being proportioned according to the specifications. Take aggregate quality control samples at random times in accordance with Materials I.M. 204.

b) Take a minimum of one aggregate gradation for each day's production that exceeds 100 tons (Mg). Higher testing frequencies may be used when defined by a pre-determined quality control plan approved by the Engineer. When more than one sample in a day's production is tested, use the average gradation to determine compliance of the daily lot.

c) Split a cold feed sample with the Engineer on the first day's production of each mixture. The Engineer will determine the need for a correction factor for the cold feed gradation based on the Engineer's cold feed gradation and ignition oven results. The Engineer may require additional cold feed split samples to evaluate the need or value of a correction factor for the cold feed and ignition oven gradation.

d) Secure aggregate gradation samples transported to the lab for determination of the ignition oven correction factor in accordance with Materials I.M. 511.

3) Uncompacted Asphalt Mixture

a) Sample the hot HMA mixture at random locations as directed and witnessed by the Engineer according to Materials I.M. 322. Secure and test the samples according to Materials I.M. 511.

b) Sampling frequency will be determined by the estimated daily production of each mixture placed. The number of sublots is defined in Table 2303.03-4:

Table 2303.03-4: Uncompacted Mixture Sublot Size

Estimated Daily Production, Tons (Mg)	Number of Sublots
101-500	1
501-1250	2
1251-2000	3
2001-4500	4
Over 4500	5

c) The Contractor may request to have a quality control plan that indicates a higher testing frequency if pre-approved by the Engineer at the preconstruction meeting.

d) Assist the Engineer with material sampling for verification testing. When the Engineer provides notification that a sample is to be taken, initiate sampling within 15 minutes. Sampling should normally be completed within 30 minutes of notification.

e) Do not take paired samples from the first 100 tons (100 Mg) of mix produced each day or the first 100 tons (100 Mg) of mix following a significant mix change.

f) For PWL analysis of laboratory voids, lot size is defined as follows:

- **(1)** No less than 8 and no more than 20 sequential tests will constitute a lot (exceptions stated below).
- **(2)** After the 8th test, all subsequent samples collected over the remainder of that week will also be included in the lot up to a maximum of 20.
- **(3)** Once a lot has been established with at least 8 tests, a new lot will begin at the start of the following week or the day following the 20th sample, whichever occurs first. Lots shall not contain partial days. When the 20th sample is reached, include all samples taken that day in the lot.
- **(4)** When determining PWL lot size for lab voids, Sunday through Saturday defines a week.
- **(5)** If the bid item's production has ended and fewer than 8 tests are available, those tests may be combined with the previous lot provided the maximum lot size has not already been reached. When combining results, if the day to be combined contains the 20th sample, include all samples for that day. Do not combine partial day's results.
- **(6)** If samples cannot be combined with the previous lot due to maximum lot size restrictions or if fewer than 8 tests are available for the entire production of a bid item, combine those tests into a single lot and use the AAD analysis in Materials I.M. 501.

(7) Test strips will be considered a separate lot.

(8) When the same mix type is produced for multiple bid items in one day, assign all box samples to each bid item's existing PWL lot for lab voids. Assign the quantity of each bid item produced to its respective lot.

g) Test the quality control sample of each production paired sample as follows:

(1) Prepare and compact two gyratory specimens according to Materials I.M. 325G. Compact loose WMA field samples, transported to the laboratory, at 240ºF (115ºC).

(2) Determine the the bulk specific gravity of compacted mixture (G_{mb}) at N_{design} for each specimen according to Materials I.M. 321. G_{mb} will be determined by compacting specimens to N_{design}. Average the results.

(3) Determine the Theoretical Maximum Specific Gravity of the uncompacted mixture according to Materials I.M. 350.

(4) Determine laboratory air voids for each sample according to Materials I.M. 501.

h) Use the target laboratory voids listed in Materials I.M. 510 Appendix A unless otherwise specified in the contract documents.

i) Use the following methods of acceptance for laboratory voids:

(1) For base widening, non-high speed ramps, non-interstate shoulders, recreational trails, and other mixture bid items not placed in travel lanes of a permanent pavement, acceptance for laboratory voids will be based on a moving absolute average deviation (AAD) from target as defined in Materials I.M. 501 of this specification. Use the production tolerance in Table 2303.03-5.

(2) For all other mixture bid items, determine PWL for each lot as defined in Materials I.M. 501. Use 1.0% below the target air voids as the lower specification limit and 1.0% above the target air voids as the upper specification limit. Lot size is defined in Article 2303.03, D, 3, b, 3, vi. When the same mix type is placed in both PWL and AAD areas in a single day, include all samples for that day in the PWL lot as well as the quantity of the mixture bid item produced and placed in the PWL area.

j) For mixture bid items in a PWL lot, ~~D~~determine the pay factor using the absolute average deviation (AAD) procedure described in Materials I.M. 501 for proportions of a mixture bid item which are produced in irregular intervals and placed in irregular areas. The following items qualify as such and shall be combined into weekly lots:

- Asphalt mixture produced and placed on gores, detours, cross-overs, temporary pavements, turning lanes, and fillets,
- Asphalt mixture produced and placed on ramps that are not high-speed ramps,
- Asphalt mixture produced and placed on non-interstate shoulders.

To be considered irregular, the production rate for mixture bid items described above is not to exceed 1000 tons (10,000 square yards (8400 m^2) for items bid in square yards in a single day.

4) Moisture Susceptibility

a) The Engineer may obtain plant produced samples for moisture susceptibility testing in accordance with Materials I.M. 507 at any time for mixtures identified in Article 2303.02, E, 2, A or Article 2303.02, E, 2, G to verify the minimum TSR has been achieved.

b) When liquid anti-strip additives are added by the Contractor at the plant, satisfy one of the following methods to regulate the quantity of additive:

(1) Present certification that the equipment used to measure and blend the liquid anti-strip additive:

- Meets the anti-strip supplier's recommended practice,
- Is directly tied to the asphalt binder supply system, and
- Has been calibrated to the equipment manufacturer's guidelines.

(2) Test the binder to measure the quantity of liquid anti-strip additive in the binder for every 5000 tons (5000Mg) of HMA production. Obtain the Engineer's approval for the supplier's test method prior to use of the test.

(3) Run the test method in Materials I.M. 507 during production. If unable to certify or test for the presence and quality, run the test method in Materials I.M. 507 each 10,000 tons (10,000 Mg) of production to measure the effectiveness of the additive. Ensure test results satisfy 80% TSR when compared to the dry strength of specimens prepared with asphalt binder containing the additive.

c. Production Control.

1) After the JMF is established, the combined aggregate furnished for the project, the quantity of asphalt binder, and the laboratory air voids should consistently comply with the JMF, as target values. Control them within the production tolerance given in Table 2303.03-5.

Table 2303.03-5: Production Tolerances

Measured Characteristic	Target Value (%)	Specification Tolerance (%) [a]
Cold feed gradation No. 4 (4.75 mm) and larger sieves	by JMF	± 7.0
Cold feed gradation No. 8 (2.36 mm)	by JMF	± 5.0
Cold feed gradation No. 30 (600 µm)	by JMF	± 4.0
Cold feed gradation No. 200 (75 µm)	by JMF	± 2.0 [b]
Field laboratory air voids absolute deviation from target [c]	0.0	≤ 1.0
Daily asphalt binder content	by JMF	± 0.3
VMA [e]	by JMF	± 1.0 [f]

(a) Based on single test unless noted otherwise.
(b) Maintain the filler/bitumen ratio of the plant produced mixture between 0.6 and 1.4.
(c) When lab voids acceptance is not based on PWL.
(e) Restricted to an asphalt film thickness as specified for the level of HMA mixture. May be waived per Materials I.M. 510, Appendix A.
(f) Based on the daily lot average.

2) Control plant production so that the plant produced HMA mixture will meet mixture design criteria (within the test tolerances given in Table 2303.03-5) for Air Voids and VMA at N_{design} gyrations of the gyratory compactor. Monitor the slope of the gyratory compaction curve of plant produced material. Slope variations in excess of ±0.40 of the mixture design gyratory compaction curve slope may indicate potential problems with uniformity of the mixture.

3) The gyratory mix design gradation control points for the size mixture designated in the project plans will not apply to plant production control.

4) Strive for the target value of the percent air void and asphalt binder by adjusting gradation and asphalt binder content.

5) Produce a uniform composition mixture complying with the JMF.

6) Adjustments to the JMF target gradation and asphalt binder content values may be made.

a) The Contractor determines from quality control testing that adjustments are necessary to achieve the specified properties.

b) Consult with the Engineer regarding adjustments to the JMF.

c) Notify the Engineer if the average daily gradation for a mixture bid item is outside the production tolerances. If

other production tolerances and mixture requirements of Materials I.M. 510 Appendix A are acceptable, a change in gradation target can be requested.

d) If filler/bitumen ratio exceeds the limits listed in Table 2303.03-5, change the JMF at the start of the next day's production for that mixture.

e) The Contractor's adjustment recommendations prevail, provided all specifications and established mix criteria are being met for plant production.

7) Measure estimated film thickness and voids in the mineral aggregate (VMA) for specification compliance every day of HMA production.

8) Prepare quality control charts according to Materials I.M. 511. Keep the charts current and available showing both individual sample results and moving average values for both lab voids and absolute deviation from target. Base moving average values on four consecutive sample results. The moving average absolute deviation from target may restart only in the event of a mandatory plant shutdown for failure to maintain the average within the production tolerance. Include the target value and specification tolerances on control charts.

9) Calculate laboratory voids for individual samples according to Materials I.M. 501. Use the individual density and individual maximum specific gravity determined for each sample. To determine the moving average of laboratory voids, use the average of the last four individual sample laboratory voids. Calculate absolute deviation from target lab voids according to Materials I.M. 501 of this specification. To determine the moving average absolute deviation from target laboratory voids, use the average of the last four individual sample absolute deviations from target laboratory voids.

10) Monitor the test results and make mix adjustments, when appropriate, to keep the mixture near the target values. Notify the Engineer whenever the process approaches a specification tolerance limit. When acceptance for lab voids is not based on PWL, cease operations when the moving average point for absolute deviation from target lab voids is outside the specification tolerance limit. Assume responsibility to cease operations, including not incorporating material which has not been placed. Do not start the production process again until notifying the Engineer of the corrective action proposed.

4. Construction.

a. Field Voids for Class I Compaction.

1) Take samples to determine field voids from the compacted mixture and test no later than the next working day following placement and compaction.

2) A lot is considered to be one layer of one mixture bid item placed during a day's operation. The Engineer may approve classifying multiple layers of construction placed during a single day as a lot provided only one mixture was used.

3) For the following situations sampling for field voids may be waived by the Engineer provided compaction has been thorough and effective, or sampling may be modified by mutual agreement to include more than one day's production provided samples are taken prior to trafficking:

- When the day's operation is not more than 2500 square yards (2500 m^2) excluding areas deducted from the field voids lot,
- When the day's operation is not more than 500 tons (500 Mg) excluding quantities deducted from the field voids lot,
- When the mixture is being placed in irregular areas, or
- When placing wedge or strengthening courses.

4) The Engineer will obtain and test samples for each lot according to Materials I.M. 204 Appendix F. The Contractor may request to have a quality control plan that indicates a higher testing frequency at no additional cost to the Contracting Authority if pre-approved by the Engineer at the preconstruction meeting. The Engineer will determine the core locations. The length laid in each lot will be divided into approximately equal sublots. Obtain one sample at a random location, as directed and witnessed by the Engineer, in each sublot. Determine a new random location for the sublot when the designated core location falls on a runout taper at an existing pavement, bridge, or bridge approach section where the thickness is less than the design thickness.

5) If a sample is damaged or measures less than 70% or more than 150% of the intended thickness, an alternate sampling location will be determined and used. Take samples from no less than 1 foot (300 mm) from the edge of a given pass of the placing equipment, from run-outs, or from day's work joints or structures.

6) Use the following methods of acceptance for field voids:

a) For mixture bid items placed in the following areas:

- Base widening placed in a travel lane,
- Non high-speed ramps,
- Bridge approaches placed as a separate operation,
- Non-interstate travel lanes intended to be in service for fewer than 12 months,
- State Park and Institutional roadways,
- Recreational trails,
- Irregular areas identified by the Engineer that may include areas not suitable for continuous paving, and
- Wedges,

the Engineer will accept the field voids lot based on the average test results or an established effective rolling pattern when approved by the Engineer. Do not exceed 8% average field voids. The Engineer may modify the sample size and frequency provided compaction is thorough and effective. The Engineer may apply the pay schedule in 2303.05, A, 3, b, 3 to areas where thorough and effective compaction is not achieved.

b) For all other areas of Class I compaction, determine PWL, as defined in Materials I.M. 501, for each lot using a lower specification limit (LSL) of 3.5% voids (96.5% of G_{mm}) and an upper specification limit (USL) of 8.5% voids (91.5% G_{mm}).

7) When the PWL falls below 80.0, use the procedure outlined in Materials I.M. 501 to identify outliers with 1.80 as the quality index criterion. Only one core may be considered an outlier in a single lot. If an outlier is identified, recalculate the PWL with the results of the remaining cores and determine whether the PWL is improved. Use the larger of the original and recalculated PWL to determine the pay factor.

8) When the PWL falls below 50.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

9) Use maximum specific gravity (Gmm) results in field voids calculations as follows:

a) When cores represent one day's production and more than one Gmm test result is available, use the average Gmm in the field voids calculation for all cores.

b) When cores represent one day's production and only one Gmm test result is available, use the single Gmm test result in the field voids calculation for all cores.

c) When the cores represent more than one day's production, use the average of all Gmm test results from all days corresponding with the cores.

b. Thickness.

1) The Engineer will measure the cores, exclusive of sealcoat, according to Materials I.M. 337. All areas of uniform and similar thickness and width for the project will be divided into lots.

2) Use the frequency specified for taking G_{mb} samples from the surface lift when measuring for completed thickness. Samples for thickness not tested for G_{mb}, because they are less than 70% of the intended thickness, are included for thickness. In these particular instances, do not measure the thickness of additional sufficiently thick samples used to determine field voids. Take thickness samples full depth of the completed course. After measurement, remove the G_{mb} samples for the top layer from the core.

3) If any of the measurements for a lot is less than the designated thickness, the quality index for thickness of that lot will be determined by the following formula:

(English)

$$QI_{Thickness} = \frac{\text{Average Thickness}_{Measured} - (\text{Thickness}_{Plan} - 0.5)}{\text{Maximum Thickness}_{Measured} - \text{Minimum Thickness}_{Measured}}$$

(Metric)

$$QI_{Thickness} = \frac{\text{Average Thickness}_{Measured} - (\text{Thickness}_{Plan} - 12.7)}{\text{Maximum Thickness}_{Measured} - \text{Minimum Thickness}_{Measured}}$$

4) Provided there is reasonable assurance that the pavement complies with the required thickness, the Engineer may waive sampling for thickness for the following situations:
- **a)** When the day's operation is 2500 square yards (2500 m^2) or less.
- **b)** When the mixture is being placed in irregular areas.
- **c)** When the mixture is being placed next to structures.

5) When the quality index falls below 0.00, the Engineer may declare the lot or parts of the lot defective.

c. Smoothness.

Apply Section 2317 to HMA surface mixture bid items of a Primary project if any individual HMA mixture bid item is 1000 tons (1000 Mg) or greater or 5000 square yards (4200 m^2) or greater. Apply Section 2316 to all other Primary projects with a surface course and when specifically required for other projects.

5. Sampling and Testing.

a. General.

1) Maintain and calibrate the quality control testing equipment using prescribed procedures. Sample and test according to the specified procedures as listed in the applicable Materials I.M. and Specifications. When the results from a Contractor's quality control lab are used as part of product acceptance, the Contractor's quality control lab is required to be qualified.

2) Identify, store, and retain all quality control samples and field lab gyratory specimens used for acceptance until the lot is accepted. The Contracting Authority will prescribe the method of securing the identity and integrity of the verification samples according to Materials I.M. 511. Store verification samples for the Contracting Authority until delivery to the Contracting Authority's lab.

3) Identify all samples using a system the Engineer approves.

b. Individual Materials and Uncompacted Mixture.

1) Complete the following as designated by the Engineer:
- Identify samples of asphalt binder, aggregate, and tack coat material.
- Secure and promptly deliver the samples to the appropriate laboratory.

2) Take paired samples of uncompacted HMA mixture (each box of the pair weighing at least 30 pounds (14 kg)) according to Materials I.M. 322.

3) Conduct quality control tests for mixture properties using representative portions of the mix from the quality control sample of each sublot.

4) Split samples for specimen preparation according to Materials I.M. 357.

5) Paired sampling may also be accomplished by taking a bulk sample and immediately splitting the sample according to Materials I.M. 322 on the grade.

6) Record and document all test results and calculations on data sheets approved by the Contracting Authority. Record specific

test results on the Daily Plant Report the Contracting Authority provides. Also include a description of the quality control actions taken (adjustment of cold feet percentages, changes in JMF, and so forth) on the Daily Plant Report.

7) Facsimile, or deliver by other methods the Engineer approves, the Daily Plant Report to the Engineer and the designated laboratory daily. At project completion, provide the Engineer a copy of the electronic file(s) containing project information generated during the progress of the work.

8) When sampling for moisture susceptibility testing, obtain a 70 pound (35 kg) sample according to Materials I.M. 322. If the Contractor's TSR results from the mixture design are less than 90%, sample at a minimum frequency of 1/10,000 tons of plant production until a complying test result is achieved, after which the minimum frequency may be reduced to 1/50,000 tons. A single sample shall represent no more than 10,000 tons of mixture. The Engineer will select, at random, the sample location. Split the sample and deliver half to the Central Materials Laboratory.

c. Compacted Pavement Cores.

1) Cut and trim samples under the direction of and witnessed by the Engineer for tests of G_{mb}, thickness, or composition by using a power driven masonry saw or by drilling a minimum 4 inch (100 mm) nominal diameter core.

2) Restore the surfaces the same day. Dry, fill with the same material, and properly compact core holes.

3) Pavement core samples will be identified, taken possession of by the Engineer, and delivered to the Contractor's quality control field laboratory.

4) The Engineer may either:

- Transport the cores directly to the lab, or
- Secure the cores and allow the Contractor to transport the cores to the lab.

5) The compacted HMA pavement will be tested in a timely manner by the Engineer's personnel who are Iowa DOT Certified to perform the test.

6) Prepare and test the cores according to Materials I.M. 320, 321, and 337.

d. Verification and Independent Assurance Testing.

1) The Contractor's quality control test results will be validated by the Engineer's verification test results on a regular basis using guidelines and tolerances set forth in Materials I.M. 216 and 511.

2) If the Engineer's verification test results validate the Contractor's test results, the Contractor's results will be used for material acceptance. Disputes between the Contractor's and Engineer's test results will be resolved according to Materials I.M. 511.

3) The Engineer will randomly select one or more of the daily production verification samples. Some or all of the samples selected will be tested in the materials laboratory designated

by the Engineer. The Engineer will use the verification test results to determine if the Contractor's test results can be used for acceptance.

4) The Engineer will test each lot of cores at the Contractor's field quality control laboratory. Cores may also be tested by the Contractor; however, the Contractor's test results will not be used for material acceptance.

5) Personnel and laboratories performing tests used in the acceptance of material are required to have participated in the statewide Independent Assurance Program according to Materials I.M. 208.

E. Quality Control for Small HMA Paving Quantities.

1. Mix Design.

Prepare the JMF. Prior to HMA production, obtain the Engineer's approval for the JMF. Comply with Article 2303.02 and Materials I.M. 510.

For mixtures meeting the criteria in Article 2303.02, E, 2, a:

a. An anti-stripping agent is required.

b. Use Materials I.M. 507 to optimize the design dosage rate.

c. When prior-approved designs have demonstrated acceptable field TSR values, the anti-stripping agent and dosage from the JMF may be used in lieu of optimization testing.

2. Plant Production.

a. Ensure HMA production plant calibration for the JMF is current and no more than 12 months old.

b. Use certified asphalt binder and approved aggregate sources meeting the JMF. Ensure the plant maintains an asphalt binder log to track the date and time of binder delivery. Ensure HMA delivery tickets identify the JMF.

c. Monitor the quality control test results and make adjustments to keep the mixture near the target JMF values.

3. Construction.

a. Take compacted mixture G_{mb} measurements, except when Class II compaction is specified, no later than the next working day following placement and compaction. Use the field quality control laboratory compaction for field G_{mb} control, as specified in Article 2303.03, D. The Engineer may accept the void content of the compacted layer based on cores or calculations from density gauge measurements. The Engineer may waive field void sampling provided the compaction has been thorough and effective.

b. For small quantities, a lot will be the entire quantity of each HMA mixture bid item.

c. The PWL for field voids will not apply to small quantities.

4. Sampling and Testing.

a. Material sampling and testing is for production quality control only. Acceptance of mixture is based on Contractor certification. Perform a minimum of one aggregate cold-feed and one uncompacted HMA test per lot. Sampling and testing of uncompacted HMA mixture is only required for mechanically placed mixture. Sample and test according to the Standard Specifications and Materials I.M.s using certified technicians and qualified testing equipment. The Engineer may approve alternative sampling procedures. Take the sample between the first 100 to 200 tons (100 to 200 Mg) of production. No split samples for agency verification testing are required.

b. Asphalt binder will be accepted based on the asphalt supplier's shipment certification. No binder sampling or testing is required.

c. Material sampling or testing is not required for daily HMA production of less than 100 tons (100 Mg) of any mixture on any project.

d. Moisture susceptibility testing on plant produced mixture is not required.

5. Certification.

a. Provide a certification for the production of any mixture in which the requirements in this article are applied. Place the test results and the following certification statement on the Daily HMA Plant Report (Form 800241).

> "The HMA mixture contains certified asphalt binder and approved aggregate as specified in the approved mix design and was produced in compliance with the provisions of Article 2303.03, E."

b. The Daily HMA Plant Report for certified HMA may be submitted at the end of the project for all certified HMA quantities, or submitted at intervals for portions of the certified quantity.

2303.04 METHOD OF MEASUREMENT.

A. Hot Mix Asphalt Mixture.

1. General.

a. Removal of fillets is incidental to the contract unit price for the mixture.

b. If the Contractor chooses to place intermediate or surface mixture in lieu of base for the outside shoulders, the quantity will be calculated from the pavement and shoulder template. If placed as a separate operation, the quantity will be calculated from scale tickets. If the substitute mixture placed on the shoulder is for an intermediate course fillet only, include the quantity in the fillet for payment in the quantity placed in the adjacent intermediate course.

c. Payment for the quality control requirements for small quantities will not be measured separately.

d. Unless stated otherwise, equivalent WMA mixtures may be substituted for specified HMA mixtures.

2. Measurement by Weight (Mass).

a. The quantity of the type specified, expressed in tons (megagrams), will be determined from the weight (mass) of individual loads, including fillets, measured to the nearest 0.01 tons (0.01 Mg).

b. Loads may be weighed in trucks, weigh hoppers, or from the weight (mass) from batch plants computed by count of batches in each truck and batch weight (mass). Article 2001.07 applies. Segregate the weights (mass) of various loads into the quantities for each pay item.

3. Measurement by Area.

a. The quantity of the type specified, expressed in square yards (square meters), will be shown in the contract documents to the nearest 0.1 square yard (0.1 m^2).

b. When constructing shoulders on a basis of payment of square yards (square meters), inspection of the profile and elevation will be based on the completed work relative to the pavement edge. The Contractor is responsible for the profile and elevation of the subgrade and for thickness.

B. Asphalt Binder.

1. Measure the amount of asphalt binder used from batch plants, continuous plants, or drum mixing plants by stick measurement in the Contractor's storage tank or in-line flow meter reading, according to Article 2001.07, B.

2. Compute the asphalt binder quantity added to the storage tank using a supplier certified transport ticket accompanying each load.

3. The quantity of asphalt binder not used in the work will be deducted.

4. When the quantity of asphalt binder in a batch is measured by weight (mass) and is separately identified by automatic or semi-automatic printout, the Engineer may compute the quantity of asphalt binder used from this printout. By mutual agreement, this method may be modified when small quantities or intermittent operations are involved.

5. The Engineer will calculate and exclude the quantity of asphalt binder used in mixtures in excess of the tolerance specified in Article 2303.03, D, 3, c.

6. When payment for-HMA is based on area, the quantity of asphalt binder used will not be measured separately for payment.

C. Recycled Asphalt Pavement.

1. A completed Daily HMA Plant Report with the certification statement is required for measurement and payment for Contractor Certified HMA. The quantity of asphalt binder will be based on the approved JMF and any plant production quality control adjustments.

2. The quantity of asphalt binder in RAP incorporated into the mixture, will be calculated in tons (megagrams). This quantity shall be based on the actual asphalt binder content determined for the mix design from the results of the Engineer's extraction tests.

3. The quantity of asphalt binder in RAP, which is incorporated into the mix, will be included in the quantity of asphalt binder used.

D. Anti-strip Agent.
Will not be measured separately. The quantity will be based on tons (megagrams) of HMA mixture with anti-strip agent added.

E. Tack Coat.
Will not be measured separately.

F. Fabric Reinforcement.
The quantity, in square yards (square meters) to the nearest 0.1 square yard (0.1 m^2), will be shown in the contract documents.

G. Hot Mix Asphalt Pavement Samples.
Will not be individually counted for payment if furnished according to Article 2303.03, D, 5, or required elsewhere in the contract documents,

H. Recycled Asphalt Shingles.
67% of the asphalt binder from RAS which is incorporated into the mixture will be included in the quantity of asphalt binder used.

2303.05 BASIS OF PAYMENT.
The costs of designing, producing, placing, and testing bituminous mixtures and the cost of furnishing and equipping the QM-A field laboratory will not be paid for separately, but are included in the contract unit price for the HMA mixes used. The application of tack coat and sand cover aggregate are incidental and will not be paid for separately. Pollution testing is at the Contractor's expense. The installation of temporary Stop Sign Rumble Strips will not be paid for separately, but is incidental to the price bid for the HMA course for which it is applied.

The quality control requirements for small quantities are incidental to the items of HMA mixtures in the contract.

A. Asphalt Concrete Mixture.

1. Payment will be the contract unit price for Hot Mix Asphalt Mixture of the type specified per ton (megagram) or square yard (square meter). Unless stated otherwise, equivalent WMA mixtures may be substituted for specified HMA mixtures with no change in the contract unit price.

2. Payment for test strips will be the contract unit price for the test strip mixture bid item per ton (megagram) regardless of lift placement.

3. Payment will be adjusted by the following Pay Factor for field voids and laboratory voids determined for the lot.

Multiply the unit price for the HMA bid item by the Pay Factor rounded to 3 decimal places.

a. Laboratory Voids

1) Payment when PWL is used for acceptance:

PWL	Pay Factor
95.1 – 100.0	PF = 0.006000*PWL + 0.430
80.0 – 95.0	1.000
50.0 – 79.9	PF = 0.008333*PWL + 0.3333
Less than 50.0	0.750

When PWL is less than 50.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

2) Payment when AAD is used for acceptance:

AAD from Target Air Void	Pay Factor
0.0 to 1.0	1.000
1.1 to 1.5	0.900
1.6 to 2.0	0.750
Over 2.0	0.500 maximum

When the AAD is more than 2.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

3) Use the following payment schedule when a test strip is constructed:

AAD from Target Air Void	Pay Factor
0.0 to 1.5	1.000
1.6 to 2.0	PF = 2.5 - AAD
Over 2.0	0.500 maximum

When the AAD is more than 2.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

b. Field Voids

1) Payment when PWL is used for acceptance:

PWL	Pay Factor
95.1 – 100.0	PF = 0.008000*PWL + 0.240
80.0 – 95.0	1.000
50.0 – 79.9	PF = 0.008333*PWL + 0.3333
Less than 50.0	0.750

When PWL is less than 50.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

2) Payment when a test strip is constructed:

Average Field Voids (Pa), %	Pay Factor
0.0 to 9.0	1.000
9.1 to 9.5	PF = 10 - Pa
Over 9.5	0.500 maximum

When the average air void content from a test strip exceeds 9.5%, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

3) Payment when PWL is not used for acceptance:

Average Field Voids (Pa), %	Pay Factor
0.0 to 8.0	1.000
8.1 to 9.5	PF=(11-Pa)/3
Over 9.5	0.500 maximum

When the average air void content exceeds 9.5%, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

4. When the basis of payment is by area, payment will be further adjusted by the appropriate percentage in Table 2303.05-2 below according to the quality index for thickness determined for that lot:

Table 2303.05-2: Payment Adjustment (by Area) for Thickness

Quality Index (Thickness) 8 Samples	Percent of Payment (Previously Adjusted for Field Voids)
Greater than 0.34	100
0.14 to 0.34	95
0.00 to 0.13	85
Less than 0.00	75 maximum

5. Payment for courses for which quality index (thickness) is not determined because of size or shape, and courses which are found to be deficient in average width, will be according to Article 1105.04.

6. When moisture susceptibility testing in accordance with Materials I.M. 507 is performed on plant produced mixture, the payment for asphalt mixture will be adjusted according to Table 2303.05-3:

Table 2303.05-3: Asphalt Mixture Payment Adjustment for Moisture Susceptibility

Contracting Authority's Results (Percent TSR)	Pay Factor
TSR ≥ 80	1.00
70 < TSR < 80	PF = 0.025*TSR - 1
TSR ≤ 70	0.75 maximum

B. Asphalt Binder.

1. Payment will be the contract unit price per ton (megagram) for the number of tons (megagrams) of asphalt binder used in the work.

2. Payment for asphalt binder will be for new asphalt binder the asphalt binder in the RAP which is incorporated in the mixture, and 67% of the asphalt binder from RAS which is incorporated into the mixture. The quantity of asphalt binder in RAM, which is incorporated into the mix, will be calculated in tons (megagrams) of asphalt binder in the RAM. This will be based on the actual asphalt binder content determined for the mix design from the results of the Engineer's extraction test.

3. When the basis of payment for HMA is in square yards (square meters), compensation for asphalt binder will be included in the contract unit price per square yard (square meter).

C. Recycled Asphalt Pavement.
RAP owned by the Contracting Authority will be made available to the Contractor for the recycled mixture at no cost to the Contractor other than loading, hauling, and processing as required for incorporation into the mix.

D. Anti-strip Agent.

1. When anti-strip agent is required, the incorporation of the anti-strip agent into the asphalt mixture will be considered as extra work ordered by the Engineer if the Contracting Authority's TSR results from the field produced mixture meet or exceed the minimum requirement and the conditioned indirect tensile strength is improved by at least 10% over that from the plant mixture without anti-strip (or original JMF conditioned strength when plant mix without anti-strip is not available). Payment will be made at the rate of $2.00 per ton (megagram) of asphalt mixture in which the anti-strip agent is incorporated. WMA mixtures designed for 10,000,000 ESALS and higher must satisfy Articles 2303.02, E, 2, a, 1 or 2 to be eligible for anti-strip payment. For mix designs (small quantities excluded) with a TSR greater than or equal to 80%, payment will stop when the Contracting Authority's TSR results of the field produced mixture without the agent are greater than or equal to 80%.

2. Payment will be full compensation for designing, adding, and testing for anti-strip agent.

E. Tack Coat.
Incidental to HMA.

F. Fabric Reinforcement.

1. Payment will be the contract unit price for Fabric Reinforcement per square yard (square meter).

2. Payment is full compensation for furnishing all materials, labor, and equipment necessary for installing the fabric as required, including the adhesive or heavy tack coat of asphalt binder used as the adhesive.

G. Hot Mix Asphalt Pavement Samples.

1. Payment will be the lump sum contract price for cutting HMA Pavement Samples to determine field voids or thickness according to the specifications, when either of these is the responsibility of the Contractor, and elsewhere when required by the contract documents.

2. Payment is full compensation for furnishing all such samples for all courses or items of work, and for delivery of samples as specified in Article 2303.03, D, 5.

Section 2304. Detour Pavement

2304.01 DESCRIPTION.
Furnish and place a PCC or HMA surface to carry traffic during construction of permanent pavement.

2304.02 MATERIALS.
Use PCC or HMA for the detour pavement. Meet the following requirements.

A. PCC Option.

1. Meet the requirements of Section 2301 for Class A PCC Pavement. Use Class 2 durability coarse aggregate, or better, as defined in Article 4115.04.

2. For median crossovers, meet the requirements of Section 2301 for Class C PCC Pavement. Use Class 3 durability coarse aggregate, or better, as defined in Article 4115.04.

B. HMA Option.

1. For detour pavement carrying less than 10,000,000 total 20 year ESALs, use HMA 1,000,000 ESAL surface or intermediate course, 1/2 inch (12.5 mm) or 3/4 inch (19 mm), with PG 64-22 asphalt binder.

2. For detour pavement carrying more than 10,000,000 total 20 year ESALs, use HMA 10,000,000 ESAL surface or intermediate course, 3/4 inch (19 mm), with PG 64-22 asphalt binder.

3. For median crossovers, use HMA 10,000,000 ESAL surface or intermediate course, 3/4 (19 mm), with PG 64-22 asphalt binder. Apply Class 1 compaction. The surface lift requires L-4 friction aggregate.

2304.03 CONSTRUCTION.
Earthwork quantities are based on the PCC option and will not be adjusted for additional HMA depth. Additional cut material may be used as earth shoulder construction.

A. PCC Option.

1. Meet the requirements of Section 2301. Transverse joints, center tie bars, and sealing of the center longitudinal joint are not required.

2. Do not apply Articles 2301.03, H, 2, 3, and 4, unless stated otherwise in the contract documents.

3. Apply Article 2316.02, A, 7.

B. HMA Option.
Meet the requirements of Section 2303.

2304.04 METHOD OF MEASUREMENT.
Detour Pavement constructed, in square yards (square meters), will be the quantity shown in the contract documents.

2304.05 BASIS OF PAYMENT.

A. Payment for Detour Pavement will be the contract unit price per square yard (square meter).

B. Payment is full compensation for furnishing material, equipment, and labor to construct the detour pavement in accordance with the contract documents.

C. Payment for detour pavement removal will be according to Section 2510.

Section 2305. Safety Edge

2305.01 DESCRIPTION.
Incorporate a Safety Edge to the dimensions shown and at locations designated on the contract documents.

2305.02 MATERIALS.
Safety Edge material shall match the adjoining pavement or paved shoulder material.

2305.03 CONSTRUCTION.

A. Asphalt Pavement.
Attach a device to the paver screed to confine material at the end gate and extrude the asphalt material in a wedge shape meeting the requirements of the plan details. Maintain contact between the device and road shoulder surface; and allow automatic transition to cross roads, driveways, and obstructions. Use the device to constrain the asphalt head, reducing the area and increasing the density of the extruded profile. Approved devices

meeting this specification are listed in Materials I.M. 502. Use of a single plate strike off will not be allowed.

Alternative devices not listed in Materials I.M. 502 may be approved by the Engineer. The Engineer may require proof that the device has been used on previous projects with acceptable results or may require a test section constructed prior to the beginning of work to demonstrate wedge compaction to the satisfaction of the Engineer.

The Engineer may allow short sections of handwork when necessary for transitions at driveways, intersections, interchanges, and bridges.

Placement of a granular fillet, per Article 2121.03, C, 4, b, is not necessary when a Safety Edge is installed.

B. PCC Pavement.
Modify paver screed to ensure the Safety Edge meets the final cross-section as detailed on the plans.

2305.04 METHOD OF MEASUREMENT.
Safety Edge will not be measured for payment.

2305.05 BASIS OF PAYMENT.
Safety Edge will not be paid for separately and shall be included in the contract unit price for the item for which it is required.

Section 2306. Bituminous Fog Seal (Pavement)

2306.01 DESCRIPTION.
Clean the pavement surface and apply diluted asphalt emulsion to the entire pavement surface using a bituminous distributor.

2306.02 MATERIALS.
Unless the Engineer directs otherwise, use asphalt emulsion grade CSS-1 or SS-1.

2306.03 CONSTRUCTION.

A. Equipment.
Use equipment meeting the requirements of Articles 2001.12 and 2001.14.

B. Cleaning.
Immediately prior to placing the emulsion, clean the entire pavement surface. Use scrapers, compressed air, or other approved methods.

C. Dilution.
Dilute the asphalt emulsion with water prior to application to the pavement surface. The dilution rate is one part of asphalt emulsion to four parts water.

D. General.
Calibrate the bituminous distributor to the specified target rate prior to start of work on the pavement surface.

E. Application.

1. Uniformly apply dilute asphalt emulsion at the rate of 0.12 gallon per square yard (0.5 L/m^2) of pavement surface. The application rate may be reduced if directed by the Engineer. For excessive application rates, the Engineer may require a light coat of sand. The Engineer may require brooming of ponded areas prior to placing traffic on the pavement.

2. Use safety and convenience to the public without soiling their vehicles as a controlling factor.

3. Apply asphalt emulsion at a width of one-half of the roadway plus an overlap of approximately 4 inches (0.1 m) at the middle of the road. Cover each width in one application while the opposite one-half of the roadway is left open to public traffic.

4. Do not apply asphalt emulsion to bridge decks or railroad rails and flangeways.

F. Limitations.

1. Do not place asphalt emulsion on a damp or wet surface unless the Engineer approves. Work will not be allowed on Sundays or holidays, according to Article 1108.03.

2. Apply asphalt emulsion during weather conditions which allow satisfactory application. Do not apply asphalt emulsion when either the pavement temperature or the air temperature is below 60°F (16°C). Do not apply asphalt emulsion after August 31 without the Engineer's permission.

3. A sand dam or other approved means may be necessary to prevent emulsion from running on to the pavement adjacent to the work area in areas of superelevated curves.

G. Traffic Control.

1. Asphalt emulsion applied over existing pavement markings will diminish their visibility. Install the signs of Paragraphs 3a, 3b, 3c, and 3d below.

2. Unless stated otherwise in the contract documents, furnish signs and mounting devices, including posts.

3. Furnish and install these signs as follows:

a. "NO PAVEMENT MARKINGS" and "NEXT_MILES" signs.
Place at the beginning and end of the project. They may be mounted on posts or skids.

b. "NO PAVEMENT MARKINGS" signs.
Place on each side of towns and on each side of intersections of Primary and County Roads. They may be mounted on posts or skids.

c. "DO NOT PASS" signs.
Place on the right-hand side of the road at the beginning of each no-passing zone. Mount on posts.

d. "PASS WITH CARE" Signs.
Place on the right-hand side of the road at the end of each no-passing zone. Mount on posts.

4. The Contracting Authority will place new pavement markings and remove the signs when the project is complete.

H. Scheduling.

1. A preconstruction conference will be required for this work. This will normally be a single conference for all work of this type in each residency.

2. At the preconstruction conference, provide the Engineer a probable schedule for work of this type in the District jurisdiction, including the sequence for each project.

2306.04 METHOD OF MEASUREMENT.
Measurement for the items involved in construction of Bituminous Fog Seal (Pavement) will be as follows:

A. Asphalt Emulsion for Fog Seal (Pavement).
Gallons (liters) of Undiluted Asphalt Emulsion as provided in Article 2307.04, B.

B. Sand.
Not measured for payment.

C. Traffic Control.
Article 2528.04 applies.

2306.05 BASIS OF PAYMENT.
Payment for the items involved in construction of Bituminous Fog Seal (Pavement), measured as provided above, will be as follows:

A. Asphalt Emulsion for Fog Seal (Pavement).

1. Contract unit price per gallon (liter) for Undiluted Asphalt Emulsion that is mixed and used on the project. Diluted asphalt emulsion that is delivered to the job site, but not applied to the roadway surface will not be considered for payment.

2. Payment is full compensation for:
- **a.** Cleaning the pavement surface.
- **b.** Furnishing and applying the diluted asphalt emulsion including water for dilution.
- **c.** Furnishing and applying sand cover.
- **d.** Brooming of ponded areas as necessary.
- **e.** Protecting the pavement adjacent to the work area in areas of superelevated curves.

B. Traffic Control.
Article 2528.05 applies.

Section 2307. Bituminous Seal Coat

2307.01 DESCRIPTION.
One or more applications of binder bitumen with one or more successive applications of cover aggregate.

2307.02 MATERIALS.
Use materials meeting the following requirements:

A. Aggregates.

1. Use cover aggregate meeting requirements of Section 4125 for the size designated. Unless designated otherwise, use sand for shoulders and winter seals, and use the 1/2 inch (12.5 mm) size crushed aggregate for other work. On Primary projects, when 1/2 inch (12.5 mm) size cover aggregate is specified, use crushed stone or crushed gravel.

2. For each contract, each load of each size of aggregate is to be similar in type and gradation. Source changes require the Engineer's approval.

3. For Primary projects, furnish the aggregate size designated in the contract. Do not use the 1/2 inch (12.5 mm) size when the 3/8 inch (9.5 mm) size is designated.

B. Bituminous Material.
Meet the requirements of Section 4140 or 4138.

1. Emulsified Asphalt.
Unless specified otherwise in the contract documents, use binder bitumen meeting the requirements for CRS-2P as specified in Section 4140.

2. Cutback Asphalt.
Furnish cutback asphalt with an approved anti-stripping additive as described in Article 4138.01.

3. Asphalt Emulsion for Dust Control.
Use grade CSS-1, CSS-1H, or SS-1H as specified in Section 4140. Dilute with water prior to application. Use an initial dilution rate of seven parts water to one part emulsion.

2307.03 CONSTRUCTION.

A. Equipment.
Use equipment meeting requirements of Section 2001 and the following:

1. Aggregate Spreaders.
- **a.** Apply Article 2001.13, B, except that, when provided in the contract documents, an aggregate spreader meeting requirements of Article 2001.13, A, may be used.
- **b.** Equip aggregate spreaders described in Article 2001.13, B, with a scalper or segregator screen (provided by the manufacturer) mounted below the feeder roll. Use scalper screen opening sizes recommended by the spreader manufacturer. When adjusted to the proper angle, the coarse fraction of the aggregate is placed first. Afterwards, the fine fraction is dropped through the screen on top of the larger particles. Adjust the screen angle as necessary on the project. Use of this screen is required.

2. Equipment for Distributing Bitumen.
- **a.** Apply Article 2001.12.
- **b.** When emulsion binder bitumen is used, use a distributor spray bar equipped with nozzles (furnished by the distributor manufacturer) which are specifically designed to apply emulsion. Before the work is started, provide the Engineer with a written statement indicating the size or part number of the nozzles recommended, and certifying that these nozzles are installed on the distributor.

3. Brooms.
- **a.** Apply Article 2001.14.
- **b.** When using a power broom to remove loose aggregate from a newly seal coated surface, ensure that it is capable of exerting uniform down pressure (for the full width of the broom and without vibration or bounce) sufficient to remove loose aggregate without dislodging particles which are stuck in the binder bitumen.

4. Heating Equipment.
Apply Article 2001.11.

5. Rollers.
- **a.** Use self propelled, pneumatic tired rollers meeting the requirements of Article 2001.05, C, to embed the cover aggregate.
- **b.** One pneumatic tired roller will be required for work involving sand cover aggregate.
- **c.** A minimum of two pneumatic tired rollers will be required for work involving other cover aggregate.

6. Weighing Equipment.
Apply Article 2001.07.

B. Bituminous Seal Coat Construction.
The rates of application for binder bitumen and cover aggregate shown in the contract documents or specified herein are approximate. These rates may be varied as found desirable on the basis of laboratory or field tests.

1. Surface Preparation.

a. Immediately before bitumen is applied, clean the entire surface to be treated, as well as the adjacent gutters, of all foreign material, including dust.

b. Blade, clean, and perform incidental work required to produce a clean surface. If the power broom fails to remove dust from depressions and pockets, use hand brooms.

c. In rural areas, blade or sweep material removed from the road surface off the road surface. In cities and towns, remove the material according to Article 1104.08. This material becomes the property of the Contractor.

d. Priming, if required, will be specified in the contract documents.

2. Heating Bituminous Materials.

a. Heat bituminous materials to a temperature which will permit uniform spreading. Temperatures between the limits in Table 2307.03-1 should produce the desired viscosity:

Table 2307.03-1: Bituminous Material Temperatures

Designation	Temperature ºF* (ºC)
CRS-1 and 2 and CRS-2P	150-185 (65-85)
MC-800	175-255 (80-125)
MC-3000	215-290 (100-145)
MC-70	145-165 (60-75)
* Some temperatures listed may be above the flash point of the material. Use extreme caution when handling to reduce fire hazard.	

b. Material which has been damaged by overheating will be rejected.

3. Spreading Bituminous Material.

a. General.

1) Before spreading bituminous material, ensure the distributor:

- Complies with recommendations of the manufacturer as to nozzle size, nozzle angle with the axis of the spray bar, and spray bar or nozzle height above the road surface.
- Has been tested to assure uniform bitumen distribution on the road surface at the specified rate.

2) Minimize longitudinal overlap of adjacent bitumen applications. Spread between 95% and 105% of the bituminous material the

Engineer prescribes. Correct the rate of application for temperature to deliver the desired volume at 60°F (16°C).

3) Use a suitable covering to protect the items below from being soiled by bitumen. Leave the protective covering in place until the bitumen has set and no splashing occurs under traffic.
- Curbs and handrails of bridges.
- Guardrails.
- Headwalls of culverts.
- Pavements.
- Curbs and gutters.
- Utility accesses.
- Intakes.
- Water and gas valves.
- Railroad flangeways.
- Other installations requiring protection.

4) Place suitable covering, as required, to prevent cover aggregate from entering intakes or other similar structures during placement and while brooming excess cover aggregate.

5) Preserve the integrity of areas with rumble strip panels. This may include (at the Contractor's option and subject to the Engineer's approval):
- Placing a suitable covering over rumble strip panels which prevents filling with bituminous seal coat, or
- Using hand labor to restore uncovered rumble strip panels.

b. Binder.

1) Sweep the surface clean of loose aggregate and foreign material which may prevent adhesion of the binder to the surface on which it is applied. This applies to fillets at intersecting roads and drives only when specified.

2) Apply binder bitumen to the surface (including fillets at intersecting roads and drives when specified) at the rates and in the manner the Engineer specifies or designates.

3) When traffic must be maintained through the work while construction is in progress and the width is 24 feet (7.2 m) or less, place the bituminous seal coat in two passes. For the first course, spread the bitumen for the first lane approximately 12 inches (0.3 m) wider than one-half of the width of the pavement to be surfaced. For other courses, spread the bitumen for each lane approximately one-half the width of the pavement to be surfaced.

4) Progress in the direction from which aggregate is to be hauled to the spreader. Complete one side for one day's run before the seal coat is applied on the adjacent lane. Auxiliary lanes may be done on the same day. One side may be completed for the full length of a short project before the seal coat is applied to the other side. It is the intention that the maximum length of road with new seal coat on only one side would be limited to approximately 6 miles (10 km). This length may be increased with the Engineer's approval.

5) Limit the length of any spread to that which can be covered with aggregate and rolling completed within 30 minutes. Limit the distance between the bitumen distributor and the aggregate spreader to 150 feet (45 m). Maintain initial roller coverage as close to the aggregate spreader as possible, not to exceed 200 feet (60 m).

6) In any case where emulsion is used, cover the binder bitumen with aggregate and initially roll within 2 minutes after the bitumen has been spread. When the 2 minute requirement for emulsion or the 30 minute requirement for all work is not met, the work may be considered not in reasonably close conformity according to Article 1105.04.

7) Apply bitumen for winter seals with limitations the Engineer deems appropriate. Apply other binder bitumen only when the road surface is free of moisture and has a temperature no less than 60°F (15°C). When the environment places a portion of the pavement in shade, use a shaded area to determine road surface temperature.

c. Joints.

1) Secure binder bitumen distribution at the specified rate of application using paper placed at the start of each distributor run. Use commercial grade building paper that is approved by the Engineer and is no less than 36 inches (0.9 m) wide.

2) When the end of the run joins newly placed seal coat, place paper at that joint also. Cut the joint straight along the off edge of the paper. Remove the seal coat material on the paper adjacent to the off edge from the roadbed surface. Ensure a smooth ride is obtained.

4. Spreading Cover Aggregate.

a. General.

1) Use specified mechanical spreaders to spread cover aggregate on the freshly applied bitumen. Avoid spillage or piling of aggregate. Correct spillage or piling using manual methods before rollers cover the area. Do not use the ballast in rollers for spreading aggregate. Vehicles other than those required to deliver aggregate to the spreader will not be permitted to pass over the treated area of the roadbed until after the aggregate has been spread and rolled.

2) Fillet surfacing at intersecting roads and drives may be placed subsequent to that on the roadbed itself, but shall promptly follow binder bitumen spreading.

b. Moisture.

At the time of spreading, ensure the surfaces of the cover aggregate are damp, but with no free water. This will be determined by visual inspection.

5. Rolling.

a. After the aggregate has been spread, promptly roll to secure early aggregate embedment in the bitumen. Complete rolling no later than 30 minutes after the bitumen is spread.

b. Do not apply succeeding applications of binder bitumen until the most recent one applied as been covered with aggregate and all rolling operations completed.

c. Satisfactory embedment usually will be secured by one roller coverage of sand cover and five roller coverages of other cover aggregate. One roller coverage is interpreted as the number of passes of the roller required to ensure that the entire area has been touched at least once by the entire roller.

d. Operate rollers at a speed of no more than 5 mph (8 km/h).

6. One Course Seal Coats.

In addition to requirements of Articles 2307.03, B, 4 and 5, apply the following:

a. Spreading Binder Bitumen.

Apply bitumen to the prepared base or surface at the rate the Engineer designates, usually within the ranges of Table 2307.03-2:

Table 2307.03-2: Bitumen Spreading Rates

Aggregate Size	Spreading Rate Gal. per Sq. Yds. (L/m^2)	Basic Rate[(a)] Gal. per Sq. Yds. (L/m^2)
Sand	0.15 - 0.20 (0.7 - 0.9)	0.15 (0.8)
3/8 inch (9.5 mm)	0.25 - 0.35 (1.1 - 1.6)	0.30 (1.4)
1/2 inch (12.5 mm)	0.35 - 0.45 (1.6 - 2.0)	0.40 (1.8)
(a) The basic rate will be used for design purposes.		

b. Spreading Cover Aggregates.

1) Uniformly spread cover aggregate of the size specified, over the treated area promptly after the spread of bitumen has been completed on any section.

2) Unless otherwise specified, use a rate of 10 pounds per square yard (5 kg/m^2) for shoulders, 15 pounds per square yard (8 kg/m^2) for winter seals, and 30 pounds per square yard (16 kg/m^2) for other applications.

3) When bituminous seal coat is placed on two lanes, spread the aggregate for the first lane to a width of 50% of the roadway to be treated.

7. Two Course Seal Coats.

In addition to requirements of Articles 2307.03, B, 4 and 5, apply the following:

a. First Course Construction.

1) Spreading Binder Bitumen.

Apply bitumen to the prepared base of surface at the rate of 0.35 gallon per square yard (1.6 L/m^2).

2) Spreading Cover Aggregate.

a) Uniformly spread cover aggregate of the size specified over the treated area at the rate of 30 pounds per square yard (16 kg/m^2) promptly after spreading bitumen on any section.

b) When bituminous seal coat is placed in each lane separately, spread the aggregate for the first lane to a width of 12 inches (0.3 m) greater than 50% of the width of the lane to be surfaced.

c) When the full width is surfaced integrally, spread the aggregate to a width such that the junction of the two aggregate spreads is offset 12 inches (0.3 m) from the center of the full width surface.

b. Second Course Construction.

1) Preparation of Roadbed.

a) After completing the first course, prepare roadbed for the second course by either:

- A vacuum machine, or
- By lightly brooming the full surfaced width with the power broom to remove loose material.

b) After cleaning, roll the entire surface once with the steel roller.

c) Complete the preparation of the roadbed in sections just prior to application of bitumen for the second course.

2) Spreading Binder Bitumen.

Spread bitumen on the prepared surface at the rate of 0.30 gallon per square yard (1.4 L/m^2).

3) Spreading Cover Aggregate.

a) Spread cover aggregate of the size specified over the treated area at the rate of 25 pounds per square yard (14 kg/m^2) promptly after spreading bitumen on any section of roadbed.

b) For two lane roadways, place the two aggregate spreads so the seam between the two spreads is near the centerline.

8. Maintenance During Construction Period.

a. If bleeding occurs during construction, the Engineer may order additional aggregate placed at the contract unit price for cover aggregate. Additional compensation will not be allowed for incidental rolling.

b. On Primary projects and where specified on other projects, gently sweep the surface free of loose cover aggregate using a rotary broom. Perform this sweeping early the next morning while the bituminous binder is hard and stuck particles will not be disturbed. Other means of removing the loose particles, such as vacuum machines or air blast, may be used with the Engineer's approval.

c. In areas with curb and gutter sections or storm sewer intakes, in addition to sweeping the surface, collect loose particles and haul them off the project. The Engineer may also designate that loose particles be hauled off the project in additional areas within municipal corporate limits, such as entrances or shallow drainage ditch locations.

d. The Engineer may require additional sweeping to remove loose cover aggregate from the surface throughout the project duration.

e. When the contract includes an item for asphalt emulsion for dust control, apply the dust control following the removal of loose particles and before other work continues, according to Article 2307.03, B, 9.

9. Dust Control Treatment.

a. On Primary Road projects where limestone or crushed gravel cover aggregate is used, apply diluted asphalt emulsion to the completed bituminous seal coat surface to control dust. Uniformly spread diluted asphalt emulsion at the initial rate of 0.12 gallon per square yard (0.5 L/m^2).

b. On non-Primary Road projects, apply dust control as specified in the contract documents.

c. Apply dust control following the removal of particles and before other work continues. Apply dust control within 24 hours after bituminous seal coat placement unless directed otherwise by the Engineer.

d. Broom off loose material and apply dust control on the calendar day following placement of bituminous seal coat.

10. Traffic Control.

a. When the road is not closed for construction, maintain normal traffic on the project. No detour will be provided. Do not delay traffic unnecessarily. Refer to the contract documents for traffic maintenance during work on shoulders of multilane pavements.

b. Traffic control setups which cause unnecessary stopping or turning movements generally will not be allowed.

c. Unless otherwise stated in the contract documents, furnish the signs and mounting devices, including posts.

d. Furnish and install the signs as follows:

1) "NO PAVEMENT MARKINGS NEXT __ MILES" signs.
Place at each end of the area where pavement markings have been obliterated, on each side of towns, and on each side of all intersections with Primary and Secondary Roads.

2) "LOOSE STONE - REDUCE SPEED" signs.
Place, along with a 35 mph advisory speed plate, approximately 500 feet (150 m) in advance of the "No Pavement Markings" signs.

3) "DO NOT PASS" signs.
Place on the right-hand side of the road at the beginning of each no-passing zone.

4) "PASS WITH CARE" signs.
Place on the right hand side of the road at the end of each no-passing zone.

e. Mount signs on posts.

f. The Contracting Authority will place new pavement markings and remove the signs when the project is complete.

g. Provisions for handling other traffic are as follows:

1) Direct traffic through restricted portions of the project using pilot cars described in Article 2528.03, D. Furnish pilot cars and pilot car signs.

2) Station one flagger immediately ahead of the application of the bitumen, one immediately behind the bitumen, and one immediately behind the section being rolled. Display suitable warning, speed limit, and fresh oil signs. Move the signs forward with the flagger as the work progresses.

3) After the bituminous seal coat has been spread, smoothed, rolled, and cured for a minimum of 2 hours, the road may be open to traffic.

4) In some areas it is more practical to place the bituminous seal coat in short sections and to allow traffic to use the completed bituminous seal coat immediately after the surface treatment has been completed. In these areas, control traffic on the newly placed bituminous seal coat to a speed of no more than 25 mph (40 km/h) for a minimum of 2 hours. The Engineer will specifically authorize such areas. The Engineer may extend the minimum 2 hour period due to low temperature and visually observed damage to the bituminous seal coat under traffic or when turning movements may damage the bituminous seal coat. (The intent of traffic modifications is to not allow traffic on completed bituminous seal coat sections until satisfactorily cured. This requires a minimum of 2 hours, depending on climatic conditions.)

11. Limitations.

a. The Engineer may prohibit construction if the weather is unfavorable for the embedment of cover aggregate in the binder bitumen as specified in Article 2307.03, B, 3.

b. Limit the area on which binder is spread to that which can be covered with aggregate, and the rolling completed, within daylight hours of the same working day. When traffic is being carried through the work, keep the entire roadbed free of construction equipment, according to Article 1107.08.

c. Except for winter seals, do not apply seal coats after September 1 on Primary projects or after September 15 on other projects. When the entire project cannot be completed by the specified cutoff date, do not complete placement on one side only for the full length of the project. Instead, complete both sides to the same location by the specified cutoff date.

d. When this contract includes pavement marking, complete traffic line construction within 72 hours after the seal coat has been completed to the full width at that location, weather permitting.

e. When dust control treatment is required, allow it to cure prior to allowing traffic on the roadway.

12. Surfacing Intersecting Roads, Driveways, and Turnouts.

a. Use seal coat applied at the same rate provided for the roadway to cover the area of any fillets of base courses constructed at driveways to farmsteads and commercial establishments, unless otherwise specified in the contract documents.

b. Surface remaining areas within the right-of-way on earth or gravel surfaced approach roads and driveways and turnouts for mail

boxes according to Section 2315. These areas will be measured and paid for according to Section 2315.

C. Finishing and Opening to Traffic.
Restore to an acceptable condition any portion of the roadway disturbed by operations related to bituminous seal coating. After the bituminous seal coat has been spread, smoothed, rolled, and cured as specified in Article 2307.03, B, the road may be opened to traffic.

2307.04 METHOD OF MEASUREMENT.

Unless otherwise provided, winter seal will not be measured for payment. Measurement for the quantities of the various classes of other work involved in bituminous seal coat, satisfactorily constructed, will be as follows:

A. Aggregate.
Tons (megagrams), except as provided in this specification, from the net weight (mass) of individual loads weighed on scales furnished by the Contractor, according to Article 2001.07. Includes fillets at intersecting roads, drives, and turnouts. At locations where the quantity of aggregate required for a single section of road is less than 300 tons (300 Mg), volume measurement will be permitted.

B. Binder Bitumen.
Gallons (liters) computed from field measurements of distributors or from tank cars or transport trucks as provided in Article 4100.03. Includes bitumen for fillets at intersecting roads, drives, and turnouts. When quantities computed from field measurements check within 1.0% of the billed gallons (liters), payment will be based on billed gallons (liters). When quantities computed from field measurements differ from billed gallons (liters) by more than 1.0%, payment will be based on the quantity from field measurements. From these quantities, any amount used by the Contractor as fuel, left in cars, or otherwise not delivered to the road surface will be deducted. The Engineer will advise the Contractor promptly, in writing, of the quantities deducted.

C. Driveway Surfacing Material.
Computed as and provided in Section 2315, for granular surfacing placed at intersecting roads, drives, and turnouts. Excavation required for placing this surfacing is considered incidental to the work and will not be measured for payment.

D. Asphalt Emulsion for Dust Control.
Undiluted asphalt emulsion measured as provided in Article 2307.04, B.

E. Traffic Control.
Article 2528.04 applies.

2307.05 BASIS OF PAYMENT.

For the various items of work involved in bituminous seal coat, measured as provided above, payment will be the contract unit price as described below. Payment for additional rolling the Engineer requires will be according to Article 1109.03, B.

A. Aggregate.

1. Per ton for the number of tons (megagrams) of roadway cover aggregate placed in accepted portions of the work.

2. Payment for roadway cover aggregate is full compensation for furnishing, delivering, and spreading the aggregate, for all brooming, rolling, final cleanup, and incidental work necessary to complete the project and not paid for as other items.

B. Binder Bitumen.
Per gallon (liter) for the quantity of binder bitumen spread on accepted portions of the road and the quantity used in making trial runs for adjustment of distributors.

C. Driveway Surfacing Material.
As provided in Section 2315 for the quantity of granular surfacing placed at intersecting roads, drives, and turnouts.

D. Asphalt Emulsion for Dust Control.

1. Per gallon (liter) for the number of gallons (liters) placed.

2. Payment is full compensation for sweeping, furnishing, mixing with water and applying the asphalt emulsion, and curing of the dust control material.

E. Traffic Control.
Article 2528.05 applies.

Section 2308. Bituminous Fog Seal (Shoulders)

2308.01 DESCRIPTION.
Apply diluted asphalt emulsion to the shoulder surface using a bituminous distributor.

2308.02 MATERIALS.
Use asphalt emulsion grade CSS-1 or SS-1 meeting the requirements of Section 4140, unless directed otherwise by the Engineer.

2308.03 CONSTRUCTION.

A. Equipment.
Meet the requirements of Section 2001.

B. Cleaning.
Immediately prior to placing the emulsion fog seal, clean the shoulder surface of foreign material.

C. Dilution.
Dilute the asphalt emulsion with water prior to application to the shoulders. The dilution rate is one part of asphalt emulsion to two parts of water. The Engineer will require documentation that the dilution is done properly.

D. Application.

1. Uniformly apply the diluted asphalt emulsion at the rate of 0.20 gallon per square yard (0.9 L/m^2) of shoulder surface. The application rate may be reduced as directed by the Engineer.

2. Use safety and convenience to the public without soiling their vehicles as a controlling factor.

3. Apply diluted asphalt emulsion so the entire shoulder surface is covered in one application.

4. Do not apply asphalt emulsion to bridge decks, PCC gore areas, or adjacent paved surfaces and painted edge lines. Replace edge lines obliterated by this operation at no additional cost to the Contracting Authority.

E. Limitations.

1. Do not apply asphalt emulsion on damp or wet surfaces without the Engineer's approval. Work will not be allowed on Sundays or holidays, according to Article 1108.03.

2. Apply asphalt emulsion during weather conditions which allow satisfactory application. Do not apply asphalt emulsion when either the pavement temperature or air temperature is below 60°F (16°C). Do not apply asphalt emulsion after August 31 without the Engineer's permission.

3. A sand dam or other approved means may be necessary to prevent emulsion from running on the pavement in areas of superelevated curves.

F. General.
The asphalt emulsion as applied shall have an appearance satisfactory to the Engineer. Dilution rate and application rate may need to be adjusted to accomplish desired results.

G. Traffic Control.
Place traffic control according to Article 1107.09 and the appropriate traffic control detail.

2308.04 METHOD OF MEASUREMENT.
Measurement for the items involved in construction of Bituminous Fog Seal (Shoulders) will be as follows:

A. Asphalt Emulsion for Fog Seal (Shoulders).
As provided in Article 2307.04, B, for undiluted Asphalt Emulsion for Fog Seal (Shoulders).

B. Sand.
Not be measured for payment.

C. Traffic Control.
Lump sum for the contract.

2308.05 BASIS OF PAYMENT.
Payment will be for the contract unit price as follows for the quantity of items involved in construction of Bituminous Fog Seal (Shoulders):

A. Asphalt Emulsion for Fog Seal.

1. Per gallon (liter) for undiluted Asphalt Emulsion for Fog Seal (Shoulders) that is mixed and used on the project. Diluted asphalt emulsion that is delivered to the job site, but not applied to the roadway surface will not be considered for payment.

2. Payment is full compensation for:
- **a.** Cleaning the shoulder surface.
- **b.** Furnishing and applying the diluted asphalt emulsion.
- **c.** Mixing water.
- **d.** Furnishing and applying sand cover.
- **e.** Protecting the adjacent pavement and edge lines, including special protection and dams in areas of superelevated curves.

B. Traffic Control.

1. Lump sum.

2. Payment is full compensation for furnishing signs, barricades, flaggers, and other traffic control devices required for this work.

Section 2309. Surface Recycling by Heater Scarification

2309.01 DESCRIPTION.

A. Recycle the existing asphalt pavement surface by heater scarification, and resurface with HMA.

B. Heater scarification and resurfacing is part of a multi-step process of asphalt surface rehabilitation. This rehabilitation consists of:

1. Preparing the existing asphalt surface,

2. Softening the surface with heat,

3. Scarifying the surface, and

4. Thoroughly stirring or tumbling and leveling the mixture in preparation for an asphalt surface course overlay.

C. The work includes furnishing and placing the new surface course.

2309.02 MATERIALS.
Use surface course materials that meet the requirements for the type of mixture specified.

2309.03 CONSTRUCTION.

A. Equipment.

1. Heater Scarifier.

a. Use a heater scarification operation consisting of preheater and heater scarification unit, capable of processing at a rate of at least 1500 square yards per hour (1250 m^2/h) over a minimum one lane width of 12 feet (3.6 m).

b. Use an equipment type for preheating, heating, and scarifying that has either:

- Operated successfully on similar work for the Contracting Authority, or
- Has proven through test results or other previous experience, or both, that it is satisfactory to the Engineer.

c. Equipment test results and other previous experience may be submitted to the Engineer prior to the letting for review.

d. Use preheating and heater scarification equipment designed for the purpose of pavement heating and capable of producing at least 10 million BTUs per hour (10 GJ/h). Apply heat under an enclosure or shielded hood.

e. Accomplish scarifying with pressure loaded rakes or scarifiers. Where scarifying to an existing curb and gutter line is required, equip the scarifying unit to scarify, and move away from gutter aprons, a 1/2 inch (13 mm) by 4 foot (1.2 m) path of existing material. Use a scarifier that will ensure continuous and undiminished pavement contact without damaging utility accesses and valve boxes.

f. Use a leveling unit capable of:

- Distributing the heated and scarified material over the width being processed to produce a uniform cross section, and
- Windrowing excess material to one side for removal when necessary.

2. Hot Mix Asphalt Construction Equipment.
For batching, mixing, hauling, placing, and compacting the surface course, use equipment meeting the requirements for the type of mixture specified.

B. Paving Plant Operation.
Meet the requirements for the type of mixture specified.

C. Construction.

1. Surface Preparation.

a. Complete base repair, if required, according to Section 2212. Locations of full depth patches will be designated by the Engineer.

b. Prepare the surface to be heater scarified by cleaning trash, debris, earth, or other deleterious substances present in sufficient quantity to interfere with the work.

2. Heating and Scarifying.

a. Evenly heat and scarify the pavement surface (as a continuously moving operation) for the full width designated in the contract documents. Ensure this combination will not char or otherwise damage the existing pavement material through exposure to heat or fire. Rate of delivery of the overlay mixture may limit the processing rate.

b. Control the heating operation to prevent open flame from exiting from under the heater. The Engineer may require that the operation be stopped when:

- The prevailing wind velocity exceeds approximately 10 mph (16 km/h) and a potential hazard exists, or
- Heating and scarifying are not possible.

c. Scarify to a minimum depth of:

1) 3/4 inch (20 mm) at the highest points, such as the edge and the high point between the wheel paths.

2) 1/2 inch (15 mm) at the lowest points, such as the wheel paths.

d. The required depth of scarification may be changed by the contract documents. Scarify to at least the depth specified with pressure loaded scarifiers that plow through the pavement and loosen it without fracturing or segregating the aggregates.

e. Ensure the surface temperature of the old pavement is below 475°F (245°C) during heating. Ensure the heated material has a temperature in a range between 220°F to 260°F (105°C to 125°C), measured immediately behind the heater scarifier. Uniformly and evenly heat the remixed layer throughout. Uncontrolled heating, causing differential softening of the upper surface, will not be permitted. Extend the heating operation at least 4 inches (100 mm) beyond the width of the scarification on both sides.

f. When a heater scarifier pass is being made adjacent to a previously placed mat, remove all damaged material and replace.

3. Leveling.

a. Following the heater scarification, level the surface to provide a uniform cross slope.

b. Use a method that consists of either of the options below, following the scarifier as closely as possible, to redistribute and level the scarified material:

- An approved system of augers with a strike off plate or screed which is an integral part of the scarifying machine, or
- An asphalt paving machine meeting the requirements of Article 2001.19.

4. Hot Mix Asphalt Surface Course Overlay.

a. After reshaping the scarified mix and before the temperature drops below 170°F (77°C), place a uniform layer of new surface course material at the rate shown in the contract documents. The Engineer may direct additional mixture to be added to correct irregularities.

b. Use equipment that meets the requirements of Article 2001.19 for placing and finishing the new surface. A non self propelled paving machine attached to the heater scarifier may be used provided the screeding unit complies with the requirements of that specification.

c. When a self propelled paving machine is used, place the new surface within 400 feet (120 m) of the scarification operation or before the surface temperature cools to 170 ºF (77 ºC), whichever occurs first.

d. Provide for alignment and control of the scarification operation. Obtain the Engineer's approval for the method used.

D. Compaction of Mixture.

After the new surface course is spread, promptly and thoroughly compact all the mixture according to Article 2303.03, C, 5, c.

E. Joints.

Construct joints according to the requirements of Article 2303.03, C, 6, and as shown in the contract documents.

F. Finished Surface.

1. Ensure the finished pavement elevations comply with the requirements of the contract documents, and the finished cross slope is a plane surface with a slope as shown.

2. Ensure all edges, radii, and handwork have a neat and finished appearance.

G. Safety Procedures.

1. Prior to construction in cities, towns, or built up areas; contact the fire chief to solicit a recommended safety procedure to be followed. Follow these recommendations. In addition to any other recommendations, follow the procedure below:

a. Ensure owners of underground utilities in the areas have checked the areas for possible gas leaks in or around their lines.

b. Ensure the city has checked storm sewers and sanitary sewers in the area for accumulations of sewer gas.

c. Ensure service stations and other businesses handling flammable fuels have been advised not to dispense these fuels while the heater burner is being operated within 100 feet (30 m) of their business places.

d. Plan the operation so as to be as safe as possible for persons and property adjacent to the work, including the traveling public. Keep this route open to traffic. Limit the operation so as to provide for this

traffic. Work may need to be conducted during periods of light traffic.

2. Take such additional precautions as is reasonable for the safety of the operation.

3. The Contractor shall hold the Contracting Authority and the State harmless for any damage or loss resulting from an accident, during the heating operation, caused by failure to fulfill the obligations as outlined in these requirements.

H. Limitations.
Apply Article 2303.03, C, 4.

2309.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Surface Recycling by Heater Scarification.
Computed as provided in Article 2303.04, A, 3, for the areas satisfactorily prepared, heated, scarified, leveled, and resurfaced (new mix excluded).

B. Hot Mix Asphalt Mixture.
As provided in Article 2303.04 for the type specified.

2309.05 BASIS OF PAYMENT.
Payment will be as follows:

A. Surface Recycling by Heater Scarification.

1. Contract unit price for the square yards (square meters) measured as provided above.

2. Payment is full compensation for furnishing labor and materials for surface recycling by heater scarification as described above.

B. Hot Mix Asphalt Mixture.
As provided in Article 2303.05 for the type specified.

Section 2310. Portland Cement Concrete Overlay

2310.01 DESCRIPTION.
Overlay an existing pavement with one of the following types of PCC overlay:

A. Bonded overlay: a PCC overlay over an existing PCC pavement.

B. Unbonded overlay: a PCC overlay over an existing pavement where a stress relief layer is placed on top of the existing PCC pavement or an existing PCC pavement that has been overlaid with HMA (composite pavement).

C. Whitetopping: a PCC overlay over an existing, full depth asphalt pavement.

2310.02 MATERIALS.

A. Concrete.
Meet the requirements of Article 2301.02.

1. Use Class C concrete for PCC Overlays as specified in Materials I.M. 529, except use a C-3WR or C-4WR mix design for Bonded Overlays. Allowable substitutions shall comply with Article 2301.02, B.

2. For coarse aggregate, meet the requirements of Section 4109.02, Aggregate Gradation Table, Gradation No. 3 or 5 of the Appendix. Ensure the nominal maximum coarse aggregate size is no greater than one-third the overlay thickness.

3. Unless otherwise specified, use coarse aggregate for bonded overlays that is the same type of aggregate as the existing pavement.

B. Hot Mix Asphalt Stress Relief Course.

1. Use an HMA stress relief course for unbonded overlays consisting of a nominal 1 inch (25 mm) course of HMA meeting the requirements of Section 2303.

2. Use PG 58-28 asphalt binder.

3. Use a mixture meeting the following:
- **a.** 300,000 ESAL, 3/8 inch (9.5 mm) HMA mix requirements.
- **b.** Target air voids of 3.0%.
- **c.** No maximum film thickness restriction and no minimum filler/bitumen ratio restriction.
- **d.** Type B Aggregate with no percent crushed particle requirements and gradation falling below the restricted zone.

2310.03 CONSTRUCTION.

Apply the requirements of Section 2301 to this work with the modifications for each type of work identified below.

A. Scarifying or Shotblasting Equipment.
Use power operated equipment capable of uniformly scarifying or removing the existing surface in a satisfactory manner and to depths required. Other types of removal devices may be used if their operation is suitable and if they can be demonstrated to the satisfaction of the Engineer. The contract documents will include a pay item for such work.

B. Preparation of Surface.

1. General.
- **a.** If full depth base repair is included in the project, complete it prior to preparation of the existing pavement surface.

b. When required, include the entire area to be resurfaced in preparation of the existing pavement surface. Materials removed in the preparation operation may be placed in the shoulder area unless specified otherwise in the contract documents.

2. Bonded Overlays.

a. Prepare the surface by shot blasting, or scarifying. Scarify to a nominal depth of 1/4 inch (5 mm).

b. Ensure preparation removes all dirt, oil, foreign materials, laitance, or loose material from the surface and edges against which new concrete will be placed.

3. Unbonded Overlays and Whitetopping.

a. Prepare surface by scarifying per Section 2214.

b. When placement of HMA stress relief layer is included as part of the contract for unbonded overlays, pavement scarification will not be required.

c. At the direction of the Engineer, trim high spots found in the existing HMA pavement. This work will be accomplished during the scarification operation, only at isolated locations, and will be considered incidental to the pavement scarification.

d. Work covered by Article 2310.03, B, 3, will be paid for according to Article 2310.05, D, Pavement Scarification.

C. Placing and Finishing Overlay.

1. General.

a. Apply Section 2317 to all PCC Pavement bid items of a Primary project if any individual PCC Pavement bid item for that project is 5000 square yards (4200 m^2) or greater. Apply Section 2316 to all other Primary projects and when specifically required for other projects.

b. Control the placing equipment to the proper elevation by string line. Take cross sections and establish a grade line. The Engineer will review and approve the new grade lines. Information detailing the pavement design thicknesses at the various survey points and material quantities will also be provided. During construction, do not alter these grades solely to account for concrete overruns. Some overrun is normal, and only with the Engineer's approval will they be adjusted.

2. Bonded Overlays.

a. Surface Cleaning.
Clean the entire surface with an air blast prior to placing concrete. After cleaning, no traffic will be permitted on the cleaned surface except that necessary for overlay construction.

b. Surface Condition.
Ensure the prepared surface is dry in order to allow some absorption of the concrete mortar.

c. Joints.

1) Use a reliable method to exactly locate and identify on both sides of the road:

a) Each contraction and expansion joint in the existing pavement.

b) The joint to be sawed at each full depth patch.

2) Saw joints in the resurfacing directly over existing joints. Saw joints to the full depth of new resurfacing concrete, including depressions created in the existing surface and as specified in the widening areas. Saw joints as soon as possible without causing excessive raveling.

3. Unbonded Overlays.

a. Hot Mix Asphalt Stress Relief Course.

Construct in accordance with Article 2303.03. Use Class II Compaction, except use only static steel wheeled rollers. Article 2303.04 shall also apply.

b. Surface Cleaning.

Clean the existing surface of all loose or adhering foreign material prior to placement of the PCC over HMA pavement. Normally this will be accomplished with a power broom. Make this broom available during paving operations to clean any loose material that the construction equipment may track onto the surface.

c. Surface Condition.

Ensure the prepared surface is dry when concrete is placed on the surface of the HMA pavement in order to allow some absorption of the concrete mortar. If the surface of the HMA is above 110ºF (40ºC), the Contractor may apply water to the surface of the HMA ahead of the paving operation in order to cool the surface. Apply water far enough in advance of the paving operation so that the surface will dry from evaporation before concrete is placed. Do not apply water to the surface of the pavement when the HMA surface temperature is below 100ºF (38ºC).

d. Joints.

When jointing is specified in which panels are smaller than a normal lane width, construct the joints to be 1/8 inch (3 mm) wide. No cleaning or sealing is required.

4. Whitetopping.

a. Surface Cleaning.

Clean existing surface of loose or adhering foreign material prior to placement of the PCC over HMA pavement. Normally this will be accomplished with a power broom. Make this broom available during paving operations to clean any loose material that the construction equipment may track onto the surface.

b. Surface Condition.

Ensure the prepared surface is dry when concrete is placed on the surface of the HMA pavement in order to allow some absorption of the concrete mortar. If the surface of the HMA is above 110ºF (40ºC), the Contractor may apply water to the surface of the HMA ahead of the paving operation in order to cool the surface. Apply

water far enough in advance of the paving operation so that the surface will dry from evaporation before concrete is placed. Do not apply water to the surface of the pavement when the HMA surface temperature is below 100ºF (38ºC).

c. Joints.
When jointing is specified in which panels are smaller than a normal lane width, construct joints 1/8 inch (3 mm) wide. No cleaning or sealing is required.

D. Limitation of Operations.

1. At forecasted air temperatures below 55°F (13°C) use the maturity method to determine the opening time. Do not place resurfacing concrete when the air or pavement temperature is below 40°F (4°C).

2. The Contractor may use the shoulders for construction activities. It will be the Contractor's responsibility to repair the shoulders, as the Engineer deems necessary, to restore the shoulders to a condition acceptable for shoulder work. This work shall be done at no additional cost to the Contracting Authority. The Contractor may elect to limit the use and vehicle loadings to minimize this work and its cost.

3. Place bonded concrete overlays between June 1 and September 30.

4. Do not place unbonded overlay or whitetopping materials on HMA when the pavement surface temperature exceeds 120° F (50°C).

2310.04 METHOD OF MEASUREMENT.

Measurement for the various items of work involved in the construction of PCC overlay will be as follows:

A. Portland Cement Concrete Overlay, Furnish Only.
Cubic yards (cubic meters) using a count of batches incorporated. Includes concrete placed in widening sections and partial depth patches.

B. Portland Cement Concrete Overlay, Placement Only.
Square yards (square meters) shown in the contract documents. Area will be determined from the longitudinal surface and the nominal pavement width, including widening sections.

C. Surface Preparation.
Square yards (square meters) shown in the contract documents. Area will be determined from the longitudinal surface and the nominal width of existing pavement.

D. Pavement Scarification

1. Measurement by Weight (Mass).
The quantity of Pavement Scarification will be determined in accordance with Article 2214.06, A, 1.

2. Measurement by Area.
The quantity of Pavement Scarification will be determined in accordance with Article 2214.06, A, 2.

E. Hot Mix Asphalt Stress Relief Course.

1. Measurement by Weight (Mass).
a. HMA will be measured according to Article 2303.04, A.
b. Asphalt binder will be measured according to Article 2303.04, B.

2. Measurement by Area.
a. HMA will be measured according to Article 2303,04, A, 2.
b. Asphalt binder used will not be measured separately for payment.

2310.05 BASIS OF PAYMENT.

Payment will be at the contract unit price as follows for the performance of acceptable work, measured as provided above.

A. Portland Cement Concrete Overlay, Furnish Only.

1. Per cubic yard (cubic meters).

2. Payment is full compensation for furnishing raw materials, proportioning, mixing, and delivery of concrete to the paving machine.

B. Portland Cement Concrete Overlay, Placement Only.

1. Per square yard (square meter).

2. Payment is full compensation for:
a. Furnishing all materials, labor, and equipment necessary to place, finish, texture, and cure the concrete.
b. Placement of tie bars for widening, if required.
c. Sawing, cleaning, and sealing the joints, if required.
d. Surface cleaning.

C. Surface Preparation.

1. Per square yard (square meter).

2. Payment is full compensation for preparation of the existing pavement, scarifying or shot blasting, and for removal of the existing pavement surface material according to Article 1104.08.

D. Pavement Scarification

1. Measurement by Weight (Mass).
The Contractor will be paid the contract unit price for Pavement Scarification in accordance with Article 2214.07, A, 1.

2. Measurement by Area.
The Contractor will be paid the contract unit price for Pavement Scarification in accordance with Article 2214.07, A, 2.

E. Hot Mix Asphalt Stress Relief Course.

1. Measurement by Weight (Mass).
- **a.** Article 2303.05 applies.
- **b.** Payment is full compensation for furnishing and placing the HMA stress relief course.
- **c.** Asphalt binder will be paid for separately according to Article 2303.05, B.

2. Measurement by Area.
- **a.** Article 2303.05 applies.
- **b.** Payment is full compensation for furnishing and placing the HMA stress relief course, including the cost of the asphalt binder.

Section 2312. Granular Surfacing

2312.01 DESCRIPTION.

A. Deliver granular material, consisting of crushed stone or pit run or screened gravel, along the shoulder of an existing road in the quantity specified in the contract.

B. Apply this specification to new construction or to resurfacing of a previously surfaced road.

2312.02 MATERIALS.
Use material that either meets requirements of Section 4120 for the class of material specified, or is pit run material from designated locations.

2312.03 CONSTRUCTION.

A. General.

1. Unless otherwise specified, furnish granular material to be spread by the Contracting Authority and consolidated under traffic. The Contracting Authority may furnish granular material from designated pits.

2. Spread all material furnished as Granular Surfacing on Road and intended as:
- **a.** Temporary surfacing.
- **b.** Temporary winter surfacing.
- **c.** Temporary surfacing of drives and side roads.
- **d.** Surfacing for local access.

3. Blading and shaping, as well as any other work in preparation for or maintaining a suitable surface will be required. This may include some excavation adjacent to paved surfaces. Place material used for local access at the locations the Engineer designates. The intention is to provide continuous, all weather access as needed and as directed by the Engineer. Payment for this work is incidental to the payment for the item of Granular Surfacing on Road. The Contractor is not responsible for continuing this work when the operation is suspended during the winter.

4. Special Winter Granular Surfacing is intended to be the same type of material furnished for Granular Surfacing on Road. The material is to be placed in a stockpile prior to winter suspension in an amount and at a location within the project limits as designated by the Engineer. With reasonable notice, the Engineer may require additional material to be added to the stockpile while the Contractor's operation is suspended during the winter.

B. Contract Schedule.

1. A contract may involve any of the following:
- **a.** Furnishing and delivering surfacing material to the road.
- **b.** Preparing and delivering material to the road furnished by the Contracting Authority at locations specified in the contract documents.
- **c.** Preparing material furnished by the Contracting Authority at locations specified in the contract documents. If hauling is required, it shall be bid in 1 mile (1 km) units of haul.

2. Prepare material the Contracting Authority furnishes by:
- Removing the material from the deposit, and
- Sorting, crushing, screening, and washing (as may be necessary) to produce finished material which will comply with the specifications for the class of material required by the contract documents.

3. Delivering or hauling includes loading, transporting, and depositing the prepared material.

4. In gravel furnished by the Contracting Authority, crush particles 7 inches (175 mm) or less in diameter to pass a 3/4 inch (19 mm) sieve. The Contractor may remove particles greater than 7 inches (175 mm) in diameter or crush them to pass a 3/4 inch (19 mm) sieve.

5. When the Contracting Authority furnishes material in deposits, furnish right-of-way necessary for a suitable road from the deposit to a public highway. The Contractor assumes responsibility for any construction or maintenance work that may be required on the road from the deposit to the public highway.

C. Equipment.

Use equipment meeting the requirements of Section 2001 and the following:

1. Weighing Equipment.
Apply Article 2001.07.

2. Spreading.
Apply Article 2001.13.

D. Preparation of Subgrade.
Unless otherwise specified, the Contracting Authority will shape the subgrade. The subgrade will be shaped to a smooth surface having proper grade and cross section.

E. Stripping and Removal of Unsuitable Material.

1. Remove materials not permitted in the surfacing material from the materials the Contracting Authority furnishes. Removal includes removing and transporting material:
- Which occurs intermingled with satisfactory surfacing material, and
- Which is removed from the surfacing material in the process of preparation.

2. Stripping includes removal and disposition of material:
- Not permitted in the prepared surfacing material, and
- Occurs in the material deposited in continuous layers 6 inches (150 mm) or more in thickness overlying, or included between layers of, satisfactory surfacing material.

3. When stripping overburden from material taken from pits controlled by or through the Contracting Authority (whether stripping is included as a pay item or not), conduct the operation as directed by the Engineer. Construct slopes so that when the excavation is complete the slopes will maintain themselves without caving or sloughing. Leave material removed for surfacing, below the stripped area, with slopes that provide stability to the overburden.

4. When stripping deposits, do not produce an unsightly appearance of the land. Remove stripped material and transport as directed by the Engineer.

F. Combining Materials on Road.
Under normal conditions, material delivered to the road will be a finished mixture meeting requirements for the class of material specified in the contract documents. With approval of the Engineer, pit run gravel which does not comply with the specified gradation may be furnished and combined on the road with coarser gravel or crushed stone to produce a mixture which complies with the specified gradation. Deliver these combinations according to the following provisions:

1. Measurement.
Whether the contract unit of measurement is 1 ton (1 Mg) or 1 cubic yard (1 m^3), weigh both materials. If the unit of measurement is 1 cubic

yard (1 m^3), the Engineer will determine the weight (mass) per unit volume of the mixture as follows:

a. Representative samples of the two materials are to be thoroughly mixed in the proportions in which they are to be delivered to the work.

b. The weight (mass) per unit volume of the mixture shall be determined by the rodding procedure and by the shoveling procedure described in AASHTO T 19M.

c. The average of the two values thus determined shall be taken as the weight (mass) per unit volume of the mixture. Use this value when converting the total weight (mass) of material delivered to cubic yards (cubic meters).

2. Quality.

a. Use materials from each separate source meeting the requirements of Section 4120 for the kind of material used, except the gradation.

b. In addition to the gradation specified, blend the final mixture to be well graded from coarse to fine.

c. Ensure the percent passing the No. 30 (600 µm) sieve is no more than 2/3 the percent passing the No. 8 (2.36 mm) sieve.

3. Proportioning.

a. From tests of representative samples of the two materials, the Engineer will compute the quantity of each material required to produce a mixture within the specified gradation. Neither material shall be less than 10% of the total quantity.

b. Deliver the materials in the proportions established.

4. Delivery.

Deliver each material into a separate windrow. Make each windrow uniform using a motor grader or windrow equalizer.

5. Mixing.

a. Mix the windrows by blading one windrow against the other and blading the single windrow formed across the roadbed at least once.

b. Coordinate delivery and mixing of materials so there will not be more than 2 miles (3 km) of roadway in a partially completed state.

c. Leave mixed material in a windrow near one shoulder of the road, as directed by the Engineer.

2312.04 METHOD OF MEASUREMENT.

The Engineer will determine the work involved for granular surfacing as follows:

A. Granular Surfacing on Road.

1. The quantity of granular surfacing of the class specified, delivered on the road, in cubic yards (cubic meters) or in tons (megagrams), will be measured as indicated in the contract documents.

2. Measurement may be converted from tons to cubic yards (megagrams to cubic meters) or cubic yards to tons (cubic meters to megagrams) with the Engineer's approval. The Engineer will determine the conversion factor.

3. When measurement is the cubic yard (cubic meter), level all loads and fill corners at the loading point. Measurement will be checked at the point of delivery. Deductions will not be made for natural settlement in transit. The tops of end gates on transporting vehicles are not to be lower than the adjacent sides.

4. Weight (mass) measurements are to be on Contractor's weighing equipment, according to Article 2001.07. Load vehicles to prevent loss of material between the scales and the point of delivery. Deduction will not be made for the weight (mass) of moisture naturally occurring in the material. When the unit of measurement is cubic yards (cubic meters) and these materials are mixed on the road surface, the Engineer will compute the number of cubic yards (cubic meters) to be paid for as outlined in Article 2312.03, F, 1.

B. Preparing and Hauling Granular Surfacing Material Furnished by the Contracting Authority.

1. Determined according to Article 2312.04, A.

2. When the contract provides compensation to the Contractor on the basis of 1 mile (1 km) haul units in addition to the contract price for preparation, the haul will be measured over the shortest practical route from point of loading to point of delivery. Beginning at the loading point, each mile (kilometer) section will be numbered consecutively toward the point of delivery.

3. The number of additional mile (kilometer) units of haul will be computed by multiplying the number of units of material (cubic yards or tons (cubic meters or megagrams)) delivered in each mile (kilometer) section by the number of that section and adding the products thus obtained.

C. Stripping (Overburden).

1. Will not be measured for payment unless the contract involves a unit price for stripping. Stripping, to be paid for as a separate item, will be measured by cross sectioning before and after excavation. The volumes will be computed by the average-end-area method.

2. Payment will not be made for material excavated prior to cross sectioning by the Engineer.

3. When removal and transportation of stripping involves a haul of more than 1000 feet (300 m), overhaul will be computed and paid according to Section 2108.

2312.05 BASIS OF PAYMENT.
Payment for the quantities of various items of work, as measured above, will be at the contract unit price as described below. Payments are full compensation for furnishing all tools, equipment, and labor and for performance of work necessary to complete the contract in conformance with the contract documents.

A. Granular Surfacing on Road.

1. Per cubic yard or ton (cubic meter or megagram), as specified in the contract for furnishing and delivering granular surfacing material on the road.

2. Payment is full compensation for furnishing, preparing, handling, transporting, and depositing the material on the road according to the contract documents.

B. Preparing and Hauling Granular Surfacing Material Furnished by the Contracting Authority.

1. Per cubic yard or ton (cubic meter or megagram) for preparing and hauling material furnished at locations by the Contracting Authority.

2. Payment is full compensation for removing, sorting, crushing, screening, washing, and transporting the material according to the contract and these specifications. The number of additional 1 mile (1 km) haul units, computed as specified above, will be paid for at the contract unit price.

C. Stripping (Overburden).

1. No payment. Incidental to the contract unit price for preparing and hauling the material.

2. If the contract provides a separate contract unit price for stripping, payment will be for the cubic yards (cubic meters) of excavation and the number of station-yards (cubic meters per metric station) of overhaul, computed as specified above.

D. Removal and Transportation.
Removal and transportation of materials which are not permitted in surfacing material will not be paid for as a separate item. This material shall be included in the payment for preparing and hauling the material.

Section 2314. Surface Application of Calcium Chloride

2314.01 DESCRIPTION.
Furnish and apply calcium chloride, with or without water furnished by the Contractor, as provided in the contract documents and according to the following provisions.

2314.02 MATERIALS.
Meet the following requirements:

A. Water.
Use water clear and free of suspended matter.

B. Calcium Chloride.
Unless otherwise provided in the contract documents, the Contractor has the option of providing calcium chloride in any of the forms meeting the requirements of Article 4194.01.

2314.03 CONSTRUCTION.

A. Equipment.
Meet the requirements of Section 2001 and the following:

1. Equipment for Applying Water or Calcium Chloride Solution.
Apply Article 2001.09.

2. Equipment for Applying Calcium Chloride in Solid Form.
Use equipment capable of calibration and control such that the quantity of calcium chloride applied in any 25 foot (10 m) length of road does not vary more than 10% from the intended quantity of material in that unit of length.

3. Belt or Spiral Flight Conveyors.
So the rate of delivery may be accurately calibrated, provide a conveniently located revolution counter for belt or spiral flight conveyors used to handle bulk shipments of solid form calcium chloride to be applied in solution.

4. Weighing Equipment.
Apply Article 2001.07.

B. Application.

1. Calcium chloride may be applied to the road surface:
- As a liquid,
- In a solid form with the water applied separately, or
- In a solid form made into a solution and applied to the road surface.

2. Do not apply calcium chloride during rain or when, in the opinion of the Engineer, the weather is unsuitable for the application.

3. Unless otherwise provided in the contract documents, when calcium chloride is to be applied to the road in the solid form, first uniformly apply water to the center portion of the roadbed at a rate sufficient to produce the desired condition of moisture on the road surface to be treated. This will require an anticipated 10,000 gallons of water per mile (23.5 kL/km) of road. This rate may be increased or decreased in increments of 1000 gallons per mile (1 kL/km) at the Engineer's direction.

4. Unless otherwise provided in the contract documents, spread the solid form at a rate which will deliver to the road surface 1 pound (0.5 kg) of calcium chloride per square yard (square meter), computed on the anhydrous basis. When calcium chloride is applied in solid form, spread it uniformly over the road within 1 hour after application of water to that section. Ensure the total quantity of calcium chloride applied on each mile (kilometer) of road is within 5% of the specified quantity.

5. When calcium chloride is applied in solution, thoroughly mix water and calcium chloride into a uniform solution completely dissolving any solid material before the solution is spread on the road. Control the concentration of the solution and the rate of distribution of the solution on the road surface to deliver to the road surface the quantity of calcium chloride specified above.

6. Unless results of laboratory analysis of samples of material actually used are available, the rate of distribution may be computed on the percentages in Table 2314.03-1 for the respective material:

Table 2314.03-1: Assumed % Calcium Chloride

Material	Assumed % Calcium Chloride by Weight (Mass) (Anhydrous Basis)
Regular Flakes	77.0%
Conc. Flakes, Pellets, or other gran. form	94.0%
Calcium Chloride Liquor	32.0 %[(a)]
(a) Total Calcium Chloride. The percentage may be modified with the Engineer's approval.	

2314.04 METHOD OF MEASUREMENT.

Measurement for the work involved in surface application of calcium chloride will be as follows:

A. Calcium Chloride Applied.

1. Without water: tons (megagrams) applied computed on the anhydrous basis from the percentage of calcium chloride contained in the material.

2. With water: tons (megagrams) applied, to the nearest 0.1 ton (0.1 Mg), computed on the anhydrous basis from the percentage by weight (mass) of calcium chloride contained in the liquid.

B. Water for Surface Application of Calcium Chloride.

Thousands of gallons (kiloliters) in the transporting vehicle or by metering the supply.

2314.05 BASIS OF PAYMENT.

Payment for the work of surface application of calcium chloride will be the contract unit price as described below. Payment is full compensation for furnishing water and

calcium chloride in a solid or liquid form and for handling, mixing, transporting, and application of materials to the road surface.

A. Calcium Chloride Applied.
Tons (megagrams) of calcium chloride in solid or liquid form applied to the road surface.

B. Water for Surface Application of Calcium Chloride.
Per 1000 gallons (kiloliters) of water applied to the road with surface application of calcium chloride.

Section 2315. Driveway Surfacing

2315.01 DESCRIPTION.
Furnish and place gravel or crushed stone on earth or gravel surfaced intersecting roads, driveways, and turnouts, as directed by the Engineer and according to the following provisions.

2315.02 MATERIALS.
When there is a contract item for granular surfacing of shoulders, use aggregate for driveway surfacing. When there is no contract item for that work, use one of the following materials:

A. Class C Gravel.
Class C gravel meeting requirements of Article 4120.03, except no less than 5% or more than 12% passing the No. 200 (75 µm) sieve.

B. Class A Crushed Stone.
Class A crushed stone meeting requirements of Article 4120.04 and if specifically designated, Class B crushed stone meeting requirements of Article 4120.05.

C. Other Aggregate.
Other aggregate meeting requirements of Section 4127, with 100% passing the 1 inch (25 mm) sieve.

2315.03 CONSTRUCTION.

A. Before surfacing material is placed, excavate to prepare a uniform subgrade, to provide for a finished surface at the general elevation of the shoulder, and to ensure drainage away from the roadbed. Spread the surfacing material to a uniform thickness.

B. The areas to be surfaced for various types of surfacing under contract are described as follows:

1. For Flexible Base and Bituminous Surface Construction.

a. The contract documents may require the construction for flexible base of wedge shaped fillets at intersecting earth or granular surfaced roads and at driveways to homesteads and commercial

establishments. The contract documents may require bituminous surface construction for the surfacing of these fillets with the corresponding type of surfacing.

b. Surface the remaining areas of earth or granular surfaced intersecting roads and driveways within the right-of-way and all turnouts for mail boxes with materials specified.

2. For Portland Cement Concrete Pavement.
Use one of the materials specified in Article 2315.02 to surface turnouts for mail boxes, entrances, and the unpaved areas of intersections along roads surfaced with PCC.

2315.04 METHOD OF MEASUREMENT.
Measurement of Driveway Surfacing placed as directed by the Engineer will be as indicated in the contract documents and according to Article 2312.04, A.

2315.05 BASIS OF PAYMENT.
Payment for Driveway Surfacing material placed will be the contract unit price per ton (megagram).

Section 2316. Pavement Smoothness

2316.01 DESCRIPTION.

A. Apply this specification when Section 2317 does not apply.

B. Test and evaluate pavement smoothness. Perform surface correction if required.

2316.02 TESTING AND EVALUATION.

A. General.

1. Evaluate pavement smoothness for all Interstate and Primary main line pavement surfaces, and all other road surfaces included on Primary projects, except when specifically excluded or modified by the contract documents. Main line pavement is defined as all permanent pavement for traffic lanes, including:

- Tapers to parallel lanes or through lanes at intersections,
- Tapers to climbing lanes, and
- Tapers to ramps and loops.

2. Evaluate pavement smoothness for all interchange ramps and loops.

3. For non-Primary projects, do not evaluate pavement smoothness unless specified in the contract documents.

4. If this specification is required by contract documents on non-Primary projects let by the Department, it will be added in its entirety. Selected portions of the specification will not be deleted.

5. Bridge approach sections which are a part of the paving contract will be tested according to Section 2428.

6. Smoothness Requirements:

a. Apply Table 2316.02-1 to all projects when specified. Smoothness requirements in inches per mile (millimeters per kilometer) are listed in Schedules A and B.

b. For through traffic which requires matching the surface of the new pavement to the surface of an existing old pavement, an Average Base Index (ABI) will be calculated as shown in Table 2316.02-1 on lanes wider than 8.5 feet (2.6 m). This will be the smoothness base in inches per mile (millimeters per kilometer) for payment for the new pavement unless specified otherwise. The requirements are shown in Schedule C.

Table 2316.02-1: Schedule for Identification of Pavements

Pavement	Schedule by Posted Speed (mph) (Existing or Proposed)	
	45 or less	over 45
Mainline, curbed (one or both sides of roadway	B	A
Mainline, not curbed	A	A
Ramps and Collector Distributor Roads	A[(c)]	A[(c)]
Loops	B	B
Side Roads	B	A
Grade Separations[(a)]	B	A
Pavement adjacent to existing pavement (added lane)	C[(b)]	C[(b)]

(a) Including municipal or Secondary Roads therein.

(b) $ABI = \frac{PI + X}{2}$

where:
PI = the profile index of the edge line of the abutting lane. If the computed ABI is less than X, use an ABI equal to X

X = 7 inches/mile (110 mm/km) if Schedule A, or 22 inches/mile (345 mm/km) if Schedule B.

(c) When a ramp or collector distributor road terminates at an intersection with a traffic signal or stop sign, the 700 feet (215 m) nearest the intersection will be evaluated under Schedule B.

7. Exclusions:
Paved shoulders will be excluded from smoothness testing unless used as a temporary driving surface. When used as a temporary driving surface, evaluate paved shoulders for bumps and dips only. Evaluate and correct as provided in Article 2316.03, C.

B. Measurement.

1. General.
- **a.** Provide and operate an Ames or California type profilograph or an inertial profiler to produce a profilogram (profile trace) of the surface tested, according to Materials I.M. 341.
- **b.** When a pavement for which smoothness is to be tested is adjacent to an existing old pavement, smoothness must also be tested on the old pavement 3 feet (1 m) from the adjacent edge for ABI calculation. Should the surface of the old pavement be specified for correction, perform smoothness testing for ABI calculation after correction.
- **c.** Remove all objects and foreign material on the pavement surface, including protective covers if used, prior to testing. If appropriate, properly replace protective covers after testing.
- **d.** Produce a profilogram for each segment of 50 feet (15 m) or more. Include the 16 feet (5 m) beyond the ends of the section in the profilogram.

2. Pavements.
- **a.** The pavement surface will be divided into sections that represent continuous placement.
- **b.** A section will terminate at a day's work joint (header), a bridge, similar interruption, or when continuous placement crosses to a section with a different smoothness designation.
- **c.** Sections longer than 778 feet or 0.147 miles (240 m) placed without interruption will be separated into segments of 0.1 mile (160 m). The terminating segment may be shorter than 0.1 mile (160 m) and greater than 250 feet (80 m) and still be considered a segment. A segment is to be in only one traffic lane. Each traffic lane will be tested and evaluated separately. Gaps for temporary crossings or similar construction sequencing which are placed in otherwise continuous sections will be tested, when placed, and included in the adjacent section evaluation. Testing will be done at the quarter point of the traffic lanes unless another location is specified in the contract documents.

C. Profilograph Testing.
Perform testing and provide the Engineer with the profilogram results. Ensure testing and evaluation are done by a trained and certified person. Ensure the evaluation is certified according to Materials I.M. 341.

1. Test each segment within 48 hours following placement. Provide the Engineer the index for each segment of paving by the end of the next day worked following the placement until there has been 3 consecutive

days of paving where the index for all segments would result in 100% payment or better.

2. Should any following day be evaluated to receive less than 100% payment, immediately notify the Engineer, and take corrective action to modify paving methods and equipment to achieve 100% payment or better.

3. Submit all final profilograph test reports and profile traces to the Engineer within 14 calendar days following completion of paving on the project. Selected reports and traces may be requested by the Engineer in advance of paving completion for purposes of validating the Contractor's test results. Incentive payments for qualifying segments will be made following receipt of appropriate documentation of certified smoothness results.

4. The Engineer will perform verification testing to validate the contractor's certified quality control testing. If the Engineer's verification test results validate the Contractor's test results, the Contractor's results will be used for acceptance. Disputes between the Contractor's and Engineer's test results will be resolved according to Materials I.M. 341. The Engineer may test the entire project length if it is determined that the Contractor certified test results are inaccurate, and the Contractor will be charged for this work at a rate of $400.00 per mile ($250.00 per kilometer), per profile track, with a minimum charge of $800.00. Furnishing inaccurate tests may result in decertification of the Contractor's certified operator.

D. Profile Index.

1. Calculate a profile index for each segment from the profilogram, according to Materials I.M. 341, except for:

- **a.** Side road connections less than 600 feet (180 m) in length.
- **b.** Single lift pavement overlays 2 inches (50 mm) or less in thickness unless the existing surface has been corrected by milling or scarification.
- **c.** Storage lanes and turn lanes.
- **d.** Pavement less than 8.5 feet (2.6 m) in width.
- **e.** The 16 feet (5 m) at the ends of the section when the Contractor is not responsible for the adjoining surface.
- **f.** Runout tapers on HMA overlays at existing pavement, bridges, or bridge approach sections when the thickness is less than the design thickness.
- **g.** Detour Pavement.
- **h.** Crossovers.
- **i.** Sections less than 50 feet (15 m) long

Evaluate pavement segments excluded from profile index calculation for bumps and dips. Evaluate and correct per Article 2316.03, C.

2. If there is a segment 250 feet or 0.047 mile (80 m) long or less at the end of a section, include the profilograph measurements for that segment in the evaluation of the adjacent segment in that section.

3. Identify bumps and dips separately on all profilograms. These appear as high or low points on the profilogram and correspond to high points (bumps) or low points (dips) on the pavement surface. They are identified by locating vertical deviations exceeding 0.5 inches for a 25 foot (12.7 mm for a 7.6 m) span for both bumps and dips as indicated on the profilogram.

2316.03 SURFACE CORRECTION.

A. General.

1. Surface correction for pavement smoothness may be required, which includes bumps or dips. Complete the correction before the determination of pavement thickness.

2. Perform bump, dip, and smoothness correction work for the full lane width of the paved surface.

3. Obtain the Engineer's approval for all correction work. After all required correction work is completed, determine the final profile index.

B. Pavements.

1. Portland Cement Concrete Pavement.

a. Accomplish PCC pavement surface correction by grinding the pavement with a diamond grinder, by PCC resurfacing, or by replacement.

b. Use grinding and texturing equipment that meets the requirements of Section 2532. Use a cutting head that is a minimum of 36 inches (900 mm) wide, unless a 24 inch (600 mm) cutting head is necessary due to space limitations.

c. Perform surface correction parallel to lane lines or edge lines as directed by the Engineer. Make each pass parallel to the previous passes. Ensure the ground surface is of a uniform texture.

d. Do not allow adjacent passes to overlap more than 1 inch (25 mm) or have a vertical difference of more than 1/8 inch (3 mm) as measured from bottom of groove to bottom of groove.

e. Begin and end smoothness correction at lines normal to the pavement lane lines or edge lines within any one corrected area. Proceed from the center line or lane line toward the pavement edge to maintain pavement cross slope.

2. Hot Mix Asphalt Pavements.

a. Accomplish asphalt pavement surface correction by:

- Diamond grinding,
- Overlaying the area,
- Replacing the area, or

- Inlaying the area.

b. For diamond grinding, perform the same work and use the same equipment specified for PCC pavement. Cover the surface that has been ground with a seal coat according to Section 2307 with the following modifications:

- The binder bitumen may be the same material used for tack coat, applied at a rate of 0.10 gallon per square yard (0.45 L/m^2). Hand methods may be used for spraying.
- Apply a cover aggregate consisting of sand at a rate of 10 pounds per square yard (5 kg/m^2). Hand methods may be used for spreading. Apply the sand slightly damp, but with no free moisture, as determined by visual inspection. Embed with at least one complete pneumatic roller coverage.
- This seal coat is intended to be placed immediately after the diamond grinding is completed in the travel lane. Complete this work when the road surface temperature is above 60ºF (16ºC).
- Labor, equipment, and materials used for this seal coat will not be paid for separately, but are incidental to the items for which correction is required.

c. If the surface is corrected by overlay, replacement, or inlay, begin and end the surface correction with a transverse saw cut normal to the pavement lane lines or edge lines within any one area. Ensure the profile of the surface is smooth with no bumps or dips at the beginning or end of correction. Overlay correction must be for the entire pavement width. Maintain pavement cross slope through the corrected areas.

C. Bumps and Dips.

Evaluate bumps and dips, including those at headers, on all pavements for which pavement smoothness is designated. Correction work will be required according to the criteria in Paragraphs 1, 2, and 3 below.

1. Bumps.

a. For all pavements evaluated, if the Engineer does not assess a price adjustment, correct all bumps exceeding 0.5 inch (12.7 mm) within a 25 foot (7.6 m) span, as indicated on the profilogram, except as stated in Article 2316.03, C, 3.

b. Corrected bumps will be considered satisfactory when measurement by the profilograph shows that the bumps are 0.3 inch (8 mm) or less in a 25 foot (7.6 m) span.

c. When a through traffic lane over 8.5 feet (2.6 m) wide is constructed adjacent to an existing old pavement, bump correction or price adjustment to the Contractor for a bump will not apply if a bump exists at that location in the adjacent existing old pavement.

2. Dips.

a. On all pavements, if the Engineer does not asses a price adjustment, correct dips of 0.5 inch to 1.0 inch (12.7 mm to 25 mm) in a 25 foot (7.6 m) span, as indicated on the profilogram, except as stated in Article 2316.03, C, 3. Replace the pavement in areas with

dips over 1.0 inch (25 mm). Corrected dips will be considered satisfactory when the profilogram shows the dips are less than 0.3 inch (8 mm) in a 25 foot (7.6 m) span.

b. When a lane over 8.5 feet (2.6 m) wide is constructed adjacent to an existing old pavement, correction of a dip or price adjustment to the Contractor for a dip will not be required if a dip exists at that location in the adjacent existing old pavement.

3. Exceptions.
When the Contractor is not responsible for the adjoining surface, bumps and dips in the 16 feet (5 m) at the end of a section will be reviewed by the Engineer. Correct all bumps and dips determined to be under the control of the Contractor and resulting from the Contractor's operations. Correction of bumps and dips determined to be beyond the control of the Contractor will be paid according to Article 1109.03, B.

2316.04 SMOOTHNESS.

Pavement smoothness will be compensated by adding to (incentive) or subtracting from (price reduction) the price bid for pavement a determined amount for each segment. These amounts are identified in the appropriate schedule of Article 2316.05.

A. Pavement Where Schedule A Smoothness is Required.

1. For the appropriate categories of highway, as shown in Schedule A, incentives for pavement smoothness will be paid for each segment of pavement with an initial index per mile (kilometer) per segment of 3.0 inches (48 mm) or less.

2. For segments with an initial index of 7.1 to 10.0 inches per mile (111 mm/km to 160 mm/km), the Contractor will be assessed a price reduction.

3. For segments with an index of 10.1 inches per mile (161 mm/km) and greater, grind the surface to a final index of 7.0 inches per mile (110 mm/km) or less.

B. Pavement Where Schedule B Smoothness is Required.

1. For all highways, incentives for pavement smoothness will be paid for each segment of pavement with an initial index of 12 inches per mile (190 mm/km) per segment or less.

2. For all segments with an initial index of 22.1 to 30.0 inches per mile (346 mm/km to 475 mm/km), the Contractor will be assessed a price reduction.

3. For segments with an index of 30.1 inches per mile (476 mm/km) and greater, grind the surface to a final index of 22.0 inches per mile (345 mm/km) or less.

C. Pavement Adjacent to Existing Pavement.

1. Smoothness will be evaluated by the Average Base Index (ABI) as defined in Article 2316.02, A, 6 or 7, for each segment of new pavement 8.5 feet (2.6 m) wide or more, and over 600 feet (180 m) in length, which is to be matched to the surface of an existing pavement.

2. Surface correction is required for smoothness exceeding ABI + 12 (190) when Schedule A is required and exceeding ABI + 30 (470) when Schedule B is required. Payment will be based on results after correction according to Schedule C.

3. Longitudinally check areas not included in the profilograph test with a 10 foot (3 m) straight edge. Ensure the surface does not deviate from a straight line by more than 1/8 inch in 10 feet (3 mm in 3 m). Meet requirements of Article 2316.03 for all corrections needed.

D. Bridge Approach Sections.
Smoothness of bridge approach sections will not be used in the calculations for incentive or price reduction of pavement segments, sections, or the project.

2316.05 SCHEDULE OF PAYMENT.

A. For each traffic lane of main line pavement and each traffic lane of interchange ramps and loops evaluated for smoothness, as defined in Article 2316.02, A, the Engineer will determine the length of each segment in miles (kilometers).

B. For roadways, the Contractor may receive an incentive payment or be assessed a price reduction based on the number of qualifying segments and the initial profile index.

C. Pavement segments excluding repair work that are subject to profilograph testing, as defined in Article 2316.02, D, will be considered for additional payment as a smoothness incentive or price reduction. For a segment to be qualified for incentive, there must be no grinding within that segment.

D. Surface correction (grinding) of bridge approach sections, and as stated in Article 2316.03, C, 3, will not count as surface correction on adjacent pavement segments and will not detract from possible incentive payments on those segments.

E. Single lift pavement resurfacing 2 inches (50 mm) thick or more that has milling or scarification of the original pavement will be rated using the multi-lift schedules.

F. A $900 price adjustment will be assessed for each dip not corrected in each pavement lane under Schedule A and B, except as stated in Article 2316.03, C, 3. In addition, a $900 price adjustment will be assessed for each bump not corrected under Schedule A and B, except as stated in Article 2316.03,

C, 3. Bumps and dips not corrected will also be included in the evaluation for the segment smoothness.

G. The cost of certified smoothness and associated traffic control is incidental to the cost of the pavement.

H. These payments or assessments will be based on the following schedules:

1. Schedule A Smoothness Requirements.
Pavement segments which are designated for Schedule A smoothness will be evaluated for incentive or price reduction assessments as follows:

Table 2316.05-1: Incentives for Pavement Smoothness

Initial Profile Index	**Single Lift Pavements**		**Multi-Lift Pavements**	
Inches Per Mile (mm / km) Per Segment [(a)]	Primary	Non-Primary	Primary	Non-Primary
	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment
0-1.0 (0-16)	700	300	250	125
1.1-2.0 (17-32)	600	250	200	100
2.1-3.0 (33-48)	450	200	150	50
3.1-7.0 (49-110)	Unit Price	Unit Price	Unit Price	Unit Price

[(a)] For each segment of pavement that has an initial index, within the limits listed, with no grinding, the Contractor will receive an incentive payment as shown in the tabulation for the appropriate category.

Table 2316.05-2: Price Reduction for Pavement Smoothness

Initial Profile Index	Single Lift Pavements		Multi-Lift Pavements	
Inches Per Mile (mm / km) Per Segment [(a)]	Primary	Non-Primary	Primary	Non-Primary
	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment	Dollars Per Segment
3.1-7.0 (48-110)	Unit Price	Unit Price	Unit Price	Unit Price
7.1-10.0 (111-160)	200	100	100	50
10.1 & Over[(a)] (161 & Over)[(a)]	Grind Only	Grind Only	Grind Only	Grind Only

[(a)] For segments with an initial index of 10.1 (161) and over, grind the surface to a final index of 7.0 (110) or better. In lieu of grinding the surface to a final index of 7.0 (110) or better, the Contractor may elect to replace part or all of the segment.

2. Schedule B Smoothness Requirements.

a. Pavement segments designated for Schedule B smoothness and indexed in segments greater than 50 feet (15 m) will be evaluated for incentive or price reduction as shown in Tables 2316.05-3 and 2316.05-4.

b. No price reduction assessment will be made for individual segments shorter than 50 feet (15 m) properly corrected if required.

Table 2316.05-3: Incentives for Pavement Smoothness

Initial Profile Index	New Pavements	Resurfaced Pavements
Inches Per Mile (mm / km) Per Segment [(a)]	Dollars Per Segment	Dollars Per Segment
0-4.0 (0-65) 4.1-8.0 (66-130) 8.1-12.0 (131-190) 12.1-22 (191-345)	600 500 400 Unit Price	300 250 200 Unit Price

(a) For each segment of pavement that has an initial index, within the limits listed, with no grinding, the Contractor will receive an incentive payment as shown in the tabulation for the appropriate category.

Table 2316.05-4: Price Reduction for Pavement Smoothness

Initial Profile Index	New Pavements	Resurfaced Pavements
Inches Per Mile (mm / km) Per Segment [(a)]	Dollars Per Segment	Dollars Per Segment
12.1-22.0 (191-345) 22.1-30.0 (346-475) 30.1 & Over (476 & Over) [(a)]	Unit Price 500 Grind Only	Unit Price 250 Grind Only
(a) For segments with an initial index of 30.1 (476) and over, grind the surface to a finish index of 22.0 (345) or better. In lieu of accepting a price reduction and grinding the surface to a final index of 22.0 (345) or better the Contractor may elect to replace part or all of the segment.		

3. Schedule C Smoothness Requirements (Pavement Adjacent to Existing Pavement).

For new pavement which has been matched to an existing old pavement for which an Average Base Index (ABI) was calculated, the pavement will be evaluated for a price reduction for each segment based on Schedule A or Schedule B payment.

Table 2316.05-5: Initial Profile Index or Profile Index after Correction

Schedule A Inches Per Mile (mm / km) Per Segment	Schedule B Inches Per Mile (mm / km) Per Segment	Dollars Per Segment
0 to ABI	0 to ABI	0
ABI + 0.1 (1) to ABI +4 (65) incl.	ABI + 0.1 (0.1) to ABI + 10 (160) incl.	0300
ABI + 4.1 (66) to ABI +8.0 (130) incl.	ABI + 10.1 (161) to ABI + 20 (315) incl.	500
ABI + 8.1 (131) to ABI +12 (190) incl.	ABI + 20.1 (316) to ABI + 30 (475) incl.	800
Greater than ABI + 12 (190)	Greater than ABI + 30 (470)	Grind Only

4. Bridge Approach Sections.

Correct bridge approach sections for smoothness as specified in Section 2428.

Section 2317. Primary and Interstate Pavement Smoothness

2317.01 GENERAL.

Evaluate pavement smoothness for all Interstate and Primary main line pavement surfaces, and all other road surfaces included on Primary projects, except when specifically excluded or modified by the contract documents. Main line pavement is defined as all permanent pavement for through lanes.

2317.02 EQUIPMENT.

A. Provide and operate an Ames type or California type profilograph or an inertial profiler to produce a profilogram (profile trace) of the surface tested according to Materials I.M. 341. Ensure the operator is trained and certified to operate the profilograph as required by the Contracting Authority.

B. If the profilograph has a mechanical recorder, provide automated trace reduction equipment according to Materials I.M. 341. If it has a computerized recorder, the trace produced will be evaluated without further reduction.

C. For corrective work by diamond grinding, use grinding and texturing equipment meeting the requirements of Section 2532.

2317.03 SURFACE TOLERANCES, TESTING, AND EVALUATION.

A pavement segment is defined as a continuous area of finished pavement 0.1 mile (161 m) in length and one lane (10 to 12 foot (3.0 to 3.7 m) nominal) in width. A partial segment may result from an interruption of the continuous pavement surface (in other words, bridge approaches, side road tie-ins, the cessation of the daily paving operations, and so forth). If the partial segment is 250 feet (80m) or less in length, include its length and roughness with the previous adjacent segment. If the partial segment length is greater than 250 feet (80 m), evaluate it as a single segment. Gaps for temporary crossings or similar construction sequencing which are placed in otherwise continuous sections will be tested, when placed, and included in one of the adjacent sections for evaluation following the procedure for partial segments above.

A. Tolerances.

Produce pavement with an average profile index per 0.1 mile (161 m) segment as shown in Table 2317.03-1.

Table 2317.03-1: Tolerance for Average Profile Index per 0.1 Mile (161 m) (0 inch (0 mm) blanking band)

Surface Type	Profile Index For greater than 45 mph	Profile Index For 45 mph or less and ramps
	Inches per mile (mm / km)	Inches per mile (mm / km)
PCC Pavement	40.0 or less (630 or less)	65.0 or less (1025 or less)
HMA Pavement	35.0 or less (550 or less)	45.0 or less (710 or less)

B. Testing.

1. Determine the pavement profiles for each lane according to the procedures for one lane, as shown in Materials I.M. 341 except for main line traffic lanes which will be tested in the wheel paths. Round the trace scallops to the nearest 0.01 inch (0.1 mm). The wheel paths are defined as the 3 feet (0.9 m) and 9 feet (2.7 m) from the center line or lane line. Average the two wheel path profile indexes for each segment.

Additional profiles may be taken only to define the limits of an out-of-tolerance surface variation.

2. The Engineer may use a 10 foot (3 m) straightedge (or other means) to detect irregularities outside the required trace paths. The Engineer may also use the straightedge to delineate the areas that require corrective action.

3. Test bridge approaches according to Section 2428.

4. Paved shoulders will be excluded from smoothness testing. When used as a temporary driving surface, evaluate paved shoulders for bumps and dips. Evaluate for high points and low points with deviations in excess of 0.5 inches (12.7 mm) in a length of 25 feet (7.6 m) or less. Take corrective action.

C. Evaluation.

1. Determine a profile index based on the 0 inch (0 mm) blanking band following the same procedures shown in Materials I.M. 341 for each segment of finished pavement surface except for:

- **a.** Primary side road connections less than 600 feet (180 m) in length.
- **b.** Non-primary side road connections, which are to be evaluated according to Section 2316.
- **c.** Bridge approaches (evaluated according to Section 2428).
- **d.** Storage lanes, turn lanes, and other auxiliary lanes less than 600 feet (180 m).
- **e.** Pavement less than 8.5 feet (2.6 m) in width.
- **f.** The 16 feet (5 m) before and the 16 feet (5 m) beyond the ends of the section when the Contractor is not responsible for the adjoining surface.
- **g.** Single lift pavement overlays 2 inches (50 mm) thick or less, unless the existing surface has been corrected by milling or scarification.
- **h.** Runout tapers on HMA overlays at existing pavement, bridges, or bridge approach sections where the thickness is less than the design thickness.
- **i.** Detour pavement.
- **j.** Crossovers.
- **k.** Individual sections of pavement less than 50 feet (15 m) in length.

Evaluate pavement segments excluded from profile index evaluation for high points and low points with deviations in excess of 0.5 inches (12.7 mm) in a length of 25 feet (7.6 m) or less. Take corrective action.

2. For the following situations, the profile index will be evaluated. If the average profile index exceeds the tolerances listed in Article 2317.03, A, the Contractor may elect to eliminate that area from the profile index for the day's paving operation.

Evaluate pavement segments eliminated from profile index evaluation for high points and low points with deviations in excess of 0.5 inches (12.7 mm) in a length of 25 feet (7.6 m) or less. Take corrective action.

a. Horizontal curves with a centerline radius of less than 1000 feet (300 m) and the pavement within the superelevation transition of such curves.

b. Crest and sag vertical curves with an L/A < 100 where L is the length of curve in feet and A is the grade change in percent (L/A < 30.5 where L is the length in meters and A is the grade change in percent).

3. Determine a daily average profile index for each day's paving operation. A day's paving operation is defined as a minimum of 0.1 mile (161 m) segment of pavement placed in a day. If less than 0.1 mile (161 m) segment is paved, the day's production will be grouped with the next day's production. If the production of the last day of project paving is less than 0.1 mile (161 m) segment, it will be grouped with the previous day's production.

4. Test each segment within 48 hours following placement. Furnish the profile index for each segment of paving to the Engineer by the end of the next day worked following the placement until there has been 3 consecutive days of paving where the index for all segments would result in 100% payment or better. Should any following day be evaluated to receive less than 100% payment, immediately notify the Engineer and take corrective action to modify paving methods and equipment to achieve 100% payment or better.

5. If the day's average profile index exceeds the values in Table 2317.03-1, notify the Engineer and suspend the paving operation until corrective action is taken. When the paving is resumed, the paving operations will be evaluated with the start-up testing procedures in the preceding paragraph.

6. Submit all final profilograph test reports and profile traces to the Engineer within 14 calendar days following completion of paving on the project. The Engineer may request selected reports and traces in advance of paving completion for purposes of validating the Contractor’s test results. Incentive payments for qualifying segments will be made following receipt of appropriate documentation of certified smoothness results.

2317.04 CORRECTIVE ACTIONS.

A. General.

1. The pavement will be evaluated in 0.1 mile (161 m) segments using the profilograph, to determine pavement segments where corrective work or pay adjustments will be necessary. Each individual profilograph trace will be evaluated (not the average of multiple traces) to determine the areas where corrective action on 0.5 inch (12.7 mm) bumps and dips is needed.

2. Within each 0.1 mile (161 m) segment, correct all areas representing high points (bumps) or low points (dips) with deviations in excess of 0.5 inches (12.7 mm) in a length of 25 feet (7.6 m) or less regardless of the profile index value. Take corrective action.

3. Separately identify bumps and dips equal to or exceeding 0.5 inches (12.7 mm) in a length of 25 feet (7.6 m) or less.

4. On lanes over 8.5 feet (2.6 m) in width, for through traffic which requires matching the surface of the new pavement to the surface of an existing pavement, an Average Base Index (ABI) will be determined according to Section 2316.

B. Roadways with a posted speed greater than 45 mph.
Correct all 0.1 mile (161 m) segments, including bumps, having an initial average profile index of greater than those tolerances shown in Article 2317.05. Correct these segments to reduce the average profile index to those shown in Table 2317.04-1 below. The Contractor has the option to replace these segments. On segments where corrections are made, test the pavement to verify that corrections have met the average profile index as shown in Table 2317.04-1 below.

C. Roadways with a posted speed of 45 mph, or less, and ramps.
Correct all 0.1 mile (161 m) segments, including bumps, having an initial average profile index of greater than those tolerances shown in Article 2317.05. Correct these segments to reduce the average profile index to those shown in Table 2317.04-1 below. The Contractor has the option to replace these segments. On segments where corrections are made, test the pavement to verify that corrections have met the average profile index as shown in Table 2317.04-1 below.

Table 2317.04-1: Average Profile Index per 0.1 Mile (161 m) after Corrections (0 inch (0 mm) blanking band)

Surface Type	Profile Index For greater than 45 mph	Profile Index For 45 mph or less and ramps
	Inches per mile (mm / km)	Inches per mile (mm / km)
PCC Pavement	40.0 or less (630 or less)	65.0 or less (1025 or less)
HMA Pavement	40.0 or less (630 or less)	50.0 or less (790 or less)

D. Bridge Approach Sections.
Correct bridge approach sections according to Section 2428.

E. Corrective Work.
When the Contractor is not responsible for the adjoining surface, bumps and dips in the 16 feet (5 m) at the end of a section will be reviewed by the Engineer. Correct bumps and dips determined to be under the control of the Contractor and resulting from the Contractor's operations. Correction of bumps and dips determined to be beyond the control of the Contractor will

be paid according to Article 1109.03, B. Complete the corrective work prior to determining pavement thickness. Do not use bush hammers or other impact devices.

1. PCC Pavement.
On PCC pavement, make corrections using an approved profiling device or by removing and replacing the pavement. Apply corrective methods to the full lane width. Ensure, when completed, the corrected area (full lane width) has uniform texture and appearance, with the beginning and ending of the corrected area squared normal to centerline of the paved surface. Where surface corrections are made, grooving will not be required.

2. HMA Pavement.

a. On HMA pavement, make corrections by diamond grinding, by overlaying the area, by replacing the area, or by inlaying the area. If the surface is corrected by diamond grinding, perform the same work and use the same equipment as specified for PCC pavement, except cover the ground surface with a seal coat according to Section 2307, with the following modifications:

1) The binder bitumen may be the emulsion or cutback asphalt used for tack coat, applied at a rate of 0.10 gallon per square yard (0.7 L/m^2). Hand methods may be used for spraying.

2) Apply a cover aggregate consisting of sand (slightly damp, but with no free moisture as determined by visual inspection) at a rate of 10 pounds per square yard (5 kg/m^2). Hand methods may be used for spreading. Embed cover aggregate with at least one complete pneumatic roller coverage.

3) This seal coat is intended to be placed immediately after the diamond grinding is completed in the travel lane. The Engineer may approve this construction when road surface temperatures are below 60ºF (16ºC).

4) Labor, equipment, and materials used for this seal coat are incidental to other items and will not be paid for separately.

b. If the surface is corrected by overlay, replacement, or inlay, begin and end the surface correction with a transverse saw cut normal to the pavement lane lines or edge lines within any one area. The profile of the surface must be smooth with no bumps or dips at the beginning or end of correction.

c. Overlay correction must be for the entire pavement width. Pavement cross slope must be maintained through the corrected areas.

F. Verification Testing.

1. The Engineer will perform verification testing to validate the Contractor's certified quality control testing. If the Engineer's verification test results validate the Contractor's test results, the Contractor's results will be used for acceptance. Disputes between the Contractor's and Engineer's test results will be resolved according to Materials I.M. 341.

2. The Engineer may test the entire project length if it is determined that the Contractor certified test results are inaccurate, The Contractor will be charged for this work at a rate of $400.00 per mile ($250.00 per kilometer), per profile track, with a minimum charge of $800.00.

3. Furnishing inaccurate tests may result in decertification of the Contractor's certified operator.

2317.05 PAY ADJUSTMENTS.

A. General.

1. Pay adjustments will be based on the initial average profile index determined for the segments prior to performing any corrective work. Areas excluded from the profilograph testing and bridges approaches will not be subject to price adjustments.

2. If the Contractor elects to remove and replace the segments, the Contractor will be paid the price adjustment that corresponds to the initial average profile index obtained on the pavement segments after replacement.

3. When the plans dictate that an area of pavement is to be hand finished, the area will not be subject to reduced payment. However, the area is to be profiled and corrected as necessary to meet these specifications.

B. PCC Pavement.

The payment will be adjusted as shown in Table 2317.05-1 according to the posted or proposed speed.

Table 2317.05-1: Schedule for Adjustment Payment for PCC Pavements (0 inch (0 mm) blanking band)

Profile Index For greater than 45 mph	Profile Index For 45 mph or less and ramps	Dollars per 0.1 mile (161 m) segment per lane	
Inches per mile (mm / km)	Inches per mile (mm / km)	Interstate & Multi-Lane Divided Segments	Other Primary Segments
22.0 or less (345 or less)	25.0 or less (395 or less)	+950.00	+850.00
22.1 to 23.5 (346 to 370)		+800.00	+650.00
23.6 to 26.0 (371 to 410)	25.1 to 30.0 (396 to 475)	+600.00	+450.00
26.1 to 40.0 (411 to 630)	30.1 to 65.0 (476 to 1025)	0.00	0.00
40.1 to 45.0 (631 to 710)	65.1 to 70.0 (1025 to 1105)	-600.00 or grind*	-450.00 or grind*
45.1 or more (711 or more)	70.1 or more (1105 or more)	0.00*	0.00*
* These segments shall be corrected to the levels shown in Table 2317.04-1.			

C. HMA Pavement.
The payment will be adjusted as shown in Table 2317.05-2 according to the posted or proposed speed.

Table 2317.05-2: Schedule for Adjustment Payment for HMA Pavements (0 inch (0 mm) blanking band)

Profile Index For greater than 45 mph	Profile Index For 45 mph or less and ramps	Dollars per 0.1 mile (161 m) segment per lane	
Inches per mile (mm / km)	Inches per mile (mm / km)	Interstate & Multi-Lane Divided Segments	Other Primary Segments
10.0 or less (160 or less)		+850.00	+750.00
10.1 to 11.5 (161 to 180)	15.0 or less (235 or less)	+650.00	+500.00
11.6 to 13.5 (181 to 215)		+500.00	+350.00
13.6 to 15.5 (216 to 245)	15.1 to 20.0 (236 to 315)	+350.00	+200.00
15.6 to 35.0 (246 to 550)	20.1 to 45.0 (316 to 710)	0.00	0.00
35.1 to 40.0 (551 to 630)	45.1 to 50.0 (711 to 790)	-350.00 or grind*	-200.00 or grind*
40.1 or more (631 or more)	50.1 or more (791 or more)	0.00*	0.00*
* These segments shall be corrected to the levels shown in Table 2317.04-1.			

Section 2318. Cold In-Place Recycled Asphalt Pavement

2318.01 DESCRIPTION.

Cold in-place recycling (CIR) consists of:

- Milling existing asphalt pavement,
- Processing and mixing RAP with an asphalt stabilizing agent and water (if required), and
- Placing and compacting the mixture.

2318.02 MATERIALS.

A. Asphalt Stabilizing Agent.
Use one of the following asphalt stabilizing agents, as specified in the contract documents:

1. Standard Asphalt Emulsion (HFMS-2s) meeting the requirements of Section 4140 shall be used on Primary and Interstate projects. CSS-1 emulsion meeting the requirements of Section 4140 may be used in place of HFMS-2s on other projects.

2. Foamed Asphalt using PG 52-34 or PG 46-34 asphalt binder meeting the requirements of Section 4137 may be used on Interstate, Primary, Secondary, and local projects.

B. Recycled Asphalt Pavement.

The processed RAP is intended to comply with the following gradation. The gradation may be revised with the approval of the Engineer. Ensure the top size of the material does not exceed 50% of the depth of the compacted recycled mat.

Sieve Size	% Passing
1 1/2 inch (37.5 mm)	98 to 100
1 inch (25 mm)	90 to 100

C. Mix Design.

1. Unless stated otherwise in the contract documents, do not perform a mix design process for standard asphalt emulsion or foamed asphalt. Use the following application rates per square yard per inch (per square meter per mm) of compacted thickness when no mix design is performed.

Table 2318.02-1: Application Rates

Asphalt Stabilizing Agent	Application Rate (/yd^2/in)	(/m^2/25 mm)
Standard Asphalt Emulsion	0.30 gallons (emulsion)	1.325 L
Foamed Asphalt	0.0011 tons (asphalt binder)	1.175 kg

2. When a mix design is required by the contract documents, provide the Engineer a representative 150 pound (22 kg) bulk sample of the existing pavement surface as directed by the Engineer following the sampling options in Materials I.M. 504, and 10 gallons (38 L) of the intended asphalt stabilizing agent. The Engineer will provide the details of the mix design no later than 6 weeks after receiving the samples. The Central Materials Laboratory will perform the mix design and will establish the amount of asphalt binder to incorporate into the RAP. The mix design shall determine the target asphalt temperature and percent of water injected into the asphalt to achieve optimum foaming.

2318.03 CONSTRUCTION.

Except in specific cases when permitted by the Engineer, CIR will only be allowed between May 1 and October 1. Do not perform recycling operations when:

- The ambient temperature is below 60°F (15°C),
- The weather is foggy or rainy, or
- Weather conditions are such that proper mixing, placing, and compacting of the recycled material cannot be accomplished.

A. Equipment.

1. Furnish a self-propelled machine equipped with automatic depth control. Ensure it is capable of:

- Milling the existing asphalt pavement to the depth shown in the contract documents in one pass.
- Maintaining a constant cutting depth and width, uniform grade, and uniform slope.
- Producing the properly sized RAP or additional screening.

- Crushing the RAP.

2. Furnish equipment capable of mixing the RAP and asphalt stabilizing agent into a homogeneous CIR mixture. Ensure the equipment meets the requirements of Article 2001.22, F. Ensure it also provides a positive means, including visual display, for accurately controlling the rate of flow and total delivery of the asphalt stabilizing agent into the mixture in relation to the quantity of RAP being recycled. Ensure the asphalt stabilizer application system is capable of adjusting for the width of recycling so that overlapped CIR mixture maintains the designed asphalt stabilization content.

3. When foamed asphalt stabilizing agent is used, ensure the asphalt foaming system accurately and uniformly injects the specified percent of water into the hot asphalt binder. Fit the equipment with a test nozzle to provide field samples of foamed asphalt. Equip tankers supplying hot asphalt binder with a thermometer to continuously measure temperature of the asphalt in the bottom third of the tank.

4. Place CIR material using a bituminous paver meeting the requirements of Article 2001.19 (heating the screed will not be permitted).

5. Compact CIR material using rollers meeting the requirements of Article 2001.05. As a minimum, have the following available for use:
- A self-propelled double drum vibratory steel roller (may be used in either the static or vibratory mode).
- A self-propelled 25 ton (25 Mg) or greater pneumatic tire roller.

B. Preparation.
Prior to initiating the recycling operation, clear all vegetation and debris within the width of pavement to be recycled according to Article 2212.03, B, 1.

C. Milling the Existing Pavement.

1. Mill the existing pavement to the specified constant depth and width in one pass. Process RAP to the required gradation. When specified in the contract documents or if the Engineer approves, the pavement surface may be pre-milled to the slope specified in the contract documents. Remove pre-milling RAP from the project.

2. When the plans note that the milling operation will encounter a paving fabric, make necessary adjustments in equipment or operations so no fabric piece has any dimension exceeding a length of 4 inches (100 mm). Remove RAP containing over-sized pieces of paving fabric.

D. Mixing the Recycled Material.

1. During recycling operations, apply asphalt stabilizing agent to the RAP at the specified application rate. The Engineer may vary the application

rate of the asphalt stabilizing agent as required by existing pavement conditions.

2. Determine the amount of additional water needed to facilitate uniform mixing with the asphalt stabilizing agent and to achieve a stable pavement layer above the minimum specified density. The water may be added prior to or concurrently with the asphalt stabilizing agent. Ensure adding water, to facilitate uniform mixing, does not adversely affect the asphalt stabilizing agent.

E. Placement of the Recycled Material.

1. Deposit CIR mixture in a windrow, into a spreader or paver (as required by Article 2318.03, A), or load into trucks, without segregation.

2. Place and finish CIR mixture in one continuous pass, without segregation. Ensure the surface of the CIR lift has a uniform cross-slope as specified in the contract documents. Ensure lift thickness is a minimum of 2 inches (50 mm). If using a pick-up machine to feed the windrow into the paver hopper, ensure it is capable of picking up the entire windrow to the underlying material.

F. Compaction and Density.

1. Comply with the following minimum field densities:

- Interstate and Primary Roads: 94% of laboratory density based on the dry weight of compacted material according to Materials I.M. 504.
- All other roads: 92%.

2. Perform initial rolling with a pneumatic tired roller. Perform final rolling using steel wheel rollers, either in static or vibratory mode, to eliminate pneumatic tire marks.

3. If rolling results in cracking, movement, or other types of pavement distress, discontinue until such time that the problem can be resolved.

4. If there is a significant change in mix proportions, weather conditions, or other controlling factors, the Engineer may require construction of test strips to check target density.

G. Opening CIR Layer to Traffic.

1. After compaction is complete, determine when CIR layer is stable enough to open to traffic.

2. The Contractor has 14 calendar days after the CIR layer is complete and initially achieves allowable moisture content to place the first lift of HMA overlay or specified surface treatment. If the first lift is placed after the 14 calendar day period and CIR layer shows damage, correct the

damage, at no additional cost to the Contracting Authority, before placing the lift.

H. Placement of Surface Course.
Subsequent HMA overlay or surface treatment will not be allowed until moisture content of the CIR layer is no more than 0.3% above the residual moisture content or 2.0%, which ever is greater. The Engineer may adjust this drying period depending on field conditions. The CIR shall be retested until the moisture content is at or below the limits stated above.

I. Quality Control.

1. The Contractor is responsible for quality control of the materials and CIR process. Perform testing according to Materials I.M. 204. Take samples and deliver them to the District Materials Laboratory according to Materials I.M. 504. A lot, for quality control sampling and testing, is defined as each day of CIR operation.

2. Sample and test the asphalt stabilizing agent according to Materials I.M. 204.

3. Apply asphalt stabilization agent at the target application rate within ± 0.06 gallon per square yard per inch (0.25 L/m^2/25 mm) for standard emulsion and within ± 0.000165 tons per square yard per inch (0.175 kg/m^2/25 mm) for foamed asphalt.

4. When foamed asphalt is used, maintain asphalt binder at a temperature within ± 20°F (10°C) of 310°F (155°C) or the optimum temperature established by the mix design. Maintain the injection water at the target ± 0.5%. Foaming characteristics of each new tanker load will be verified by measuring a sample from the equipment's test nozzle.

5. If required by the Engineer, measure the profile of the center of each lane of the compacted CIR mat with a profilograph. Correct, at no additional cost to the Contracting Authority, bumps and dips in the profile greater than 1 inch (25 mm) in 25 feet (7.6 m). Ensure the cross-slope of the compacted CIR mat is within 0.4% of the desired slope. Payment will be $400 per lane-mile ($250/lane-km) for profiling the length directed by the Engineer.

6. Perform nuclear gauge moisture and density tests according to Materials I.M. 504 within 24 hours of completing each lot at locations determined by the Engineer. During each lot of CIR production, furnish a 40 pound (18 kg) sample of loose CIR mixture, sealed in plastic, from a location the Engineer determines. Each day, deliver the sample as soon as possible after sampling to the District Materials Laboratory for density determination. The Quality Index for density does not apply. Recompact sublots that do not achieve the minimum required density. Recompact them within 2 calendar days after the CIR layer was placed to meet the target density.

J. Limitations.
When HMA resurfacing is part of the contract, cover cold in-place recycled surfaces with at least one full lift of HMA prior to winter shutdown.

2318.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Cold In-Place Recycled Asphalt Pavement.
Square yards (square meters) computed from the measured longitudinal length of pavement and the width of pavement specified in the contract documents.

B. Asphalt Stabilizing Agent.
Gallons (liters) at 60°F (15°C) for standard emulsion, or tons (megagrams) for asphalt binder, through a calibrated pump used for metering the total delivery of the agent or through delivery ticket quantity.

2318.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Cold In-Place Recycled Asphalt Pavement.

1. Per square yard (square meter) for Cold In-Place Recycled Asphalt Pavement.

2. Payment is full compensation for all labor, material (including mixing water), and equipment necessary for:
- Obtaining and delivering bulk sample for mix design,
- Quality control, and
- Milling, mixing, spreading, placing, shaping, and compaction of the completed Cold In-Place Recycled Asphalt Pavement.

B. Asphalt Stabilizing Agent.

1. Per gallon (liter) or ton (megagram) for Asphalt Stabilizing Agent.

2. Payment is full compensation for all labor, materials, and equipment necessary for furnishing the stabilizing agent.

Section 2319. Slurry Leveling, Slurry Wedge, and Strip Slurry Treatment

2319.01 DESCRIPTION.
Evenly spread a properly proportioned mixture of emulsified asphalt, mineral aggregate, and water on a prepared surface as specified in the contract documents. When crack cleaning and filling is a part of this work, that work will be covered by a separate specification.

A. Slurry Leveling: use fine slurry mixtures to fill shallow depressions in the pavement and adjacent to cracks.

B. Slurry Wedge (Edge Rut Treatment): place a fine or coarse slurry mixture in a narrow wedge-shaped strip to correct the differential elevation between the pavement edge and the shoulder, as designated in the contract documents.

C. Strip Slurry Treatment: longitudinal applications of fine or coarse slurry mixtures as designated in the contract documents.

2319.02 MATERIALS.

A. Asphalt Emulsion.
Use a Grade CSS-1H or SS-1H emulsified asphalt meeting the requirements of Section 4140.

B. Aggregate.
Use a mineral aggregate consisting of crushed stone or a combination of crushed stone and mineral filler meeting the below requirements. The use of other crushed aggregates will be allowed when the Engineer approves. This may require the addition of an approved anti-strip additive to the slurry mixture.

1. Crushed Stone.
Use crushed aggregates meeting the requirements of Section 4124.

2. Mineral Filler.
Mineral filler may be required to obtain the desired mixture consistency and the addition rate will be established by the Engineer, based on laboratory or field trials. Use mineral filler meeting the requirements for Type I Portland Cement.

3. Gradation.
Use composite aggregate, excluding mineral filler, that complies with the following gradation limits for the specified slurry mixture required:

a. Fine Slurry Mixture.
Use aggregate meeting the requirements for Gradation No. 22 of the Aggregate Gradation Table in Section 4109.

b. Coarse Slurry Mixture.
Use aggregate meeting the requirements for Gradation No. 23 of the Aggregate Gradation Table in Section 4109.

C. Water.
Use fresh water which is free of sediment and salt contaminants. If the water is not compatible with the slurry mixture, the Contractor may be required to use water from another source.

2319.03 CONSTRUCTION.

A. Slurry Mixture

1. Composition and Quality of Mixture.

a. Aggregate proposed for use on the project will be sampled by representatives of the Contracting Authority to determine a job-mix formula. After consulting with the Contractor, the Engineer will establish a job-mix formula for the mixture on the basis of gradation, asphalt content, durability, stability, and asphalt compatibility. This formula remains in effect until modified in writing by the Engineer. When noncomplying results or other unsatisfactory conditions make it necessary, the Engineer will establish a new job-mix formula, after consulting with the Contractor. Should a change in sources of materials be made, set a job-mix formula before the new material is used.

b. Provide the Engineer with a copy of the certified gradations of aggregate proposed for use.

2. Asphalt Binder Content.

Requirements:

a. Estimated asphalt residue content: 7% to 14% of the dry weight (mass) of the aggregate.

b. Mixture design film thickness: 7.5 microns (190 µm) (target value) with a ± 0.75 microns (29 µm) permissible range.

B. Handling and Sampling Slurry Materials.

1. Stockpiling of Aggregate.

a. Take precautions to prevent stockpile contamination with oversized rock, clay, silt, or moisture in excess of that which would interfere with the amount of asphalt emulsion required in producing the desired homogeneous slurry mixture.

b. Place the stockpile in a well drained area. Do not allow the aggregate to become segregated.

c. Control the moisture in the aggregate to be within ± 1.5% of the moisture content of the aggregate at the time of calibration.

2. Storage.

a. Provide suitable storage facilities for the asphalt emulsion. Use a container equipped to prevent water from entering the emulsion.

b. Provide suitable and adequate heat to prevent freezing and to facilitate handling of the asphalt emulsion.

3. Sampling.

Furnish samples of materials during the process of the work as directed by the Engineer.

C. Equipment.

Obtain the Engineer’s approval for all equipment, tools, and machines and maintain in satisfactory working order at all times.

1. Slurry Mixing Equipment.

a. Use a continuous flow mixing unit capable of:
- Accurately delivering a predetermined proportion of aggregate, water, and asphalt emulsion to the mixing chamber, and
- Discharging the thoroughly mixed product on a continuous basis.

b. Pre-wet the aggregate immediately prior to mixing with the emulsion. Use a pugmill capable of thoroughly blending all ingredients together.

c. Use a mixing machine equipped with an approved fines feeder that provides an accurate metering device, or method, to introduce a predetermined proportion of mineral filler into the mixer at the same time and location that the aggregate is fed. Use a fines feeder to add mineral filler when required as part of the aggregate blend.

d. Use an aggregate feed to the mixer equipped with a revolution counter or similar device so the amount of aggregate used may be determined at any time.

e. Use a positive displacement type emulsion pump equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time.

f. For adding water to the mixer, use a pump equipped with a valve to establish the required water flow.

g. Mechanically tie all controls to ensure accurate proportioning of all materials at all times, including starts and stops. On some machines, this can be a simultaneous start and stop of all materials. On other machines, depending on where the materials are introduced into the mixing chamber, the feeds must be properly synchronized.

h. Use a one-lever or one-button operation with no means for the operator to adjust the mix proportions, except for the water.

i. Use revolution counters that count 0.1 revolutions on mechanisms which turn less than 100 rpm.

j. Attach a metering device to the slurry machine for the addition of additive to the mixture or any component material. Use a device that has positive, quick-acting controls, is easily calibrated, and maintains accurate and uniform flow.

k. Provide a means for calibrating the mixer. Calibrate and properly mark the controls for proportioning each material to be added to the mix. Use equipment with controls placed so they are readily accessible for calibration and so the Engineer may determine the amount of each material being used at any time. A minimum of three aggregate gate settings will be required for calibration and, if changes in emulsion delivery are necessary, a minimum of three pump changes will be required.

l. Use a mixing machine that:
- Is equipped with a water pressure system and fog type spray bar adequate for complete fogging of the surface preceding spreading equipment,
- Is controllable to an application range of 0.05 gallon per square yard (0.25 L/m^2), and

- Provides sufficient machine storage capacity to properly mix and apply a minimum of 5 tons (4.5 Mg) of the slurry, except when the mixing machine is operated in a continuous manner and is supplied by separate nurse type equipment.

2. Slurry Spreading Equipment.

a. Slurry Wedge, Strip Slurry Treatment.

1) Use a mixer machine with an attached mechanical type squeegee distributor equipped with flexible material in contact with the surface to prevent loss of slurry from the distributor. Maintain the squeegee to prevent loss of slurry on varying grades and crown. Include a steering device and a flexible strike off.

2) Use a spreader box capable of placing the slurry mixture to the width specified in the contract documents. Use a spreader box equipped with vertical adjustment devices attached to horizontal support devices (such as runners) located a minimum of 6 inches (150 mm) inside both ends at the side of the box. This is to ensure uniform distribution on varying grades and crowns. Use vertical adjustment devices of sufficient weight (mass) to keep the horizontal support devices in contact with the roadway surface during operation. Use flexible strike off material of sufficient stiffness to produce the desired texture and rate of application.

3) Keep the spreader box clean. Do not allow build up of asphalt and aggregate on the box.

b. Slurry Leveling.

Use metal lutes of varying widths for spreading the slurry mixture in the depressed areas. Ensure the face of each lute is indented (arched) slightly (1/8 inch to 3/16 inch (3 mm to 5 mm)) to aid in controlling the spread. The Contractor may contact the Office of Maintenance Operations concerning design of these lutes.

3. Cleaning Equipment.

Use power brooms, power blowers, air compressors, water flushing equipment, or hand brooms for cleaning the surface and cracks.

4. Auxiliary Equipment.

Furnish hand squeegees, shovels, and other equipment as necessary to perform the work.

5. Screening Unit.

Use a screening unit to remove objectionable oversize and foreign material that may be encountered. Screen material before loading the slurry machine and/or weighing for payment.

D. Preparation of Surface.

1. Clean all loose material, soil tracked on the roadway surface, vegetation, and other objectionable material from the surface and cracks immediately prior to applying the slurry material. Clean cracks to

a depth of 1 inch (25 mm) if they have not been completely filled prior to applying the slurry treatment.

2. Any standard cleaning method used to clean pavements, such as power brooms, compressed air, high-pressure water, and hand tools will be acceptable.

3. Water flushing will not be permitted in areas where considerable cracks are present in the pavement surface.

4. Obtain the Engineer's approval for surface preparation.

E. Tack Coat.

1. After surface preparation, tack coat the surface using a diluted emulsion of the same type and grade used in the slurry mixture. Dilute the emulsion (3 parts water to 1 part emulsion) and apply to the surface at a rate between 0.05 to 0.10 gallon per square yard (0.25 L/m^2 to 0.45 L/m^2).

2. Obtain the Engineer's approval for the rate of application used.

3. Apply the tack coat the same day as the slurry seal.

F. Composition Rate and Application of the Slurry Mix.

1. Blend the amount of asphalt emulsion with the aggregate as determined by the laboratory mix design and after final adjustment.

2. Water may be added as necessary to obtain a fluid and homogeneous mixture.

3. Obtain the Engineer's approval for the mixture design application methods and rate of application.

G. Application of the Slurry Material.

1. General.

a. The Engineer may direct that the surface of the pavement be fogged with water, approximately 0.05 gallon per square yard (0.25 L/m^2), immediately preceding the pass of the spreader. Ensure the mixture is of a consistency such that it "rolls" in the spreader in a continuous mass. Slurry that segregates in the spreader box so that flowing of liquids (water and emulsion) is evident is not acceptable, so do not apply to the surface.

b. Do not allow the total time for mixing aggregate and emulsion to exceed 4 minutes. Ensure a sufficient amount of slurry is present in the spreader at all times to ensure that complete coverage is obtained. Lumping, balling, or unmixed aggregate will not be permitted. Do not allow emulsion and aggregate fines to become segregated from the coarse aggregate. If the coarse aggregate

settles to the bottom of the mix, remove the slurry from the pavement.

c. Keep breaking of the emulsion in the spreader box to a minimum to allow for a uniform distribution of the slurry mixture on the pavement. Do not leave streaks, such as those caused by over-sized aggregate, in the finished surfaces.

d. Apply Strip Slurry Treatment parallel to the center line, edge line, or other reference using a guide extending at least 3 feet (1 m) ahead of the application equipment.

e. A mechanical device, such as an auger, may be used to distribute the slurry in the spreader box. The use of a mechanical device in the slurry distribution box for strip slurry treatment and slurry wedge application will generally not be required. The contract documents will state if a mechanical device is required.

2. Mix Consistency.

a. To obtain a workable mix consistency and to eliminate overwatering, test the mix consistency according to Iowa Test Method 508, using Procedure B.2, Slurry Flow Test. The Engineer will determine the maximum flow for each slurry mixture.

b. Once the maximum flow has been established, remove all slurry mix from the roadway that is found to exceed this maximum and replace with an approved mixture, at no additional cost to the Contracting Authority.

c. Testing for consistency will be at the Engineer's discretion. The Engineer will inform the Contractor of the boundaries represented by the test sample when a change in the mixture is apparent.

3. Joints.

a. Excessive build-up or unsightly appearance will not be permitted on longitudinal or transverse joints. Obtain the Engineer’s approval for the use of burlap drags or other types of drags.

b. A stringline will be required to obtain a neat appearing, straight line, longitudinal alignment. The Engineer will establish reference points. Set, follow, maintain, and remove the stringline. The stringline may be referenced to the mixing machine or the spreader box.

4. Hand Work.

Use approved squeegees to spread slurry in areas inaccessible to the slurry mixer. Do not leave an unsightly appearance from hand work.

5. Curing and Opening to Traffic.

a. Allow the treated area to cure until it may be opened to traffic without pick-up or raveling of the slurry mixture.

b. Repair any damage caused to the slurry surface by premature opening to traffic at no additional cost to the Contracting Authority.

6. Application of Slurry Leveling.

a. Ensure the surface to which the slurry leveling is to be applied is moist and clean of dust and foreign material. Scraping and brooming may be necessary.

b. Spread the slurry leveling mixture in depressions at and adjacent to cracks in the pavement. Spread to the full width of the depression. Level the slurry with a metal lute of the proper width to provide a smooth riding surface. Ensure the slurry leveling is neat in appearance. Do not allow spillage around and between leveled areas. Keep excess material at the pavement edge to a minimum. Scatter excess material across the adjacent shoulder.

c. Allow the slurry leveling to cure until such time as the area may be open to traffic without pick-up or raveling of the leveling mixture.

d. Ensure the cured slurry has a homogeneous appearance and a uniform texture, fills all cracks in the application area, and adheres to the surface.

H. Limitations.

1. Schedule slurry placement to ensure the traffic lanes are opened to traffic 30 minutes before sundown of the same working day. When traffic is maintained, keep the entire roadbed free of construction equipment during non-working hours.

2. Work will not be permitted on days described in Article 1108.03.

3. Do not place slurry mixture when the temperature on a shaded portion of the road is less than 50°F (10°C). Do not place slurry mixture after October 1 without written permission from the Engineer.

4. When this work is done in conjunction with crack cleaning and filling, clean and fill cracks before performing slurry work. The application of slurry and the crack cleaning and filling activity may be done as one coordinated operation.

5. When placing a strip slurry treatment, both edges of the slurry box must run on the pavement surface. Replace all pavement markings the day they are obliterated. Payment for pavement markings will be at contract unit price for this work.

6. When the installation of strip slurry treatment is required at a pavement centerline or lane line, the Engineer may require such placement in two separate applications.

7. When performing slurry wedge placement, one edge of the slurry box must run on the edge of the pavement surface. Do not allow this work to obliterate the pavement edge line. Replace all obliterated pavement markings the day they are obliterated and at no additional cost to the Contracting Authority.

I. Maintenance of Traffic.

1. Maintain Traffic Control according to the contract documents.

2. Repair damage to uncured slurry due to traffic at no additional cost to the Contracting Authority.

2319.04 METHOD OF MEASUREMENT.

Measurement will be as described below. Materials used for calibration purposes will be included in quantities measured for payment. These amounts are not to exceed 5 tons (5 Mg) of aggregate and 100 gallons (400 L) of asphalt emulsion.

A. Slurry Leveling.

Computed from the number of centerline miles (kilometers), measured to the nearest 0.1 mile (0.1 km), of slurry leveling based on the two-lane pavement width which exists in the limits of the work area. Application of slurry leveling work to auxiliary lanes within the limits of the project will not be measured for payment.

B. Slurry Wedge.

1. Slurry Wedge Aggregate.

a. Tons (megagrams) of the type specified, measured to the nearest 0.1 ton (0.1 Mg), will be the quantity by weight (mass) of individual loads of aggregate used in accepted portions of the work.

b. Deduction will not be made for moisture naturally occurring in the aggregate.

c. The quantity of mineral filler will be included with the aggregate quantity.

2. Surface Preparation for Slurry Wedge.

Shoulder miles (kilometers) measured to the nearest 0.1 mile (0.1 km).

C. Strip Slurry Treatment.

1. Aggregate for Strip Slurry Treatment.

a. Tons (megagrams) of the type specified, measured to the nearest 0.1 ton (0.1 Mg), will be the quantity by weight (mass) of individual loads of aggregate used in accepted portions of the work.

b. Deduction will not be made for moisture naturally occurring in the aggregate.

c. The quantity of mineral filler will be included with the aggregate quantity.

2. Surface Preparation for Strip Slurry Treatment.

Miles (kilometers) placed.

D. Asphalt Emulsion for Slurry Leveling, Slurry Wedge, and Slurry Treatment.

1. Gallons (liters). This volume will be computed using a calibrated tank stick or by the weight (mass) of asphalt emulsion used.

2. No deduction will be made for water in approved emulsion.

3. The gallons (liters) will be corrected for temperature to 60°F (16°C).

E. Tack Coat for Slurry Wedge and Strip Slurry Treatment.
The undiluted asphalt emulsion used for tack coat is incidental to asphalt emulsion, and will not be measured separately for payment.

2319.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Slurry Leveling.

1. Per mile (kilometer).

2. Payment is full compensation for furnishing all the materials for the slurry mixture except the asphalt emulsion. It includes surface preparation, mixing, placing the mixture, and furnishing all equipment, tools, and labor.

B. Slurry Wedge.

1. Slurry Wedge Aggregate.
a. Per ton (megagram) of aggregate of the type specified used measured as provided above.
b. Payment is full compensation for furnishing all materials except the asphalt emulsion and tack coat. It includes all equipment and labor necessary to mix and apply the slurry.

2. Surface Preparation for Slurry Wedge.
Per mile (kilometer) for the number of miles (kilometers) of surface preparation satisfactorily completed.

C. Strip Slurry Treatment.

1. Aggregate for Strip Slurry Treatment.
a. Per ton (megagram) of aggregate of the type specified used measured as provided above.
b. Payment is full compensation for furnishing all materials except asphalt emulsion and tack coat. It includes all equipment and labor necessary to mix and apply the slurry.

2. Surface Preparation for Strip Slurry Treatment.
Per mile (kilometer) for the number of miles (kilometers) of surface preparation satisfactorily completed.

D. Asphalt Emulsion for Slurry Leveling, Slurry Wedge, and Slurry Treatment.

1. Per gallon (liter) for the number of gallons (liters) of asphalt emulsion used, measured as provided above.

2. Payment is full compensation for furnishing the asphalt emulsion.

E. Tack Coat for Slurry Wedge and Strip Slurry Treatment.
The undiluted asphalt emulsion used for tack coat is incidental to asphalt emulsion and the cost is to be included in the contract unit price for asphalt emulsion.

DIVISION 24. STRUCTURES

This work consists of constructing various types of wood, steel, or concrete structures for bridges, viaducts, grade separations, retaining walls culverts, or other structures, according to the contract documents and requirements for the respective types in the sections listed below. Clearing and grubbing, channel change, and revetment will be constructed, measured, and paid for as provided in Sections 2101, 2104, and 2507, respectively.

For work involved in Division 24, use equipment complying with the appropriate part of Division 20 and as further provided in the particular section.

After completing projects involving work of any section of Division 24, place all portions of right-of-way disturbed by the Contractor's operations in acceptable condition. Apply Article 1104.08.

2401. Removal of Existing Structures.
2402. Excavation for Structures.
2403. Structural Concrete.
2404. Reinforcement.
2405. Foundations and Substructures.
2406. Concrete Structures.
2407. Precast and Prestressed Concrete Bridge Units.
2408. Steel Structures.
2409. Timber Structures.
2410. Plank Decks.
2411. Laminated Wood Decks.
2412. Concrete Bridge Decks.
2413. Bridge Deck Surfacing, Repair, and Overlay.
2414. Railings.
2415. Concrete Box, Arch, and Circular Culverts.
2416. Rigid Pipe Culverts.
2417. Corrugated Culverts.
2420. Structural Plate Pipes, Pipe Arches, and Arches.
2422. Unclassified Pipe Culverts.
2423. Support Structures for Highway Signs, Luminaires, and Traffic Signals.
2424. Shotcrete.
2425. Precast Prestressed Concrete Deck Panels.
2426. Structural Concrete Repair.
2427. Bridge Cleaning.
2428. Smoothness of Bridge Decks and Bridge Deck Overlays.
2429. Pre-Engineered Steel Truss Recreational Trail Bridge.
2430. Modular Block Retaining Wall.
2431. Segmental Retaining Wall.
2432. Mechanically Stabilized Earth (MSE) Retaining Wall.
2433. Concrete Drilled Shaft.
2434. Disc Bearing Assembly.
2435. Sanitary and Storm Sewer Structures.

Section 2401. Removal of Existing Structures

2401.01 DESCRIPTION.

A. Remove all portions of an existing structure from the project, except the portions that may be required or permitted to be left in place.

B. Unless provided otherwise, all structures or parts of structures to be removed become the Contractor's property.

2401.02 MATERIALS.

None.

2401.03 CONSTRUCTION.

A. Notification for Complete Removal of Bridges.

1. Notify the Iowa DNR by mail and the Engineer, with the "Notification of Demolition" form, no less than 10 business days prior to the start of bridge demolition.

2. If unable to begin work on the original intended start date, notify the Iowa DNR and the Engineer, by sending a revised "Notification of Demolition" form, of the new intended start date. Provide notification of the inability to commence work on the intended start date no later than 1 business day prior to the original intended start date. Failure to notify the Engineer of a change in start date 1 business day prior to the original intended start date will result in the need for a new 10 business day notification to the Iowa DNR and the Engineer.

3. The Contracting Authority has inspected the existing bridge for asbestos. Unless otherwise indicated in the contract documents, no asbestos was found, or it has been removed prior to the letting. The Contractor may use this information to complete the "Notification of Demolition" form.

B. Removal of Superstructures.

1. Dismantle and remove steel structures which may be re-erected in new locations in a manner that will avoid damage to any of the members.
   a. Separate members at field connections.
   b. Clearly and neatly match mark all members of trusses with white paint before dismantling. Similarly mark all pins, nuts, loose plates, and so on to indicate their proper location in the structure.
   c. Clean and coat all pins, pin holes, and machined surfaces with waterproof National Lubricating Grease Institute, No. 3 multipurpose grease, or an approved equal.
   d. Wire all loose parts to adjacent members or pack in suitable containers.

2. Concrete superstructures which are to be completely removed may be removed by any means consistent with regulations regarding safety and protection of adjacent property. Complete all operations which might endanger new work before constructing the new structure.

C. Removal of Substructures.

1. Remove substructures of existing structures to 1 foot (0.3 m) below natural stream bottom, unless otherwise provided or ordered. Remove those parts outside the stream to 1 foot (0.3 m) below natural ground surface. Where these portions of existing structures lie wholly or in part within limits for a new structure, remove as necessary to accommodate construction of the proposed structure.

2. Prior to placing new work, complete blasting or other operations which are necessary for removal of an existing structure or obstruction and which may damage new construction.

D. Remodeling of Structures.

1. On remodeling projects, match mark steel superstructure parts that are to be removed and reused. Store as designated in the contract documents. Dismantle and handle in such a way to not impair strength or usefulness of the material.

2. When contract documents require removal of existing concrete, carefully and accurately remove to lines indicated. Do not damage adjacent concrete, exposed reinforcing, or structural steel which the contract documents require to be incorporated into the remodeled structure. Saw match lines 3/4 inch (20 mm) deep where concrete floors are to be partially removed. This depth may require adjustment to ensure that the existing reinforcing steel is not damaged.

3. Demolition by impact methods with wrecking ball, pile hammer, and so on, or by explosives will be permitted only when superstructures are designated in the contract documents as unfit for re-erection. Apply Article 2403.03, I, when bonding new and old work. Do not use explosives for removing a part of a structure to which an addition is to be made, except in the case of massive sections and only with the Engineer's written permission. When explosives have been used, remove the concrete for at least 6 inches (150 mm) beyond the point of visible damage using methods that will not damage the concrete that is to remain.

E. Removal of Steel.

1. Store structural steel members specified to remain the Contracting Authority's property in neat piles at locations specified in the contract

documents or within the right-of-way in the vicinity of the work at points the Engineer designates.

2. Neatly store members of structures which are to be re-erected on skids above the surface of the ground.

3. When the contract documents specify that the removed steel is to become the Contractor's property, the contract documents will show an indication of total lead and total chromium in the existing paint system.

F. Removal of Concrete and Masonry.
Unless otherwise provided, concrete and masonry removed from old structures will become property of the Contractor. Remove according to Article 1104.08.

G. Lumber.

1. If designated for salvage, remove lumber from structures by methods which preserves its usefulness. Remove nails, spikes, bolts, and other hardware from lumber, and pile the lumber in neat piles at locations designated by the Engineer.

2. If not designated for salvage, lumber becomes the Contractor's property. Remove according to Article 1104.08.

H. Other Structures.

1. Remove pipe culverts and other small structures which are designated in the contract documents as suitable for salvage using methods which preserves their usefulness. Store these items nearby within the right-of-way.

2. If not so designated, these materials become the Contractor's property. Remove from the site.

I. Part or All of an Old Structure Lying Outside New Construction Limits.
Unless otherwise specified, for any excavation below finished grade line for the purpose of removing the old structure, place suitable earth backfill material to the original level or to the finished grade line (whichever is the lower) according to Article 2402.03, H.

2401.04 METHOD OF MEASUREMENT.

Lump sum. No method of measurement.

2401.05 BASIS OF PAYMENT.

A. When the contract includes an item for Removal of Existing Structures, payment will be the Lump Sum contract price. When provisions in the contract documents do not cover payment for removal of a structure, including encased culvert pipe, footings, or other unforeseen obstacles to be removed, payment for their removal will include placement of backfill

material made necessary by their removal. This payment will be as provided in Article 1109.03, B.

B. The payment for removal of an existing structure is full compensation for:
- Furnishing all material, equipment, and labor and for performance of all work necessary for removal of the old structure from the project, and
- Placement of backfill material made necessary by these operations, and
- If the existing structure will become the property of the Contracting Authority, payment for proper storage, salvage, and delivery of the structure shall be according to Section 2555.

Section 2402. Excavation for Structures

2402.01 DESCRIPTION.

A. Remove all material necessary for construction of the work included in the contract, in conformity with the contract documents.

B. Furnish, place, and remove all cofferdams, shoring, and bracing.

C. Remove all surplus material.

D. Sounding and test boring data shown in the contract documents were accumulated for design and estimating purposes. Their appearance in the contract documents does not constitute a guarantee that conditions other than those indicated will not be encountered in the excavation or in material penetrated by piling.

2402.02 MATERIALS.
As required in Article 2402.03.

2402.03 CONSTRUCTION.
Provide a safe slope for construction in the conditions encountered.

A. Clearing and Grubbing.

1. Remove all trees, stumps, and brush existing on the site of the work which shall be removed for completion of the work. As part of the contract for a structure, the Engineer may order trees and stumps which are near, but not on, the site of the work to be removed, if:
- Their presence will interfere with completion of adjacent parts of the improvement of which the structure is a part, and
- Their later removal by usual methods would endanger the structure.

2. No blasting within 50 feet (15 m) of any completed part of the structure.

3. Refer to Section 2101 for the work and payment for clearing and grubbing.

B. Elevations and Dimensions of Footings.
Under normal construction conditions, construct footings to elevations shown in the contract documents. The Engineer may order, in writing, changes necessary in dimensions or elevations of footings to secure a satisfactory foundation.

C. Treatment of Foundations.

1. If a footing on rock is specified, perform excavation in a manner to allow the rock to be exposed and prepared according to Article 2405.03, C. If the footing shall rest on firm earth, take special care not to disturb the bottom of the excavation. If the footing excavation bottom is wet, wait until just before placing the footing to complete final finishing.

2. Control drainage in the foundation area to reduce moisture and mud problems to a practical minimum. Prepare and maintain the area in an acceptable condition prior to and during placement of concrete. The Engineer may require improved drainage, removal of mud, filling with suitable material, or other procedures to obtain a reasonably suitable condition in the area. This requirement is not to be construed as an order for foundation treatment material or as a basis for extra compensation.

3. If the foundation material is unsuitable, the Engineer may direct that the foundation be over excavated and backfill consisting of granular surfacing materials approved by the Engineer be placed. Place backfill material according to Article 2402.03, H.

D. Construction of Cofferdams.
Construct cofferdams according to Article 2405.03, A.

E. Removal of Cofferdams.
Unless shown otherwise in the contract documents, remove cofferdams, sheeting, and bracing.

F. Inspection of Excavation.

1. After each excavation is completed, notify the Engineer, who will inspect the depth of excavation and character of foundation material.

2. Do not place concrete until after the Engineer has approved the depth of excavation and character of foundation material.

3. The Contracting Authority will be responsible for delays caused by failure to make inspection within 24 hours after the Contractor has given notice to the Engineer.

G. Removal of Excavated Material.

1. Use all material excavated for bridge and culvert work suitable for placing backfill material or foreslope construction for that purpose. If

material is unsuitable due to excessive moisture, dry it prior to placement.

2. Do not use unsuitable material for either placing backfill materials or in approach fills. Remove excess material from the project according to Article 1104.08.

H. Placing Backfill Materials.

1. Place backfill material next to completed structures according to the following provisions or according to Section 2506. Use excavated material when flowable mortar or granular backfill material is not specified in the contract documents. Place backfill to natural ground line unless there is an inadequate quantity of suitable excavated material. If there is an inadequate quantity of suitable excavated material, continue placing backfill until the suitable material is depleted.

2. Use backfill material free from organic material, boulders, or broken concrete over 8 inches (200 mm) in the greatest dimension; or frozen material.

3. Ensure moisture content for soil is suitable for compaction at the time it is placed for backfill material. When compaction with moisture control is required by the contract documents, increase or reduce the moisture content in backfill material, as necessary, to bring the moisture within the designated moisture limits prior to and during placement and compaction.

4. When granular backfill material is specified, use backfill material meeting the requirements of Section 4133. When the volume of material excavated exceeds that of backfill material required by the contract documents, increase the quantity of granular backfill material furnished to provide backfill material for the excess volume of excavation. Place granular backfill material in layers no more than 8 inches (200 mm) thick. Thoroughly tamp or vibrate each layer to insure compaction. The Engineer may require granular backfill material to be moistened with water while being placed.

5. Except as provided in Article 2403.03, N, allow at least 14 calendar days to elapse after concrete has been placed before placing backfill material against:

- Concrete culverts, abutments, piers, arches, and wingwalls, or
- Timber abutments or wingwalls which depend on cast-in-place concrete anchors.

6. Do not place backfill material against timber abutments or wingwalls until all required anchor rods are in place and ready to function. Do not place backfill material against timber abutment or wingwall designed to

gain support from a superstructure until the superstructure is in place and permanently fastened to the substructure.

7. Backfill material may be placed in water only when removal of water from the area in which backfill material is to be placed is impractical, for example:

- Around piers or abutments located within the waterway, or
- In other deep excavations where removal of cofferdams is required before placing backfill material, and such removal prevents dewatering.

8. Backfill material placed in water need not be consolidated. Use granular backfill material when placing material under water and over which an embankment is to be placed.

9. When placing backfill material above the water line, place it in layers no more than 8 inches (200 mm) in loose thickness. Thoroughly compact each layer material before the next layer is placed. Except as noted below, accomplish all compaction by rolling with an approved roller or by tamping with a mechanical tamper. Operate pneumatic tampers according to the manufacturer's recommendations.

10. Place backfill material in layers no more than 8 inches (200 mm) in loose thickness when moisture control is required by the contract documents. Level and thoroughly compact each layer before the next layer is placed. Use a tamping type roller described in Article 2001.05, A. Compact at no less than one roller passage per inch (25 mm) of loose thickness. In areas inaccessible to the roller, use a mechanical tamper described in Article 2001.04 for each layer. Excavate to a width to accommodate the roller to be used and provide a reasonably level area for the roller operation for the first and all subsequent layers.

11. Where backfill material is required on both sides of a concrete wall, abutment, or other monolithic structure, fill on both sides of the structure simultaneously so that the two fills are kept at approximately the same elevation at all times. For the purposes of this paragraph, consider concrete boxes, arches, and circular culverts and rigid frame bridges, except wingwalls, to be monolithic structures.

12. Where backfill material is to be placed on one side only of retaining walls, or wingwalls of culverts 8 feet (2.5 m) high or more, do not perform rolling operations within 3 feet (1 m) of the wall face. Compact the 3 feet (1 m) closest to these walls or wing faces using pneumatic or hand tampers only.

13. Remove material excavated for concrete culvert construction as provided in Article 2402.03, G, and within 7 working days after concrete can be subjected to flexural stresses as provided in Article 2403.03, N, 2. Prepare the site for placing the adjacent embankment. The Engineer may extend the time period for removing excavated material if the extension will not interfere with work of others or the public. For culvert

extensions on roads open to traffic, complete backfill material placement to the top of the culvert within 14 working days after the curing period has expired.

I. Embankments Adjacent to Bridges, Culverts, or Structures.
Apply Article 2107.03, O, when the contract requires construction of an embankment adjacent to a bridge, culvert, or other structure unless the contract documents require the placement of flowable mortar according to Section 2506.

J. Classification of Excavation.
Excavation for structures will be classified as Class 20, Class 21, Class 22, Class 23, or Class 24, as follows:

1. Class 20 Excavation.
Includes excavation for bridges above the excavation classification line shown in the contract documents and not classified as Class 22 excavation. Also includes all excavation for culverts not classified as Class 22, 23, or 24 excavation. None of the excavation for culverts is to be classified as Class 21 excavation.

2. Class 21 Excavation.
Includes excavation for bridges below the excavation classification line shown in the contract documents and not classified as Class 22 excavation.

3. Class 22 Excavation
Includes the measured volume of granite, trap, quartzite, chert, limestone, sandstone, hard shale, or slate in natural ledges. Also includes the estimated or measured volume of rock fragments or boulders having a volume of 1 cubic foot (0.03 m^3) or greater.

4. Class 23 Excavation.
Includes excavation included in the definitions of Classes 20, 21, and 22 and any other material encountered regardless of its nature, except for removal of old structures or parts of structures.

5. Class 24 Excavation.
Includes the additional excavation necessary to provide material for backfills, approach fills, berms, or a roadway over the structure when material resulting from other classes of excavation for the structure is of insufficient quantity or of unsatisfactory quality for these purposes.

2402.04 METHOD OF MEASUREMENT.

A. General.

1. If a single contract involves both channel excavation and excavation for structures, excavation included within the volume limits of channel

excavation, as shown in the contract documents, will not be included in measurement of excavation for structures.

2. Excavation for structures to the limits indicated in this article is for pay quantities only.

3. Quantities of Class 20, 22, 23, and 24 excavation will be measured in cubic yards (cubic meters) by the cross section method or other appropriate method. Boulders may be measured after excavation. Class 21 excavation will be computed in cubic yards (cubic meters) within the boundaries specified and from data shown in the contract documents.

4. When the location of part or all of an existing structure scheduled to be removed falls within the planes describing the excavation volume for either structures or culverts (Article 2402.04, B and C), the volumes of excavation performed for payment on the new structure will include any volume of excavation performed as part of the removal of the existing structure which is:

- Above the elevation of the bottom of footings, and
- Within the excavation limits described below.

5. All other excavation performed in conjunction with removal of structures will be considered incidental to removal. Additional payment will not be made. Reduction in excavation quantity will not be made for portions of existing structures removed from the excavation limits of new structures.

B. Excavation for Structures.

1. The quantity of Class 21 excavation measured, unless modified in Article 2402.05, will be shown in the contract documents.

2. For other classes of excavation, the quantity measured for payment will be that actually removed except as provided in this article for culverts. Unless required by the contract documents or ordered by the Engineer, measurement will not be made of material removed outside areas bounded by vertical planes parallel to the boundaries of the structure or part of structure and located as follows:

a. For concrete structures and parts of structures without footings, 36 inches (1 m) outside the horizontal projection of the structure.
b. For concrete structures with footings, 36 inches (1 m) outside the footings.
c. For timber abutments and wingwalls, 24 inches (0.6 m) behind the backing plank.
d. For anchor rods, 12 inches (0.3 m) on each side of the rod.
e. For buried anchors, the face of the buried anchor on one side and 24 inches (0.6 m) outside the buried anchor on the other face.

3. For roadway pipe culverts, the amount of excavation measured for payment will be computed from an excavation centered on the center line of the pipe, to the required depth, length, and a width of 42 inches (1 m) plus the specified diameter of the pipe in inches (millimeters). The

vertical plane as described above will be changed to a 1:1 slope from the bottom of the excavation sloping away from the structure. When the 1:1 slope is used, it is to extend the length of the structure unless indicated otherwise in the contract documents. This does not apply to culvert extensions unless indicated in the contract documents. Modification will not be made in the quantity shown in the contract documents for variations in wall thickness of the pipe. Modification will be made for changes in location or flow line as provided in this section.

4. For cast-in-place culverts the amount of excavation measured for payment will be computed from an excavation centered on the center line of the culvert, to the required depth, length, and a width 2 feet (0.6 m) greater than the width of the footing. The vertical plane as described above will be changed to a 1:1 slope from the bottom of the excavation sloping away from the structure. When the 1:1 slope is used, it will extend the length of the structure unless otherwise indicated in the contract documents. This does not apply to culvert extensions unless indicated in the contract documents. Modification will be made for changes in location or flow line as provided in this section.

5. When moisture control is required by the contract documents, the amount of excavation measured for payment will be computed for an excavation to the required depth and length and a width extending 6 feet (2 m) beyond the limits of the structure.

6. The Engineer may require a 48 hour notice prior to beginning excavation so necessary measurements of the existing ground may be made. Payment will not be made for material removed before these measurements are made.

7. In the case of two or more footings supporting a pier or similar structure which is continuous between footings at any elevation below the excavation classification line, the planes described above will be located as if the footings were continuous and of the width of the footings to be built.

8. When the quantity of Class 20 excavation is based on the assumption that prior Class 10 excavation by a grading contractor will be made, the depth of Class 20 excavation, if removed by the bridge contractor, will be increased by the depth of Class 10 excavation (grading) not completed prior to commencement of the Class 20 excavation, if the Class 10 excavation is not in actual progress or completed by the starting date of the bridge contract. This increase will not apply if the projects involving Class 10 (grading) and Class 20 (bridge) excavation are part of the same contract.

9. The estimated quantities of excavation are computed from data available when plans are prepared. Unless contract quantities are agreed to, estimated quantities are not to be used as the measured

quantity, except for Class 21 excavation and as specified below for culvert excavation.

C. Excavation for Culverts.

1. When a culvert is built without a change in location, dimensions, or elevation, the quantities of Class 24 and Class 20 or Class 23 excavation as shown in the contract documents will be the quantity for which payment is made.

2. When the location, width, length, or flow line elevation of a culvert has been changed from that specified in the contract documents, the quantities of excavation will be measured by the Engineer as indicated above.

D. Embankments.

1. Construction of embankments adjacent to bridges, culverts, or structures will not be measured for payment, but will be considered incidental to the type of excavation specified.

2. Materials removed from old fills or embankment for the convenience of the Contractor to facilitate use of rolling or hauling equipment will not be measured for payment.

E. Granular Backfill.

1. The quantity of granular backfill material shown in the contract documents will be the quantity for which payment is made.

2. Granular backfill material required and furnished for structural concrete placement at bridge abutments will not be measured separately for payment.

F. Foundation Treatment Material.

1. The Engineer will compute the quantity of excavation for foundation treatment material measured for payment in cubic yards (cubic meters).

2. Foundation treatment material not ordered placed by the Engineer or quantities in excess of the quantity ordered placed by the Engineer will not be measured for payment.

G. Compaction with Moisture Control (Structures).
Compaction with moisture control (structures) will be the number of cubic yards (cubic meters) of backfill material placement or embankment, or both, placed with moisture control, as required, regardless of the class of excavation.

H. Flowable Mortar.
When flowable mortar is specified in the contract documents, it will be measured as specified in Section 2506.

2402.05 BASIS OF PAYMENT.

A. General.

1. Payment for the quantities of Class 20, Class 21, Class 22, Class 23, and Class 24 excavation, measured as provided above, will be the contract unit prices per cubic yard (cubic meter) except as provided in the following Paragraphs B, C, D, and E.

2. Payments in all cases are full compensation for:
- Removing, transporting, and cleaning up all excavated material as provided above,
- Pumping,
- Placing and removing all cofferdams except as provided in Article 2402.05, B and C,
- Shoring and bracing,
- Placing and consolidation of backfill material, including granular backfill material and foundation treatment material, and
- Leveling and shaping abutment berms to the elevation and dimensions shown in the contract documents.

3. When the contract documents do not provide for payment for removal of old structures or parts of structures, this removal is considered as extra work and payment will be as provided in Article 1109.03, B.

4. Payment for dressing of slopes outside the area of the structure not disturbed by the Contractor's operations will be as provided in Article 1109.03, B.

B. Extra Depth Excavation for Structures Other than Culverts.

1. Upon written order of the Engineer, excavate for footings to depths below those shown in the contract documents. When the extra depth of excavation does not exceed 6 feet (1.8 m), payment will be made for extra depth at percentages shown in Table 2402.05-1 of the contract unit price for the excavation to the footing elevation shown in the contract documents.

Table 2402.05-1: Percentages for Payment for Extra Depth

Depth	Excavation Above Classification Line	Excavation Below Classification Line
First foot (0 to 0.3 m)	100%	100%
Second foot (0.31 m to 0.60 m)	120%	140%
Third foot (0.61 m to 0.9 m)	130%	160%
Fourth foot (0.91 m to 1.2 m)	140%	180%
Fifth foot (1.21 m to 1.50 m)	150%	200%
Sixth foot (1.51 m to 1.80 m)	160%	220%
Note: If the bridge plans fail to show an excavation line, low water elevation as shown in the contract documents is to be considered as the excavation classification line for the above purpose.		

2. When the extra depth excavation exceeds 6 feet (1.8 m), all excavation below the elevation of the bottom of the footing, as shown in the contract documents, payment will be as extra work as provided in Article 1109.03, B.

3. When the extra depth excavation necessitates removal and reconstruction of a cofferdam which complied with Article 2405.03, A, the cost of removal of the old cofferdam and construction of the new one will be paid for as provided in Article 1109.03, B.

C. Excavation for Changes in Horizontal Dimensions of Footings.
On written order of the Engineer, construct footings having horizontal dimensions other than those shown in the contract documents. When such a change necessitates removal and reconstruction of a cofferdam which complies fully with the requirements of Article 2405.03, A, the cost of removal of the old cofferdam and construction of the new ones will be paid for as provided in Article 1109.03, B. Payment for excavation will be made at the same unit prices as if there had been no change in dimensions of the footings.

D. Overhaul.

1. Material from classes of excavation other than Class 24 will ordinarily be deposited within 200 feet (60 m) from the point of excavation as directed by the Engineer. Payment for overhaul beyond the free haul limit of 200 feet (60 m) will be as provided in Article 1109.03, B.

2. Payment for overhaul on Class 24 excavation will be as provided in Section 2108, except the free haul limit will be 500 feet (150 m).

E. Unexpected Rock Excavation.

1. When the contract documents provide unit prices for Class 20 and Class 21 excavation, but do not provide a price for Class 22 excavation,

payment for any material required to be excavated which conforms to the definitions for Class 22 excavation will be at 3.5 times the contract unit price for the class of excavation in which it is encountered, subject to the provisions for extra depth as provided in Article 2402.05, B.

2. When the contract provides a unit price for Class 23 excavation only, payment will not be made for unexpected rock.

F. Foundation Treatment Material.
Payment for foundation treatment material furnished according to Article 2402.03, C, will be at the Contractor's unit delivered cost ton (Mg) plus the applicable contract unit price per cubic yard (Mg) for the class of excavation performed.

G. Granular Backfill.
Payment for granular backfill material will be at the contract unit price per cubic yard or ton (cubic meter or megagram). The cost of granular backfill material required and furnished for structural concrete placement at bridge abutments is included in the contract unit price for the structural concrete.

H. Compaction with Moisture Control (Structures).
Payment for the quantity of backfill material or embankment, or both, placed with moisture control, will be the contract unit price per cubic yard (cubic meter).

I. Flowable Mortar.
When flowable mortar is specified in the contract documents, payment will be according to Section 2506.

Section 2403. Structural Concrete

2403.01 DESCRIPTION.
Portland Cement Concrete used for constructing bridges and other structures. For PCC Pavement, refer to Section 2301.

2403.02 MATERIALS.

A. General.

1. Meet the requirements for the respective items in Division 41.

2. Unless otherwise specified, use Class 2 durability coarse aggregate, or better, as defined in Section 4115.

3. Unless otherwise specified, use the following:
- **a.** Class BR or Class C concrete for bridge barrier rails.
- **b.** Class X concrete for seal courses.
- **c.** Class C concrete for all other structural concrete, including concrete for bridge curbs, bridge medians, and bridge sidewalks.

Refer to Article 2412.02 for concrete used for one course bridge floors and the first course of two course bridge floors.

B. Proportions.

1. General.

a. Materials for structural concrete may be mixed in proportions for any of the mixes allowed for the class of concrete specified in the contract documents and the current Materials I.M. 529, provided the gradation of each aggregate conforms to the gradation required for that proportion.

b. The contract documents will indicate where each class shall be used and the approximate quantities of each class.

c. Class D or Class M mixtures may be substituted for Class C proportions, except in bridge floors.

2. Water and Consistency.

a. Place with a slump between 1 and 3 inches (25 and 75 mm) as a target range, allowing a maximum of 4 inches (100 mm) as a tolerance.

b. If the characteristics of the materials used are such that the total quantity of water used (including free water in aggregate) to secure the required consistency reduces, by more than 2%, the batch volume computed on the basis of absolute volumes of the batch quantities used, the proportions may be adjusted accordingly.

c. If the characteristics of the materials used are so that the required consistency is not secured within the specified maximum water content, increase the proportions of cement to aggregate as necessary to secure the required consistency within the specified maximum water content. Additional cement will be considered as incidental, and no additional payment will be allowed. Free moisture in the aggregate plus the total mixing water shall not exceed that shown in Table 2403.03-1.

Table 2403.03-1: Mixing Water and Free Moisture

Class of Concrete	Pounds (kg) of Water per Pound (kg) of Cementitious Material
C Separated Aggregate	0.488
X Separated Aggregate	0.444
C with Class V Aggregate	0.444
X with Class V Aggregate	0.422
D57	0.437

3. Entrained Air Content.

Use an approved air entraining agent complying with Section 4103 to accomplish air entrainment. Air content will be tested according to Materials I.M. 318. The intended air entrainment is 6%. To allow for loss during placement, use a target value of 6.5%, with a maximum variation

of -1.0% and +1.5%, for the air content of fresh, unvibrated structural concrete.

4. Other Admixtures.

a. Other approved admixtures may be used with the Engineer's approval.

b. Approved retarding admixture complying with Section 4103 may be required by the contract documents or by the Engineer. Add the retarding admixture in amounts recommended by the manufacturer for conditions which prevail on the project and as approved by the Engineer. When used, introduce it into the mixer after all other ingredients are in the mixer. The Engineer may approve other procedures.

c. Ensure retarding admixtures are compatible with the air entraining agent used. Previous experience, satisfactory to the Engineer, will be required to indicate the approximate adjustments necessary by the addition of the admixture and compatibility with other materials to be used. Agitate the retarding admixture prior to and during its use.

d. Calcium chloride will not be allowed where reinforcing steel is used.

5. Use of Fly Ash and GGBFS.

The Contractor may use fly ash or GGBFS as a substitute for a portion of the Portland cement in structural concrete. Use fly ash and GGBFS meeting the requirements of Section 4108. The maximum allowable substitution rates are 20% for fly ash and 35% for GGBFS with a maximum total mineral admixture substitution rate of 50%.

C. Proportions for Lightweight Structural Concrete.

When lightweight concrete is specified, the aggregate quality, proportions, mixture characteristics, and controls will be included in the contract documents.

D. Proportioning and Mixing of Concrete.

Apply the respective paragraphs of Article 2301.02, C, to storage and handling of cement, fly ash, aggregates, measurement of materials, and ready mixed concrete, except for the truck dumping area required in Article 2301.02, C, 1, c.

1. Mixing of Materials.

Thoroughly mix materials in an approved mixer at the site of placement or by an approved ready mix plant. The Engineer may withhold approval for using ready mixed concrete from any plant with a previous record of unsatisfactory performance.

2. Concrete Mixed on the Site.

a. When using approved mixers at the site of placement, mix materials according to the specific requirements for the equipment used. Use a mixing capacity so that finishing operations can

proceed at a steady pace with final finishing completed before concrete starts its initial set.

b. Ensure concrete discharged from the mixer is uniform in composition and consistency. Thoroughly discharge each batch of concrete from the mixer before the next batch is introduced. Thoroughly clean and flush the mixer upon cessation of mixing for any considerable length of time.

3. Heating Aggregates.
When aggregates are heated, heat and handle them to avoid damage by overheating and to ensure uniform moisture content of aggregate entering the mixer. Aggregates may be heated by steam pipes or coils through aggregate piles. Do not heat aggregates by direct, dry heat unless they are mechanically agitated during the heating process.

2403.03 CONSTRUCTION.

A. Equipment General.
Use equipment meeting the requirements of Section 2001 and the following:

1. Weighing and Proportioning Equipment.
Apply Article 2001.20.

2. Mixing Equipment.
Apply Article 2001.21.

3. Bins.
Apply Article 2001.06.

B. Placing and Finishing Equipment.
Use equipment complying with the following requirements:

1. Above Water or Dry Placement Equipment.

a. Tremies.
When required, use a tremie to deposit concrete in the dry. Use a tremie that:

- Is no more than 12 inches (300 mm) in diameter,
- Has no aluminum parts in contact with the concrete, and
- Is of sufficient length to extend to the bottom of the placement area.

b. Chutes.
Use chutes for depositing concrete that are constructed of metal or have a metal lining, and:

- Have no aluminum in contact with the concrete,
- Are of sufficient length for the delivery point to be as close as possible to the point of deposit, and
- Provide a slope to allow the concrete to flow slowly without segregation.

2. Underwater Placement Equipment.

a. Place concrete under water using a tremie, pump, or other equipment which meets the Engineer's approval.

b. Use a tremie that:

- Is constructed to be water tight and readily discharge concrete,
- Is no more than 12 inches (300 mm) in diameter,
- Has no aluminum parts in contact with concrete,
- Has the discharge end constructed to prevent water intrusion and permit free flow of concrete during placement operations, and
- Is of sufficient weight (mass) and length to rest on the bottom of the placement area prior to start of concrete placement.

c. Support the tremie so that it can be raised or lowered to increase or reduce the discharge of concrete.

3. Consolidation.

a. Use vibrating units to vibrate all concrete for box and arch culverts, bridge substructures, bridge decks, and bridge deck overlays. Operate all vibrators at speeds no less than 3500 vibrations per minute.

b. Furnish adequate vibration equipment to avoid delays due to breakdown.

c. Use a sufficient number of vibrating units to properly consolidate the concrete placed.

d. Use vibrator heads covered with rubber or other resilient material approved for consolidation when consolidating concrete reinforced with epoxy coated bars.

4. Heating and Protection Equipment.

Meet the following requirements whenever heating is done:

a. Equip the attendant with no less than one non-freezing fire extinguisher of adequate capacity.

b. To prevent movement or overturning, adequately support, anchor, and guy any heating equipment involving combustion in or near the space to be heated.

c. Use of a salamander or other type of open flame heating unit is prohibited.

d. Use heating equipment constructed with a shield so that metal in direct contact with the open flame is not exposed.

5. Forms.

a. Use forms that are:

- Metal, surfaced lumber, plywood, masonite, hard pressed composition board, or other approved material backed by suitable studding, walers, and so on, and
- Are free from knotholes, cracks, splits, warps, or other defects which would prevent it from producing the strength, accuracy, and appearance necessary in the finished concrete surface.

b. Construct forms with mortar tight joints. Use material sufficient in strength to hold concrete without bulging between supports.

c. Design forms for strength as specified in Article 2403.03, O. Use metal, plywood, fiberglass, or hard pressed water resistant composition board no less than 3/16 inch (5 mm) thick to line wood forms for all exposed surfaces, except:

- wingwalls parallel to the culvert barrel,
- headwalls, and
- such portions as may be completely covered by a single board.

d. Use forms in good condition. Make joints in the lining mortar tight. Smoothly cut and break joints with the form lumber. Small irregular areas may be formed with lumber against concrete to be rubbed, provided there is no joint in lumber used on any flat surface of concrete except at angles, ribs, bevels, molding, and so on where there is a juncture between two surfaces. Place blocks, ribs, bevels, moldings, and so on for ornamental effect on lined surfaces inside the lining.

e. Design and construct forms so that they may be removed without damage to the concrete. Remove blocks and bracing with the forms. In no case leave any portion of wood forms in the concrete.

f. Construct forms so that the finished concrete is of the form and dimensions shown in the contract documents, and true to line and grade. Fillet forms 3/4 inch (20 mm) at all sharp corners (90 degrees or sharper). Give a draft in the case of all projections, such as girders, copings, and so on, sufficient to insure their easy removal. Ties and bracing shall be sufficient to support the expected load.

g. When forms appear to be insufficiently braced or unsatisfactorily constructed either prior to or during placement of concrete, the Engineer will order the work stopped until defects have been corrected.

h. Coat forms with an approved form release agent prior to the placement of concrete. Thoroughly wet forms with water immediately prior to concrete placement. Thoroughly clean reused forms and ensure they are free of bulges, splits, warps, or bends.

i. Use stay-in-place forms only when specified in the contract documents.

C. Placing Concrete.

1. Place concrete mixed at the site of the work immediately after mixing. Place ready mixed concrete as soon as practical after delivery, but in all cases within the specified time limit for the equipment used for delivery.

2. Place concrete in a manner which will avoid segregation or separation of the ingredients. In placing concrete, observe all the following precautions:

a. In handling concrete from the mixer to the place of deposit, take care to avoid segregation.

b. When concrete is deposited through a chute, slope the chute to allow concrete to flow slowly without segregation. Place the delivery

point of the chute as close as possible to the point of deposit. Keep chutes and spouts clean. Thoroughly flush them with water before and after each run. Discharge the water outside the forms. Do not pump concrete through aluminum conduit or tubing.

c. A tremie is not required when filling steel pipe piles or encasing steel H-piles. Use a tremie whenever the distance through which other concrete must be dropped vertically exceeds 6 feet (2 m). Do not exceed a drop of 3 foot (1 m) for bridge floors and culvert slabs. A tremie is not required for concrete placement of elements which have a maximum dimension no greater than 12 inches (300 mm) provided that Paragraph d below is adhered to and concrete is placed in lifts.

d. Do not deposit concrete in large quantities at a single point, causing it to flow along inside the forms.

e. In depositing concrete, take care to fill the form entirely without bulging the form or disturbing its alignment.

f. Manipulate and vibrate concrete in a manner to bring a thick layer of mortar into contact with forms and reinforcement and to prevent formation of pockets of coarse aggregate.

g. Do not place concrete in flowing water within the area of a footing. Control such flowing water in pipes or trenches outside the forms. In extreme cases, a seal course may be ordered to overcome this difficulty.

h. Protect concrete placed when the air temperature is at or below 40°F (4°C) as provided in Article 2403.03, I.

3. Maintain an adequate supply of water suitable for washing testing equipment at a convenient location, as directed by the Engineer, near the site of concrete placing operations.

4. When concrete is being placed during cold weather, provide an approved, conveniently located shelter (enclosed on at least three sides and covered), suitable for use in performing on the site tests of the concrete being placed. Place the shelter to provide maximum protection from the weather.

D. Vibration of Concrete.

1. Manipulate vibrators through all available space in the mass of concrete, with particular attention to corners and faces of concrete against forms and joints. Use caution to prevent the vibrator from penetrating any portion of previously set concrete.

2. Vibrate each batch of concrete as it is placed in the form to settle and thoroughly consolidate the concrete into close contact with the forms, reinforcement, and previously placed concrete. Discontinue vibration before segregation or localized areas of grout form. Ensure placement and consolidating operations result in concrete that, upon removal of

forms, is smooth and dense and free from all honeycomb or pockets of segregated aggregate.

3. Design forms to withstand effects of vibration without appreciable distortion from the desired shape or position.

E. Protection and Curing of Concrete.

1. Protect concrete which has been placed from external stress between the time it ceases to be plastic and the time it may be stressed, as provided in Article 2403.03, N.

2. Ensure runways for transporting materials over concrete floors less than 7 calendar days old are supported directly over structural members, piers, or abutments so the floor concrete is subjected to compressive stress only.

3. Ensure runways built over portions of formed, but unpoured floors are supported on floor forms or beams.

4. Unless concrete is protected as specified in Article 2403.03, I, protect exposed surfaces, including surfaces from which forms have been removed less than 60 hours after the concrete has been placed, in the following manner for at least 4 calendar days after concrete is placed:

a. Coat the surface immediately after required finishing operations are completed with white pigmented curing compound, meeting requirements of Article 4105.05, applied at a rate of no more than 135 square feet per gallon (3.3 m^2/L).

b. As alternatives, the surfaces may be covered with paper or plastic film, meeting requirements of Section 4106, or the surface may be covered with burlap, straw, or sand kept continuously wet.

5. Do not use white pigmented curing compound on surfaces against which concrete is to be placed or which will receive a sealer. When the Contractor elects to use white pigmented curing compound on any part of an integral unit, the Engineer may require use of the curing compound on adjacent areas of the integral unit so that each pier, abutment, or other surface visible after construction presents a uniform and pleasing appearance.

6. Cure concrete floors as provided in Article 2412.03, E.

7. Cure barrier railing as provided in Article 2414.03, A.

F. Placing and Protection in Cold Weather.

1. Do not place concrete, without notifying the Engineer, when the air temperature is 40°F (4°C) or less.

2. Do not use frozen materials in the concrete.

3. Do not place concrete against frozen forms, earth, or rock or against other concrete having a temperature below 40°F (4°C).

4. In addition to protecting the concrete against chilling or freezing, heat the water or aggregates, or both, so that when placed the concrete will have a temperature appropriate for the mass and dimensions of the portion of the structure being placed, but from 45°F (7°C) or to 80°F (27°C).

5. Before concrete is placed at ambient air temperatures below 40°F (4°C) or when these temperatures might occur during the protection period, provide heating or protecting facilities, or both, meeting requirements of Article 2403.03, B, 4, adequate to protect the work as follows:

- **a.** Maintain the concrete temperature at no less than 50°F (10°C) for the first 48 hours after placing. Then gradually reduce the concrete temperature at a rate not exceeding 25°F (15°C) in 24 hours. When heating and housing is used, locate temperature monitors in the concrete at the furthest and closest point from the heat source. Do not allow the maximum temperature of the monitor point closest to the heat source to exceed 150°F (65°C).
- **b**. In lieu of protection involving housing and heating, the Contractor may protect concrete by the use of forms insulated with a commercial insulating material adequate to maintain the concrete temperature at no less than 50°F (10°C) for the first 48 hours after placing. Leave these insulated forms undisturbed for the next 48 hours, after which they may be removed. When forms are insulated, protect exposed horizontal surfaces with a similar layer of the insulating material or an adequate layer of hay or straw, properly secured.
- **c.** Make suitable provision, including cast-in-wells for thermometers, to provide a means for determining the temperature of the concrete.
- **d.** Whenever heating is done, firmly secure combustible material to prevent contact with any source of heat, and take adequate precautions to prevent fires.
- **e.** If all the concrete is at least 1 foot (0.3 m) below ground water level, it may be placed at a temperature no less than 40°F (4°C) and flooded to a minimum depth of 1 foot (0.3 m) in lieu of other methods of protection and curing. Ensure that concrete cured in this manner is not subjected to freezing temperatures within 10 calendar days after it is placed. In lieu of flooding, culvert footings may be protected from freezing by an adequate layer of straw or hay for at least 5 calendar days.

G. Placing Large Volumes of Concrete.

Whenever the volume is too great to be placed in one continuous operation, subdivide the work as shown in the contract documents or as directed by the Engineer.

H. Bonding Construction Joints.

1. When concrete placement in any section of a structure must be interrupted, locate the construction joint as specified in Article 2403.03, O. Leave the surface of the concrete in horizontal joints rough (except in the area near the form) to increase the bond with concrete that is to be placed later. Finish the top surface of the concrete adjacent to the forms to a horizontal 3/4 inch (20 mm) bevel strip.

2. Embed keyways no less than 1 1/2 inches by 3 inches (35 mm by 75 mm) into the surface of the concrete. Form tapered sections, which would otherwise result in a feather edge, by an insert so that the succeeding layer of concrete will end in a section no less than 6 inches (150 mm) thick. In addition to the key notches in concrete that is not reinforced, set steel dowels no smaller than 3/4 inch (20 mm) around the edge of the section at intervals no greater than 2 feet (0.6 m). Set the dowels to project at least 1 foot (0.3 m) on each side of the joint.

I. Bonding New and Old Work.

1. When new concrete is placed in contact with existing concrete, first thoroughly clean the existing concrete surface of laitance, loose particles of concrete, dirt, or other foreign materials by sandblasting followed by an air blast. Next, place forms against the existing concrete, using care to avoid contamination of the cleaned surface. Finally, place fresh concrete against the clean, dry surface and thoroughly consolidate it to ensure a tight joint and a good bond.

2. Bonding agent may be required as specified in the contract documents.

J. Displacing Water with Concrete.
Do not place concrete into or under flowing water. Concrete may be placed in still water only under the following conditions and under the Engineer's supervision.

1. The Contractor may place the concrete starting at a point most removed from the sumps and progressing toward the sumps, shoving and displacing water as the placement progresses if:
- Water courses and sumps are provided outside the area over which concrete is placed, and
- It is demonstrated that the water elevation can be controlled to an elevation at or near the elevation of the bottom of the concrete to be placed to the extent that no appreciable or objectionable flow crosses said area.

2. Maintain the water elevation within the forms at the start of placing at substantially the same elevation through the pour by bailing or pumping. Direct pumping from inside the forms will not be permitted in excess of the pumping necessary to remove the quantity of water displaced by concrete.

3. The Contractor may slowly displace entrapped water with concrete during placement if:
- There are required excavations or trenches within the area, the bottoms of which are below the general elevation of the area, and
- It is impossible or impractical to provide gravity drainage to the sumps.

4. The Contractor may be required to bail or otherwise dewater the trench immediately prior to or during the placement. A prerequisite to placing concrete in excavations or trenches is that the depth of water shall not appreciably exceed 30% of the depth of concrete being placed.

5. Place seal courses in the following manner if other methods for placement are not provided in the contract documents:
- **a.** When possible, place seal courses in one continuous operation. Place concrete to approximately the required depth. Progress from one end over the entire area in such a manner that the volume of concrete will be gradually expanded without dropping the concrete through water. Minimize agitation. Ensure the surface of the seal course is approximately level. Place sumps or depressions for pumping out the water outside the area of the footing.
- **b.** Place concrete using equipment described in Article 2403.03, B, 2. In operating a tremie, keep the tremie filled at all times. Raise the discharge end only an amount sufficient to permit the concrete to be discharged.
- **c.** When pile encasements are placed by use of a tremie and the bottom of the encasement is below the controlled water level, provide drain holes no less than 1 inch (25 mm) in diameter in the encasement form at intervals of 1 foot, 2 feet, and 3 feet (0.3 m, 0.6 m, and 0.9 m) above the controlled water elevation. Place the concrete in this area at a rate so no free water is entrapped inside the form above the top drain hole.

K. Laitance.

Remove laitance from the surface of seal courses before the footing is placed. Use care in placing other concrete to prevent formation of laitance on the surface of the concrete. Entirely remove laitance by means of shovels, stiff wire brooms, or by other suitable methods before the succeeding layer of concrete is placed.

L. Design and Construction of Forms and Falsework.

1. General.
- **a.** Have a Professional Engineer licensed in the State of Iowa design and certify falsework plans.
- **b.** Materials for forms and falsework may be either new or used. It is the Contractor's responsibility to ensure that materials are suitable for the use intended. Material which the Engineer determines to be damaged, defective, or otherwise unsuitable will be rejected.

2. Construction of Forms.

- **a.** Use materials, and construct forms that will be in direct contact with concrete, as specified in Article 2403.03, B.
- **b.** For wall or column forms, use studs, wales, and ties designed to withstand the maximum fluid pressure discussed below.
- **c.** Use prefabricated form systems certified for the expected pressures.
- **d.** Guy, shore, and/or brace forms for walls and columns to withstand wind loads and to prevent alignment shift resulting from construction live load.

3. Construction of Falsework.

- **a.** Build falsework used to support construction of reinforced concrete superstructures, reinforced beams, and substructure cantilevers, on sufficiently strong foundations to carry the loads safely and without significant deflection. Drive ample falsework piling to support falsework which cannot be founded on rock, shale, thick deposits of compact gravels, coarse sand, or the firm clays in natural beds. On the soils materials listed above, mudsills or other spread footings may be used. Determine their sizes considering the applied loads and the bearing value of the soil.
- **b.** Determine bearing values of all piles used to support falsework as provided in Section 2501. Bearing values are to be at least equal to the applied loads.
- **c.** Transversely sway brace pile bents exceeding 10 feet (3 m) in height to resist lateral loads. Longitudinally brace pile bents exceeding 10 feet (3 m) in height to resist construction live loads, unless the bents are secured to longitudinal members which are secured against longitudinal movement. Bracing and connections are to be shown on falsework plans. The Engineer will review adequacy of bracing and connections.
- **d.** Secure pile caps to each pile. Ensure blocks, wedges, and jacks for height adjustment are secure and stable. The Engineer will review them before concrete placement. Hold transverse joists against individual collapse. Use a positive spreader system over each support of a longitudinal stringer.
- **e.** Secure continuous members against uplift from unbalanced concrete placement. Place concrete in a manner which will minimize unequal loads on hanger legs.

4. Design Loads.

Design formwork and falsework for the following loads:

- **a.** Vertical load of concrete with a density of 150 pounds per cubic foot (2400 kg/m^3).
- **b.** Horizontal load of fresh concrete as a liquid with a density of 150 pounds per cubic foot (2400 kg/m^3) for the depth of plastic concrete.
- **c.** Vertical load of forms and falsework.
- **d.** Construction live load equal to 50 pounds per square foot (2.4 kPa) of horizontal projection.

e. Wind loads on walls and columns according to the requirements of the ACI.

5. Design Stresses.

a. Design formwork and falsework using working stresses and a normal duration of load, as for a permanent structure. Calculate lumber strength on the basis of dressed size and, except for sheathing, a dry condition. Publications of the ACI and the National Forest Products Association will be considered standard references for design and analysis of timber falsework.

b. Do not exceed 50 times the dimension of the least side for the unsupported length of wooden columns and compression members. Analyze the member as a column.

c. Unless the Contractor certifies a higher stress grade or value, adequacy of falsework material will be checked on the basis of the following values:

1) Structural steel stresses per AASHTO for 30,000 psi (207 MPa) yield strength and 22,500 psi (155 MPa) maximum working stress.

2) Plywood sheathing stresses per American Plywood Association for concrete form grade, Class I, wet use, permanent loading, span-perpendicular-to-face grain. Orientation of plywood panels must be shown on drawings if advantage is taken of greater strength with span-parallel-to-face grain.

3) Stresses for lumber 4 inches (100 mm) or less in thickness, in psi (MPa) as follows:

f_b, bending	= 1000 (6.90)
f_t, tension	= 625 (4.30)
f_v, shear	= 120 (0.83)
f_c, perpendicular to grain	= 345 (2.40)
f_c, parallel to grain	= 1050 (7.20)
E, modulus	= 1,500,000 (10,300)

4) Stresses for lumber 5 inches (125 mm) thick and thicker in psi (MPs) as follows:

f_b, bending	= 1200 (8.30)
f_t, tension	= 1000 (6.90)
f_v, shear	= 120 (0.83)
f_c, perpendicular to grain	= 390 (2.70)
f_c, parallel to grain	= 1000 (6.90)
E, modulus	= 1,600,000 (11,000)

5) Safe bearing value of coarse sand, gravel, very firm clay, and other similar confined soils in thick beds at 1500 pounds per square foot (72 kPa) unless recommended otherwise by a Professional Engineer licensed in the State of Iowa. Safe bearing value of compacted berms at 2000 pounds per square foot (96 kPa).

6. Deflection.

a. Ensure falsework for slab and girder bridges provides for slight settlements, deformations of members, crushing, and closing of joints. Sag in excess of 1 inch (25 mm) or 1/800 of the span length, whichever is greater, in the soffit of a girder or slab may be cause for rejection.

b. Limit deflection of sheathing and joists to 1/360 of the span length. Calculate deflection of falsework stringers. Adjust screed guides to compensate.

7. Falsework Plans.

a. Submit plans for falsework and centering on all concrete slab and cast-in-place concrete girder bridges according to Article 1105.03. Submittal of forming details for bridge decks on concrete beam and steel beam bridges is not required unless specified in the contract documents.

b. The Engineer may require calculations or evidence of adequacy. The Engineer may require revised plans later because of unforeseen site conditions, unusual construction procedures, or deviation from original falsework plans.

M. Removal of Forms and Falsework.

Remove forms and falsework, unless otherwise indicated in the contract documents. Normally, they may normally be removed according to the following provisions. However, in cool or unfavorable weather, the Engineer may require forms to remain in place for longer periods.

1. Forms Which May be Removed in Less than 5 Calendar Days.

a. Forms for ornamental work, railings, parapets, curbs, and any other vertical surfaces may be removed whenever the concrete will not be damaged by doing so, but no less than 12 hours after the concrete is placed.

b. Do not remove forms for concrete open railing less than 24 hours after concrete placement.

c. Forms for roofs of culverts may be removed when the concrete has attained an age of 3 calendar days and a flexural strength of:

- 350 psi (2.4 MPa) for spans of 4 feet (1.2 m) or less,
- 400 psi (2.8 MPa) for spans 4 to 6 feet (1.2 m to 1.8 m), and
- 450 psi (3.1 MPa) for spans exceeding 6 feet (1.8 m).

d. When Maturity Method (according to Materials I.M. 383) for strength determination is used, the above stated flexural strengths will be required. The days of age will depend on the Maturity Curve for the concrete mix used.

2. Forms Which Shall Remain in Place 5 Calendar Days or Longer.

a. Except when form removal is permitted in less than 5 calendar days, forms may be removed as soon after 5 calendar days as the concrete has attained the strength required in Article 2403.03, N, 2. When Maturity Method (according to Materials I.M. 383) for strength determination is used, the flexural strength of 550 psi (3.8

MPa) will be required. The days of age will depend on the Maturity Curve for the concrete mix used.

b. When strength is not determined, forms for box culverts 4 feet (1.2 m) or less in width may be removed after the concrete has attained an age of 7 calendar days. Forms for other concrete may be removed after the concrete has attained an age of 14 calendar days.

c. Remove forms and supporting falsework for continuous concrete slabs, concrete girders, and rigid frame structures in the following manner:

Ensure there is at least one span for which the concrete has attained the age (or age and strength) specified above between the span from which forms are about to be removed and any span for which the concrete has not attained the age (or age and strength) specified above.

3. Falsework and Falsework Piling.

Remove falsework and falsework piling in the berm slope fill, extended to the streambed, to at least 1 foot (0.3 m) below the finished berm line or berm line extended. For falsework and falsework piling in the channel area:

a. For structures spanning natural streams or overflow channels of natural streams, removal to at least 1 foot (0.3 m) below streambed elevation will be required.

b. For structures spanning drainage channels constructed under the drainage laws of Iowa, removal to at least 4 feet (1.2 m) below streambed elevation will be required unless complete removal is specified.

N. Subjecting Concrete to Exterior Loads.

Concrete may not be subjected to loads other than the load caused by the weight (mass) of the concrete itself except as follows:

1. Loads Producing Simple Compressive Stress Only.

Concrete may be subjected to simple compressive stress as soon as it sets sufficiently to prevent the surface being marred or the edges being chipped from the effect of such loads.

2. Loads Producing Flexural Stresses.

a. Unless otherwise indicated in the contract documents, concrete may be subjected to loads due to placing backfill material or to legal traffic when the concrete has reached the minimum age stipulated in Table 2403.03-2 and developed a flexural strength of at least 550 psi (3.8 MPa).

Table 2403.03-2: Minimum Age for Concrete

Portland cement (Type I and Type II with or without Class C fly ash)	7 calendar days
With Class F fly ash substitution	8 calendar days
Class M mix (with or without Class C or Class F fly ash)	3 calendar days
If strength is not determined (regardless of type of cement or class of fly ash)	14 calendar days

b. Determine flexural strength by testing (according to Materials I.M. 316) specimens of concrete used in the part of the structure in question, cured under conditions similar to those of the concrete in the structure.

c. Footings for piers supported by piling may be subjected to loads of subsequent pier stem concrete placement no less than 18 hours after footing placement is complete, with no minimum strength requirements.

d. Unless otherwise specified in the contract documents, the Contractor may request, the time for subjecting to loads to be determined through the use of the Maturity Method as described in Materials I.M. 383. When the Maturity Method is used, the time for loading will be based on strength requirements only, as specified above. Furnish labor, equipment, and materials necessary for the development of the maturity-strength relationship as described in Materials I.M. 383.

e. Determining sufficient strength has been achieved for loading a part of a structure remains the Engineer’s responsibility when the Maturity Method is used. The Contractor's maturity testing may be used as the basis for this determination. Provide sufficient documentation of maturity testing before loading a part of a structure or opening to traffic.

f. Apply the following when the Maturity Method is used:

1) Should circumstances arise beyond the Contractor's or Engineer's control and strength cannot be determined by the Maturity Method, the minimum age, minimum flexural strength, and fly ash restrictions apply. Cure flexural strength specimens under conditions similar to those of the concrete in the structure.

2) Any changes of a material source or proportion in the concrete mixture require a new maturity curve.

O. Joints.

Unless otherwise provided in the contract documents, construct joints in the following manner:

1. Construction Joints.

a. Place construction joints between successive layers of concrete as provided in Article 2403.03, K.

b. The location of required or optional construction joints in the structure will be shown in the contract documents. If the volume of

concrete is too great to be placed without use of additional construction joints, locate and construct these joints in a manner not impairing the strength and appearance of the structure.

c. Locate construction joints in planes perpendicular to principal lines of stress and at points the Engineer designates.

2. Expansion Joints.
Construct expansion joints as shown in the contract documents.

P. Surface Finish.
Finish and seal concrete surfaces exposed, or will likely be exposed, after the structure is completed as follows:

1. Finish concrete floors and concrete sidewalks as provided in Sections 2412, 2413, and 2511.

2. Provide a Class 1, finish to horizontal surfaces not cast against a form and not subject to wear (for example, bridge seats, tops of backwalls, piers, abutments, wingwalls, retaining walls, spandrel walls, struts between pedestal piers, and horizontal surfaces of curbs and sidewalks of the bridge). For all other surfaces required to be finished, provide a Class 2, finish to low water line or 1 foot (0.3 m) below the finished ground line. Provide a Class 3, finish to those areas designated in the contract documents.

a. Class 1, Floated Surface Finish.
Overfill forms with concrete. Strike off concrete to the required elevation with a template and thoroughly work the surface with a wood float until the surface is uniformly smooth, dense, and true.

b. Class 2, Strip Down Surface Finish.
Immediately after removal of the forms, complete the following:

1) Remove rods and other devices used as form ties to the extent contemplated in their design.

2) Remove paper or fiber tubes used to facilitate removal of rod ties.

3) Except as designated below, cut off wires used as form ties flush with the surface of the concrete and drive them 1/4 inch (5 mm) below the surface.

4) Remove all fins and irregular projections from the concrete surfaces required to be finished.

5) On surfaces, thoroughly clean the cavities produced by form ties and all other holes, honeycomb spots, and broken corners and edges. After being saturated with water, carefully fill, point, and true with a mortar of cement and fine aggregate of the same kind as that which was used in the concrete being finished. Shallow voids, other than honeycomb, which appear on the formed surface after proper consolidation will not be considered as holes and need not be filled unless they appear in an abnormal concentration.

6) Clean the entire surface required to be finished of stains from form oil or other substances.
7) Ensure the resulting surfaces are true and uniform.
8) Clip off flush with the surface wire ties or reinforcing steel chairs protruding through culvert barrels or the bottom of bridge floors.
9) Leave construction and expansion joints in the completed work carefully tooled and free from mortar and concrete.
10) Leave expansion joint filler exposed for its full length and thickness and with clean true edges.

c. Class 3, Special Surface Finish.
This operation shall obtain a surface reasonably smooth and uniform in texture and appearance.
1) Apply a bonding agent mixed with standard or commercially packaged mortar. More than one application may be necessary. Products approved for this use are identified in Materials I.M. 491.10. Use the same materials and methods for all surfaces to be given a Class 3 finish.
2) The Class 3 finish requirements do not relieve the Contractor of the responsibility for performing the Class 2 finish as specified prior to commencing Class 3 finish operations.
3) Do not commence application of the Class 3 finish until:
- All other work which may mar the surface finish has been completed, or
- Finishing operations can be carried on continuously from beginning to completion on any one bridge or structure.

3. Concrete Sealer.
a. Use sealer material meeting the requirements of Article 4139.01, B, when designated in the contract documents.
b. The contract documents may designate a sealer for the bridge seat surface or tops of piers or both. This surface includes bridge seat steps and edge fillets. The contract documents or the Engineer may also designate other concrete surfaces to be sealed.
c. All surfaces to be sealed shall be sound, clean, and dry. For existing surfaces, the Engineer may require removal of unsound material by hand methods or sandblasting, or both. As a minimum, all designated surfaces, both existing and new, shall receive a light sandblast (brush blast), followed by air cleaning. Clean sufficiently to remove road film and contamination from existing concrete and form oil from new concrete.
d. Perform application procedures according to the manufacturer's recommendations. Unless otherwise required in the contract documents, apply sealer material at the coverage rates in Materials I.M. 491.12.

2403.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Structural Concrete:

1. Quantity shown in the contract documents.

2. The Engineer will compute in cubic yards (cubic meters) the total volume of the respective classes of structural concrete placed using dimensions shown in the contract documents, along with the changes that have been made according to a written order from the Engineer. From this volume, 0.8 cubic foot (0.075 m^3) will be deducted for each linear foot (meter) of concrete, steel shell, or wood piling projecting into the footings or caps. Deductions from the volume of concrete will not be made for the volume of concrete displaced by the steel reinforcement, floor drains, expansion joints, shear lugs, beam flanges, H-piles, or metal strips for sealing joints.

3. Additional concrete required to bring floors, curbs, and handrails to the required elevation will not be measured for payment if such addition is made necessary by inaccuracies in the shape or placement of steel or concrete beams or by distortion of falsework.

B. Reinforcing Steel and Structural Steel: according to Sections 2404 and 2408, respectively.

C. The surface area on which concrete sealer is applied to structural concrete: not measured separately for payment.

D. Subdrains, porous backfill material, and granular backfill material required and furnished for structural concrete placement at bridge abutments: not measured separately for payment.

2403.05 BASIS OF PAYMENT.
Payment will be as follows:

A. Net volume of Structural Concrete as specified above:

1. Contract unit price per cubic yard (cubic meter).

2. For concrete placed within the contract period between November 15 and April 1, additional payment will be made for heating or protecting or both; however, no payment will be made when winter work is specified in the contract documents.

3. Payment for heating will be made when materials which are proportioned and mixed at the site are heated to meet requirements of Article 2403.03, F, or when heating is charged by the supplier of ready mixed concrete. For concrete proportioned and mixed at the site, the additional payment for heating will be $5.00 per cubic yard ($6.60 per cubic meter). For ready mixed concrete, the additional payment for heating will be the customary amount charged for heating, and separately identified on the invoice, with a maximum of $5.00 per cubic yard ($6.60 per cubic meter). Heating, protection, or both, required

outside the above dates, will be paid for when approved by the Engineer.

4. Payment for protection will be made when heated housing or insulated forms are used to meet requirements of Article 2403.03, I. The additional payment for protection will be $7.00 per cubic yard ($9.25 per cubic meter). If a footing is protected by flooding with water, no payment will be made. If footings are protected with coverings of burlap, hay, straw, plastic, insulation, and/or other materials sufficient to meet the temperatures and time specified in Article 2403.03, I, payment for protection will be made.

B. Reinforcing Steel and Structural Steel: according to Sections 2404 and 2408, respectively.

C. Concrete sealer application to structural concrete: included in the contract unit price for structural concrete.

D. Subdrains, porous backfill material, and granular backfill material required and furnished for structural concrete placement at bridge abutments: included in the contract unit price for the structural concrete.

E. When an admixture is required to be added by the contract documents or the Engineer for the purpose of retarding the set, the cost of the retarding admixture is incidental to the contract unit price per cubic yard (cubic meter) of structural concrete

F. Payment is full compensation for:
- Furnishing all materials, including materials for filling and sealing joints, but not including structural steel or steel reinforcement.
- Furnishing, constructing, and removing all forms, ties, and falsework.
- Incidental work necessary for completion of the work in conformance with the contract documents.

G. Heating frozen soil or protecting soil from freezing, or both, prior to concrete placement is incidental regardless of winter work being specified on the contract documents.

Section 2404. Reinforcement

2404.01 DESCRIPTION.
Furnish and place all reinforcing bars and fabrics used in concrete according to the contract documents.

2404.02 MATERIALS.
Use reinforcement meeting the requirements of Section 4151.

2404.03 CONSTRUCTION.

A. Cleaning.

1. Ensure that reinforcement is free from dirt, detrimental scale, rust, paint, oil, or other foreign substances.

2. For uncoated bars, thin powdery rust and tight rust is not considered detrimental and need not be removed.

3. Appreciable reduction in section caused by corrosion is sufficient cause for rejection of reinforcement.

B. Fabrication.

1. Exercise care so reinforcement is not damaged during bending. Employ proper appliances and competent workers for the work.

2. Ensure reinforcement is cold bent, except in shops where accurate control of temperature is provided.

3. Ensure Grade 60 (Grade 400) or higher deformed bars, and bars of No. 8 (No. 25) size and larger, are shop bent.

4. Ensure reinforcement is accurately bent to the dimensions and shapes shown in the contract documents. Do not field bend bars partially embedded in concrete except as shown in the contract documents.

5. When galvanized reinforcement is required, ensure cutting and bending are completed before galvanizing.

6. When epoxy coated reinforcement is required, ensure fabrication is completed according to Article 4151.03, C.

7. Ensure fabrication of reinforcement, including bending details, is completed according to ACI Code 318.

8. Ensure bar reinforcement is shipped in standard bundles, tagged, and marked according to the CRSI Manual of Standard Practice.

C. Straightening.

Straighten reinforcement that may have become bent during shipment or handling before placing in the work. Straighten without heating in a manner that minimizes damage to any coating.

D. Placing and Fastening.

1. Place reinforcement in the position indicated in the contract documents. Ensure reinforcement is held securely in place during placing and hardening of the concrete.

2. Tie reinforcement bars at all intersections except where spacing is less than 1 foot (300 mm) in each direction, in which case tie alternate intersections.

3. The Engineer will inspect and approve the locations, fastening, and condition of reinforcement before concrete is placed around it.

4. Welding of reinforcing steel will not be permitted unless specified in the contract documents or approved by the Engineer.

5. In floors of culverts and in other footings without piling, suspend reinforcement from cross wales above the tops of the forms or support on steel stakes driven into the subgrade or on chairs.

6. Install dowels, deformed bars, inserts, or other articles into existing pavements and structures as shown in the contract documents. When installed with epoxy material, complete the procedure according to Article 2301.03, E. Cut reinforcing steel, in the field, using mechanical methods. Do not flame cut.

E. Reinforcing Supports and Spacers.

1. Support horizontal reinforcement using support devices, or tie to vertical reinforcing steel.

2. Position vertical reinforcement using side-form spacers. Use support devices and side-form spacers, either plastic or steel, meeting the requirements of Materials I.M. 451.01.

3. Hold epoxy coated reinforcing steel in place with epoxy or plastic coated bar supports, and epoxy or plastic coated tie wires.

4. Do not use concrete block inserts, bricks, stones, wood blocks, wood stakes, and similar materials to support reinforcement if by their use they may become embedded in the concrete.

5. Space support devices according to the manufacturer's recommendations or as recommended by the current CRSI Manual of Standard Practice. Use a support system with spacing not to exceed 4 feet (1.2 m) in each direction for bolsters or continuous high chairs and 3 feet (0.9 m) in each direction for individual bar chairs.

6. Rest the base of chairs and support bolsters on the supporting false work. Use supporting chairs that have either upturned legs or a horizontal bar spot welded at the base of the leg.

7. Cross-tie legs at their bases or nail them to the forms if necessary to prevent spreading of upturned legs.

8. For situations where two or more separate mats of reinforcing steel are required, support each mat independently using an approved support system.

9. Place side-form spacers at intervals sufficient to ensure that all reinforcing is at the required clearance.

F. Splicing.

1. Splice reinforcement only at points shown in the contract documents or when approve by the Engineer. When lapped splices are used in reinforcement in which the critical design stress is tensile, do not use splices at points of maximum stress. Place bars in close contact and wire tightly in a manner that the specified clear distance to the surface of the concrete is maintained.

2. Lap reinforcing steel for the minimum length according to that specified in AASHTO Standard Specifications for Highway Bridges.

2404.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the weight (mass) in pounds (kilograms) of reinforcement from the theoretical weight (mass) of the nominal sizes and actual lengths of the various sizes of reinforcement shown in the contract documents.

B. No adjustment will be made for galvanizing or epoxy coating.

C. If a greater or lesser quantity of reinforcement than shown in the contract documents is directed by the Engineer, the quantity will be recomputed from the theoretical weight (mass) of the reinforcement actually used.

D. The weight (mass) of reinforcement, shown in the contract documents, will be presumed to be correct and will provide the quantity used as the basis of payment; however, if the Contractor presents evidence that the weight (mass) computed is in error by more than 1.0%, the Engineer will re-compute the weights (mass).

2404.05 BASIS OF PAYMENT.

A. Payment will be at the contract unit price per pound (kilogram) for the weight (mass) of Reinforcing Steel, Galvanized Reinforcing Steel, and Epoxy Coated Reinforcing Steel computed as specified above.

B. Payment is full compensation for furnishing and placing the reinforcement, ties, and supports as may be required to hold the reinforcement in proper position.

Section 2405. Foundations and Substructures

2405.01 DESCRIPTION.

A. Bases or supports upon which a superstructure rests and they may consist of abutments and piers with or without piling or drilled shafts.

B. Do not apply the requirements of this section to culverts.

2405.02 MATERIALS.

Refer to the materials requirements for Sections 2401, 2402, 2403, 2404, 2408, 2414, and 2501.

2405.03 CONSTRUCTION.

Construct foundations and substructures complying with the contract documents and with requirements of this section and various sections applying to the type of construction designated. Apply the provisions of Sections 2401, 2402, 2403, 2404, 2408, 2414, and 2501 as well as the provisions of this section.

A. Construction of Cofferdams.

1. Construct the cofferdams used for construction of foundations and substructures in a manner capable of resisting earth and water pressure without appreciable displacement.

2. If submittal for review is designated in the contract documents or requested by the Engineer, furnish details to show the cofferdams will meet these requirements. Submit cofferdam plans, including the computations and drawings, according to Article 1105.03. Do not start work prior to receiving the agreed upon plans. This review does not relieve the Contractor of responsibility for satisfactory results and safety of the workers on the project.

3. For cofferdams use steel sheeting of such length that it may be driven to a depth to prevent unstable material from flowing into the excavation. Ensure the sheeting will form a safe and adequate cofferdam. Strongly brace cofferdams, but place the bracing so it will not be encased in the concrete of the structure, except as provided in the following paragraphs and with the Engineer's approval:

a. If the bracing is at elevations that it will not be exposed in the finished structure, cut the bracing off flush with the surface of the concrete. If the bracing is at elevations that it will be exposed in the finished structure, recess it and cut off at least 4 inches (100 mm) inside the face of the concrete.

b. Form pockets around the bracing. Neatly fill these pockets with concrete after the bracing is cut off. Small openings may be left in diaphragm walls and other thin sections to provide for cofferdam bracing, provided these openings are not located to interfere with

the structural integrity of the structure and are located in places where they can be filled later in a satisfactory manner.

c. Do not place cofferdam bracing to bear against heavy concrete sections less than 3 calendar days old. In the case of thin sections or unfavorable weather conditions, this time may be increased at the Engineer's discretion.

4. Provide a clear space of at least 36 inches (1 m) on all sides between the footing and the cofferdam. Except for seal courses, do not use the cofferdam as a form for the concrete footing. Build an independent form for the footing. Use sheeting for the cofferdam of such a type, and drive the sheeting, to prevent as nearly as possible water entering through the walls of the cofferdam. Provide pumps of sufficient capacity to keep the excavation free from water, according to Article 2403.03, J, until the concrete has reached initial set.

5. After the foundation is in place, place backfill material in all excavated areas in and around cofferdams to the original ground surface or streambed with materials meeting the provisions for the appropriate required regulatory permits. If additional material has been added adjacent to the pier sites, remove this material to the ground line or streambed.

B. Seal Courses.

1. The Engineer may require the Contractor to seal the cofferdam with concrete if:

- The material encountered at the designed elevation of the bottom of the footing is so porous that water enters at a rate that it is impractical to lower the water level to this elevation by pumping, or
- The material cannot be prevented from flowing into the excavation by driving sheeting to reasonable depths.

2. Place the seal course below the elevation of the bottom of the footing in the manner prescribed in Article 2403.03, J. The cost of this work will be paid for according to Article 1109.03. After placement of the seal course, do not dewater the cofferdam until test beams show a flexural strength of no less than 500 psi (3.5 MPa).

C. Footings.

1. Construct footings as shown in the contract documents or as the Engineer orders in writing. Anchor footings resting upon solid rock by extending the footing at least 6 inches (150 mm) into the solid rock. Adjustment in quantities will not be made for extending the dimensions horizontally beyond the neat lines shown in the contract documents. Remove all loose boulders and fragments of rock before the footing is placed.

2. Do not place concrete in a footing until the Engineer has inspected and approved the depth of excavation and integrity of the foundation materials, and has given permission to proceed.

3. When the contract includes an item for Excavate and Dewater, construct the footings for piers in the dry using either:
   - Steel sheet pile cofferdams and tremie concrete seal courses, or
   - Other means of maintaining a dry excavation, as may be developed by the Contractor and approved by the Engineer.

4. Prevent water from seeping through the bottom of the excavation during placement of the footing concrete. Prevent unbalanced water pressure from acting on the bottom of the footing during curing of the footing concrete.

5. Approval of the Contractor's recommended procedure does not relieve the Contractor from responsibility to place the footing and pier concrete in the dry. The Engineer reserves the right to require the Contractor to provide cofferdams and tremie concrete seal courses if, during construction, the Engineer determines that the excavation cannot be satisfactorily dewatered by the Contractor's recommended procedure.

D. Class of Concrete.

1. Construct foundations and substructures using Class C concrete unless specified otherwise in the contract documents.

2. For concrete in seal courses use Class X concrete (not air entrained) mixed with sufficient water to provide a satisfactory mix having a slump of no more than 8 inches (200 mm).

E. Placing Concrete.

1. Apply the provisions of Section 2403 to concrete placed in foundations and substructures.

2. In reinforced concrete substructures, securely fasten in position reinforcement extending into footings.

3. Request the Engineer inspect before any concrete is placed.

4. Use suitable wood or metal forms to enclose footing concrete, except for extension into rock as provided in Article 2405.03, C.

F. Construction Joints.

1. In general, construct each footing as a monolith.

2. If construction joints are required, construct them as specified in Article 2403.03, H.

G. Ice Breakers.

1. Set ice breakers true to alignment and with correct batter.

2. Place the anchorage before placing concrete.

3. The ice breaker is considered part of the substructure.

H. Anchor Bolts for Bridge Bearings and Foundations.

1. General.

a. Use bolts, nuts and washers, galvanized according to ASTM A 153, Class C; or ASTM B 695, Class 50.

b. Use full-length galvanized anchor bolts that:
Meet the requirements of ASTM F 1554, Grade 36.
Are Unified Coarse Thread Series, and
Have Class 2A tolerance.

c. Color code in blue the end of each anchor bolt intended to project from the concrete in order to identify the grade. Use galvanized washers that meet the requirements of ASTM F 436. Use heavy hex, galvanized nuts that meet the requirements of ASTM A 563, DH. Nuts may be over-tapped in accordance with the allowance requirements of ASTM A 563.

2. Bridge Bearings.

Unless otherwise specified in the contract documents, set anchor bolts to be embedded in concrete in drilled holes. Set them prior to the time the concrete is placed, when specified in the contract documents.

a. Anchor Bolts Set in Drilled Holes.

1) In clean, dry holes accurately set anchor bolts for bridge bearings perpendicular to the plane of the bridge seat. Vary the locations of anchor bolts in relation to slotted holes in expansion shoes to compensate for the temperature of the structure. Adjust the nuts on anchor bolts at the expansion bearings of spans to permit movement of the span with changes in temperature. Set anchor bolts with a hydraulic cement or polymer grout.

2) When hydraulic cement grout is used, use one that meets the requirements of Materials I.M. 491.13. Make the diameter of the hole 1/2 inch (13 mm) larger than the bolt diameter. Slightly overfill the annular space with grout.

3) When polymer grout is used, use one meeting the requirements of Materials I.M. 491.11. Make the diameter of the hole 1/8 inch (3 mm) larger than the bolt diameter. Fill the annular space with the grout according to the manufacturer's recommendations and limitations, as approved by the Engineer.

b. Preset Anchor Bolts.

1) When specified by the contract documents, set the anchor bolts for bridge bearings during the placing of concrete.

2) Per Article 2405.03, H, 3.

3. Foundations.

a. Hold the bolts firmly in a rigid template which spans the concrete with sufficient clearance to permit proper finishing of the surface of the concrete. Obtain a template from the manufacturer/fabricator for proper placement of the anchor bolts. Do not weld anchor bolts.

b. Leave the template in place until the concrete has hardened.

c. Accurately set anchor bolts, plumb to within 1/4 inch (6 mm) per 12 inches (300 mm), at points specified in the contract documents.

I. Finish.

Finish surfaces of concrete foundations and substructures as provided in Article 2403.03, P.

J. Placing Superstructure.

Apply the provisions of Article 2403.03, N, to placing superstructures on piers and abutments.

K. Reconstruction of Substructures.

1. When the work involves reconstruction of an existing substructure, submit to the Engineer detailed plans for supporting the superstructure according to Article 1105.03.

2. Securely shore or guy the superstructure at all times while it is raised off the substructure to prevent overturning or slipping from the temporary supports.

L. Pile Substructures.

1. When designated in the contract documents, construct the substructure by driving piling for abutments and piers. Drive piles according to Section 2501.

2. Support earth approaches laterally by sheet piling or by backing planks resting against the abutment piling.

3. Complete wood, steel, and concrete construction in connection with pile substructures according to Sections 2403, 2407, 2408, or 2409.

2405.04 METHOD OF MEASUREMENT.

A. Measurement for the quantities involved in foundations and substructures, will be as provided in the following sections:

1. Excavation for Structures: Section 2402.04 applies.

2. Structural Concrete: Section 2403.04 applies.

3. Reinforcement: Section 2404.04 applies.

4. Precast and Prestressed Concrete: Section 2407.04 applies.

5. Structural Steel: Section 2408.04 applies.

6. Timber and Lumber: Section 2409.04 applies.

7. Piles: Section 2501.04 applies.

B. No measurement will be made for Excavate and Dewater.

2405.05 BASIS OF PAYMENT.

A. Payment for the quantities involved in foundations and substructures will be as follows:

1. Excavation for Structures: Section 2402.05 applies.

2. Structural Concrete: Section 2403.05 applies.

3. Reinforcement: Section 2404.05 applies.

4. Precast and Prestressed Concrete: Section 2407.05 applies.

5. Structural Steel: Section 2408.05 applies.

6. Timber and Lumber: Section 2409.05 applies.

7. Piles: Section 2501.05 applies.

B. Payments are full compensation for furnishing materials, equipment, and labor and for performance of work necessary to complete the substructure in conformance with the contract documents.

C. When the contract documents do not provide a separate price for Class X concrete, payment for this concrete, when ordered by the Engineer, will be per Article 1109.03, B. The quantity paid for is limited to that concrete placed within 18 inches (0.5 m) of the footing, as shown in the contract documents.

D. When the contract includes an item for Excavate and Dewater, payment will be made at the contract lump sum price each for Excavate and Dewater. Payment is full compensation for:

- Class 20 and Class 21 excavation,
- Cofferdams and tremie concrete seals, if used,
- Costs of other procedures required to dewater the excavations,
- Pumping,

- Bailing and drainage, and
- Materials, work, labor, and equipment required to place the footings and piers in the dry, including the cost of furnishing design computations and drawings.

E. Additional compensation will not be allowed for any delays resulting from compliance with the above requirements.

Section 2406. Concrete Structures

2406.01 DESCRIPTION.

A. Apply the provisions of this section to bridge structures for which the main members spanning the various supports are composed of concrete.

B. Place the concrete superstructure on a substructure constructed according to Section 2405.

C. Also, in addition to this section, apply the provisions of Sections 2403, 2404, 2405, 2407, 2412, 2413, and 2414.

2406.02 MATERIALS.

Refer to the materials requirements for Sections 2403, 2404, 2405, 2407, 2412, 2413, and 2414.

2406.03 CONSTRUCTION.

A. Falsework and Forms.

1. Construct falsework and forms to conform to Articles 2403.03, B, 5 and 2403.03, L.

2. Notify the Engineer at least 24 hours before placing any concrete in the superstructure of a concrete bridge so the Engineer may inspect the falsework and forms for conformance with falsework plans, alignment, and general fitness. Do not place concrete until the Engineer has inspected the falsework and forms.

3. Ensure falsework and forms provide for the full camber and roadway crown specified in the contract documents. Remove forms according to Article 2403.03, M.

B. Placing Concrete.

Place concrete as provided in Section 2403 and the following:

1. Placing Concrete in Slab Superstructures.

a. Place concrete for each span to its full depth in one continuous operation and without joints except as provided in the contract documents.

b. The Contractor will be required to provide adequate material, labor, and equipment to assure that the concrete required to be

completed in a single, continuous operation can be placed in 10 hours.

2. Placing Concrete in Deck Girder Superstructures.

a. Place concrete for each girder continuously for the entire length of the girder in level, horizontal layers, unless provided otherwise in the contract documents.

b. Place concrete for the floor to the required thickness in a single placement. Place the floor as quickly as possible after completion of its supporting girders. Complete the floor within the same working day as the girders.

C. Joints.

Construct joints in the locations shown on the plans and according to Article 2403.03, H.

D. Drainage.

1. Construct and place floor drains at the locations shown on the plans.

2. Install drains behind abutments, wingwalls, and similar structures as specified in Section 2502.

E. Surface Finish.

1. Finish concrete superstructures according to Article 2403.03, P.

2. Finish concrete floors according to Section 2412.

2406.04 METHOD OF MEASUREMENT.

A. Measurement for the quantities involved in concrete structures will be as provided in the following sections:

1. Structural Concrete: Article 2403.04 applies.

2. Reinforcement: Article 2404.04 applies.

3. Structural Steel: Article 2408.04 applies.

4. Precast and Prestressed Concrete Units: Article 2407.04 applies.

B. The volume of concrete displaced by floor drains, expansion joints, or metal strips for sealing joints will not be measured.

2406.05 BASIS OF PAYMENT.

A. Payment for the quantities involved in concrete structures will be as provided in the following sections:

1. Structural Concrete: Article 2403.05 applies.

2. Reinforcement: Article 2404.05 applies.

3. Structural Steel: Article 2408.05 applies.

4. Precast and Prestressed Concrete Units: Article 2407.05 applies.

B. Payments are full compensation for:
- Furnishing all materials, equipment, and labor, and
- Performance of all work necessary to complete the concrete structure in conformance with the contract documents.

C. Deduction will not be made for the volume of concrete displaced by floor drains, expansion joints, or metal strips for sealing joints.

D. The cost of all bituminous expansion joint material, metal strips for sealing joints, and other small miscellaneous items is included in the price per cubic yard (cubic meter) for structural concrete.

E. The weight (mass) of structural steel paid for will include all steel expansion plates, castings of steel or iron, or welded shapes for floor drains, bearing plates, anchor bolts, fasteners, and other steel parts except steel reinforcement for concrete.

Section 2407. Precast and Prestressed Concrete Bridge Units

2407.01 DESCRIPTION.

A. Provide prestressed and precast concrete bridge units produced in a plant for which equipment, procedures, and quality of concrete have been approved by the Contracting Authority.

B. Provide, or have the fabricator provide, technical personnel experienced and skilled in the application of the prestressing system being used. Ensure technical personnel cooperate fully with the Engineer in all technical aspects of the work.

C. Apply the provisions of this section to production and construction of precast concrete and prestressed concrete as defined in Section 1101.

D. Unless modified elsewhere in the contract documents, all fabrication is required to be done only in precast fabrication plants that are approved prior to the letting as per Materials I.M. 445.

2407.02 MATERIALS.

Use materials in prestressed and precast concrete meeting the requirements of Division 41 for the respective material, and the following:

A. Aggregates.

1. Apply Sections 4110 and 4115, except the gradation requirements of Articles 4110.02 and 4115.03. If high performance concrete (HPC) is being used for prestressed concrete beams, use a coarse aggregate consisting of crushed limestone meeting class 3 durability or better.

2. Submit aggregate gradations and proportions with the mix design to the District Materials Engineer for approval.

3. Use aggregates similar to Class V only when 30% or more of the total weight (mass) of aggregate is limestone.

B. Admixtures.
When authorized by the Engineer, approved admixtures complying with Section 4103 may be used.

C. Steel for Prestressing.
Apply Article 4151.05.

D. Reinforcement.
Apply Article 4151.03.

E. Steel Sole and Masonry Plates.
Apply Section 2508 and Articles 2408.03, B, 2408.03, E, and 4152.02.

F. Neoprene Bearing Pads.
Apply Article 4195.02.

G. Bolts and Other Metal Fastenings.

1. Unless indicated otherwise in the contract documents, use non-high-strength fasteners meeting requirements of Article 4153.06.

2. For other fastenings use structural steel meeting the requirements of Article 4152.02, except for anchors and ties for diaphragm connections and hold down devices for deflected tendons. These items will generally be proprietary products and will require the Engineer's approval. The Engineer will approve only those samples that show an ultimate strength of 50% in excess of the manufacturer's advertised safe loads. Use fastenings that are of a type to be cast in the concrete.

3. Use bolts, nuts, washers, and other metal fastenings that have been galvanized as specified for steel structures in Article 4100.07.

H. Cement.
Apply Section 4101, unless otherwise specified. If the use of Type III Portland cement has been authorized, use it in the same proportions as specified for Type I Portland cement. Cement with total equivalent sodium

oxide between 0.61% and 0.75% may be used, provided it is non-reactive with the proposed aggregate when tested according to ASTM C 1260, C 1567, or C 1293.

I. Supplementary Cementitious Materials.

1. Apply Section 4108.

2. Fly ash may be substituted for Portland cement. Use a substitution rate of no more than 25% by weight (mass).

3. GGBFS may substituted for Portland cement. Use a substitution rate of no more than 35% by weight (mass) for GGBFS as a mineral admixture.

4. The maximum total supplementary cementitious materials substitution shall not exceed 50%.

2407.03 CONSTRUCTION.

A. Equipment.
Use equipment meeting the requirements of Section 2001 and the following:

1. Casting Beds.
- **a.** For precast concrete and prestressed concrete, use casting beds rigidly constructed and supported so that under the weight (mass) of the concrete and the vertical reactions of holdups and hold downs there will be no vertical deformation of the bed.
- **b.** For pretensioned work use end anchorages, whether self anchored or supported horizontally by the bed, capable of resisting the maximum prestress force to which they will be subjected without permanent displacement.

2. Forms.
- **a.** Use forms for precast and prestressed concrete true to the dimensions as shown in the contract documents, true to line, mortar tight, and of sufficient rigidity to not sag or bulge out of shape under placement and vibration of concrete. Ensure inside surfaces are smooth and free of any projections, indentations, or offsets that might restrict differential movements of forms and concrete.
- **b.** On long beds for multiple pretensioned beam production where continuous forms and pallets are used, take necessary precautions to prevent damage to the beams from differential movements of forms and concrete due to temperature changes.

3. Stressing Equipment.
- **a.** To tension tendons, use equipment of a type so the prestressing force may be accurately known. Use load cells, dynamometers, and hydraulic gages of hydraulic pump and jacking systems capable of measuring the force applied to the tendons within 2% of the actual force. Calibrate this equipment at least once every 12 months or

anytime the tensioning system indicates erratic results. Calibrate hydraulic gages, pumps, hoses and connections as a system.

b. Perform all tensioning equipment calibrations using load cells calibrated by a testing laboratory or calibration service. For calibration purposes use equipment that has current calibration references. Allow the Engineer the opportunity to witness calibration of equipment during the Engineer's normal working hours or at a mutual agreeable time.

4. Weighing and Proportioning Equipment.
Apply Article 2001.20, except that a vibrator will not be required on the cement batch hopper.

5. Mixing Equipment.
Apply Article 2001.21.

6. Bins.
Apply Article 2001.06.

B. Concrete.

1. For precast and prestressed construction, use at least than 610 pounds (360 kg) of total cementitious material per cubic yard (cubic meter) of concrete. Do not exceed the maximum water-cementitious ratio, including free moisture in the aggregate, of 0.450 pound per pound (0.450 kg/kg).

2. If the units will form curbs or floors of structures, add an approved air-entraining admixture. The intended air entrainment of the finished concrete is 6%. To allow for loss during placement, use a target value of 6.5% for the air content of fresh unvibrated concrete, with a maximum variation of ± 1.0%.

3. Properly proportion, mix, place, and cure concrete within these limits to produce concrete of a minimum compressive strength specified in Table 2407.03-1 at the designated age.

Table 2407.03-1: Concrete Strength

Classification	Concrete Strength Before Moving or Prestressing, psi (MPa)	Concrete Strength at Age 28 calendar days, psi (MPa)
Precast Sheet or Bearing Piles	3500 (24)	4500 (31)
Precast Bridge Deck Units	3500 (24)	5000 (35)
Prestressed Piles	4000 (28)	5000 (35)
Prestressed Deck Panels	4000 (28)	5000 (35)
All Other Prestressed Concrete[(a)]	4500 (31)	5000 (35)

[(a)] Unless noted otherwise in the contract documents.

NOTE: Do not ship beams until the concrete has attained the 28 day strength.

4. If using HPC for prestressed concrete beams, use a mix design that has been evaluated according to ASTM C 1202 and approved by the Engineer. To obtain mix design approval either:

- **a.** Submit to the Engineer ASTM C 1202 results from mix samples taken and tested by an independent laboratory. The results shall be 1500 coulombs or less when cured using accelerated moist curing.
- **b.** Contact the Engineer and arrange for a trial batch. The producer certified technician shall cast 4 inch by 8 inch cylinders for testing by the Materials Laboratory. The ASTM C 1202 results shall be 1500 coulombs or less when cured using accelerated moist curing.
- **c.** When silica fume, class F fly ash, or GGBFS is used in the mix, the Engineer may waive ASTM C 1202 testing.

C. Proportioning, Mixing, and Placing Concrete.

1. Proportion and mix concrete according to the applicable requirements of Article 2403.02, D, 3.

2. Do not place concrete when the ambient temperature is below 35°F (2°C) unless the Engineer has approved the plant for cold weather concrete placement. When necessary, heat the aggregate or water, or both, so that the temperature of concrete when deposited in the forms is 40°F to 90°F (4°C to 32°C). Do not use frozen material in concrete.

3. When a series of units is cast in a line, cast the entire series in one continuous operation, or as directed by the Engineer. Place successive batches before the preceding batch has perceptibly hardened or dried. Do not allow more than 45 minutes to pass between the placement of successive batches of concrete in a unit. Do not retemper the concrete or add water to the interface of the concrete between batches.

4. Carefully work and consolidate concrete around reinforcement without displacing it. Ensure the formation of honeycomb, stone pockets, or similar defects has not occured. Consolidate the concrete using small diameter vibrators or by other means the Engineer approves. Overfill

the forms during consolidation. Screed off excess concrete and finish the surface to the desired texture.

5. On specific request and approval, provisions may be made for inserts in beams as an aid to stripping floor forms. Complete this according to the conditions of such approval.

D. Curing.

1. Use a method of curing that prevents loss of moisture and maintains an internal concrete temperature at least 40°F (4°C) during the curing period. Obtain the Engineer's approval for this method.

2. When using accelerated heat curing, do so under a suitable enclosure. Use equipment and procedures that will ensure uniform control and distribution of heat and prevent local overheating. Ensure the curing process is under the direct supervision and control of competent operators.

3. When accelerated heat is used to obtain temperatures above 100°F (38°C):

- **a.** Record the temperature of the interior of the concrete using a system capable of automatically producing a temperature record at intervals of no more than 15 minutes during the entire curing period.
- **b.** Space the systems at a minimum of one location per 100 feet (30 m) of length per unit or fraction thereof, with a maximum of three locations along each line of units being cured.
- **c.** Ensure all units, when calibrated individually, are accurate within ± 5°F (3°C).
- **d.** Do not artificially raise the temperature of the concrete above 100°F (38°C) for a minimum of 2 hours after the units have been cast. After the 2 hour period, the temperature of the concrete may be raised to a maximum temperature of 160°F (71°C) at a rate not to exceed 25°F (15°C) per hour.
- **e.** Hold the maximum temperature for a period sufficient to develop the strength required for release of prestress or for post tensioning, as the case may be.
- **f.** Lower the temperature of the concrete at a rate not to exceed 40°F (22°C) per hour by reducing the amount of heat applied until the interior of the concrete has reached the temperature of the surrounding air.

4. In all cases, cover the concrete and leave covered until curing is completed. Side forms and pans forming the underside of channel shapes may be removed during this period if the cover is immediately replaced. Do not, under any circumstances, remove units from the casting bed until the strength requirements are met.

5. For pretensioned beams, maintain the temperature of the beams and exposed strands at normal curing temperature until the stress has been released from the end anchorages.

E. Placing Reinforcement.

1. Place all reinforcement carefully and accurately and secure in the proper position according to the contract documents. Apply Article 2404.03.

2. Only welders qualified according to Article 2408.03, B, may perform welding if it is employed in placement of reinforcing steel, or the interconnection of plate connectors, sole plates, or masonry plates. Apply Article 2408.03, B, to the period of effectiveness for all welders. For tack welding reinforcing bars, follow all other requirements as outlined in the latest edition of AWS D1.4, including Table 5.2, Minimum Preheat and Interpass Temperature, except do not allow the minimum preheat and interpass temperature to drop below 50°F (10°C). Ensure the minimum preheat and interpass temperatures for structural steel remain as in Article 2408.03, B.

3. Protect prestressing tendons from heat and weld spatter. Tack welding of reinforcing steel at noncritical stress areas in combination with sacrificial reinforcing bars, if required, will be allowed without regard to preheat and interpass temperature restrictions. Obtain the Engineer's approval for any such modification.

F. Removal of Forms.

If forms are removed before the concrete has attained the strength which will permit the units to be moved or stressed, remove protection only from the immediate section from which forms are being removed. Immediately replace the protection and resume curing after the forms are removed. Do not remove protection any time before the units attain the specified compressive strength when the surrounding air temperature is below 20°F (-7°C).

G. Prestressing Steel Stresses.

1. Position the number and size of individual tendons (7wire strand) according to the contract documents. Prestress to the force shown in the contract documents.

2. If anchored at other than 70°F (20°C), adjust the initial prestressing force as shown in Table 2407.03-2:

Table 2407.03-2: Initial Prestressing Force

Temperature of Strands	Initial Prestressing Force
70°F (20°C)	As shown in the contract documents
Below 70°F (20°C)	Increase 1.0% per 10°F (5°C)
Above 70°F (20°C)	Decrease 1.0% per 10°F (5°C)

3. After tendons have been positioned, apply an initial force between 1000 and 4500 pounds (4.5 kN and 20 kN) to each tendon. Measure the initial force within a tolerance of:

- ± 100 pounds (0.5 kN) for initial forces under 3000 pounds (13 kN), and
- ± 200 pounds (1 kN) for initial forces of 3000 pounds (13 kN) or more.

4. The theoretical elongation of the tendons is calculated from material properties furnished by the manufacturer and allowable losses. Allowable losses may include seating losses, bed shortening, abutment movement, and temperature adjustments.

5. Measure the pretensioning by the net elongation of the tendons. Consider the calculated theoretical net elongation to be the target. A tolerance of ±1/2 inch (13 mm) from the calculated net elongation, after seating, may be allowed.

6. Conduct the tensioning procedure so the indicated stress, measured by the tensioning system, is within 5% of the calculated stress, based upon the corresponding elongation. Verify the distribution of the stress is within 5% of the calculated stress at all points along the tendon or when measured at the end of the bed.

7. Temporary overstressing of the tendons is allowed; however, at no time exceed 80% of the specified tensile strength of the tendons. Do not seat tendons in this overstress condition.

8. Tension tendons between fixed end anchorages by means of jacks either separately or in a group. Several units may be cast in one continuous line. In this case tension them simultaneously.

9. Deflected tendons may be tensioned in place. Alternatively, deflected tendons may be partially tensioned and then raised to the predetermined final position at the beam ends, achieving the required prestressing force. Tendons may be raised simultaneously to the predetermined final position or at any one point, in a single lift, provided the sequence of lifting commences at the point nearest the center of the bed and then progresses alternately at points equidistant from the center to the ends.

10. Support tendons at each deflection point on a freely rotating metal pulley no less than 3/4 inch (19 mm) in diameter.

11. Limit the number of broken strand wires to no more than 2% of the total number of strand wires or no more than one broken wire of any one strand.

H. Prestress Transfer.

1. When accelerated heat curing is used, perform prestress transfer immediately after the curing period is completed and while the concrete is warm and moist.

2. Deflected tendons, if any, are to be released first either by:
- Lowering holdup devices at beam ends as nearly simultaneously as practical, or if this is not feasible,
- Flame cutting deflected tendons in each beam interval in rotation until all deflected tendons are released. Obtain the Engineer's approval for the procedure used to flame cut deflected tendons.

3. Next, release the hold down devices and simultaneously and gradually release the straight line tendons using the jack. If this is not feasible, heat the tendons as follows:
- **a.** For each tendon, simultaneously heat a minimum of two locations along the casting bed.
- **b.** Apply heat along the tendon over a minimum 5 inch (125 mm) distance.
- **c.** Control heat application so that failure of the first wire in the tendon does not occur for at least 5 seconds after heat is applied, followed by gradual elongation and failure of the remaining wires. Heat the tendon until failure occurs at each beam interval before proceeding to the next tendon.
- **d.** Sequence prestress transfer between individual tendons so that there is minimum eccentricity of prestress load.
- **e.** Alternate procedures for releasing deflected or straight line tendons may be submitted for the Engineer's approval.

4. Measure the camber due to prestress while the beam is on the bed by checking the beam profile within three hours after prestress transfer.

I. Post Tensioned Prestressed Concrete.
When post tensioned construction is designated, detailed procedures will be included in the contract documents.

J. Tolerances.
Apply the following tolerances for precast and prestressed units:

1. Precast Nonprestressed Units.
- **a.** Limit variation from dimensions shown in the contract documents to no more than 1/8 inch (3 mm). For overruns, greater deviation may be accepted if, in the Engineer's opinion, it does not impair the suitability of the member for its intended use.
- **b.** Ensure beam seat bearing areas at each end of the unit are flat and true and perpendicular transversely to the vertical axis of the beam.
- **c.** Limit the difference of cambers between two adjacent units, as assembled, to no more than 1/8 inch (3 mm).

2. Precast Prestressed Units.
Limit variation from dimensions shown in the contract documents to the tolerances shown in Table 2407.03-3:

Table 2407.03-3: Tolerances

Length	±1/4" per 25' and ±1" max. for beams 100' or longer (±6 mm per 8 m and ±25 mm max. for beams 30 m or longer)
Width (flanges and fillets)	+3/8" or -1/4" (+10 mm or -6 mm)
Depth (overall)	+1/2" or -1/4" (+13 mm or -6 mm)
Width (web)	+3/8" or -1/4" (+10 mm or -6 mm)
Depth (flanges and fillets)	±1/4" (±6 mm)
Bearing plates (ctr. to ctr.)	1/8" per 10' of beam length, max. ±3/4" (1 mm per 1 m of beam length, max. ±20 mm)
Sweep (deviations from straight line parallel to center line of member)	L/80 (L in feet, sweep is in inches) L(L in meters, sweep is in millimeters)
Camber deviation from design camber	±30% of plan camber
Stirrup bars (project above top of beam)	+1/4" or -3/4" (+6 mm or -20 mm)
Individual tendon position	
Straight strands	±1/4" (±6 mm)
Draped strands at end of beam	±1/2" (±13 mm)
Tendon position	
Center of gravity of strand group	±1/4" (±6 mm)
Center of gravity of depressed strand group at end of beam	±1" (±25 mm)
Deviation from net theoretical elongation after final seating	± 1/2" (13 mm)
Position of deflection points for deflected strands	5% of beam span toward end of beam
Position of handling devices	±6" (±150 mm)
Bearing plates (ctr. to end of beam)	±3/8" (±10 mm)
Side inserts (ctr. to ctr and ctr. to end)	±1/2" (±13 mm)
Exposed beam ends (deviation from square or designated skew)	
Horizontal	±1/4" (±6 mm)
Vertical	±1/8" per foot of beam depth (±10 mm per 1 m)
Bearing area deviation from plane	±1/16" (±2 mm)
Stirrup bars (longitudinal spacing)	±1" (±25 mm)
Position of post tensioning duct	±1/4" (±6 mm)
Position of weld plates	±1" (±25 mm)
Elongation (standard gauge length to be a minimum of 20 feet (6 m))	±5% (±5%)

K. Handling and Storage.

1. When lifting and handling precast or prestressed units, support them at or near the points designated in the contract documents. Do not allow the overhang to exceed 5% of the length of the beam, unless specified otherwise in the contract documents.

2. Do not lift or strain units in any way before they have developed the strength specified. In storage, support units at points adjacent to the bearings.

3. Support piles near the one-fifth points measured from the ends. In stacking units for storage, arrange the bearings one directly above another.

4. Legibly mark piles with the casting date in fresh concrete near the head of the pile, using numerals only.

5. During fabrication, storage, handling, and hauling take care to prevent cracking, twisting, unnecessary roughness, or other damage. In particular, do not allow tiedowns to come in direct contact with concrete surfaces. Do not subject units to excessive impact. Replace at no additional cost to the Contracting Authority units that are, in the Engineer's opinion, damaged in a way to impair their strength or suitability for their intended use.

L. Finish.

1. Finish all surfaces which will be exposed in the finished structure as provided in Article 2403.03, P, 2, b, and ensure they are free of honeycomb or surface defects. Submit Structural Repair procedures to the Engineer for approval.

2. Finish the outer surface of exterior beams as follows:
- **a.** As soon as practical after removal of the forms, remove all fins and other surface projections.
- **b.** Brush or spray a prepared grout onto the prewetted surface. Use a grout consisting of one part of silica sand and one part of Portland cement blended with acrylic bonding agent and water to produce a consistency sufficient to fill the cavities. The Engineer may require white Portland cement to be used in amounts necessary to obtain a uniform finish.
- **c.** Immediately after applying the grout, float finish the surface with a cork or other suitable float. Ensure this operation completely fills all holes and depressions on the surface.
- **d.** When the grout is of such plasticity that it will not be pulled from holes or depressions, use a sponge rubber float to remove all excess grout.
- **e.** When the surface is thoroughly dry, rub it vigorously with dry burlap to completely remove excess dried grout.

f. Cure the surface finish in a manner satisfactory to the Engineer. Heat curing may be required in cold weather.

g. Ensure, when finished, the surface is free from stains and has a uniform color.

3. Cut and bend tendon projections as detailed in the contract documents. Cut the tendon off flush with the concrete where the tendon end will be exposed in the complete structure. Clean the end of each cut off tendon to a bright appearance.

4. Coat and seal beam ends exposed in the complete structure with an approved gray or clear epoxy listed in Materials I.M. 491.19, Appendix B. Coat and seal beam ends as indicated on the plans. Apply the epoxy coating and beam end sealing at the fabricating plant.

2407.04 METHOD OF MEASUREMENT.

A. For precast or prestressed structural units, the Engineer will determine the number of units of each of the various respective sizes, lengths, and types from actual count. Measurement of precast sheet piles or precast or prestressed bearing piles will be according to Article 2501.04.

B. For cast-in-place prestressed concrete, measurement for concrete, reinforcing steel, and structural steel will be according to Article 2403.04 for structural concrete, and the prestressing will be a lump sum item.

2407.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price for the number of approved precast or prestressed structural units of each size and length incorporated in the project.

B. Payment is full compensation for:

- Producing and furnishing the units complete as shown in the contract documents, with all plates, pads, bolts, grout enclosures, reinforcing steel, prestressing material, coil rods, hold down devices, and any other items to be cast in the concrete,
- Transporting units to the site and placing them in the structure,
- Furnishing and installing bearing plates and anchor bolts or neoprene pads when specified in the contract documents.

C. Payment for furnishing precast sheet piles or precast or prestressed bearing piles will be as provided in Article 2501.05.

D. Payment for cast-in-place prestressed concrete will be according to Article 2403.05. The prestressing will be paid for as a lump sum item. The lump sum amount is full payment for furnishing and placing the required material and stressing, anchoring, and grouting the prestressing steel according to the contract documents.

Section 2408. Steel Structures

2408.01 DESCRIPTION.

A. Fabrication and erection of:

1. All types of bridge structures for which the main members spanning the various supports are composed of steel.

2. Other structures or parts of structures where the design or intended use of steel is based on physical or chemical properties of the steel.

B. The quality of work and finish is to be equal to the best practice in modern bridge shops. Perform shearing and chipping neatly and accurately. Neatly finish all portions of the work exposed to view.

2408.02 MATERIALS REQUIREMENTS, IDENTIFICATION, AND FABRICATION.

Unless elsewhere modified in the contract documents, all fabrication to which this section applies shall be done in the states, territories, and possessions of the United States and in other locations within the geographic limits of North America and in steel fabrication shops and plants that are approved prior to the letting according to Materials I.M. 557. All main member fabrication, except bearing devices, must be fabricated by plants certified as Category III, Major Steel Bridges, under the provisions of AISC's Quality Certification Program.

A. Base Materials.
Use materials meeting the requirements of Division 41 for the following:

1. Rolled Plates, Shapes, and Eyebars.
Apply Section 4152.

2. Forgings and Castings.
Apply Section 4153.

3. Bronze Metal (rolled or cast).
Apply Article 4190.03.

4. Bolts, Nuts, and Washers.
Apply Article 4153.06.

5. Bearing Pads.
Apply Article 4195.02.

6. Galvanizing.
Apply Article 4100.07.

B. Identification of Steel during Fabrication.

1. Main members of steel structures are defined to include the following. The contract documents may also designate other members as main members.

- Rolled sections or flange and web plates in main beams and girders,
- Floor beams,
- Stringers,
- Abutment diaphragms,
- Cross frames carrying direct live loads,
- Lateral bracing and cross frames in horizontally curved bridges,
- Cover plates, splice plates, and gusset plates,
- Bearing stiffeners and bearing devices, and
- Stiffeners connecting live load carrying members to main beam or girder webs.

2. Before steel, as received, is cut for fabrication, provide the Engineer two copies of certified mill test reports showing chemical and physical test results for the steel involved.

3. For all steels, use a record keeping system for individual pieces, and issue cutting instructions to the shop that will maintain identity of the mill test report number. Generally, this record keeping system consists of cross referencing assembly marks shown on the shop drawings with the corresponding item, covered on the mill purchase order. Provide the inspector with a copy of the cutting instructions.

4. The Contractor may furnish material from stock which can be identified by heat number and mill test report.

5. Identify main members and component parts thereof by heat number, unless the Engineer allows exception. Ensure each piece of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) clearly and legibly shows its proper color code. Maintain these identifications until the steel is cleaned for painting.

6. Provided the heat number or color code remains legible, individually marked pieces of steel may be used without further color coding if they are used in furnished size or reduced from furnished size only by end or edge trim that does not disturb the heat number or color code or leave any usable piece.

7. Before cutting, legibly mark pieces of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) which are to be cut to smaller size pieces with the proper color code.

8. Upon being removed from the bundle or lift, immediately mark with the proper color code individual pieces of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) which are furnished in tagged lifts or bundles.

9. Mark for grade by steel die stamping, or by a firmly attached substantial tag, pieces of steel (other than ASTM A 709/A 709M Grade 36 (Grade

250) steel) which, prior to assembling into members, will be subject to fabricating operations, for example blast cleaning, galvanizing, heating for forming, or painting, that might obliterate paint color code marking.

10. During fabrication, up to the point of assembling members, ensure each piece of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) clearly and legibly shows its specification identification color code as shown in Table 2408.02-1:

Table 2408.02-1: Specification Identification Color Code

Section	Steel Grade	Color Code
ASTM A709/A 709M	100 (690)	Red
ASTM A 709/A 709M	100W (690W)	Red and Orange
ASTM A 709/A 709M	50 (345)	Green and Yellow
ASTM A 709/A 709M	50W (345W)	Blue and Yellow

11. Ensure other steels not covered above and not included in ASTM A 6/A 6M have an individual color code established and on record for the Engineer.

12. Provide an affidavit in the form of a cutting list, listing heat numbers and grade of steel, and a statement certifying that throughout the fabrication operation the identification of steel has been maintained according to this specification.

C. Fasteners.

1. Where indicated in the contract documents, "rough bolted connections" may be used. In these connections, bolts may be hex-head bolts meeting the requirements of ASTM A 307. Ribbed bolts may be used when specified in the contract documents. Under the nut of each ASTM A 307 hex-head bolt, fit one ANSI B18.21.1 helical spring lock washer, except for:

- Expansion joint bolts that are to be removed after the expansion joint is installed, or
- Anchor bolts through slotted holes where a cut washer is provided.

2. When rough bolts or ribbed bolts are to be used, furnish 5% more than the number of bolts of each size and length shown in the contract documents. When turned bolts or high strength bolts are to be used, furnish 2% more than the number of bolts and corresponding washers and nuts shown in the contract documents.

D. Pins and Rollers.

1. Turn pins and rollers to the specified dimensions. Ensure they are smooth, straight, and free from flaws.

2. Forge and anneal pins and rollers more than 9 inches (225 mm) in diameter.

3. For pins larger than 9 inches (225 mm) in diameter, longitudinally bore a 2 inch (50 mm) hole through the center after the forging has cooled below the critical range and before the forging is annealed. Reject pins showing a defective interior condition.

E. Bars and Plates.

1. Unless otherwise noted on the plans, and as excepted below, roll edges of all main stress carrying members composed of plates and all steel material designated on plans as "bar" or "UM plate". They may be thermal cut, provided that with thermal cut plates a smooth surface is secured by the use of a mechanical guide the Engineer approves according to Article 2408.03, B. Web splice plates and bearing stiffeners 5/8 inch (16 mm) or less in thickness may be made of sheared plates.

2. Unless otherwise noted in the contract documents, secondary stress members may be made of sheared plates. If sheared plates are used, dull their exposed sharp corners by grinding.

3. Cut plates so the direction of stress in main members is in the direction of rolling, except web splice plates.

4. For main stress carrying members, use members defined in Article 2408.02, B as main members.

F. Bent Plates.

Use unwelded, cold bent, load carrying, rolled steel plates complying with the following:

1. They are taken from the stock plates so the bend line is at right angles to the direction of rolling.

2. They are bent in such a manner that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in Table 2408.02-2 for all grades of structural steel in this specification.

Table 2408.02-2: Minimum Bend Radii

Thickness in Inches (millimeters)					
	Up to 1/2 (12)	Over ½ to 1 (12 to 25)	Over 1 to 1 1/2 (25 to 40)	Over 1 1/2 to 2 1/2 (40 to 60)	Over 2 1/2 to 4 (60 to 100)
Minimum Bend Radii for Metal Thickness (t)	2t	2.5t	3t	3.5t	4t
NOTE: Low alloy steel in thickness over 2 1/2 inch (12 mm) may require hot bending for small radii.					

a. Allowance for springback of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel should be about three times that for structural carbon steel. For brake press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advised.

b. If a shorter radius is essential, hot bend plates at a temperature no greater than 1200°F (650°C), except for ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel. If ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel plates are bent at temperatures greater than 1125°F (610°C), they must be requenched and tempered in accordance with the producing mill's practice. For hot bent plates, conform to Article 2408.02, F, 1.

3. Before they are bent, round the plate corners to a radius of 1/16 inch (1.6 mm) throughout that portion of the plate at which the bending is to occur.

G. Sheared Edge Finish.

Plane, to a depth of 1/4 inch (6 mm), sheared edges of plates more than 5/8 inch (16 mm) in thickness and carrying calculated stress. Grind, if necessary, to secure a finish equivalent to an ANSI 1000 (25 µm) surface roughness. Fillet re-entrant corners to a minimum radius of 1 inch (25 mm) before cutting.

H. Thermal Cutting.

Apply Article 2408.03, B. Thermal cut main stress carrying members only when the steel in the area of the cut is above 40°F (4°C) and in a dry surface condition.

I. Stress Relief Heat Treatment.

1. For structural members which are indicated in the contract documents to be stress relieved, perform finish machining, boring, and straightening subsequent to heat treatment. Perform stress relief heat treatment according to Section 4.4 AASHTO/AWS D1.5M/D1.5-02.

2. Do not anneal or normalize members made of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel. Stress relieve only with the Engineer’s approval.

3. For each furnace charge, maintain a record that identifies pieces in the charge and shows the temperatures and schedule actually used. Provide instruments, such as recording pyrometers, for determining the temperature of members in the furnace at any time. Submit the treatment operation records to the Engineer for approval.

4. Unless stated otherwise in the contract documents, stress relieve all members, such as bridge shoes, pedestals, rockers, or other parts, which are built up by welding sections of plate together.

J. Plate Girders.

Fabricate welded plate girders according to the following requirements:

1. Web Plates.

a. Cut edges of a girder web true and straight or to camber and other detailed curvatures with the accuracy necessary to serve a correct fit up to the flange plate.

b. Weld web plates completely in shop separately before assembly with the flange plates as shown in the contract documents.

2. Web Stiffeners.

a. Bearing Stiffeners.

1) Ensure end stiffeners of girders and stiffeners intended as supports for concentrated loads have full bearing on the flanges to which they transmit load or from which they receive load.

2) Mill or grind these surfaces, or on weldable steel in compression areas of flanges, weld as shown in the contract documents.

b. Intermediate Stiffeners.

Ensure intermediate stiffeners (not intended to support concentrated loads) fit sufficiently tight to be in close contact with the flanges, unless shown or specified otherwise.

c. Stiffener Welding.

1) Start the fillet welds connecting the stiffener or connection plate to the web at the end of the stiffener that is adjacent to the tension flange.

2) Progress toward the compression flange.

3) Before welding, ensure no gap exists between the web and the intermediate stiffeners, bearing stiffener, or connection plates in excess of 3/32 inch (2.4 mm).

3. Flange Plates.

a. Fabricate flange plates using universal mill plates or thermal cut plates which are cut according to Article 2408.02, H.

b. Weld flange plates for welded girders completely in shop separately before assembly with the web plate as shown in the contract documents.

4. Tack Welding.

Submit tack welding and fit up procedures to the Engineer for review and approval.

K. Camber of Rolled Beam and Plate Girder Spans.

1. When specified in the contract documents, camber the rolled beams and plate girders constituting the main supporting members of a span. Unless specified otherwise in the contract documents, camber to a uniform, approximately circular curve for the entire length of the beam or between designated points. Compound or reverse curves may be required on special designs as shown on the plans.

2. Camber of beam spans may be produced either in the rolling mill or in the fabricating shop. Camber of beam spans may also be induced or corrected by local heating. In all cases, ensure beams conform to the specified shape within tolerance limits. Ensure beams are free from kinks, buckles, or other local imperfections. Improper heating or cooling which might affect grain structure, strength, or ductility of the metal are causes for rejection.

3. Rolled beams may be cambered by heating in the following manner:

a. Complete welding of cover plates before commencing final heating operations.

b. Support the beam near its ends in such a manner that the side to be made concave faces upward.

c. Apply heat with an oxyacetylene, butane, natural gas, or other approved gas flame to areas so selected that distortion other than the required camber will not occur. Apply heat by playing the flame over the section to be heated until the metal attains a temperature of 1000°F to 1200°F (540°C to 650°C). Use temperature indicating crayons, liquids, or bimetal thermometers to control the temperature. Notify the Engineer before any heating is done.

4. Use wedge or triangular shaped heated areas with an included angle between 20 and 45 degrees. Locate the vertex of the angle approximately 1 inch (25 mm) above the point on the web midway between flanges. Slowly play the flame from the torch (or torches) over the area to be heated. Commence at the vertex of the angle and finish at the widest part of the heated wedge, which extends across the width of the flange on the side to be made concave. Manipulate the torch (or torches) so that the total area of the heated zone is rapidly brought to the proper temperature at the same time as nearly as practical.

5. Uniformly space the heated sections at short intervals to produce uniform curvature. Heat no fewer than three sections. Heating of additional sections may be required in the case of unusually long or heavily cambered beams. Air cool the metal slowly and away from wind or drafts. Do not use water to cool the metal. Do not heat any area more than once.

6. Camber plate girders by cutting the web plate to the proper curvature to produce a camber within the allowable tolerance. When cutting the web plate, include an allowance to compensate for the effect of the heat of welding operations to be performed on the girder during fabrication.

7. Do not induce or correct camber in plate girders by local heating without the Engineer's prior approval. Do not heat ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steels.

L. Bolt Holes.

1. General.

a. Drill or punch all bolt holes. Do not punch holes in metal thicker than 3/4 inch (19 mm) for carbon steel and 5/8 inch (16 mm) for alloy steel. Instead, subdrill and ream holes, or drill holes to full size. Subpunch and ream, subdrill and ream, or drill full size holes in main stress carrying members. Punch or drill full size holes for members (other than main stress carrying members) made of metal no thicker than 3/4 inch (19 mm) for carbon steel and 5/8 inch (16 mm) for alloy steel.

b. When reaming is required, subpunch or subdrill all holes. Subdrilling will be required if thickness limitations govern. Subpunch or subdrill holes 3/16 inch (5 mm) smaller than the nominal diameter of the bolts. After assembling, either ream holes to 1/16 inch (2 mm) larger or drill holes full size to 1/16 inch (2 mm) larger than the nominal diameter of the bolts.

c. In steel templates, place hardened steel bushings in holes accurately dimensioned from the centerline of the connections as inscribed on the template. Use the centerline to accurately locate the template from the milled or scribed ends of the members.

2. Punched Holes.

Limit the diameter of the die to at the most 1/16 inch (2 mm) more than the diameter of the punch. If any holes must be enlarged to admit the bolts, do so by reaming. Holes shall be clean cut without torn or ragged edges. The slightly conical hole that naturally results from punching operations is considered acceptable with the Engineer's approval.

3. Reamed or Drilled Holes.

Ream or drill holes cylindrical and perpendicular to the member. Where practical, use mechanical means to direct reamers. Perform reaming and drilling using twist drills, twist reamers or rotobroach cutters.

Assemble connecting parts that require reamed or drilled holes and then securely hold while reaming or drilling. Match-mark parts before disassembling.

4. Accuracy of Holes.
Holes fabricated using a drill or reamer of the nominal diameter and not more than 1/32 inch (1 mm) larger in diameter than the true decimal equivalent of the nominal diameter are considered acceptable. Limit the width of slotted holes, produced by flame cutting or a combination of drilling or punching and flame cutting, to no more than 1/32 inch (1 mm) greater than the nominal width. Grind the flame cut surface smooth.

5. Accuracy Before Reaming.
Subpunch or subdrill all holes accurately enough that after assembling (before any reaming is done) a cylindrical pin 1/8 inch (3 mm) smaller in diameter than the nominal size of the hole may be entered perpendicular to the face of the member (without drifting) in at least 75% of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly subpunched or subdrilled pieces will be rejected. Any hole that does not allow a pin 3/16 inch (5 mm) smaller in diameter than the nominal size of the subpunched or subdrilled hole to pass will be rejected.

6. Accuracy After Reaming or Drilling.
Ensure that at least 85% of reamed or drilled holes in a contiguous group show no offset greater than 1/32 inch (1 mm) between adjacent thicknesses of metal.

7. Misplaced Holes.
Misplaced holes may be a basis for rejection. Repair only with the Engineer's approval.

8. Removal of Burrs.
Remove burrs on outside or faying surfaces. If the Engineer requires, disassemble assembled parts to remove burrs.

M. Boring Pin Holes.
Unless otherwise required, bore pin holes to be: 1) true to detailed dimensions; 2) smooth; and 3) straight at right angles with the axis of the member and parallel with each other. Finish cut according to Article 2408.03, E.

N. Reaming Subpunched Field Connections.

1. When subpunched and reamed holes are required for field connections, fully assemble main members of the structure and firmly bolt together.

2. Adjust main members to line and fit before reaming holes in connecting joints.

3. Before parts are disassembled for shipping and handling, match-mark respective pieces with a low stress riser steel stamp so that they can be reassembled in the same position when the structure is erected in the field. Steel stamping on the edges of plates will not be permitted.

4. In lieu of subpunching and reaming holes, the fabricator may drill holes full size, while members are assembled, by any of the following procedures:

- By laying out the location of the holes on the outside plate with center punch marks and drilling full size, or
- By subpunching holes in the outside plate and enlarging subpunched holes by drilling full size, and drilling full size through the remaining plates, or
- By predrilling splice plates or plates full size and using these as a template to drill full size through the remaining plates.

5. Ensure the accuracy of drilled holes is as specified in Article 2408.02, L, 4.

6. Do not interchange reamed parts. Ream connecting joints (such as floor beam and stringer connections not assembled as provided above) to a metal template.

O. Pilot and Driving Nuts.

On pin connected spans, furnish pilot and driving nuts for each size pin, unless provided otherwise in the contract documents.

P. Mill and Shop Inspection.

1. General.

a. Provide the Engineer ample notice of the beginning of work at the mill and shop so inspection may be provided. Mill inspection of rolling will not be required unless the Engineer requests. If inspection of rolling is not requested, provide the Engineer complete test reports of mill inspections, showing chemical and physical tests for each heat of all structural steel sections as specified in Articles 2408.02, A and 4152.02.

b. Notify the Engineer before fabricating material.

2. Inspector's Authority.

a. The inspector has the authority to reject material or work which does not fulfill the requirements of these specifications. In cases of dispute, appeal to the Engineer, whose decision is final.

b. Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility in regard to imperfect material or quality of work and the necessity for replacing the same.

3. Facilities for Inspection.
Furnish facilities for inspection of material and workmanship in the mill and shop. Allow inspectors free access to necessary parts of the premises.

4. Mill Orders and Shipping Statements.
Provide the Engineer with as many copies of mill orders and shipping statements (showing the weights (mass) of individual members) as may be requested.

5. Rejection.
Approval of any material or finished members will not be a bar to their subsequent rejection, if found defective. Promptly replace, or make good, rejected material and work.

Q. Shop Painting.
This portion describes surface preparation and shop painting of weathering and non-weathering structural steel and incidental parts, as well as the requirements for water washing of weathering structural steel. The work includes the following items: preparation of all surfaces to be painted, application of paint, protection, drying of paint coatings, and repairing and repainting of coating damaged in the shop or after erection, or both.

1. Surface Preparation.

a. General.

1) Provide a near white metal blast cleaning to steel surfaces to be painted according to SSPC-SP10. First clean bearing assemblies of any surface contamination using suitable solvents according to SSPC-SP1, and then provide a near white metal blast cleaning according to SSPC-SP10. The standard used for acceptance of the surface preparation will be SSPC-VIS 1, Visual Standard for Abrasive Blast Cleaned Steel.

2) Do not blast clean machined surfaces designated in the contract documents to have a surface roughness of ANSI 125 (3.125 µm) or less. Masking or other protection is required if these parts are subjected to the blast cleaning process.

3) Use a clean, dry abrasive free from organic contamination. After blasting, thoroughly clean the surface to be painted with dry, oil free, compressed air to remove all blast residue.

4) Achieve a sharp, angular blast profile of a minimum 1 mil (25 µm) and maximum 3 mils (75 µm) on all surfaces, including thermal cut edges. When shot is used for blasting, use a blast media containing at least 10% steel grit.

b. Non-weathering Structural Steel Applications.

1) Remove oily or greasy residues with solvent according to SSPC-SP1, Solvent Cleaning, before the top coat is applied.

2) Ensure surfaces to be top coated comply with the specifications and are dry.

c. Weathering Structural Steel Applications.

1) For weathering structural steel applications, provide a Commercial Blast according to specification SSPC-SP6 to surfaces not requiring painting.

2) After blasting, apply at least three uniform applications of water mist (at 24 hour intervals between applications) to all unpainted areas of outside surfaces of the fascia girders to ensure uniform weathering. Apply each application on dry surfaces. Perform the water mist application within 48 hours after the painted surfaces have been properly cured. Ensure all water mist applications are witnessed by a representative of the Contracting Authority.

2. Painting.

a. General.

1) Perform shop painting only in a facility approved by AISC, SSPC, or the Engineer. Allow only painters who are trained and certified by an independent outside agency for the type of work performed to apply the paint.

2) Prior to painting, ensure all surfaces are free of all moisture, dirt, oxidation products, oil, and other detrimental material, and is of a suitable temperature according to the manufacturer's recommendations. Follow the paint manufacturer's application recommendations regarding mixing, thinning, application, pot life, steel temperature, and weather conditions. Apply paint so the painted areas have a smooth, uniform, adhering coat that is free of over-spray, dry spray, mud cracking, runs, sags, cracks, holidays, or other defects.

3) Do not paint machined surfaces with small clearances between moving components, such as full circle pins and pin holes, partial circle pins and pin recesses in castings, and similar surfaces. Instead, shop coat these surfaces with an application of waterproof multipurpose grease complying with National Lubricating Grease Institute No. 3, or other approved protective coating. Thoroughly clean machined surfaces before applying grease. Apply protective coating as soon as practical after component parts have been machined, welded if required, and blasted.

4) Before erection, wipe machined surfaces clean and apply a second shop coat of the same grease used above.

b. Non-weathering Structural Steel Applications.

1) General.

a) Use prime coat and topcoat paints manufactured by the same company. Protect painted surfaces to prevent soiling during painting and through the tack-free stage. Take care not to damage the paint system during handling, delivery, storage, and erection of the structural steel. Repair prime coat damage attributable to shop activities according to the paint manufacturer's recommendations before

shipment to the field. Repair topcoat damage according to the manufacturer's recommendations.

b) Shop apply a prime coat to structural steel surfaces, including faying surfaces of high strength bolt connections. Also shop apply a prime coat to all bearing assemblies, except galvanized masonry plates and galvanized swedged bolts unless specified otherwise in the plans.

2) Shear Studs.

a) When shear studs are welded to the top of the top flange of a beam or girder after the paint system is applied, grind the paint off in the areas of the weld to facilitate welding.

b) After welding, repair paint damage on the underside of the top flange. Touch-up on the top side of the top flange is not required (this will be covered with PCC).

3) Prime Coat.

a) Apply a coat of zinc silicate paint to all surfaces as soon as possible after blasting and before formation of any surface rust, and no later than 16 hours after blasting the surface. Approved paints are shown in Materials I.M. 482.02, Appendix A. Use a target average dry film thickness of 4 mils (100 µm) with no spot measurement below 3 mils (75 µm) or above 6 mils (150 µm).

b) Perform repairs or build-up of the paint film as soon as possible, and no later than 24 hours from the initial application.

c) Completely reblast and repaint steel members with coating areas measuring less than 3 mils (75 µm) that have not been corrected within 24 hours.

d) Correct, to the Engineer’s satisfaction, all defects in application such as runs, sags, mud cracking, over-spray, and dry spray.

e) Excessive coating thickness is as equally undesirable as unacceptably thin coating thickness, and both will be sufficient cause for rejection. Excessive thickness will be evaluated on a case-by-case basis in consultation with the coating manufacturer.

f) Inorganic zinc silicate paint film will be considered cured and ready for shipment after achieving a resistance rating of 4 as verified by 50 Methyl Ethyl Ketone (MEK) rubs as per ASTM D 4752. Moisture misting and plastic tenting may be required during cold application temperatures and low relative humidity conditions to aid in prime coat curing.

4) Top Coat.

a) When designated by the contract documents, shop apply a topcoat of waterborne acrylic paint to all primed surfaces. Paint galvanized fasteners according to Article 2408.02, Q, 2, b, 5, after bolting. It is recommended that application be initiated with a mist coat applied prior to full coat application. To avoid moisture condensation, keep the top coat under a roof, protected from dirt, dust, and moisture, in an area where the temperature is maintained

above 40°F (5°C) for a minimum 24 hours after painting is completed.

b) Shield concrete at all junction points of concrete and steel so that application of paint on steel is complete without overspray on the concrete.

c) Approved paints are listed in Materials I.M. 482.05, Appendix A. Ensure the dry film thickness of the top coat is a minimum of 2 mils (50 µm). Unless otherwise specified in the contract documents, use a topcoat color that is Iowa standard foliage green Federal Color Standard Number 14223.

5) Field Repair and Painting.

a) After erection, repair and repaint paint damage due to transportation, handling, or construction activities. Use an approved zinc rich epoxy paint listed in Materials I.M. 482.02, Appendix C, for repairing primer, priming un-galvanized fasteners, and any coating damage to galvanized fasteners.

b) Ensure areas to be repaired and repainted are clean, dry, and free from grease, oil, corrosion products, and other detrimental materials. Do not apply paint to surfaces unless they are free from moisture or frost. Follow the paint manufacturer's recommendations for repair.

c) When designated by the contract documents, include a field applied waterborne acrylic topcoat.

6) Cleaning of Paint Surfaces.

Upon completion of concrete placement, clean exposed structural steel surfaces to remove all concrete and laitance before the concrete sets up.

c. Weathering Structural Steel Applications.

1) Apply a coat of zinc silicate paint to all surfaces as soon as possible after blasting and before formation of any surface rust, and no later than 16 hours after blasting the surface. Approved paints are shown in Materials I.M. 482.02, Appendix A and Appendix C. Ensure the minimum average dry film thickness is 4 mils (100 µm) with no spot measurement below 3 mils (75 µm) or above 6 mils (150 µm). Perform any repairs or build up to the applied prime coat as soon as possible and no later than 24 hours from the initial application.

2) Apply a top coat of waterborne acrylic paint from the approved lists shown in Materials I.M.s 482.05, Appendix A; or 482.07, Appendix A, to the primed surfaces after the primer has cured to a resistance rating of 4 as verified by 50 MEK rubs as per ASTM D 4752 for inorganic zinc rich primers. Use a top coat color matching Federal Color Standard Number 20045. Ensure the top coat covers all the primed surfaces, except faying surfaces of bolted joints, with a uniform film of paint. Apply the top coat in the shop unless otherwise permitted in writing by the Engineer.

3) Paint the following areas:
- **a)** All the weathering steel for a distance of 1.5 times the girder depth on each side of the expansion joints.
- **b)** All the bearing assemblies except galvanized masonry plates and galvanized swedged bolts unless specified otherwise in the plans.
- **c)** Embedded girder ends over the entire embedment length plus an additional distance of 1.0 foot (300 mm). Seal the crevice between the embedded steel and concrete by caulking with a neutral cure and non-sag silicone. Two products meeting these criteria are Dow 888 or CSL 342 joint seal.
- **d)** Prepare exterior surfaces of all galvanized components indicated in the plans to be painted and all galvanized floor drains according to the written recommendations of the paint manufacturer. Paint with the same type of waterborne acrylic paint used for top coat as noted in this specification.

4) After erection of the bridge, prepare all fasteners in the painted areas using suitable hand tools, mechanical tools, or blasting equipment. Prime with a zinc rich epoxy paint from the approved list shown in Materials I.M. 482.02, Appendix C. Clean the primed surfaces and apply a top coat of waterborne acrylic paint from the approved list shown in Materials I.M. 482.05, Appendix A. Use a top coat color matching Federal Color Standard Number 20045.

5) After completing construction, prepare and repaint defects or damage to the paint system.

6) Ensure all steel surfaces are free of contaminants, including dirt or concrete.

R. Marking and Shipping.

1. Ship pins, small parts, and small packages of bolts, washers, and nuts in boxes, crates, kegs, or barrels. Do not allow the gross weight (mass) of any package to exceed 300 pounds (135 kg). Plainly mark a list and description of the contained material on the outside of the shipping container.

2. Pack bolts of one length and diameter and loose nuts or washers of each size separately. Also pack items from different manufacturers or from different lots separately.

S. Shop Storage of Material.

Store structural material, whether plain or fabricated, above ground upon platforms, skids, or other supports. Keep it free from dirt, grease, and other foreign material.

2408.03 CONSTRUCTION.

Place the steel superstructure on a substructure constructed as provided in Section 2405. Apply the requirements of Sections 2403, 2404, 2410, 2411, 2412, 2413, and 2508 to the various types of construction.

A. Working Drawings, Shop Drawings, Changes, and Substitutions. Submit detailed shop drawings according to Article 1105.03. Welding procedures will be considered an integral part of shop drawings and will be reviewed for each contract.

1. All material ordered or work done prior to review of the shop drawings is at the Contractor's risk. Ensure shop drawings for steel structures give detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts, such as pins, nuts, bolts, drains, etc.

2. Ensure shop drawings identify each piece that is to be made of steel required to be other than ASTM A 709/A 709M Grade 36 (Grade 250) steel. Ensure pieces made of different grades of steel are not given the same assembling or erecting mark, even though they are of identical dimensions and detail.

3. Sections other than those shown on shop drawings reviewed by the Engineer may be used under the following provisions:
- **a.** The substitute section is equal in strength and stiffness to the section originally shown.
- **b.** The substitution is approved by the Engineer.
- **c.** The substitution is made at no additional cost to the Contracting Authority.

4. Ensure shop drawings for steel structures show accumulated dimensions for each line of beams or girders in laydown. Ensure the accumulated dimensions are shown at the locations of the following details: bearings, welded or bolted splices, stiffeners, gusset plates, and drain connecting holes.

B. Welding.

1. Comply with ANSI/AWS D1.1 Structural Welding Code procedures and requirements for the following items, except comply with AASHTO/AWS D1.5M/D1.5-02 as modified below for filler metal and welder qualification requirements.
- **a.** Bridge Components and Miscellaneous Items. This includes bearing assemblies, sole plates, expansion joint devices, pile and appurtenances, drainage system components, guardrail connections, metal railing, chain link enclosures and wire fence components, conduit systems, and tread plates.
- **b.** Traffic Signal Components.
- **c.** Sign Support Components.
- **d.** Lighting Structure Components.

e. Pre-Engineered Pedestrian Bridges.

2. Comply with AASHTO/AWS D1.5M/D1.5-02, as modified by this specification, for welding and fabricating steel structures.

3. Each of the modifications in this article is referenced by the appropriate paragraph number in AASHTO/AWS D1.5M/D1.5-02, to which it is a modification.

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for
Modifications to ANSI/AASHTO/AWS D1.5 95 Bridge Welding Code

SECTION 1. General Provisions

1.3 Welding Processes

ADD the following Paragraphs after the existing 1.3.1:

1.3.1.1 Welding of main members and welding of attachments thereto shall be performed using only shielded metal arc, flux cored arc, submerged arc, and/or stud welding processes. Unless otherwise approved by the Engineer, all welding of butt splices and flange to web welds and stiffeners to web welds shall be done using the submerged arc process. Shielded metal arc welding may be used for repairs to butt splices and flange to web welds.

1.3.1.2 The WPS shall be initialed by the welder and posted at the welder's workstation at all times during welding operations.

REPLACE Paragraph 1.3.2 with the following:

Electroslag (ESW) and electrogas (EGW) welding are specifically disapproved for use.

SECTION 3. Workmanship

3.2 Preparation of Base Metal

ADD the following paragraph before the existing first Paragraph 3.2.2:

For main members, thermal cutting is limited to oxygen cutting except that plasma arc cutting of web and stiffeners may be used when approved by the Engineer.

DELETE the last sentence of Paragraph 3.2.7 which reads "Excess Camber may be corrected by heating without the engineer's approval."

3.5 Dimensional Tolerances

REPLACE all of the text and tables of Paragraph 3.5.1.3 with the following:

Camber of main members of continuous or simple span bridges with lines composed of rolled beams, beams and girders, or girders, shall be fabricated so that when the members are assembled in laydown with bearing points accurately positioned as shown on the erection diagram, points on any member shall not vary in the offset position from that indicated in the erection diagram by more than ± 1/2 inch (13 mm).

The erection diagram on the shop drawings shall show camber offsets at bearing points and splice points, and at midpoints of individually cambered beams or girders.

REPLACE Paragraph 3.5.1.4 with the following:

Permissible variation in specified sweep for horizontally curved welded beams or girders is

$$\frac{\pm\ 1/8 \text{ in. x No. of ft. of total length}}{10} \quad (\pm\ 1 \text{ mm/m of the total length})$$

provided the member has sufficient lateral flexibility to permit the attachment of diaphragms, cross-frames, lateral bracing, etc., without damaging the structural member or its attachments.

REPLACE Paragraph 3.5.1.14 with the following:

Mechanically connected joints and splices of main members with surfaces intended to be parallel planes shall be nearly parallel after connection, and the surfaces to be in contact shall have an offset no greater than 1/16 inch (1.6 mm) after all filler plates have been added, if any. The accuracy of the angle of connecting stiffeners, angles, or plates shall be ± 0.5 degrees, when measured at the hole locations.

3.7 Repairs

REPLACE Paragraph 3.7.4 with the following:

Prior approval of the Engineer shall be obtained for repairs to base metal, repair of major or delayed cracks, or for a revised design to compensate for deficiencies.

ADD the following paragraph before the existing Paragraph 3.7.7:

The approval of the Engineer is required for all corrections of mislocated holes.

ADD the following Paragraph after the existing 3.7.7:

3.7.8 The maximum number of repairs to unacceptable defects in a butt splice shall be three, i.e., the times a butt splice may be opened, welded closed, and resubmitted for NDT inspection, unless otherwise approved by the Engineer.

SECTION 5. Qualifications

Part A. General Requirements

5.2 Qualification Responsibility

REPLACE Paragraph 5.2 with the following:

To qualify welding procedures, the Contractor shall produce test weldments, perform nondestructive testing and machine specimens for mechanical testing in accordance with this code. The Contracting

Authority will witness the production of test weldments and conduct mechanical tests.

Part B. Welder, Welding Operator, and Tack Welder Qualification

5.21 General Requirements

REPLACE Paragraph 5.21.4 with the following**:**

Shop welder's, welding operator's, or tack welders qualification herein specified shall be considered as remaining in effect from the end of the month in which the tests were taken, for a period of 1 year. The qualification for the above may be extended annually, based on a letter from the fabricator/Contractor certifying that they have been engaged in the process(es) for which they qualified without interruption of more than 6 months during the preceding twelve months, or by requalification. The field welder's qualification herein specified will be considered as remaining in effect from the end of the month in which the test was taken, for a period of 1 year. For field welders who have successfully passed their qualification tests without failure for 3 consecutive years, requalification will only be required every 2 years. Requalification may be required at any time there is a specific reason to question a welder's ability to make sound welds.

5.21.6 Responsibility

REPLACE Paragraph 5.21.6.1 with the following:

To qualify welders, welding operators, and tackers, the Contractor shall furnish test weldments, and perform nondestructive testing in accordance with this code. The Contracting Authority shall witness the production of test weldments and conduct mechanical tests. The Contractor may, at no additional cost to the Contracting Authority, engage an outside firm or agency to witness production of test weldments and conduct mechanical tests. The acceptance of work performed by an outside firm or agency is the prerogative of the Contracting Authority.

5.23 Qualification Tests Required

ADD Subparagraph 5.23.1 (5) after the existing 5.23.1 (4):
Plate weld tests may also be accepted for qualification of welding pipe piling of any diameter.

REPLACE Paragraph 5.23.3 with the following:

Tack Welder Qualification. A tack welder shall be qualified by fillet-weld-break specimen made using the same criteria as listed for plate-fillet welder qualification in Table 5.6. The tack welder shall make a 1/4 inch

(6 mm) maximum size tack weld approximately 2 inches (50 mm) long on the fillet-weld-break specimen, as shown in Fig. 5.28.

SECTION 6. Inspection

Part A. General Requirements

6.7 Nondestructive Testing

REPLACE Subparagraph 6.7.1.2(1) with the following:

100% of each joint subject to tension or reversals of stress, except that on vertical butt weld splices in beam or girder webs, only 1/3 of the web depth beginning at the point, or points, or maximum tension need be tested. If unacceptable discontinuities are found in the first 1/3, the remainder of the weld shall be tested.

REPLACE Subparagraph 6.7.1.2(2) with the following:

50% of each joint subject to compression or shear in each main member including longitudinal butt weld splices in beam or girder webs. If unacceptable discontinuities are found in the first 50% of joint, the entire length shall be tested.

Part B. Radiographic Testing of Groove Welds in Butt Joints

6.10 Radiographic Procedure

ADD the following Paragraph after existing 6.10.5.3:

6.10.5.4 Where areas being radiographed are adjacent to the edge of the plate, edge block shall be used.

6.12 Examination, Report, and Disposition of Radiographs

REPLACE Paragraph 6.12.3 with the following:

Two sets of radiographs shall be taken for welds subject to radiographic testing, including any that show unacceptable quality prior to repair. One radiograph of each test shall, upon completion of Q.C. and Q. A. interpretation, be forwarded to the Office of Materials, Ames, Iowa. The second set of radiographs shall be retained by the Contractor as part of on-site inspection records. Upon completion of the project, this second set will become the property of the Contractor.

C. Shop Assembly.
Assemble the various parts of the structure in the shop as follows:

1. If zinc silicate primer is to be used, clean and shop paint surfaces which will be in contact before assembly according to the contract documents. If zinc silicate primer is not to be used, carefully clean to be free from loose mill scale, dirt, or other foreign material, surfaces which will be in contact. Do not paint before assembly.

2. After assembly, paint and protect all surfaces, except those against which plastic concrete will be placed, as provided in Article 2408.03, X, and the contract documents.

3. Ensure members are free from objectionable twists, bends, or other deformations.

4. Bring members to be welded into correct alignment and hold in position by bolts, clamps, wedges, guylines, struts, tack welds, or other suitable devices, until welding is completed. Use jigs and fixtures where practical. Allow for warpage and shrinkage.

D. Drifting of Bolt Holes.
Allow drifting during assembling only to the extent of bringing the parts into position, but not sufficient to enlarge the holes or distort the metal.

E. Facing Bearing Surfaces.

1. Mill ends of columns and pedestals to true surfaces and correct bevels. Plane warped or deformed base and cap plates to fit accurately.

2. Attach connection angles for base and cap plates to columns before ends are faced. Perform milling only after the member has been fully assembled.

3. Mill bearing surfaces of warped or deformed base and cap plates that are not to be placed in contact with concrete after the plates are attached to the column. Ensure surfaces of base plates that are to be placed in contact with concrete are free from warps and other deformations.

4. All bearing surfaces of castings are to be machined flat. Ensure that:
- Sole plates of beams, girders, and trusses have full contact with the flanges, and the bearing surface is smooth and true and is truly perpendicular to the web of the member.
- Curved sole plates make full line bearing with masonry plates, which line (unless shown otherwise in the contract documents) is at right angles to the axis of the beam, girder, or truss, and with the web of the member.

- Bottom surfaces of masonry plates are free from warps and projections.

5. For bearing material in contact with other material, except as otherwise indicated, apply the following tolerances for flatness:
1/32 inch in 12 inches (1 mm in 400 mm), and
1/16 inch (2 mm) tolerance overall.

6. The degree of surface finish required will be indicated in the contract documents. Ensure the surface finish of bearing and base plates and other bearing surfaces that are to come into contact with each other or with concrete meet the surface roughness requirements as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part 1. Unless indicated otherwise on the plans, finish the following parts to the degree indicated in Table 2408.03-1:

Table 2408.03-1: Surface Finish

Steel slabs including masonry plates and cast shoes in contact with concrete	ANSI 2,000 (50 µm)
Heavy plates in contact in shoes to be welded	ANSI 1000 (25 µm)
Milled ends of compression members, stiffeners, and fillers	ANSI 500 (12.5 µm)
Bridge rollers, rockers, and top surfaces of masonry plates in contact with rollers and rockers	ANSI 250 (6.25 µm)
Pins and pinholes	ANSI 125 (3.125 µm)
Slide bearings	ANSI 125 (3.125 µm)

7. Ensure surfaces of bronze bearing plates intended for sliding bearings are smooth and free from surface projections.

8. In machining sliding bearing surfaces, set the cut of the tool to be in the direction of movement. In machining nonsliding bearing surfaces, set the cut of the tool to be either parallel or normal to the direction of movement.

F. Abutting Joints.

1. Ends of Compression Members.
Accurately face abutting ends of compression members after the members are assembled, to secure an even bearing when assembled in the structure.

2. Ends of Tension Members.
Neatly shear or cut ends of tension members at splices with openings not exceeding 1/4 inch (6 mm).

3. Splices of Continuous Beams and Girders.
Neatly shear or cut ends of beams and girders to be spliced with a minimum opening of 1/8 inch (3 mm) and a maximum opening not exceeding 1/4 inch (6 mm) for rolled beam spans and 1/2 inch (13 mm)

for plate girder spans. This dimension shall be detailed on the shop drawings.

G. End Connection Angles.

Ensure end connection angles of floor beams and stringers are flush with each other and accurately set to position and length of member. In general, do not machine end connection angles unless indicated in the contract documents. However, faulty assembling may be cause for requiring them to be milled. In this case, do not reduce their thickness by more than 1/16 inch (2 mm). Do not reduce their bolt bearing value below the design requirements.

H. Pin Clearance.

Ensure the diameter of the pin hole does not exceed that of the pin by more than 1/50 inch (0.5 mm) for pins 5 inches (125 mm) or less in diameter, or 1/32 inch (0.8 mm) for larger pins.

I. Finished Members.

Ensure pieces forming one built up member are straight and close fitting. Ensure finished members are true to detailed dimensions and free from twists, bends, open joints, or other defects resulting from faulty fabrication or defective work.

J. Shop Erection.

1. Completely assemble the main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames for inspection in the shop when complete assembly is feasible. In lieu of complete assembly, at the option of the Contractor, progressive truss or girder assembly will be permissible, as follows:

a. Initially for each truss, arch rib, bent, tower face, or rigid frame:

- Assemble at least three contiguous shop sections, or
- In the case of structures longer than 150 feet (45 m), assemble all members in at least three contiguous panels, but no less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices) and no less than 150 feet (45 m).

b. In order that the assembled portion of the structure is never less than specified above, include a sufficient number of sections or chord lengths in each laydown so the assembled portion will remain long enough when the rearward section or chord is removed after inspection of the laydown. At the Contractor's option, the portion of the structure which is retained may be disassembled and reassembled in a new location for the new laydown.

c. Initially for each continuous beam or plate girder line, assemble at least three contiguous shop sections. In the case of structures larger than 150 feet (45 m), assemble no less than 150 feet (45 m) of structure. Accomplish each succeeding laydown in such a manner that at least one contiguous section is retained from the

previous laydown, and no less than 150 feet (45 m) of structure is assembled (except that the last laydown in a line may be less than 150 feet (45 m) long). At the Contractor's option, the portion of the structure which is retained may be disassembled and reassembled in a new location for the new laydown.

2. As shop sections are progressively assembled and removed, place each retained section in the new laydown with the same relative orientation to the erection base line as it was found to have in the previous laydown.

3. As shop sections are progressively assembled and removed, scribe suitable marks on the sections remaining so that accurate center to center of bearing dimensions and overall length can be achieved.

K. Field Handling and Storage.

1. Load, transport, unload, and pile structural members so the metal will be kept clean and free from damage by rough handling. Pad shipping supports, lifting devices, and deck form support points to minimize paint damage.

2. Store material in a manner to prevent deterioration by rust or loss of minor parts. Do not pile material to rest upon the ground or in water; instead, place material on suitable skids or platforms. Place girders and beams upright and shore. Ensure skids beneath long members, such as columns or chords, are close enough to prevent damaging the members by deflection.

L. Falsework.

1. Provide detailed plans for falsework or centering, according to Article 1105.03. In no case is the Contractor relieved of responsibility for results obtained by use of these plans or safety of workers on the project. Have the Engineer review and check the adequacy of falsework before erecting the structure which the falsework is to carry.

2. Design falsework for supporting steel during erection to carry, without appreciable settlement or deformation, the full load coming upon it. Use either full length pile bents or framed bents supported by piles or spread footings.

3. Determine bearing values of piles according to Article 2501.03, H, and set them to be at least equal to the loads imposed upon them during construction.

4. To determine the number and size of spread footings or mudsills to be used, use the load to be supported and the bearing value of the soil on which they rest, giving due consideration to soils softening during high water, frozen ground thawing, etc. Do not use mudsills on soils or in situations where scour may occur.

5. Use 1500 pounds per square foot (70 kPa) as a safe bearing value for sand, gravel, firm clay, and other similar confined materials in beds thicker than the falsework footing width.

6. If necessary to extend falsework above the elevation to which piles are driven, cut off at least the majority of all piles in any bent at the same elevation and cap. Construct a framed bent to the required height. Cap each falsework bent transversely at the proper elevation with material of adequate size securely fastened to each pile or post in the bent. Securely brace all bents longitudinally and transversely with diagonal bracing.

M. Preparation of Bearing Area.

1. Ensure column bases, truss and girder pedestals, and shoes have a full uniform bearing upon the concrete of the substructure.

2. Correct bridge seats of piers or abutments which are improperly finished, deformed, or irregular within the bearing area of masonry plates before the plates are placed.

3. Bed the pedestals and shoes for truss and girder spans, as well as columns for steel viaducts, on the bearing area so as to have full and even bearing. Unless otherwise required, use a bedding consisting of a single layer of 1/8 inch (3 mm) sheet lead meeting requirements in Article 4195.01.

N. Handling Members.

1. Handle component parts of a structure using methods and appliances that does not produce damage to the member by twisting, bending, or otherwise deforming the metal.

2. Do not place any member that is slightly bent or twisted into its place until its defects are corrected.

3. Members that have been seriously damaged in handling may be rejected.

O. Straightening Bent Material.

1. When the Engineer permits straightening of plates, angles, other shapes, and built up members, straighten using methods that will not produce fracture or other injury. Straighten distorted members using mechanical means.

2. If the Engineer approves, distorted members may be straightened by the carefully planned and supervised application of a limited amount of localized heat, except perform heat straightening of ASTM A 709/A

709M Grade 100/100W (Grade 690/690W) steel members only under rigidly controlled procedures, with each application requiring the Engineer's approval. In no case allow the maximum temperature of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel to exceed 1125°F (610°C), or allow the temperature to exceed 950°F (510°C) at the weld metal or within 6 inches (150 mm) of the weld metal. Do not apply heat directly on weld metal. In all other steels, do not allow the temperature of the heated area to exceed 1200°F (610°C) (a dull red) as controlled by use of temperature indicating crayons, liquids, or bimetal thermometers.

P. Straightening Material and Placing Members.

1. Rolled material shall be straight when it is laid out for work. If straightening is necessary, do so by means which will not damage the metal.

2. Sharp kinks or bends is sufficient cause for rejection of the material.

3. Perform heat correction only when the Engineer approves. Heat straightening of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel will not be permitted.

4. Unless otherwise shown in the contract documents or ordered by the Engineer, place members which deviate from a straight line by an amount within the tolerance specified in ASTM A 6/A 6M in the structure in such a manner that the stress to be imposed will tend to straighten the member.

5. Heat straighten parts to be substantially free of stress and external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

6. Inspect metal surface following straightening of a bend or buckle for evidence of fracture. Repair or replace members showing fracture.

Q. Assembling Steel.

1. Accurately assemble parts as shown in the contract documents. Follow a match-marking system.

2. Handle material so that parts will not be bent, broken, or otherwise damaged. Do not hammer in a manner which will damage or distort the members.

3. Clean bearing surfaces and surfaces to be in permanent contact before the members are assembled.

4. Ensure important connections in trusses, girders, floor systems, and so forth have at least 25% of the holes on each side of the connection filled with drift pins, and another 25% of the holes on each side of the

connection filled with temporary fitting up bolts drawn up snugly before the temporary support is removed. If the ultimate connection is to be made with high strength bolts, these bolts may be used as fitting up bolts. At milled connections of compression chords of truss spans, except the hip connection, the number of drift pins may be reduced to no less than 10% of the number of holes.

R. Alignment.

1. Before placing permanent bolts in field connections, adjust the structure to correct grade and alignment. For truss spans, block up the elevation of each panel point (ends of floor beams) on the falsework to the correct camber as shown in the contract documents and shop drawings. Leave this blocking in place until all tension chord splices are fully bolted and all other truss connections are pinned and bolted.

2. Support splice joints of continuous beams and girders using adequate falsework or other approved means as directed by the Engineer. Adjust as closely as possible to the required position before bolting is started.

S. Bolting.

Make main connections with high strength bolts, nuts, and washers meeting the requirements of Article 4153.06. All other fasteners will be considered non-high strength fasteners and may be used only where shown on the plans.

1. Length of Bolts.

a. Ensure the length of high strength bolts so that, when properly installed in a snug tight condition, the end of the bolt is flush with or outside the face of the nut.

b. Ensure the length of non-high strength bolts so that when tightened there is no less than 1/4 inch (6 mm) of bolt protruding from the nut.

c. Ensure the length of turned bolts so that when the nut is fully threaded there is no more than:

- 1/8 inch (3 mm) of thread within the thickness of metal to be gripped, and
- 1/4 inch (6 mm) of thread protruding from the nut.

d. Furnish ribbed bolts in a variety of diameters and lengths that:

- When installed will result in a drive tight fit, and
- When tightened will fill the nut and protrude no more than 3/16 inch (5 mm).

2. Bolt Holes.

Ensure holes for non-high strength and high strength bolts permit free entry of the bolt without driving. Carefully ream holes for ribbed bolts to provide for a driving fit. Ream holes for ribbed bolts to be cylindrical and to permit entry of the bolts at right angles to the faying surfaces.

3. Storage of High Strength Fasteners.
Protect bolts, nuts, and washers from the elements.

4. Fastener Acceptance Testing.

a. Prior to steel erection and in the presence of the Engineer, test two representative fastener assemblies from each rotational-capacity test lot as described in Materials I.M. 453.06B. A fastener assembly consists of a bolt, nut, and washer from the same rotational-capacity lot as furnished by the supplier.

b. The Engineer may order additional rotational-capacity tests if there is reason to suspect any change in fastener condition or level of lubrication.

c. Failure of rotational-capacity tests will be cause for rejection of that fastener lot.

5. Installing High Strength Fasteners.
Assemble, tension, and inspect high strength fasteners as described below. In special cases other methods may be used with prior approval of the Engineer.

a. Assembly.

1) Ensure that:

- Surfaces of bolted parts adjacent to the bolt head and nuts are parallel.
- Bolted parts fit solidly together when assembled, without containing gaskets or any other flexible material.
- Holes are no more than 1/16 inch (2 mm) in diameter greater than the nominal bolt diameter.

2) For slotted holes, the dimensions will be shown on the plans or shop drawings.

3) For painted applications, clean and prime the faying surfaces with zinc silicate paint. For unpainted applications, blast clean faying surfaces to:

- Remove mill scale, and
- Be free from paint, lacquer, dirt, oil, burrs, pits, or other defects which would prevent the solid seating of parts or would interfere with the development of friction between parts.

4) Ensure the fastener assembly installed in the field is made up of bolts, nuts, and washers from the same rotational-capacity lot number. Assemble fasteners with one hardened washer under the turned element (either bolt head or nut). When galvanized fasteners are specified:

- Furnish nuts that are pre-lubricated with a dyed lubricant according to ASTM A 563, or
- Field lubricate fastener threads with beeswax or other approved wax-based lubricant.

5) Use high strength weathering fasteners for weathering structural steel. Use galvanized high strength fasteners for non-weathering structural steel, with or without a specified field top coat.

6) Properly tighten each fastener to at least the minimum bolt tension shown in Table 2408.03-2:

Table 2408.03-2: Minimum Bolt Tension

Bolt Dia. inches (mm)	Min. Bolt Tension, lbf.[(a)] (kN[(a)])	Bolt Dia. inches (mm)	Min. Bolt Tension, lbf.[(a)] (kN[(a)])
1/2 (12.7)	12,050 (53.6)	1 1/8 (28.6)	56,450 (251.1)
5/8 (15.9)	19,200 (85.4)	1 1/4 (31.8)	71,700 (318.9)
3/4 (19.0)	28,400 (126.3)	1 3/8 (34.9)	85,450 (380.1)
7/8 (22.2)	39,250 (174.6)	1 1/2 (38.1)	104,000 (462.6)
1 (25.4)	51,500 (229.1)		

[(a)] Equal to the proof load (length measurement method) given in ASTM A 325.

7) Tighten high strength bolts using the turn-of-nut method.

8) Ensure impact wrenches (if used) are of adequate capacity and sufficiently supplied with air to develop the minimum tension of each bolt in approximately 10 seconds.

b. Turn-of-Nut Method.

1) Use the turn-of-nut method to provide the minimum bolt tension specified above.

2) Install bolts in all holes of the connection and bring to a "snug tight" condition. Consider bolts to be "snug tight" when tensioned to approximately 20% of the minimum bolt tension listed above and faying surfaces are in full contact. If full contact of faying surfaces is not achieved after all bolts have been tensioned to 20% of minimum tension, submit a corrective procedure to the Engineer for approval.

3) Systematically progress with snug tightening starting at the center of the connection and working out to the free edges. Check the fasteners of the connection in a similar systematic manner. Retighten as necessary until all fasteners are simultaneously in a "snug tight" condition and the faying surfaces are in full and continuous contact.

4) When all fasteners in the connection are "snug tight", match-mark the face of the connecting part, the nut, and the bolt point using paint, crayon, or other approved means to provide a reference for determining the relative rotation of the parts during final tightening.

5) Following this operation, tighten all fasteners in the connection further by the applicable amount of rotation specified in Table 2408.03-3. Systematically progress with tightening starting at the center of the joint and working out to the free edges. During this operation, do not rotate the part without using the wrench.

Table 2408.03-3: Nut Rotation from "Snug Tight" Conditions[a] (Disposition of Outer Faces of Bolted Connections)

Bolt Length (Under side of head to end of bolt)	Both faces normal to bolt axis	One face normal to bolt axis and other slope not more than 1:20 (beveled washer not used)	Both faces sloped not more than 1:20 from normal to the bolt axis (beveled washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters[b]	2/3 turn	5/6 turn	1 turn

[a] Nut rotation is relative to the bolt, regardless of the element (nut or bolt) being turned. For bolts installed using 1/2 turn and less, use a tolerance of ± 30 degrees. For bolts installed using 2/3 turn and more, use a tolerance of ± 45 degrees.

[b] For bolt lengths exceeding 12 diameters, the required rotation must be determined by actual field tests in a suitable tension measuring device which simulates conditions of solidly fitted steel.

c. Inspection.

1) Check bolted connections, after tightening, in the presence of the Engineer for proper installation, applicable rotation, and general joint condition. The inspection of fasteners, with a torque wrench, at connections of steel diaphragms to concrete beams will not be required.

2) Furnish and use an inspecting wrench which is calibrated and capable of measuring torque.

3) To calibrate the inspecting wrench:

a) Select a representative sample of no less than three bolts and nuts of each diameter, length, grade, and turned element, to be tensioned that day.

b) Check the samples prior to inspection in a device capable of indicating bolt tension. Turn the same element during testing that will be turned during actual work.

c) Use the inspecting wrench to tension the bolt and determine the torque necessary to achieve a bolt tension 5% greater than the specified minimum bolt tension.

d) Use the average of the three torque values for the job inspecting torque value(s).

4) Establish the job inspecting torque value(s) at least once prior to each day's inspection. Have an approved testing agency calibrate the tension measuring device at least every 6 months.

5) Inspect installed and tightened fasteners, represented by the above tests, for acceptance by attempting to tighten the fastener using the inspection torque wrench and the predetermined inspection torque value(s). Acceptance will be based on the random checking of at least 10% of the fasteners in each connection. A minimum of two fasteners per connection will be checked. The connection will be accepted as properly tightened if:

- The faying surfaces are in full and continuous contact, and
- No bolt or nut is turned at a torque value less than or equal to the inspection torque value(s).

6) If any bolt or nut is turned at torque values below the inspection torque value(s), check all fasteners in that connection. Tighten and reinspect all bolts or nuts which turn below inspection torque values.

7) Bolts tightened by the turn-of-nut method may reach tensions substantially above the values specified, but this is not cause for rejection.

d. Reuse of Bolts.

1) Do not reuse high strength bolts and nuts. Do not incorporate construction bolts or fit-up bolts into the final connection.

2) Tensioning of fasteners up to a snug-tight condition as described in Article 2408.03, S, 5, will not be considered as reuse.

3) Retightening (touching up) previously tightened bolts which may have been loosened by the tightening of adjacent bolts will not be considered as reuse.

T. Swinging the Span.

After permanent bolting of truss spans has been inspected and accepted, remove the centering and swing the span free on its permanent supports. Fully bolt all main connections before the span is swung, except permanently bolt milled compression chord connections after the span is swung.

U. Adjustment of Pin Nuts.

Adjust nuts on pins to the amount specified in the contract documents. Locate pins in the holes so the members take full and even bearing.

V. Setting Anchor Bolts.

1. Refer to Article 2405.03, H, for setting anchor bolts for bridge bearings.

2. Set anchor bolts, other than those for bridge bearings, in concrete with a polymer grout, according to Article 2405.03, H, or with a mechanical grip system. When the mechanical grip system is used:

- Ensure the diameter of the hole is suitable for the device used,
- Hold the anchor firmly in place using an expanding metal device approved by the Engineer, and
- Fill the annular space with cement grout or other material approved by the Engineer.

W. Setting Rocker Bearings.

1. Adjust rocker bearings at expansion ends of spans to provide for:
- Movement due to temperature,
- Elongation of bottom chord, and
- Probable substructure movement.

2. Assume a mean temperature of 50°F (10°C) when determining temperature movements.

X. Field Painting.
Field paint steel structures or parts of structures as required in the contract documents.

2408.04 METHOD OF MEASUREMENT.
The Engineer will compute the quantity of various items of structural concrete, steel reinforcement, structural steel, and incidental metal parts involved in construction of steel structures as follows:

A. Structural Concrete.
Article 2403.04 applies.

B. Steel Reinforcement.
Article 2404.04 applies.

C. Structural Steel and Incidental Metal Parts.

1. Structural Steel.
a. The weight (mass) of structural steel measured for payment includes the weight (mass) of:
- rolled shapes and plates, as fabricated, and
- incidental parts, such as castings, bearing plates, expansion devices, bolts, and incidental metal parts necessary for completion of the structure.

b. Unless the contract contains a separate item for metal railings, material for such railings is included with structural steel. Incidental materials, such as bronze, wrought iron, lead, castings, and so forth will be classed as structural steel unless covered by a separate item in the contract.

c. Reinforcement for concrete is not included in this item.

2. Weight (Mass).
a. The weight (mass) of structural steel as defined above, for which payment will be made, is the weight (mass) in pounds (kilograms) computed by the Engineer as shown in the contract documents. In

the case of a substitution, by the Contractor, of a heavier section than that shown, the weight (mass) of the section shown in the contract documents is the measured quantity.

b. The weight (mass) of structural steel, computed by the Engineer and shown in the contract documents, is presumed to be correct and provides the basis of payment. If the Contractor presents evidence that the weight (mass) computed by the Engineer is in error by more than 0.50%, the weight (mass) will be recomputed.

3. Variation in Weight (Mass).

If the weight (mass) of any member is less than 97.5% of the computed weight (mass), such member may be rejected.

4. Computed Weight (Mass).

a. The Engineer will compute the weight (mass) of structural steel on the basis of the following assumptions:

1) Steel: 490 pounds per cubic foot (7850 kg/m^3)

2) Cast Iron: 450 pounds per cubic foot (7210 kg/m^3)

b. The weight (mass) of rolled shapes and plates is computed on the basis of their nominal weights (mass) and dimensions as shown in the contract documents, deducting for copes and cuts.

c. The weight (mass) of welds is to be included in the computed weight (mass), assuming the weights (mass) of fillet welds to be used as in Table 2408.04-1:

Table 2408.04-1: Weight (Mass) of Welds

Size of Weld in. (mm)	Wt. per Linear Ft., lb. (Mass per Meter), (kg)	Size of Weld in. (mm)	Wt. Per Linear Ft., lb. (Mass per Meter), (kg)
1/4 (6)	0.16 (0.21)	1/2 (13)	0.64 (0.99)
5/16(8)	0.25 (0.38)	5/8 (16)	1.00 (1.51)
3/8 (10)	0.36 (0.59)	3/4 (19)	1.44 (2.13)

d. The weight (mass) of heads, nuts, single washers, and threaded stick through all high strength shop bolts is to be included in the computed weight (mass) on the basis of the weights (mass) shown in Table 2408.04-2:

Table 2408.04-2: Weight (Mass) of Bolts

Dia. Of Bolt in. (mm)	Wt. per 100 Bolts, lb. (Mass per 100 Bolts), (kg)	Dia. Of Bolt in. (mm)	Wt. Per 100 Bolts, lb. (Mass per 100 Bolts), (kg)
12 (12.7)	19.7 (8.9)	1 1/8 (28.6)	165.1 (74.9)
5/8 (15.9)	31.7 (14.4)	1 1/4 (31.8)	212.0 (96.2)
3/4 (19.0)	52.4 (23.8)	1 3/8 (34.9)	280.0 (127.0)
7/8 (22.2)	80.4 (36.5)	1 1/2 (38.1)	340.2 (154.3)
1 (25.4)	116.7 (52.9)		

e. The computed weight (mass) includes the total weight (mass) of field bolts as specified in Article 2408.02, C, and the total weight (mass) of shims required to be furnished for incorporation into the structure.

f. The weight (mass) of castings will be computed from the dimensions shown in the contract documents with an addition of 5% for fillets and overrun.

D. Surface Preparation and Painting Structural Steel.
Surface preparation and painting structural steel will not be measured.

2408.05 BASIS OF PAYMENT.

Payment for various items of Structural Concrete, Steel Reinforcement, Structural Steel, and Incidental Metal Parts will be as follows:

A. Structural Concrete.
Article 2403.05 applies.

B. Steel Reinforcement.
Article 2404.05 applies.

C. Structural Steel and Incidental Parts.

1. Contract unit price per pound (kilogram) or lump sum for metal railing and structural steel.

2. Payment is full compensation for:

- Furnishing all materials.
- Preparation, including fabrication, nondestructive testing and inspection required by the contract documents, transportation, and erection.
- Furnishing all labor.
- Equipment.
- Incidentals to complete the structure including the surface preparation and painting of the completed structure.
- Repair and cleaning of the paint at the shop and after erection.

D. Surface Preparation and Painting Structural Steel.
Incidental to the structure.

Section 2409. Timber Structures

2409.01 DESCRIPTION.

Construct structures composed wholly of timber or of timber combined with structural steel or concrete.

2409.02 MATERIALS.

Use materials for timber construction that meet requirements of Division 41 for the respective material as follows:

A. Timber and Lumber.
Use untreated structural parts to be painted that are furnished surfaced on four sides. Use stringers that are surfaced on two edges, top and bottom. Use timber that is furnished rough for all other sawed timber, unless specified otherwise.

1. Untreated Structural and Common Timber.
Apply Section 4162.

2. Treated Timber.
Apply Section 4163.

3. Piling.
Apply Section 4165.

B. Steel.
Apply Section 4152 to steel rods for tension members or tie rods for wingwalls, all plates and structural shapes, and all drift pins and dowels. Apply Section 4151 to concrete reinforcement.

C. Hardware and Nails.
Apply Article 4153.07.

D. Paint.
Use the paint specified in the contract documents.

E. Wood Preservative.
Apply Article 4160.01.

F. Waterproofing Materials.
Use the waterproofing materials specified in the contract documents.

G. Timber Connectors.

1. Use connectors for resisting shearing stresses between tension members and for spreading the stress over the entire member that are of a design the Engineer approves. Fabricate connectors from metal and make them rugged enough to withstand handling and installing without damage.

2. When the contract documents specify tie rods to be coated with waterproofing, first clean the rods according to Article 2508.01, A, and then paint according to the manufacturer's recommendations.

3. For fastening and bracing other members to piles, use bolts in a variety of lengths which will conform to the diameter, shape, and position of the piles so that extra washers or shims will not be required to take up the extra length of bolt.

H. Concrete.
Use concrete in connection with timber structures that meets requirements of Section 2403.

2409.03 CONSTRUCTION.

A. General.

1. Apply the provisions of Sections 2401, 2402, 2403, 2404, 2405, 2408, and 2501 to various phases of the construction. Build timber portions of the structure to comply with the contract documents and requirements of this section.

2. Ensure all framing is true and exact. Drive nails and spikes with no more force than what is required to set the heads flush with the wood surface. Deep hammer marks in wood surfaces will be considered as evidence of poor work quality. Use washers under all bolt heads and nuts which would otherwise be in contact with wood.

3. Carefully handle treated timbers without sudden dropping, breaking of outer fibers, bruising, or penetrating the treated surface with tools, such as cant hooks, peaveys, timber tongs, or pike poles.

B. Storage of Materials.

1. Store lumber and timber delivered to the work site in neat piles. Clear the ground underneath and in the vicinity of material piles of all weeds and rubbish. Arrange lumber piles to shed water and prevent warping. If stored over a long period, further protect wood piles with a suitable covering.

2. Open stack untreated lumber on suitable skids at least 12 inches (0.3 m) above ground and above possible high water.

3. Close stack and pile treated timber and treated piling. When stored for long periods, cover the tops of stacks and ends of pieces to protect the material from the direct sunlight.

4. Store miscellaneous material and hardware so as to prevent loss or damage.

C. Holes for Bolts, Dowels, Rods, and Screws.

1. Bore the holes for drift bolts and dowels 1/16 inch (2 mm) smaller than the nominal diameter of the bolt or dowel used. Bore the holes for lag screws with a bit no larger than the body of the screw at the base of the thread.

2. Bore the holes for rods and bolts, other than drifts and dowels, to diameters as follows:
- **a.** In timber that is to be treated, bore the holes 1/8 inch (3 mm) larger than the nominal diameter of the bolt or rod used.
- **b.** In timber that has already been treated or that is not to be treated, bore the holes to be the same as the nominal diameter of the bolt or rod used.
- **c.** Countersink the heads of bolts or lag screws that would interfere with traffic or with other structural parts.

D. Treatment of Treated Pile Heads.
Treat all surfaces of treated pile heads cut after treatment with material specified in Section 4161.

E. Framing.

1. Accurately cut all lumber and timber and frame to a close fit in such manner that joints will have even bearing over the entire contact surfaces.

2. Bore the holes in all stringers, rails, posts, post blocks, and scupper blocks before the timber is treated. Complete all cutting, framing, and boring of treated timbers before treatment, whenever practical. Whenever boring or framing must be performed after preservative treatment, treat newly exposed surfaces as follows:
- **a.** Apply two coats of copper naphthanate to all daps, cuts, chamfers, and all abrasions, after carefully trimming these features.
- **b.** Apply two coats of copper naphthanate to all countersunk holes before the bolt is placed.

3. Ensure grooves and daps for timber connectors make a tight fit with that part which is embedded in wood. For types of connectors which permit, draw adjacent wood surfaces into tight contact with each other. For types which will not permit this surface contact, fill the opening left by the connector with plastic cement troweled upon the surface before the joint is finally assembled. After assembly, strike off flush excess plastic cement that is squeezed out, and point fill any opening in the joint.

F. Pile Bents.

1. Drive pile bents as accurately as possible in the correct location and to vertical or batter lines indicated on the plans. If a pile is driven out of

line, straighten it without damage before cutting it off or bracing it. Remove and replace piles driven below grade or damaged in driving or straightening if so directed by the Engineer. Do not shim the tops of piles.

2. Carefully select, as to size, piles for any one bent to avoid undue bending or distortion of sway bracing.

3. Accurately cut off piles to ensure satisfactory bearing between the cap and all piles of a bent. Trim edges of piles outside the cap to a slope approximately 45 degrees with horizontal.

G. Framed Bents.

1. Construct framed bents as shown in the contract documents. In general, they will be supported by piles cut off approximately 3 feet (1 m) above ground level.

2. Remove soil from contact with sills to allow free circulation of air.

3. Fasten sills to the piles. Fasten posts to sills using dowels no smaller than 3/4 inch (19 mm) in diameter, projecting into both pile and sill no less than 6 inches (150 mm).

H. Caps.

1. Place timber caps to secure an even, uniform bearing on the top of supporting piles or posts. Fasten them to the piles using drift pins no less than 3/4 inch (19 mm) in diameter, extending at least 9 inches (225 mm) into the piles.

2. Place drift pins approximately in the center of the pile or cap. When steel channel caps are used, accurately shape the tops of all piles to provide a snug fit in the caps.

I. Bracing.

1. Bolt the ends of bracing through the pile, post, or cap with bolts no less than 5/8 inch (16 mm) in diameter. Fasten intermediate intersections with bolts and spikes as shown in the contract documents. Use spikes in addition to bolts in all cases.

2. Avoid notching the piles or shimming under the bracing whenever possible.

J. Stringers.

1. Size stringers at bearings and place in position so that knots near the edges are in top portions of the stringers. Outside stringers may have butt joints. Lap the interior stringers to take full bearing on caps. Fasten stringers to caps as shown in the contract documents.

2. Use bridging that is of the size and type shown in the contract documents. With untreated stringers and floors, place bridging so that an air space of at least 1 inch (25 mm) is left beneath the floor. With treated stringers and floors, place bridging flush with the top of the stringers.

K. Painting.

1. Wood surfaces of the structure which are to be painted will be designated in the contract documents. Clean all surfaces to be painted according to Article 2508.01, A, 1 and 2. Paint with a paint system specified in the contract documents. Paint according to the paint manufacturer's recommendations.

2. Paint all metal work, except galvanized hardware, as provided in Article 2408.02, Q.

L. Decks.
Construct decks for timber structures of the type specified in the contract documents. Construct decks according to the provisions of Sections 2410, 2411, and 2412.

2409.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the quantity of timber and lumber in thousands of board feet (cubic meters) from the nominal width and thickness, and the length measured to the nearest foot (0.1 m) for the material used in the finished work.

B. The weight (mass) of structural steel measured includes net weights (the mass) of rolled shapes or plates, of rods used as tension members, and of all bolts and rivets used to fasten steel parts together.

C. The weight (mass) of drift bolts, dowels, washers, bolts, and other hardware used to fasten wood parts together or to steel members will not be included in the weight (mass) of structural steel. The weight (mass) of these items is included in the weight (mass) of miscellaneous hardware. The Engineer will compute the weight (mass).

D. Spikes and nails are incidental to timber construction and will not be measured separately for payment.

2409.05 BASIS OF PAYMENT.

A. Payment for the quantities involved in timber structures will be according to the following:

- Excavation for Structures: Section 2402.
- Structural Concrete: Section 2403.

- Steel Reinforcement: Section 2404.
- Structural Steel: Section 2408.

B. Payment for miscellaneous hardware will be the contract unit price per pound (kilogram).

C. Payment for treated and untreated timber and lumber will be the contract unit price per thousand board feet (cubic meter), which includes the cost of spikes and nails.

D. Payment is full compensation for:
- Furnishing all materials, equipment, and labor, and
- Performance of all incidental work necessary to complete the structure in conformance with the contract documents.

Section 2410. Plank Decks

2410.01 DESCRIPTION.
Furnish and install either treated or untreated single or double plank decks according to the contract documents.

2410.02 MATERIALS.
Use materials meeting the requirements of the contract documents.

A. Lumber.
Use treated or untreated lumber as specified. Apply Section 4163 to treated lumber, and Section 4162 to untreated lumber.

B. Hardware.
Apply Article 4153.07.

2410.03 CONSTRUCTION.

A. General.

1. Lay rough planks with no more than 1/4 inch (5 mm) opening between the planks. Do not allow adjacent planks to vary more than 1/4 inch (5 mm) in thickness. Tightly fit surfaced planks together to present a smooth, uniform surface without variation due to difference in thickness or surfacing of the planks.

2. When the design requires wood stringers or nailing strips on steel beams, securely spike each plank to each nailing strip, or joist with no less than two wire spikes. Use spikes 3 inches (75 mm) longer than the nominal thickness of the plank.

3. Securely fasten all shims and scupper blocks to the plank deck. Cut ends of the plank to a true line parallel to the center line of the roadway.

4. Unless alternate hardware is provided, attach the deck to steel stringers or joists by steel clips, or by pins driven through the flange, using a process subject to approval of the Engineer. Ensure clips are securely held between the planks by double pointed nails or by hooks or fins on the clips which engage both adjacent planks. When double pointed nails are used, use 20d for 3 inch planks and 40d for 4 inch planks (5.72 mm diameter by 100 mm long for 75 mm planks and 6.65 mm diameter by 125 mm long for 100 mm planks). Position clips so that they will hold the plank in close contact with the top flanges of beams to prevent the planks from working loose due to relative movement between the planks and flanges.

5. If methods the Contractor uses for driving adjacent planks onto double pointed nails indicate damage to the plank or unsatisfactory joints, the Engineer may require the Contractor to jack the plank into position hydraulically with no less than three jacking points per plank. Sledges and blocks may be used to facilitate jacking.

6. Ensure timber for subfloors for asphalt wearing surface or for double plank decks are given full pressure preservative treatment as specified in Section 4161, unless specified otherwise in the contract documents.

B. Single Plank Decks.
Construct single plank decks to consist of a single layer of wood planks of the size and type specified. When the plank deck is to be covered with asphalt wearing surface, use deck planks surfaced on at least one face and one edge.

C. Double Plank Decks.
Construct double plank decks to consist of two layers of planks supported by stringers or joists. Lay the lower course of planks parallel to bridge abutments. Lay the top course parallel to the roadway center line. Fasten each top course plank to the lower course by spikes placed in pairs at intervals of no more than 4 feet (1.2 m). Use spikes 3 inches (75 mm) longer than the nominal thickness of the plank. At bridge ends, bevel planks in a manner to provide a smooth riding surface.

2410.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the quantity of Plank Deck Lumber used in plank decks in thousands of board feet (cubic meters) as provided in Article 2409.04.

B. Nails, clips, and other hardware are incidental to plank deck construction and will not be measured separately for payment.

2410.05 BASIS OF PAYMENT.

A. Payment for Plank Deck Lumber will be the contract unit price per thousand board feet (cubic meters) for the types and grades of lumber specified in the contract.

B. Payment is full compensation for:
- Furnishing all lumber, nails, miscellaneous hardware, and other materials, and
- Performance of all incidental work necessary to complete the structure according to the contract documents.

Section 2411. Laminated Wood Decks

2411.01 DESCRIPTION.
Furnish and install treated laminated decks according to the contract documents and the following provisions.

2411.02 MATERIALS.

A. Lumber.
Install deck strips of the nominal dimensions shown on the plans. Use deck strips that are:
- Of common class timber, either Douglas Fir or Southern Pine, meeting requirements of Article 4162.05,
- Surfaced on four sides, and
- Treated with preservative according to Section 4161.

B. Hardware.
Apply Article 4153.07.

2411.03 CONSTRUCTION.

A. Place deck strips on edge and securely nail to preceding strips with at least one nail in each space between stringers or joists. Use nails that are no less than 2.5 times longer than the nominal thickness of the strips. For decks with wood stringers or with nailing strips on steel beams, nail each deck strip to each stringer or nailing strip with 20d (5.72 mm diameter by 100 mm long) nails.

B. When instructed in the contract documents, attach laminated decks directly to steel beams by means of clips. Securely nail each clip to deck strips with no less than two 20d (5.72 mm diameter by 100 mm long) nails. Position clips so they will hold the plank in close contact with top flanges of beams to prevent the plank from working loose due to relative movement between the plank and flanges.

C. Place and fasten successive strips to bear firmly on all supports and to be in close contact with the preceding strip. Do not allow the space between any two adjacent strips to exceed 1/8 inch (3 mm). Ensure the surface of the

completed deck shows no variation in elevation greater than 1/8 inch (3 mm) between adjacent strips.

D. Cut the ends of the strips in lines parallel to the center line of the roadway.

E. Crown the roadway surface to provide deck drainage, when specified in the contract documents.

2411.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the quantity of lumber used in Laminated Wood Decks in thousands of board feet (cubic meters) from the nominal widths and thicknesses of the strips and overall dimensions of the floor parallel to the length of the strips.

B. Nails, clips, and other hardware will be considered incidental and will not be measured separately for payment.

2411.05 BASIS OF PAYMENT.

A. Payment for Laminated Wood Deck will be at the contract unit price per thousand board feet (cubic meters) for common class lumber as defined in Section 4162.

B. Payment is full compensation for:

- Furnishing all lumber, hardware, and other material, and
- Performance of all incidental work necessary to complete the structure in accordance with the contract documents.

Section 2412. Concrete Bridge Decks

2412.01 DESCRIPTION.

Construct concrete decks on timber stringers, concrete beams, or steel girders. Apply Sections 2403 and 2404.

2412.02 MATERIALS.

A. Use materials for concrete decks meeting the requirements for the respective materials in Division 41.

B. Use concrete that meets the requirements for C-4WR and C-V47B concrete mixtures, as specified in Materials I.M. 529. Use Gradation No. 3 or 5 of the Aggregate Gradation Table in Section 4109. Meet the requirements of Section 4108 for fly ash and GGBFS. Refer to Table 2412.02-1 for the maximum allowable substitution rates:

Table 2412.02-1: Maximum Allowable Substitution Rates.

Cement Type	Maximum Allowable Substitution[(a)]	Time Period
Type I, Type II	35% GGBFS 20% Fly Ash	March 16 through October 15
Type IS, IP	0% GGBFS 20% Fly Ash	March 16 through October 15
Type I, II, IS, IP	0% GGBFS 0% Fly Ash	October 16 through March 15
[(a)] Maximum total mineral admixture substitution is 50%.		

Between October 16 and March 15, substitution of Type I/II cement with fly ash and GGBFS will be allowed when maturity method is used to determine time of opening. When heating or protection is required per Article 2403.03, F, 5, maintain 50°F (10°C) until opening strength by maturity method is reached.

C. Either the contract documents or the Engineer may require a retarding admixture. Use a water reducing/retarding admixture meeting the requirements of Materials I.M. 403, Appendix B, according to Section 2403. When placements require extended working times, increase the dosage rate for the appropriate working time and temperature. For placements requiring normal working times, set the dosage rate according to Section 4103. The Engineer may approve other admixtures.

D. Use retarding admixtures compatible with the air entraining agent used. Previous experience, satisfactory to the Engineer, will be required to indicate the approximate adjustments in proportions made necessary by the addition of the admixture and compatibility with other materials used. Agitate the retarding admixture prior to and during its use.

E. Use a single source of cement during an individual placement. Drain all aggregate for at least 24 hours after washing and before batching.

2412.03 CONSTRUCTION.

When a two course construction with a second course of bridge deck surfacing or other wearing course is specified, use the requirements of Section 2413 or in the contract documents for the second course. When an overlay for an existing deck in conjunction with repair is specified, use the requirements of Section 2413 or in the contract documents for the overlay and repair.

A. Swinging the Span and Support of Forms.

1. Before concrete is placed in the floor of a steel span, strike the centering of the span and swing the span free on its permanent supports. Support the forms for concrete decks and curbs entirely by the beams which are to support the concrete, unless specified otherwise in the contract documents.

2. Do not use temporary welds to attach hangers to prestressed or steel beams to support deck form joists. Coat deck hangers that are embedded in prestressed beams and deck hangers that drape across steel girder or prestressed beams using one of the following methods:

a. Electroplating in accordance with ASTM B 633, Service Condition SC4, minimum coating thickness of 1.0 mil (25 µm). Classification and Coating Suffix: Fe/Zn 25.

b. Mechanical galvanizing in accordance with ASTM B 695, Type I, Class 50. Minimum coating thickness of 2.0 mils (50 µm).

3. Do not weld on structural steel in the field, unless allowed in the contract documents or approved by the Engineer.

B. Placing Reinforcement.

1. Accurately place all reinforcement in the positions shown in the contract documents. Do not weld reinforcing steel unless allowed in the contract documents or approved by the Engineer.

2. In lieu of tying requirements in Article 2404.03, D, tie reinforcement rigidly using wire at alternate intersections so 50% of the intersections are tied. For steel fabric reinforcement, use electrically welded rectangular mesh in flat sheets.

3. Support horizontal reinforcement using an adequate number of supports as specified in Article 2404.03, E. Hold the upper horizontal reinforcement securely in place with tiedowns a maximum of 4 feet (1.2 m) apart to ensure the reinforcement will not rise during concrete placement.

4. Allow the Engineer to inspect and approve reinforcement placing and fastening. The Engineer's approval is required before concrete can be placed in a deck. Make adjustments when checks indicate anticipated concrete cover over reinforcement different than specified in the contract documents. If the lack of concrete cover over reinforcement is due to over camber of the beams or improper elevation of beam splice points, adjust the beam haunch to provide proper cover, while maintaining a smooth profile for the length of the deck.

5. When the self propelled finishing machine described in Article 2412.03, D, is required, check the elevation of upper reinforcement using this machine (properly adjusted for finishing) with a suitable attached template adjusted to detect any reinforcement too close to the surface. Set the template to a tolerance of minus 1/4 inch (6 mm) to allow clearance of wire ties.

C. Placing Concrete.

1. Place concrete deck sections according to the sequence shown in the contract documents or as modified by the Engineer.

2. When cold weather protection is necessary, do not place concrete without the Engineer's written permission.

3. Do not place concrete if the temperature of the plastic concrete, at the time of placing exceeds 90°F (32°C). The Contractor may (at their own expense) cool the plastic concrete below 90°F (32°C) by a method the Engineer approves.

4. Do not place concrete if the theoretical rate of evaporation for that day exceeds 0.2 lbs. per square foot per hour (1 kg/m^2 per hour). Use the Theoretical Rate of Evaporation Chart located within the appendix to calculate the theoretical rate of evaporation. For this chart, use:
- The National Weather Service's maximum air temperature, relative humidity, and maximum steady wind velocity without gusts for the date and the location of the concrete deck placement, and
- The temperature of plastic concrete at time of placement.

D. Surface Finish.

1. After placing and vibrating the concrete as provided in Articles 2403.03, C and D, promptly strike it off with a template to provide a smooth surface with the proper crown. Ensure supports for the strike off template are parallel to the center line of the structure, firmly fastened in place, and set to the correct elevation. Include proper allowance for deflection caused by the concrete. Ensure screed supports extend sufficiently beyond each end of the bridge to accommodate the strike off template or finishing machine. Ensure they provide support for bridges when operating a longitudinal float. If required, provide any or all of the items specified in Article 2301.03, A, 3, which may be adapted to the work.

2. In lieu of the above requirements, apply the following to all bridges longer than 60 feet (20 m):
- **a.** After depositing and vibrating the concrete as provided in Articles 2403.03, C and D, promptly strike it off to the proper elevation using an approved self propelled and mechanically operated finishing machine.
- **b.** Ensure the finishing machine operates on adequately supported rails adjusted to conform to the grade specified. Include allowance for anticipated dead load deflection shown in the contract documents.
- **c.** Ensure supporting rails extend beyond each end of the bridge a sufficient distance to accommodate the finishing machine.
- **d.** Ensure the finishing machine will not cause undue deflection of the bridge members or falsework.

e. The screeds of the finishing machine may be of metal or metal shod wood.

f. Make a sufficient number of passes with the finishing machine to obtain a void free surface struck off to the elevation specified.

g. Finishing machines other than as described above will be considered for approval.

3. After the final pass of the finishing machine or after the floating operation (if used), smooth the surface to meet the requirements of Article 2301.03, H. Check with 10 foot (3 m) straightedges. Correct surface irregularities.

4. After smoothing and checking for smoothness, promptly give the surface a final finish while the concrete is still plastic. When the contract documents show a second course of bridge floor surfacing or other wearing course, finish the surface of the first course with a burlap drag. Smooth and check the final surface for smoothness without additional finishing for one course bridge decks on Interstate and Primary projects.

a. Interstate and Primary Projects.

1) Transverse grooving or tining in plastic concrete of bridge decks (and bridge approaches when included in the bridge project) will not be allowed unless otherwise stated in the contract documents.

2) Cut longitudinal grooves into hardened concrete surfaces using a mechanical cutting device. Perform longitudinal grooving after surface correction grinding.

3) Ensure longitudinal grooves are:

a) 1/8 inch ± 1/64 inch (3 mm ± 0.4 mm) wide,

b) 1/8 inch +1/32 inch or -1/16 inch (3 mm +0.8 mm or -1.6 mm) deep, and

c) Uniformly spaced at 3/4 inch (19 mm) intervals measured center to center of groove.

4) Terminate longitudinal grooving approximately 6 inches (150 mm) from bridge joints.

5) Ensure longitudinal grooving on the bridge deck and double reinforced bridge approach sections is not placed within the area approximately 1.5 feet (0.5 m) adjacent to the curbs. To accommodate varying widths of grooving equipment, the width of the ungrooved area adjacent to curbs may be up to 3.0 feet (0.9 m).

6) Ensure longitudinal grooving of single reinforced and non-reinforced bridge approach sections is not placed within 6 inches (150 mm) of the edge of outside lane lines.

7) For staged bridge and bridge approach construction:

a) The Contractor may cut longitudinal grooves in the hardened concrete at the end of each stage of construction or wait until all stages have been completed. If the Contractor elects to delay cutting of the longitudinal grooves until completion of all stages, apply an interim

coarse broom finish on the concrete deck and bridge approach during placement for all stages opened to traffic.

b) Within 30 calendar days following completion of the last stage of the project, establish temporary lane closures to accomplish longitudinal grooving for all stages.

c) The interim coarse broom finish will not be allowed as a surface texture when opened to traffic over a winter season. If the interim coarse broom texture is present and the Contractor is not in a position to finish all stages of the project, cut longitudinal grooving into the hardened concrete in order to establish an acceptable driving surface texture for the winter season.

b. Other Projects.
When the surface being placed is the wearing course, apply a suitable grooving by hand methods to the entire surface, except the area within approximately 2 feet (0.6 m) of the curbs. Apply grooving similar to that described in Article 2301.03, H, 3, with the following exceptions:

- Transverse to the centerline of the roadway.
- Randomly spaced from 3/4 inch to 1 5/8 inches (20 mm to 40 mm) with no more than 50% of the spacings exceeding 1 1/4 inches (30 mm) with a minimum of four different spacings in a 2 foot (0.6 m) width.

5. When the surface being placed is the final surface of a bridge sidewalk, give the surface of the sidewalk a transverse coarse broom texture.

6. Apply Section 2428 to smoothness of the completed deck surface for Primary projects and when specifically required for other projects.

E. Curing Concrete Decks.
Use burlap prewetted with sufficient water, prior to placement, to prevent absorption of moisture from the concrete surface. Keep the burlap wet.

1. Place the first layer of prewetted burlap in the following manner:

a. Interstate and Primary Projects.
Place on the concrete within 10 minutes after final finishing.

b. Other Projects.
Immediately after final finishing and grooving, cover the area finished with white pigmented curing compound meeting requirements of Article 4105.05 applied at a maximum rate of 135 square feet per gallon (3.3 square meters per liter). Place the first layer of prewetted burlap on the concrete within 30 minutes after the concrete has been finished and grooved.

2. As soon as practical, but no later than 2 hours after placing the first layer, place a second layer of burlap on the deck.

3. Apply water to the burlap covering for a period of 4 calendar days. Use a pressure sprinkling system that is effective in keeping the burlap wet during the moist curing period. The system may be interrupted only to

replenish the water supply, during periods of natural moisture, or during construction contiguous to the concrete being cured. The Engineer may approve interruptions for periods longer than 4 hours on the basis of the method for keeping the concrete moist.

4. Maintain continuous contact, except as noted above, between all parts of the concrete deck and the burlap during the 4 calendar day moist curing period.

5. On concrete decks placed after October 1 and prior to April 1, after 20 hours of the application of water, the Contractor may substitute the application of a moisture proof plastic film no less than 3.4 mils (86 µm) thick over the wet burlap in lieu of applying water. Maintain intimate contact between the surface of the concrete, the burlap, and the plastic film.

F. Curbs.

Place curbs and barrier railing separately from the deck slab. Place them in the manner shown in the contract documents.

G. Expansion Joints.

Locate and construct expansion joints as shown in the contract documents. If steel expansion plates are required, the Contractor for the superstructure shall furnish and install all such plates including those required at the end of the bridge.

H. Filling and Sealing Joints.

After removing dummy filler strips, allow the concrete to harden during the remainder of the cure period. Clean and complete the joint after it has dried. Use filler and sealer meeting the requirements of Section 4136. When the type is not specifically designated, furnish resilient filler.

1. When using premolded filler, shape it to the proper cross section. Place it in a manner that leaves at least a 1/2 inch (15 mm) deep space in the joint from surface to filler. Seal the space above the filler. Joint edge priming may be required if the sealer manufacturer recommends. Carefully fill the space completely without smearing adjacent concrete. After the sealer has set, the surface may be lightly covered with Portland cement to prevent tracking from traffic.

2. When contract documents require an elastomeric compression type preformed seal, use material of the nominal dimensions shown. Use a heavy duty type for bridge floor application with a rated capacity which will accommodate the joint movement. Submit, for prior approval, the manufacturer’s name and a description of the specific seal to be used. Ensure steel armor fabrication shop details comply with the manufacturer's recommended setting depth. Install the elastomeric compression seal according to the contract documents, the manufacturer’s recommendations, and the follow provisions:

a. Install the seal using suitable hand or machine tools. Thoroughly secure in place with lubricant adhesive covering both sides of the seal over the full area in contact with the sides of the joint. Adhesive may be applied to the concrete or steel joints or to the seals or in combination. Install seals in a substantially fully compressed condition. Unless the contract documents or manufacturer's recommendations specify otherwise, install at least 1/4 inch (5 mm) and no more than 1/2 inch (15 mm) below the surface at all points.

b. For transverse joints across roadways, use a one piece seal for the full width of the transverse joint. For longitudinal joints, provide the seal in lengths as long as is practical. Seal all joints between lengths of seals with additional adhesive.

c. Seals may be installed in concrete joints immediately after the curing period using the lubricant-adhesive. Observe the manufacturer's temperature limitations for the adhesive. Ensure joints are clean, dry, and free of all foreign material immediately prior to seal installation. Repair spalled surfaces in concrete joints to the Engineer's satisfaction.

2412.04 METHOD OF MEASUREMENT.

A. Measurement for structural concrete, reinforcement, and structural steel will be according to Articles 2403.04, 2404.04, and 2408.04, respectively.

B. Longitudinal Grooving in Concrete, in square yards (square meters), will be the plan quantity shown in the contract documents.

2412.05 BASIS OF PAYMENT.

A. Payment for structural concrete, reinforcement, and structural steel will be according to Articles 2403.05, 2404.05, and 2408.05, respectively.

B. Payment is full compensation for furnishing all materials, equipment, and labor and for performing all work necessary to complete the structure in conformance with the contract documents.

C. When Section 2428 applies, payment may be modified as specified therein.

D. Deductions will not be made for the volume of concrete displaced by deck drains, expansion joints, shear lugs, beam flanges, and joint material. The cost of joint material and metal strips for sealing joints is included in the contract unit price per cubic yard (cubic meter) for structural concrete. The weight (mass) in pounds (kilograms) of structural steel paid for includes all:

- Steel expansion plates,
- Castings of steel or iron,
- Welded shapes for deck drains,
- Bearing plates,
- Anchor bolts and other steel parts, except steel reinforcement for concrete and the associated metal fastenings.

E. The cost of any additional concrete required to meet the requirements of Article 2412.03, B, is incidental to the cost of the structural concrete.

F. Payment for Longitudinal Grooving in Concrete will be the contract unit price for per square yard (square meter).

Section 2413. Bridge Deck Surfacing, Repair, and Overlay

2413.01 DESCRIPTION.

A. Deck Surfacing.
Place a wearing course on the prepared surface of a new bridge deck. Perform other necessary work shown in the contract documents.

B. Deck Repair.

1. Class A Deck Repair.
Remove deck concrete below the level described for Deck Overlay, but less than full depth. Replace the excavated volume with concrete to a level bounding the Deck Overlay classification.

2. Class B Deck Repair.
Remove deck concrete below the level described for Deck Overlay for the full depth of the floor. Replace the excavated volume with concrete to a level bounding the Deck Overlay classification.

C. Deck Overlay.
Remove deck concrete to a depth 1/4 inch (5 mm) below the existing finished surface, and overlay with a concrete course of a depth designated. Unless specified otherwise in the contract documents, overlay is to accomplish a raise of the existing roadway surface and cover the entire concrete deck surface, including those areas to be repaired.

2413.02 MATERIALS.

A. Use materials meeting the requirements for the respective items in Division 41. When structural repairs are included in the project, Class C concrete may be mixed using equipment meeting requirements of Article 2413.03, A, 3. The concrete mixture used for the overlay may be used for the repair. Use the water and consistency specified in Article 2403.02, B, 2.

B. Use a single source of cement during an individual placement.

C. Apply Sections 4110 and 4115 to the aggregates. Use only those coarse aggregates specifically allowed by Article 4115.05 for this work.

D. Use one of the following mixes:

1. Class O Portland Cement Concrete.

a. Use Class O PCC meeting the requirements of Materials I.M. 529 and the following requirements:

1) The slump, measured according to Materials I.M. 317, shall be 3/4 inch (20 mm) with a maximum of 1 inch (25 mm) and no minimum requirement. Commence testing for concrete slump from a continuous mixer within 2 to 4 minutes after the concrete is discharged.

2) The intended air entrainment of the finished concrete is 6%. Ensure the air content of fresh, unvibrated concrete at the time of placement, as determined by Materials I.M. 318 is 6.5%, with a maximum variation of plus 2.0% and minus 1.0%.

b. Fly ash substitution is not permitted for Class O PCC.

2. Class HPC-O High Performance Concrete.

Meet the requirements of Materials I.M. 529 and the following:

a. A slump of 1 inch (25 mm) to 4 inches (100 mm), measured according to Materials I.M. 317, with a maximum of 5 inches (125 mm). Commence testing for concrete slump from a continuous mixer within 2 to 4 minutes after the concrete is discharged. Before placing ready mix concrete, test the slump.

b. Use a mid-range water reducing admixture meeting the requirements of Materials I.M. 403, Appendix C and a retarder listed in Materials I.M. 403 Appendix G. When the expected haul time is less than 30 minutes or the maximum air temperature expected is less than 75°F (24°C), addition of a retarder is not required. The intent of the mid-range water reducer is to achieve a workable, dense, and low w/c ratio concrete. The Engineer may approve other admixtures or combinations of admixtures and dosages to achieve a workable low w/c ratio mix.

c. Increase moisture testing of coarse and fine aggregate to ensure batch-to-batch consistency and reduce water addition at job site. Perform moisture testing of coarse and fine aggregate prior to batching when batch weights are determined and then again half-way through the placement.

d. Air content is to be the same as required for Class O PCC.

e. Use Type IS or Type IP cement. If Type I/II is used, 25% replacement with GGBFS is required.

f. Limit fly ash substitution to 20% replacement by weight.

g. For projects with deck overlay quantities greater than 1800 square yards (1500 m^2), make a trial batch of the mix (minimum 3 cubic yards) at the anticipated concrete temperature during delivery. Initially test the slump and air content. Let the mixer run for the time anticipated, including batching, delivery to the project, estimated waiting time for discharge of the load, and the time to discharge the load. Test the slump and air content again. If the slump at the discharge time is 2 inches (50 mm) or less, the proposed mix is not suitable and an additional trial batch will be required. The intent is to ensure the admixture or combination of admixtures will maintain the desired slump without additional water at the discharge site. If unacceptable slump loss occurs during the project placement so

that the slump is 2 inches (50 mm) or less, one or all of the following steps will be required:

1) Change the dosage rate of admixture(s).
2) Change the brand of admixture(s).
3) Change the location of mixing admixture(s). For example: incorporate admixture(s) in the ready mix truck on the project site instead of at the ready mix plant.
4) Reduce the concrete temperature. For example: use ice or chilled water.

E. To bond new concrete to previously placed concrete, use a grout consisting of a mixture of about 5 to 6 gallons of water to each 94 pound bag (0.45 to 0.50 L/kg) of cement. Mix to a consistency such that the slurry can be applied with a stiff brush or broom to the previously placed concrete in a thin, even coating that will not run or puddle in low spots. An equivalent grout of Portland cement and water, applied by pressure spray may be substituted with approval of the Engineer. For sealing vertical joints between adjacent lanes and at the curbs, thin this grout to paint consistency.

2413.03 CONSTRUCTION.

A. Equipment.

Use equipment approved by the Engineer and complying with the following:

1. General.

a. Ensure the overall combination of labor and equipment for proportioning, mixing, placing, and finishing the new surface is of such minimum capability as to meet the requirements of Table 2413.03-1, except when noted otherwise in the contract documents.

Table 2413.03-1: Minimum Capacity and Labor Requirements

Total Surface Area per Bridge, sq. yd. (m^2)	Minimum Requirement, cu. yd. per hour (m^3 per hour)
0-328 (0-274)	1.0 (0.8)
329-492 (274.1-410)	1.5 (1.2)
493-656 (410.1-550)	2.0 (1.6)
over 656 (over 550.1)	2.5 (2.0)

b. Use a finishing machine designed so the elapsed time between depositing the mixture on the floor and final screeding does not exceed 10 minutes when the mixture is being mixed and placed at the specified minimum rate under normal operating conditions.

2. Preparation Equipment.

Use the following types of preparation equipment:

a. Sawing Equipment.
Use sawing equipment capable of sawing concrete to the specified depth.

b. Sandblasting or Shot Blasting Equipment.
Use sandblasting or shot blasting equipment capable of removing rust, oil, and concrete laitance from the existing surface of the bridge deck and exposed uncoated reinforcing bars.

c. Power Driven Hand Tools.
Power driven hand tools will be permitted with the following restrictions:

1) Do not use jack hammers heavier than nominal 30 pound class (14 kg)

2) Do not operate jack hammers or mechanical chipping tools at an angle exceeding 45 degrees measured from the surface of the deck.

3) Do not use chipping hammers heavier than a nominal 15 pound (7 kg) class.

d. Hand Tools.
Provide hand tools, such as hammers and chisels, for removal of final particles of unsound concrete or to achieve the required depth.

e. High Pressure Water Blasting Equipment.
Use high pressure water blasting equipment capable of removing rust, oil, concrete laitance, and unsound concrete from the existing surface of the bridge floor and exposed uncoated reinforcing bars.

3. Proportioning and Mixing Equipment.

a. Use proportioning and mixing equipment for Class O PCC or Class HPC-O that meets requirements of Articles 2001.20, E, and 2001.21, D. Use equipment capable of proportioning water accurately to within 1.0%. Use a rotating paddle type concrete mixer (construction or stationary). A continuous mixer used in conjunction with volumetric proportioning, described above, is acceptable.

b. Provide sufficient mixing capacity so the intended quantity can be placed without interruption.

c. The cement, fly ash, and GGBFS for Class HPC-O shall be pre-blended by the producer or by using equipment capable of thoroughly mixing the materials to the tolerances in ASTM C 685 when concrete is produced using a volumetric mixer.

d. For Class HPC-O, ready mixed concrete equipment meeting the requirements of Articles 2001.20 and 2001.21 is acceptable. For ready mixed concrete, the cement, fly ash, and GGBFS are not required to be pre-blended.

4. Placing and Finishing Equipment for Deck Surfacing and Deck Overlay.

a. Include adequate hand tools for placing the mixture and working it down to approximately the correct level for striking off with the screed. A self propelled finishing machine is required for all surfacing and overlays. Use a machine that operates on supporting rails which:

- Are adequately secured to the previously placed surface and are adjustable to the correct profile without shimming,
- Do not deflect under the load of the machine, and
- May be removed without damage to the edge of the new surface that remains in place.

b. When placing the mixture in a lane abutting a previously completed lane, equip the side of the finishing machine adjacent to the completed lane to travel on the completed lane. The Engineer will inspect the finishing machine. The Engineer's approval of the finishing machine is required before starting work on each project.

c. Use a finishing machine meeting the requirements of Article 2412.03, D. This machine shall be self propelled, capable of forward and reverse movement under positive control, and provide for raising all screeds to clear the screeded surface for traveling in reverse. The machine shall meet the following additional requirements for the type of mixture to be placed.

1) Class O Portland Cement Concrete.

The machine shall:

a) Have a mechanical strike off to provide a uniform thickness of mixture in front of the screed designed to consolidate the mixture by vibration, as specified.

b) Have a front screed designed to consolidate the mixture to be placed to 100% of the rodded density.

c) Have the bottom face for each screed at least 5 inches (125 mm) wide with a turned up or rounded leading edge to minimize tearing of the surface of the plastic concrete.

d) Have an effective weight (mass) for each screed at least 75 pounds for each square foot (365 kg/m^2) of bottom face area.

e) Have positive control of the vertical position, the angle of tilt, and the shape of the crown for each screed provided.

f) Be designed so that, together with appurtenant equipment, obtains positive machine screeding of the plastic concrete within 1 inch (25 mm) of the face of the existing curbs.

g) Have a screed long enough to:

- Extend at least 6 inches (150 mm) beyond the line where a saw cut is intended to form the edge of a subsequent placement section, and
- Overlap the sawed edge of a previously placed course at least 6 inches (150 mm).

h) Have internal vibration equipment for consolidation at the edges of the placement.

2) Class HPC-O High Performance Concrete.

The machine shall:

a) Be capable of finishing the surface to within 1 foot (0.3 m) of the edges of the area being placed.

b) Have positive control of the vertical position of the screeds.

c) Be equipped to provide vibration at the finishing drum.

d. Provide supplemental vibration for the concrete between the curb and the end of the drum finisher and along the construction joint adjacent to the current or future placement. Vibration with a standard stinger, whether point vibrating or dragging through the concrete, is not an acceptable method of supplemental vibration.

B. Preparation of Surface for Deck Surfacing and Deck Overlays.

1. Remove material for test wells (for Class O PCC density testing) and all loose, disintegrated, or unsound concrete from the bridge deck, as designated by the Engineer. Test wells for nuclear density checks shall have nominal dimensions of 1 1/2 inches x 10 inches x 10 inches (40 mm x 250 mm x 250 mm). On bridge deck overlays, Class A bridge deck repair removal areas may be used as test wells provided they meet the nominal dimensions and are located in the testing frequency areas. Nuclear density testing of Class O PCC will be according to Materials I.M. 358.

2. For bridge deck overlays, uniformly scarify or prepare the entire existing concrete floor area to a depth of 1/4 inch (5 mm), except over areas of Class A and Class B repair where the 1/4 inch (5 mm) removal may be coincidental with operations for repair removal. Removal to a greater depth will be required at drains and elsewhere as noted in the contract documents. Measure the thickness of the concrete overlay from a level 1/4 inch (5 mm) below the original surface to a final raised surface as shown. Use a minimum thickness of abutting overlay of 3/4 inch (20 mm) and taper to the full designated thickness where removal to a level lower than 1/4 inch (5 mm) below the original surface is necessary because of surface fixtures.

3. Place all new concrete above the prepared surface for bridge deck surfacing at the thickness specified in the contract documents. The thickness of concrete above the prepared surface (for bridge deck surfacing) and above the prepared surface or reinforcing steel (for bridge deck overlay) is to be at least 1 3/4 inches (45 mm), and greater if specified in the contract documents. Check the thickness and clearance in the following manner before concrete is placed:

a. To the bottom of the screed, attach a filler block having a thickness 1/4 inch (5 mm) less than the overlay thickness. With screed guides in place, pass the screed over the area to be concreted. An alternate to passing the finishing machine is passing an approved template, supported by the screed guides, over the area to be concreted. Where the intended clearance does not allow use of this method, use a string line or other means as approved by the Engineer. If the filler block or other method used to check does not clear the area to be concreted, adjust the profile of the new surface to the Engineer's satisfaction.

b. Prepare the surface for placement of new concrete by sandblasting or shot blasting, followed by an air blast. Ensure this cleaning removes all dirt, oil, and other foreign material. Ensure it removes all unsound concrete, laitance, or loose material from the surface

and edges against which the surface mixture is to be placed. The cleaning should roughen the surface in order to provide satisfactory bond with the surfacing mixture. Protect metal floor drains and areas of the curb or railing above the proposed surface from the cleaning.

c. Keep areas from which concrete has been removed free of slurry produced by wet sawing of concrete joints. Remove all slurry from prepared areas before placing new concrete.

d. Use hand tools to remove final particles of concrete or to achieve the required depth. Sandblast or shot blast the entire surface against which new concrete is to be placed, including curbs and exposed reinforcement. Remove all dirt, oil, and other foreign material, as well as any unsound concrete. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Clean the surface with an air blast immediately before applying grout in preparation for placement of concrete.

e. Do not presaturate existing concrete prepared for repair, surfacing, or overlay with water before placing grout and new concrete. Allow the prepared surface to dry to allow some absorption of the grout.

f. At the time of placement of either Class O PCC or Class HPC-O, ensure the area is clean and all exposed reinforcement free of rust. Rust forming overnight because of dew on clean reinforcement will not be considered objectionable, but reinforcement with a greater amount of rust must be recleaned before the concrete is placed. Clean the area by air blast before the concrete is placed.

C. Preparation of Surface for Deck Repair.

Remove concrete from each area (either designated in the contract documents or by the Engineer) to a depth and in a manner consistent with the classification for that area. Areas as shown in the contract documents are based on the best information available. The Engineer will determine actual areas.

1. General.

a. Keep areas from which concrete has been removed free of slurry produced by wet sawing concrete joints. Remove all slurry from prepared areas before concrete is placed.

b. Use hand tools to remove final particles of concrete or to achieve the required depth. Sandblast or shot blast all surfaces against which new concrete is to be placed, including curbs and exposed reinforcement. Remove all dirt, oil, and other foreign material, as well as any unsound concrete. Clean the surface with an air blast immediately before applying grout in preparation for placement of new concrete.

c. Thoroughly clean all reinforcing bars and newly exposed concrete by sandblasting or shot blasting. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Where bond between existing concrete and reinforcing steel has been destroyed, remove the concrete adjacent to the bar to a depth that

will permit new concrete to bond to the entire periphery of the exposed bar. A minimum of 3/4 inch (20 mm) clearance is required around the bar. Exercise care to prevent cutting, stretching, or damaging any exposed reinforcing steel. The Engineer may require enlarging a designated area should inspection indicate deterioration of concrete or corrosion of reinforcing beyond the limits previously designated.

d. Do not presaturate existing concrete prepared for surfacing before grout and new concrete is placed. Allow the prepared surface to dry to allow some absorption of the grout.

e. At the time of placement of either Class O PCC or Class HPC-O, ensure the area is clean and the reinforcement free of rust. Rust forming overnight because of dew on clean reinforcement will not be considered objectionable; however, reinforcement with a greater amount of rust shall be recleaned before placing the concrete. Clean the area with an air blast before the concrete is placed.

2. Class A Deck Repair.

a. Class A repair removal is considered to start 1/4 inch (5 mm) below the existing surface. This does not preclude removal coincidental with preparation for overlay. Removal for Class A repair extends at least to the level of the top reinforcing bars, and deeper, as determined by the Engineer, to remove unsound concrete.

b. Concrete may be removed by chipping, shot blasting, hydro blasting, or by a combination of these. Complete the final cleanup using hand tools.

c. For Class A repair and in preparation for bridge deck overlay, the deck surface may also be prepared or partially prepared using a high pressure water system, at the Contractor's option. Use the equipment manufacturer’s recommended procedures, subject to the Engineer’s approval, and within such limitations as may be imposed.

d. Additional removal may be required to provide for test wells.

3. Class B Deck Repair.

a. Class B repair removal is considered to start 1/4 inch (5 mm) below the existing surface. This does not preclude removal coincidental with preparation for overlay. Remove all concrete within all areas designated for Class B repair, and in all areas designated for Class A repair in which the depth of the remaining sound concrete is less than 50% of the original depth of the bridge deck.

b. Designated Class A repair areas will be measured as Class B Deck Repair when full depth removal is required. At the Engineer’s direction, limited areas of removal greater than 50% of the floor thickness (such as beneath reinforcing) may be allowed. These limited areas of excess depth will be measured as Class A Deck Repair.

c. Remove concrete using a jack hammer or chipping hammer, or by using a combination of a scarifyier and chipping hammer. Accomplish the final removal at the periphery of Class B repair using a 15 pound (7 kg) jack hammer, chipping hammer, or hand

tools. Provide a method of removal at the bottom of the bridge deck that will prevent feather edging of the concrete.

d. Provide forms to enable placement of new concrete in the full depth opening. Use forms that, preferably, are suspended from existing reinforcing bars by wire ties. In the case of large area openings, forms may be supported by blocking from the beam flanges. Support all forms by elements of the existing superstructure unless specifically noted or shown otherwise in the contract documents.

D. Proportioning and Mixing.

1. General.

a. Proportion and mix Class O PCC at the project site. Ready mixed concrete will not be approved.

b. For Class HPC-O, ready mixed concrete or portioned and mixed concrete at the project site will be allowed.

c. Mix the water reducing admixture for improved workability of Class O PCC or HPC-O into the concrete according to the manufacturer's recommendations and the Engineer's instructions.

2. Stationary Mixer.

When a construction or stationary mixer is used, proportion and mix according to applicable provisions of Article 2403.02, D.

3. Continuous Mixing Equipment.

When continuous mixing equipment is used, apply the following:

a. Use mobile continuous mixers that accurately proportion all materials for the specified mixture.

b. Calibrate the proportioning equipment for each material in the presence of the inspector. The Engineer may accept a previous calibration and require satisfactory verification checks only, at the settings indicated by the previous calibration.

c. Operate the proportioning equipment at the speed recommended by the manufacturer during calibration, checks, or normal operation.

d. Recharge continuous mixers at the site.

e. The Contractor may make yield checks or other checks and the inspector will cooperate in such checking.

f. Mix the materials in an approved mixer within 1 mile (2 km) of the site of placement. Mix the materials according to the specified requirements for the equipment used. Ensure the mixture, as discharged from the mixer, is uniform in composition and consistency.

E. Placing and Finishing.

1. Repairs.

Apply the following to repair work:

a. Although repair classes are considered to begin 1/4 inch (5 mm) below the original concrete surface, place repair concrete

monolithically with the overlay course, except as described for larger areas of Class B repair. Internally vibrate fresh concrete 3 inches (75 mm) or more in thickness.

b. For Class B repair areas 2 square yards (2 m^2) or greater:
- **1)** Use floor forms supported by beams or stringers.
- **2)** Bring the individual concrete replacement to the lower boundary for the superimposed overlay.
- **3)** Use Class C structural concrete meeting the requirements of Sections 2403 and 2412 for Class B repair.
- **4)** Leave the surfaces of individual placements rough.
- **5)** Complete placements for each construction stage before starting the overlay course.
- **6)** If a full depth repair is staged, provide a beveled keyway not less than 1 1/2 inch by 3 inches (35 mm by 75 mm) at the vertical joint.
- **7)** Ensure concrete placement and reinforcing support comply with applicable portions of these specifications except as modified by the contract documents.
- **8)** Deck repair concrete, described in Article 2413.02, or Class C structural concrete, meeting requirements of Sections 2403 and 2412, may be used when individual placements are placed to the lower boundary for the superimposed overlay.
- **9)** Wet cure the partial placement for 96 hours.
- **10)** After the cure, surface dry, sandblast or shot blast, and clean individual placements before applying overlay course or grout.

c. For Class A repair areas, use Class O or Class HPC-O concrete when repair concrete is placed monolithically with the overlay.

2. Deck Surfacing and Deck Overlay.

a. Use an approved finishing machine as specified in Article 2413.03, A, 4.

b. Place the support rails upon which the finishing machine travels outside the area to be surfaced. Make provisions for anchorage of supporting rails that provide for horizontal and vertical stability. The Engineer may require positive anchorage. Do not use a hold down device shot into concrete unless the concrete shall be subsequently surfaced. Hold down devices of other types leaving holes in exposed areas will be approved provided the holes remaining are grouted full. Submit support rail anchoring plans and the mixture placing procedure to the Engineer for approval.

c. The locations of longitudinal joints may be shown in the contract documents. If not shown, locate longitudinal joints as approved by the Engineer. The approval will be based on avoiding joints in the wheel paths as much as practical.

d. In order to assure a junction with properly consolidated concrete, saw the surface course previously placed to a straight and vertical edge at longitudinal and transverse joints and remove before adjacent concrete is placed. The Engineer will determine the extent of such removal.

e. Take every reasonable precaution to secure a smooth riding bridge deck. Prior to placement operations, review the equipment,

procedures, personnel, and previous results with the Engineer. The Engineer will review inspection procedures to assure coordination. Include the following precautions:

1) Assurance that concrete can be produced and placed within the specified limits, continuously and with uniformity.

2) After finishing, check the surface with a 10 foot (3 m) straightedge. Eliminate causes for irregularities exceeding 1/8 inch (3 mm) and make corrections, if practical.

3) The Engineer will check each placement according to Section 2428 the day following placement or before another section is placed.

f. After cleaning the surface and immediately before placing Class O PCC or Class HPC-O, scrub a thin coating of bonding grout into the dry, prepared surface. At the Contractor's option, the grout may be sprayed onto the surface in a manner subject the Engineer's approval. Exercise care to assure that all parts receive a thorough even coating, and that no excess grout is permitted to collect in pockets. Limit the rate of progress for applying grout so that the grout does not become dry before it is covered with new concrete. If the grout becomes dry, remove it by sandblasting and apply new grout.

g. Place concrete in a continuous operation. For Class O PCC, manipulate the new concrete and mechanically strike it off slightly above final grade. Then mechanically consolidate it to 100% of the rodded density, with a minus tolerance of 2%. Screed the new concrete to final grade. The Engineer will determine rodded density according to Materials I.M. 358.

h. The rodded density measurement is not required for Class HPC-O.

i. For Class O PCC, use internal vibration for consolidation at the curb side, and along the longitudinal construction joint adjacent to a previously constructed lane. For Class HPC-O PCC, use supplemental surface vibration for consolidation at the curb side, and along the longitudinal joint adjacent to the current or future placement.

j. Ensure concrete temperature and theoretical evaporation rate comply with Article 2412.03, C.

k. Apply Section 2428 to smoothness of the completed bridge deck surfacing and bridge deck overlay for Interstate and Primary projects and when specifically required for other projects.

3. Placement of Grooving.

a. Interstate and Primary Projects.

1) Transverse grooving or tining in plastic concrete of bridge deck surfacing or bridge deck overlay (and bridge approach overlay when included in a bridge deck overlay project) will not be allowed.

2) Perform longitudinal grooving according to Article 2412.03, D.

b. Other Projects.

1) After achieving a tight, uniform surface, apply a suitable grooving, by hand methods, similar to that described in Article 2301.03, H, 3, with the following exceptions:

- Grooving is to be transverse to the centerline of roadway.
- Transverse grooving is to be randomly spaced from 3/4 inch to 1 5/8 inches (20 mm by 40 mm) with no more than 50% of the spacings exceeding 1 1/4 inches (30 mm) with a minimum of four different spacings in a 2 foot (0.6 m) width.

2) Perform this operation at a time and in a manner to achieve the desired texture while minimizing displacement of the larger aggregate particles. The texture should not extend into the areas within approximately 2 feet (0.5 m) of curbs. As soon as finishing has been completed, seal all vertical joints with adjacent concrete by painting with thinned grout.

F. Curing.

1. Place the first layer of prewetted burlap on the concrete as follows:

a. Interstate and Primary Projects.
Place within 10 minutes after finishing. If Class O PCC is revibrated because of failure to meet density requirements with initial vibration, place the prewetted burlap within 10 minutes after finishing of the revibrated area.

b. Other Projects.
Immediately after final finishing, cover the area finished with white pigmented curing compound meeting the requirements of Article 4105.05, applied at a rate of no more than 135 square feet per gallon (3.3 square meters per liter). Place the first layer of prewetted burlap on the concrete within 30 minutes after the concrete has been deposited on the deck. If Class O PCC is revibrated because of failure to meet density requirements with initial vibration, this time limit will be extended by 15 minutes.

2. Cure the concrete as follows:

a. For Class O PCC or Class HPC-O:

1) Allow the surface to cure for at least 72 hours. When Class HPC-O is used on projects with a deck overlay quantity greater than 1800 square yards (1500 m^2), allow the surface to cure for 168 hours.

2) Keep the burlap continuously wet by means of an automatic sprinkling or wetting system.

3) Failure to apply wet burlap within the required time is cause for rejecting the affected work. Remove the surface concrete in the rejected area and replace at no additional cost to the Contracting Authority.

b. Prewet the burlap with sufficient water, prior to placement, to prevent absorption of moisture from the concrete surface.

G. Sealing for Deck Overlay.

Seal the tops and traffic sides of curbs, retrofit barrier rails, and concrete barrier rails according to Article 2403.03, P, 3. In addition, for Class O PCC overlay or Class HPC-O overlay, apply the sealer along each gutter line, extending 1 foot (0.3 m) onto the roadway. The Engineer or the contract documents may designate other areas requiring concrete sealer.

H. Limitations of Operations.

1. Do not commence work on the surface until the lower course meets the requirements of Article 2403.03, N, 2.

2. If traffic shall be maintained during the construction period of this contract, it will be noted in the contract documents. Provide traffic controls required by the contract documents.

3. Night work will be permitted. Furnish adequate lights for nighttime work at the direction of the Engineer at no additional cost to the Contracting Authority. Provide the Engineer with advanced notice.

4. If there is a major delay in the placement operation, place a construction dam or bulkhead. During minor delays of 1 hour or less, the end of the placement may be protected from drying with several layers of wet burlap.

5. Protect freshly placed concrete from sudden or unexpected rain. The Engineer may order removal of concrete damaged by rainfall.

6. Screed rails may be removed at any time after the concrete has taken initial set. Protect the edge of the new surface from damage during screed removal.

7. Do not place concrete adjacent to a surface course less than 36 hours old (this restriction does not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip).

8. If concrete placement is stopped or delayed for a period of 90 minutes or more, discontinue further placement. Resume only after a period of no less than 12 hours. This restriction does not prohibit continuation of placement provided a gap is left in the lane or strip. Ensure the gap is sufficiently long for the finishing machine to clear previously placed concrete.

9. Preparation work will not be allowed in a lane or strip until the lane is closed to traffic. In areas where there is no traffic, preparation of the area may be started in a lane or strip adjacent to newly placed surface the day following its placement. If this work is started before the end of the 72 hour curing period or 168 hour curing period for Class HPC-O

projects with greater than 1800 square yards (1500 m^2), the work will be restricted as follows:

- **a.** Limit the interference sawing, or other operations, has on curing to the minimum time practical, and to the immediate area only. Resume curing promptly.
- **b.** Do not use chipping hammers heavier than a nominal 15 pound (with a mass greater than 7 kg) class.
- **c.** Operate air compressors on the deck only directly over the piers.
- **d.** Do not allow loads, other than construction equipment, on any portion of the bridge deck that has undergone preparation in advance of new concrete placement and curing.

10. Do not allow traffic on a finished surface course until 72 hours after placement or 168 hours for Class HPC-O projects with greater than 1800 square yards (1500 m^2). At temperatures below 55°F (13°C), the Engineer may require a longer waiting time.

11. Do not place PCC when the air or floor temperature is below 40°F (4°C).

12. Do not place concrete mixture after October 1 and before April 1 without the Engineer's written approval.

2413.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Deck Surfacing (Class O PCC), Deck Surfacing (Class HPC-O), Class A Deck Repair, Class B Deck Repair, Deck Overlay (Class O PCC), and Deck Overlay (Class HPC-O): square yards (square meters) computed from measurements of the areas surfaced, repaired, or overlaid. For deck surfacing, the Engineer may require concrete removal for Class O PCC test wells. This removal will not be measured for payment.

B. Sealing (as required in Article 2413.03, G): not measured separately for payment.

C. Longitudinal Grooving in Concrete: according to Article 2412.04.

2413.05 BASIS OF PAYMENT.

Payment will be as described below. The profile may be improved by raising the finished overlay surfaces up to 1/2 inch (15 mm) above that shown in the contract documents, with no additional compensation to the Contractor. Locations where the raise exceeds 1/2 inch (15 mm), payment will be made as extra work for the materials which represent the volume in excess of the 1/2 inch (15 mm) raise.

A. Deck Surfacing (Class O PCC) or Deck Surfacing (Class HPC-O):

1. Contract unit price per square yard (square meter).

2. Payment is full compensation for furnishing all material, equipment, forms, and labor necessary to complete this work according to the contract documents.

B. Class A Deck Repair, Class B Deck Repair, Deck Overlay (Class O PCC), and Deck Overlay (Class HPC-O):

1. Contract unit price per square yard (square meters).

2. Payment is full compensation for removal of excess concrete from the project and it becoming the property of the Contractor, for furnishing all material, equipment, forms, and labor necessary to complete the work according to the contract documents.

3. When there is no item for Class B Deck Repair, but such work is required, payment for each square yard for 5 square yards (square meter for 4 m^2) or less will be at three times the contract unit price per square yard (square meter) for Class A Deck Repair. Should the quantity exceed 5 square yards (4 m^2), payment will be made as extra work.

C. Sealing as required in Article 2413.03, G: included in the contract unit price for Deck Overlay (Class O PCC) or Deck Overlay (Class HPC-O).

D. Longitudinal Grooving in Concrete: according to Article 2412.05.

E. When Section 2428 applies, payment may be modified as specified therein.

Section 2414. Railings

2414.01 DESCRIPTION.
Furnish and construct railings of the type, dimensions, and materials shown in the contract documents.

2414.02 MATERIALS.
Apply Section 2403.

A. Concrete Railings.

1. Concrete Barrier Railing.
Apply Section 2406 and Article 2513.02.

2. Concrete Open Railing.
Apply Section 2406.

3. Retrofit Concrete Barrier Railing.
Apply Section 2406 and Article 2513.02.

B. Pipe and Structural Steel Pedestrian Hand Railings.

1. Use pipe that meets the requirements of Section 4153. Use structural steel that meets the requirements of Section 4152.

2. On all Primary projects and when specified on Secondary projects, use pipe and structural steel railings galvanized according to Article 4100.07.

C. Wood Railings.
Unless provided otherwise in the contract documents, apply Section 4162.

D. Formed Steel Beam Guardrail.

1. Meet the requirements of Section 4155.

2. On Primary projects and when specified for Secondary projects, use steel galvanized according to Article 4100.07 for posts which are placed on concrete by means of anchor bolts.

E. Aluminum Pedestrian Hand Railings.

1. **Aluminum Parts.**
Apply Section 4190.

2. **Anchor Bolts, Nuts, and Washers.**
Apply Article 4153.06 unless shown otherwise in the contract documents.

2414.03 CONSTRUCTION.

Apply Section 2403.

A. Concrete Railings.

1. **Concrete Barrier Railing.**
Construct to the dimensions and length shown in the contract documents and according to Sections 2406 and 2513.

2. **Concrete Open Railing.**
Construct to the dimensions and length shown in the contract documents. Apply the requirements of Section 2406.

3. **Retrofit Concrete Barrier Railing.**
Construct to the dimensions and length shown in the contract documents. Apply the requirements of Sections 2406 and 2513.

B. Pipe and Structural Steel Pedestrian Hand Railings.

1. Construct pipe hand railings, structural steel hand railings, and posts as indicated in the contract documents. Install posts as provided in Article 2414.03, E, 2.

2. The Contractor for the substructure shall furnish and install protection railings on abutments.

3. Paint ungalvanized metal railings according to Section 2508. The Contractor for the superstructure shall furnish and apply field coats of paint.

C. Wood Railings.
Unless provided otherwise in the contract documents, construct wood railings of common class lumber as defined in Section 4162. Ensure details of the construction comply with Section 2409. Paint wood railings as provided in Article 2409.03, K.

D. Formed Steel Beam Guardrail.
Furnish and install formed steel beam guardrail for bridge structures or approaches according to the contract documents and Section 2505. Use structural steel posts furnished and installed as part of the bridge structure for rails on new bridge structures.

E. Aluminum Pedestrian Hand Railings.
Construct aluminum hand railings with aluminum posts supporting rails of aluminum tubing according to the contract documents and the following:

1. Handling and Storage.
- **a.** Carefully handle and store aluminum posts and rails at the work site. Do not store aluminum parts in contact with the ground or where they may be attacked by acid or alkali.
- **b.** Replace members which are marred or damaged to the extent that their usefulness or appearance is impaired at no additional cost to the Contracting Authority.

2. Installation.
- **a.** Set anchor bolts in the concrete curb at the correct location and elevation. Hold them firmly in place using suitable templates that will insure their correct position during placing and hardening of the concrete.
- **b.** Assemble and align the rails. If necessary, shim the rails to bring them to the correct elevation. Tighten anchor nuts to hold the rails firmly in place. After aligning the rails, position them to accommodate the anticipated expansion. Tighten the setscrews to hold the rails firmly in place. Cap the ends of tubular rails.
- **c.** After erection, carefully remove all dirt and grease from the rails, posts, and concrete around the post base using a cleaning method the Engineer approves.

2414.04 METHOD OF MEASUREMENT.

Measurement for the various items involved in the construction of railings will be as follows:

A. Concrete Railings.

1. Concrete Barrier Railing.
Linear feet (meters) shown in the contract documents, measured from end to end of the barrier, including end sections and transition sections. Measurement for the weight (mass) of reinforcement steel installed in the barrier will be according to Article 2404.04.

2. Concrete Open Railing.
Linear feet (meters) shown in the contract documents, measured from end to end of the barrier, including end sections and transition sections. Measurement for the weight (mass) of reinforcement steel installed in the barrier will be according to Article 2404.04.

3. Retrofit Concrete Barrier Railing.
Linear feet (meters) shown in the contract documents, measured from end to end of the barrier, including end sections and transition sections. Reinforcement steel in Retrofit Concrete Barrier Railing will not be measured for payment.

4. Electrical Circuits.
When electrical conduit and junction boxes are installed as part of Section 2525, Article 2525.04 applies; otherwise, electrical conduit and junction boxes will not be measured.

B. Steel Pipe Pedestrian Hand Railing and Structural Steel Pedestrian Hand Railing.
Linear feet (meters) shown in the contract documents, from end to end of the railing.

C. Wood Railings.
Article 2409.04 applies.

D. Formed Steel Beam Guardrail.

1. Article 2505.04 applies.

2. Section 2408 applies for steel posts.

E. Aluminum Pedestrian Hand Railings.
Aluminum railing will be the quantity shown in linear feet (meters) in the contract documents for Aluminum Pedestrian Hand Railing.

2414.05 BASIS OF PAYMENT.
Payment for the quantities of various items of construction, measured as specified in Article 2414.04, will be the contract unit price as described below. Payment is full compensation for furnishing all materials, equipment, and labor necessary to construct the rail as shown in the contract documents.

A. Concrete Railings.

1. Concrete Barrier Railing, Concrete Open Railing, or Retrofit Concrete Barrier Railing: per linear foot (meter).

2. Reinforcement measured for payment: Article 2404.05 applies. The reinforcement quantities may be included in the quantities for the superstructure or abutments. Reinforcement Steel in Retrofit Concrete Barrier Railing will not be paid for separately, but will be included in the price bid for Retrofit Concrete Barrier Railing.

3. Electrical Circuits: When electrical conduit and junction boxes are installed as part of Section 2525, payment will be according to Article 2525.05; otherwise, electrical conduit and junction boxes will be incidental to the concrete railing.

B. Steel Pipe Pedestrian Hand Railing and Structural Steel Pedestrian Hand Railing.
Contract unit price for structural steel when measured by weight (mass), and contract unit price per linear foot (meter) when measured in linear feet (meters).

C. Wood Railings.
Article 2409.05 for lumber and hardware.

D. Formed Steel Beam Guardrail.

1. Apply Article 2505.05.

2. Article 2408.05 applies for steel posts.

E. Aluminum Pedestrian Hand Railings.
Per linear foot (meter).

Section 2415. Concrete Box, Arch, and Circular Culverts

2415.01 DESCRIPTION.

A. Cast-in-place.
Construct a cast-in-place concrete box, arch, or circular culvert.

B. Precast.

1. Precast box culverts may be accepted when shown in the contract documents.

2. Use culvert sections that meet the requirements of ASTM C 1433.

3. The contract documents will designate the span, rise, and either the design earth cover, or the design loading, both defined in ASTM C 1433.

4. Apply Section 2407 to the aggregates used in the concrete.

5. Apply the appropriate requirements of Section 2407 to manufacturing process inspection.

6. Concrete strength will be based on cylinder tests.

2415.02 MATERIALS.
Use Class C structural concrete meeting the requirements of Section 2403, unless specified otherwise.

2415.03 CONSTRUCTION.
Apply the requirements of Sections 2401, 2402, 2403, 2404, and 2414.

A. Footings.

1. Construct footings to the elevations shown in the contract documents, unless directed otherwise by the Engineer.

2. Footing depths may be increased when necessary to prevent undermining or scour or to secure adequate bearing. In general, decrease footing depth only when solid rock is encountered at elevations above those shown.

3. Use suitable wood or metal forms according to Section 2403 to enclose all footing concrete.

B. Placing Concrete.

1. **Footings.**
   a. Do not allow dirt, mud, or other foreign material to become mixed with concrete which is being placed in the footing.
   b. Monolithically construct footings, pavements, and curtain walls between construction joints if practical.
   c. Provide a key notch of the form shown in the contract documents between the walls and footings to insure proper anchorage.
   d. Remove all dirt, dust, shavings, or other foreign material from the key notch and wall forms before placing concrete.

2. **Barrels of Culverts.**
   a. The sidewalls and top slab may be constructed as a monolith between construction joints, or the concrete in sidewalls may be placed and allowed to harden before the top slab is placed, at the discretion of the Contractor.
   b. If the sidewalls and top slab are constructed as a monolith, all necessary construction joints are to be vertical and at right angles to the axis of the culvert. If the sidewalls are placed and allowed to

harden before the top slab is placed, leave appropriate keys in the sidewalls for anchoring the cover slab.

c. Place forming and reinforcement for the entire barrel section between construction joints before concrete is placed in the sidewalls or headwalls.

3. Headwalls.

a. In general, construct headwalls monolithically. However, when construction joints are unavoidable, place them in a horizontal or vertical position and locate them so no joint is visible above the roadbed.

b. Place triangular fillet strips in the forms to avoid sharp edges and corners.

4. Placing Concrete in Arch Culverts.
Place concrete in arch culverts as provided in Section 2403.

C. Surface Finish.
Surface all exposed parts of the wingwalls, headwalls, and railings according to Article 2403.03, P.

D. Placing Backfill Material.
Place backfill material according to Article 2402.03, H.

E. Protection Railings.

1. Furnish and install protection railings shown in the contract documents.

2. Paint protection railings, other than aluminum or galvanized railings, as provided in Section 2508.

2415.04 METHOD OF MEASUREMENT.

A. Excavation for structures, structural concrete, steel reinforcement, and other items in the contract documents will be the quantity shown in the contract documents.

B. Protection railing (when specified in the contract documents) will be the quantity shown in the contract documents.

2415.05 BASIS OF PAYMENT.

A. Payment for all concrete box, arch, or circular culverts will be the contract unit price for excavation for structures, structural concrete, steel reinforcement, and other items included in the contract documents.

B. Payment for protection railings will be the contract unit price for the railing material.

C. Payments are full compensation for furnishing all materials, equipment, and labor and for performance of all work necessary to complete the structures in conformance with the contract documents or as ordered by the Engineer.

Section 2416. Rigid Pipe Culverts

2416.01 DESCRIPTION.

Furnish and install concrete pipe for roadway and entrance culverts.

A. Roadway culverts are defined as culverts placed on a public way, whether Primary Road, Secondary Road, city street, or other way maintained for public traffic.

B. Entrance culverts are defined as culverts for private drives such as entrances to farms, city lots, and so on, which are not maintained for public traffic.

C. Low clearance pipe is defined as either arch pipe or elliptical pipe. When low clearance pipe is specified, the Contractor may supply either pipe shape.

2416.02 MATERIALS.

Meet the requirements of Section 4145 for the type and strength (class) of pipe specified in the contract documents.

2416.03 CONSTRUCTION.

A. 1500D (Class II) (75D) pipe may be used for entrance culverts only. Use 2000D (Class III), 3000D (Class IV), or 3750D (Class V) (100D, 150D, or 175D) pipes for roadway culverts, or if conditions require, for entrance culverts. Table 2416.03-1 provides minimum and maximum allowable pipe sizes.

Table 2416.03-1: Minimum and Maximum Allowable Pipe Sizes

Culvert Use	Minimum Pipe Size in. (mm)	Maximum Pipe Size in. (mm)
Roadway Culvert	18 (450)	108 (2700)
Entrance Culvert	15 (375)	108 (2700)

B. For 24 inch (600 mm) or larger diameter pipes, the number of 4 foot (1.2 m) sections is to be the minimum necessary to produce the length of culvert required.

C. Where a new fill is being constructed, place roadway pipe in a trench only when the total fill over the pipe is 5 feet (1.5 m) or less. Place embankment within the restrictions of Article 1105.14.

D. Except as indicated otherwise in the contract documents, install pipe culverts according to the following requirements:

1. Trench Width.

Ensure the trench is wide enough to permit tamping of bedding material under and around the pipes. The Contractor has the option to cut a trench wide enough to accommodate a tamping type roller on each side of the pipe.

2. Base Preparation.

a. Bring the surface upon which the pipe sections are to rest to a suitable elevation to fit the desired grade and camber. Prepare the base as shown in the contract documents. Use Class B bedding unless specified otherwise.

1) Class B Bedding.

Class B bedding consists of a 2 inch (50 mm) cushion of sand shaped with a template to a concave saddle in compacted or natural earth to such a depth that 15% of the height of the pipe rests on the sand cushion below the adjacent ground line.

2) Class C Bedding.

Class C bedding consists of a concave saddle shaped with a template, or shaped by other means and checked with a template, in compacted or natural earth to such a depth that 10% of the height of the pipe rests below the adjacent ground line.

b. Where bedrock, shale, or very hard clay is encountered, excavate the trench below the bottom of the pipe for a depth of at least 1 foot (0.3 m). Place earth backfill material and thoroughly tamp.

c. If the bottom of the footing is of an unstable nature, the Engineer may direct that the foundation be treated by first excavating below the required elevation and then placing backfill materials consisting of one of the granular surfacing materials listed in Section 4120 or other suitable material approved by the Engineer. Place backfill material according to Article 2402.03, H, or as directed by the Engineer.

d. Unless bedding is specifically designated in the contract documents, Class B bedding will not be required for entrance pipe 24 inches (600 mm) or less in diameter. Instead, the pipe may be bedded carefully in suitable material and the backfill material compacted with a mechanical tamper to mid-height elevation of the pipe. Complete remaining backfill material placement according to 2416.03, D, 4.

3. Placing Pipe Sections.

a. Provide proper facilities for lowering sections into place without damage to the pipe.

b. Carefully lay pipe with hub, bell, or groove ends upstream.

c. Carefully bed and place each section in close contact with adjacent sections, with lifting holes (if provided) at the top.

d. Place pipe section to alignment and grade established or approved by the Engineer.

e. Fill lifting holes (if provided) with concrete or precast concrete plugs prior to placing backfill material.

4. Placing Backfill Material around Pipe Culverts.

a. Thoroughly tamp under and around the pipe in layers not to exceed 8 inches (200 mm) for the full length and width of the pipe.

b. Fill and thoroughly tamp earth around and over the culvert for its full length, according to Articles 2402.03, G and 2402.03, H. Ensure that adjacent to the pipe on each side is an embankment of thoroughly tamped or undisturbed earth.

c. Extend the embankment on both sides of the culvert from the original ground line to at least 1 foot (0.3 m) above the top of the pipe with a slope as shown in the contract documents. Ensure the width of this fill at its top is no less than the outside diameter of the culvert and extends one-half its width on each side of the culvert center line. Increase the height of fill, if necessary to accommodate construction traffic, to the nominal diameter of the pipe or 3 feet (1 m), whichever is greater.

d. When pipes are laid wholly or partly in a trench, granular backfill material may be required for backfill material as provided in Article 2402.03, H. Use compacted earth for the remainder of the fill, to at least 1 foot (0.3 m) above the top of the pipe, with slopes as outlined above.

e. If the trench is cut wide enough to permit the use of a roller, first bed the pipe and then thoroughly tamp the backfill material under and alongside the pipe to the mid-height elevation of the pipe. Place and compact the remainder of the backfill material according to Section 2107.

f. If a roadway pipe culvert is being placed after construction of an embankment and moisture control is not required, place the pipe using methods that will produce results equivalent to those required for construction of the embankment. For this situation, moisture determinations will be waived for backfill material placement completed within 48 hours after excavation.

g. When ordered by the Engineer, build approach fills to provide a roadway 10 feet (3 m) in width over the culvert with grades not steeper than 10%.

5. Concrete Pipe Joints.

a. When required by the contract documents, wrap concrete pipe joints with Engineering Fabric of the type specified.

b. Ensure joint openings on the outside or inside of the bottom half of the pipe do not exceed 1/4 inch (6 mm) for pipe with an internal diameter of 24 inches (600 mm) or less.

c. For pipe with an internal diameter of more than 24 inches (600 mm), ensure joint openings on the outside or inside of the bottom half of the pipe do not exceed 1/8 inch per foot (1 mm per 0.1 m) of internal diameter, with a maximum allowable joint opening of 5/8 inch (15 mm).

d. Fully encase larger joint openings, unless they are required for pipe camber, with a Type C-1 concrete collar. Use Class C structural

concrete as specified in Section 2401. Point the collar and inner surface of the joint full and flush using sand cement mortar for the lower 75% of the pipe perimeter.

E. Trenchless Construction.
Apply Section 2553.

F. Stockpile removed aprons that are to be reinstalled. Replace aprons damaged by Contractor's operations at no additional cost to Contracting Authority.

2416.04 METHOD OF MEASUREMENT.
Measurement for the items associated with rigid pipe culverts will be as follows:

A. Pipe culvert: measured length, in feet (meters), of culvert installed, excluding aprons, to the nearest foot (0.1 m) with no deductions for elbows, tees, and other fittings. Quantity will be determined along the axis. Measurement for pipe laterals terminating at a tee will be from the point of inlet to a point 6 inches (150 mm) from the outside of the main, less the length of the apron, if any.

B. Aprons: quantity shown in the contract documents.

C. Appurtenances (elbows, tees, and other fittings): not measured for payment, but quantity will be shown on the contract documents.

D. Type C adaptors required by the contract documents or installed to correct faulty work will not be measured for payment.

E. Excavation for culverts:

1. Roadway culverts: Article 2402.04, C applies.

2. Entrance culverts: not measured for payment.

3. Sand required for Type B bedding: not measured for payment.

F. Granular Backfill (when required and furnished): Article 2402.04, E, applies.

G. Foundation treatment material (when placed at the direction of the Engineer): Article 2402.04, F, applies.

H. Trenchless: Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along the centerline of the pipe.

I. Removal and Reinstallation:

1. Aprons: Each apron removed and reinstalled will be counted for each size class.

2. Pipe culvert: Measurement of pipe removed and reinstalled for each size class specified will be in linear feet (meters) from end to end.

2416.05 BASIS OF PAYMENT.

Payment for the items associated with rigid pipe culverts will be the contract unit price as follows:

A. Pipe culvert: per linear foot (meter) for type and size specified.

B. Wrapping pipe joints, Type C adapters, and appurtenances: included in the contract unit price per linear foot (meter) for the pipe culvert.

C. Aprons: per unit for the size specified.

D. Payment for Type C adaptors not shown in the contract documents, but required because of changes in alignment will be as extra work according to Article 1109.03, B.

E. Excavation for culverts:

1. Roadway culverts and the quantity of extra excavation for embankments: per cubic yard (cubic meter).

2. Entrance culverts: incidental to the contract unit price for rigid pipe culvert.

3. Sand required for Class B bedding: incidental to the contract unit price for pipe culvert.

F. Granular Backfill (when required and furnished): Article 2402.05, G, applies.

G. Foundation treatment material (furnished and placed): Article 2402.05, F, applies.

H. Trenchless:

1. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe.

2. Payment is full compensation for:

- Furnishing and installing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material, and
- Pipe connections.

I. Removal and Reinstallation:

1. Aprons: Per unit for each size class of apron removed and reinstalled. Payment is full compensation removing, stockpiling, and reinstalling aprons, as well as necessary excavation.

2. Pipe culvert: Per linear foot (meter) for each size class of pipe removed and reinstalled. Payment is full compensation for removal and reinstallation of pipe.

Section 2417. Corrugated Culverts

2417.01 DESCRIPTION.

A. Furnish and install corrugated culverts.

B. Roadway and entrance culverts are defined in Article 2416.01.

2417.02 MATERIALS.

A. Use corrugated culverts that meet the requirements of Section 4141, or Section 4146 when polyethylene culvert pipe is designated.

B. Use round culvert pipe, unless specified otherwise. When required, elongate round pipe. When specified, use arch type pipe.

C. When placing under roadway, use corrugated steel culverts coated according to Article 4141.02.

D. A paved invert may be required according to the contract documents.

2417.03 CONSTRUCTION.

A. Maximum and Minimum Sizes.

1. Table 2417.03-1 provides minimum allowable pipe sizes.

Table 2417.03-1: Minimum Allowable Pipe Sizes

Culvert Use	Minimum Pipe Size in. (mm)
Roadway Culvert	18 (450)
Entrance Culvert	15 (375)

2. Table 2417.03-2 provides maximum allowable pipe sizes.

Table 2417.03-2: Maximum Allowable Pipe Sizes

Corrugation Depth in. (mm)	Maximum Pipe Size in. (mm)
1/2 (13)	84 (2100)
1 (25)	120 (3000)

3. When culverts of sizes outside the limitations in Tables 2417.03-1 and 2417.03-2 are specified, they will be covered by the contract documents.

B. Minimum Depth of Fill.

1. Place a minimum of 1 foot (0.3 m) of fill over entrance culverts.

2. Place a minimum of 2 feet (0.6 m) of fill over roadway culverts.

3. If necessary to accommodate construction traffic, increase depth of fill over roadway culverts to the nominal diameter of the pipe or 3 feet (1 m), whichever is greater.

C. Installation.

1. Class B Bedding.
When installing corrugated metal pipe or polyethylene pipe for roadway culverts, use Class B Bedding described in Article 2416.03, D, 2.

2. Deflection Testing for Polyethylene Pipes.

a. General.

1) No sooner than 30 calendar days following pipe installation compaction and placing backfill material, or before paving, perform deflection testing on at least 10% of the pipe locations along their entire length at locations determined by the Engineer.

2) The internal diameter of a pipe is not to be reduced by more than 5.0% of its nominal inside diameter.

3) If any pipe fails post installation testing, the Engineer may require the Contractor to perform post installation testing on any additional pipes or all of the remaining pipes.

4) Pipes failing post installation testing will be considered unacceptable. Replace with new pipe or reinstall undamaged pipe. Test for deflection.

b. Pipe Diameter of 30 Inches (750 mm) or Less.
Perform deflection testing using a properly sized nine-point mandrel test.

c. Pipe Diameter Greater than 30 Inches (750 mm).
Ensure the internal diameter of the entire length of the pipe is not reduced by more than 5.0% of it nominal inside diameter.

2417.04 METHOD OF MEASUREMENT.

Measurement for the items associated with corrugated pipe culverts will be as follows:

A. Pipe culvert: measured length, in feet (meters), of culvert installed, excluding aprons, to the nearest foot (0.1 m). Quantity of pipe will be determined along the axis. Measurement for pipe laterals terminating at a tee will be from the point of inlet to a point 6 inches (150 mm) from the outside of the main, less the length of the apron, if any.

B. Aprons: quantity shown in the contract documents.

C. Appurtenances (elbows, tees, and other fittings): not measured for payment, but quantity will be shown on the contract documents.

D. Excavation for culverts:

1. Roadway culverts: Article 2402.04, E, applies.

2. Entrance culverts: not measured for payment.

E. Granular Backfill (when required and furnished): Article 2402.04, E, applies.

F. Foundation treatment material (when placed at the direction of the Engineer): Article 2402.04, F, applies.

G. Beveled Pipe and Guard: Quantity shown in the contract documents.

H. Removal and Reinstallation:

1. Aprons: Each apron removed and reinstalled will be counted for each size class.

2. Pipe culvert: Measurement of pipe removed for each size class specified will be in linear feet (meters) from end to end.

2417.05 BASIS OF PAYMENT.

Payment for the items associated with corrugated pipe culvert will be at the contract unit price as follows:

A. Pipe culvert: per linear foot (meter) for type and size specified.

B. Aprons: per unit for the size specified

C. Appurtenances: included in the contract unit price per linear foot (meter) for the pipe culvert.

D. Excavation for culverts:

1. Roadway culverts and the quantity of extra excavation for embankments: per cubic yard (cubic meter).

2. Entrance culverts: incidental to the contract unit price for corrugated pipe culvert.

E. Granular Backfill (when required and furnished): Article 2402.05, G, applies.

F. Foundation treatment material (furnished and placed): Article 2402.05, F, applies.

G. Deflection testing required according to the contract documents: incidental to the contract unit price for polyethylene pipe.

H. Beveled Pipe and Guard: Per unit for the size specified.

I. Removal and Reinstallation:

1. Aprons: Per unit for each size class of apron removed and reinstalled. Payment is full compensation for removal and reinstallation of apron.

2. Pipe culvert: Per linear foot (meter) for each size class of pipe removed and reinstalled. Payment is full compensation for removal and reinstallation of pipe.

Section 2420. Structural Plate Pipes, Pipe Arches, and Arches

2420.01 DESCRIPTION.

Furnish and construct structural plate pipes, pipe arches, or arches meeting requirements of these specifications and of the sizes and dimensions shown in the contract documents.

2420.02 MATERIALS.

A. Use materials for structural plate pipe, pipe arches, and arches that meet the requirements of Section 4144.

B. Unless specified otherwise, furnish a galvanized corrugated steel structure.

2420.03 CONSTRUCTION.

A. Quality of Work.

1. In addition to compliance with the details of construction, the completed structure must demonstrate high quality work. Plates on which the galvanizing has been damaged or broken, either in the shop or in shipping, or which show defective work will be rejected. The requirement applies not only to the individual plates but to the shipment for any contract as a whole.

2. Among others, the following defects are specified as constituting poor quality work. The presence of any or all of them in any individual culvert plate, in any shipment, or, in general, in the completed culvert, will constitute sufficient cause for rejection:
- **a.** Uneven laps.
- **b.** Elliptical shaping (unless specified), or otherwise excessive distortion.
- **c.** Variations from a straight center line.
- **d.** Ragged edges.
- **e.** Loose, unevenly lined or spaced bolts.
- **f.** Illegible brand.
- **g.** Damaged, scaled, or broken galvanizing.
- **h.** Dents or bends in the metal itself.

B. Bedding.

1. When a pipe structure is to be erected in a trench, construct the trench to be wide enough to permit thorough tamping of the earth backfill material against every plate except the bottom one.

2. Bed the pipe in an earth foundation of uniform density. Carefully shape the foundation with a template, or use other means and check with a template. Support the pipe at the desired grade. Ensure pipe has the required camber to fit the lower plate of the pipe.

3. When rock in either ledge or boulder formation is encountered, remove it below grade. Replace the rock with suitable materials in a manner to provide a minimum 8 inch (200 mm) thick compacted earth cushion having a thickness under the pipe no less than 1/2 inch per foot (40 mm/m) of fill over the pipe.

4. When firm foundation is not encountered at the grade established, due to soft, spongy, or other unsuitable soil, remove all unsuitable soil for a maximum distance of one diameter under and on each side of the pipe. Replace with suitable earth or granular material properly compacted to provide adequate support of the pipe. Use other special construction methods if specified. Excavate unsuitable soil below grade and place backfill material only at the at the Engineer's direction. This will be paid for as extra work unless provided otherwise in the contract documents.

5. Prepare the base according to Article 2416.03, D, 2. Ensure the bedding provides camber to allow for settlement after placing the fill. Vary the amount of camber to suit the height of fill and nature of supporting soil. Provide a minimum camber of 1% of the length of the pipe.

C. Multiple Structures.

When multiple structures of pipe or pipe arches are used, space them so that the adjacent sides of pipe are from 50% of the diameter to a maximum

of 4 feet (1 m) apart to permit tamping of backfill material. Ensure the distance between plates at skewback of multiple arch spans is no less than 10% of the longer adjoining span.

D. Field Erection, Structural Plate Pipe, and Pipe Arches.

1. Beginning at the downstream end, place full sized bottom plates along the center line of the structure, lapping each plate one corrugation with the previous plate. Use fasteners to connect plates at longitudinal and circumferential seams. Stagger joints so that no more than three plates come together at one point.

2. After all plates have been placed, tighten all bolts to a minimum torque value of 100 foot pounds (135 N·m) and a maximum of 300 foot pounds (400 N·m).

3. When end treatment requires a rigid headwall, anchor the plates to the headwall with anchor bolts no smaller than 3/4 inch (19 mm) and spaced at no more than 19 inch (480 mm) on center.

4. Assemble pipe arch plates so they form cross sections made up of four circular arcs that are tangent to each other at their junctions and are symmetrical about the vertical axis.

E. Skewed Arch Spans.

Ensure the end skew of arches does not exceed 45 degrees. When the skew is more than 15 degrees, adjust the length of the structure so that no portion of the live load will be carried by the cut portion of the end. Where right-of-way or other conditions do not permit the required length, support the cut end with rigid headwalls designed to meet the conditions. Anchor the plates to the headwall with 3/4 inch (19 mm) bolts spaced at no more than 19 inch (480 mm) on center.

F. Arch Anchorage.

Anchor each side of the arch to the foundation by means of a formed channel or a structural angle bolted to the bottom row of plates. Ensure the arch plates bear directly on the channel or angle. Use channels or angles made of the same material as the plates. Anchor them to the foundation at intervals of no more than 24 inches (0.6 m).

G. Field Erection, Arches.

1. Begin erection of arch plates at the downstream end by bolting the side plates, at intervals no greater than 24 inches (0.6 m), to the angle or channel attached to the foundation.

2. Set plates inside the vertical leg of the angle or the longer leg of the channel. Ensure they bear directly on the horizontal leg of the angle or the web of the channel.

3. Assemble succeeding plates so that joints at right angles to the center line of the arch are staggered and not continuous for more than the width of one plate.

4. Support the upper edge of each plate of the first ring in its proper place until the full number of plates for the ring is in position.

5. Tighten bolts in each section as required in Article 2420.03, D.

H. Shop Forming.

1. When specified, shop form structural plate pipes to increase the vertical diameter approximately 5% out of round before placement of the fill.

2. A tolerance of ± 2.5% of the nominal pipe diameter or 5 inches (125 mm), whichever is less, will be permitted.

I. Placing Backfill Material.

1. After the structure has been assembled, place backfill material according to Articles 2402.03, G; 2402.03, H; and 2402.03, I. Thoroughly tamp each layer between the structure and the sides of the trench or for a distance on each side of the structure equal to the diameter of the structure.

2. After the fill over the structure has been completed to the full height, release and remove the struts, if any.

3. Exercise care when placing backfill material to prevent excessive distortion of the shape of the structure, either in peaking action or rolling action. Deflection in any direction greater than 2.5% from the original specified shape will not be allowed during the backfill material placement operation.

4. In addition to placing backfill material as required above, when the Engineer orders, build approach fills that will provide a roadway 10 feet (3 m) wide over the culvert, with grades no steeper than 10%.

2420.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Structural pipe culvert: feet (meters) to the nearest foot (0.1 m) shown in the contract documents for each culvert. The quantity of pipe will be determined as follows:

1. Pipes and arches with either square or skewed vertical ends: end to end of metal on center line of structure.

2. Pipes or pipe arches with square ends, beveled: average end to end at top and bottom of pipe.

3. Pipes or pipe arches with skewed ends, beveled: average end to end at top and bottom of pipe parallel to center line.

4. Arches with ends other than vertical: as noted in the contract documents.

B. Excavation for structural plate pipe: as specified for culverts in Article 2402.04. When the pipe is installed without change in location, dimensions, or elevation, the quantities of Class 20 or Class 23 and Class 24 excavation, as shown in the contract documents, will be the quantities for which payment is made.

C. Excavation for structural plate arches: as specified for structures in Article 2402.04 for the respective classes of excavation performed.

D. Structural concrete: Article 2403.04 applies.

E. Steel reinforcement: Article 2404.04 applies.

2420.05 BASIS OF PAYMENT.

A. Payment for structural pipe culvert of type and size specified will be the contract unit price for per linear foot (meter).

B. Payment is full compensation for furnishing all materials, labor, and equipment necessary to complete the work.

C. Excavation for structures, structural concrete, and reinforcement will be paid for separately.

Section 2422. Unclassified Pipe Culverts

2422.01 DESCRIPTION.

A. Construct and install roadway and entrance culverts for which inside dimensions and length are specified.

B. The selection of pipe of a type permitted by this specification, or other approved types permitted in the contract documents, will be optional with the Contractor.

C. Refer to Article 2416.01 for definitions of roadway and entrance culverts.

2422.02 MATERIALS.
Select the type of pipe culvert for unclassified roadway and unclassified entrance from the following tables.

Table 2422.02-1: Unclassified Roadway Pipe Culvert

Concrete - 2000D (100D)	Section 2416
Coated Corrugated Steel	Section 2417
Polyethylene Pipe	Section 2417

Table 2422.02-2: Unclassified Entrance Pipe Culvert

Unclassified roadway pipe culverts	Any type permitted
Concrete Pipe - 1500D (75D)	Section 2416
Corrugated Steel Pipe	Section 2417

Table 2422.03-3: Unclassified Roadway Letdown Pipe Culvert

Coated Corrugated Steel	Section 2417
Polyethylene Pipe	Section 2417

2422.03 CONSTRUCTION.

A. Install according to the contract documents and in conformance with applicable requirements for the particular type of pipe used.

B. Using more than one type of pipe at one installation site will not be permitted unless by written approval of the Engineer.

C. When rigid pipe culverts are furnished, install as provided in Article 2416.03. When corrugated pipe culverts are furnished, install as provided in Articles 2417.03, B and 2417.03, C.

2422.04 METHOD OF MEASUREMENT.

Measurement for the items associated with unclassified pipe culverts will be as follows:

A. Unclassified pipe culverts: Articles 2416.04 and 2417.04 apply.

B. Excavation for culverts:

1. Roadway pipe culverts: will be measured as provided in Article 2402.04. The plan quantity of excavation will be based on an excavation, centered for the pipe, of the required depth, length, and a width of 42 inches (1 m) plus the specified diameter of the pipe. Modification will not be made in the quantity shown in the contract documents for variations in wall thickness of the various types of pipe. Modifications will be made in the quantity of excavation for changes in location or flowline as provided in Article 2402.04.

2. Entrance culverts: incidental to pipe installation and will not be measured separately for payment.

C. Granular Backfill (if required and furnished): Article 2402.04, E, applies.

D. Foundation treatment (if placed at the direction of the Engineer): Article 2402.04, F, applies.

2422.05 BASIS OF PAYMENT.
Payment for the items associated with unclassified pipe culverts will be the contract unit price as follows:

A. Unclassified pipe culverts: Articles 2416.05 and 2417.05 apply.

B. Excavation for culverts:

1. Roadway culverts and the quantity of extra excavation for embankments: per cubic yard (cubic meter).

2. Entrance culverts: incidental to the contract unit price for unclassified pipe culvert.

C. Granular Backfill (when required and furnished): Article 2402.05, G, applies.

D. Foundation treatment material (furnished and placed): Article 2402.05, F, applies.

Section 2423. Support Structures for Highway Signs, Luminaires, and Traffic Signals

2423.01 DESCRIPTION.
Fabricate, furnish, and erect support structures for highway signs, luminaires, and traffic signals. Design according to the contract documents and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

2423.02 MATERIALS.
Apply Section 4187.

2423.03 CONSTRUCTION.

A. General Requirements.

1. Before fabrication, submit shop drawings according to Article 1105.03.

2. Provide the Engineer ample notice:
- Prior to the start of shop fabrication so that required inspection can be performed, and
- Prior to shipment so that final shop inspections can be performed.

3. Fabricate support structures according to the contract documents. Present proposed design or material changes to the Engineer in written form, plan form, or both. Do not make changes without the Engineer's written approval. The Engineer will not approve substitution of material

or design detail changes which constitute a reduction in quality or strength of the structure.

4. The Contractor is to defend and save the Contracting Authority harmless from any and all patent infringement suits resulting from the use of any design, device, material, process, portion, or phase thereof, employed in the manufacture or use of overhead sign support structures according to the contract documents and Article 1107.04.

B. Fabrication and Assembly.
Fabricate structural steel supports according the Structural Welding Code – Steel, AWS D1.1, current edition, or the Structural Welding Code – Aluminum, AWS D1.2, current edition, with the following exceptions:

1. Apply AWS D1.1, Section 6, Part D to non-destructive tests of welds for steel structures, and include tests of column-to-base plate full penetration welds. Apply AWS D1.2, Section 5, to non-destructive tests of welds for aluminum structures and limit tests to the flange connections of the overhead section and the end supports.

2. Apply Article 2408.03, B, relative to qualifications of welders, welding operators, and tackers and the effective period of their qualifications.

3. The provisions of AWS D1.2, Paragraph 9.1.2 do not apply. Structures are Class II structures.

4. Clean weld splatter, black smoke, and residue from fabrication before shipping completed structure to the job site. The fabricator is required to warrant that each complete structure is free from misfits or structural deficiencies prior to shipment.

C. Packing.
Pack prefabricated structural units in a manner to prevent damage or defacement during transportation.

D. Acceptance and Rejection.
Failure of the structure to meet requirements of this specification may be cause for rejection.

2423.04 METHOD OF MEASUREMENT.

Measurement for items for construction of support structures for highway signs, luminaires, and traffic signs will be as follows:

A. Superstructure.
Each overhead sign support structure will be counted by the span and type specified and shown in the contract documents.

B. Substructures.

1. Excavation: as specified in Article 2402.04 for the class shown in the contract documents.

2. Concrete: as specified in Article 2403.04.

3. Reinforcement: as specified in Article 2404.04.

2423.05 BASIS OF PAYMENT.

Payment for acceptable portions of the following items of work will be at the contract unit price as follows:

A. Superstructure.

1. For overhead sign support structures, payment will be for each span and type specified.

2. Payment is full compensation for the following:
- **a.** Furnishing prefabricated structural units, supports, necessary fastenings for assembly of the structure, anchor bolts, and fittings for bolting the upright supports to the concrete bases.
- **b.** Erection of the structure as designated by the contract documents or by the Engineer.

B. Substructures.

1. Excavation:
- **a.** As specified in Article 2402.05 for the class shown in the contract documents.
- **b.** Payment is full compensation for excavation, placing backfill material, compaction of backfill material, replacement and compaction of special shoulder construction materials at the same depth and elevation encountered in the excavation, and depositing of unused excavated materials in a manner satisfactory to the Engineer.

2. Concrete:
- **a.** As specified in Article 2403.05.
- **b.** Payment is full compensation for furnishing, placing, and finishing according to the provisions of Section 2405.

3. Reinforcement: As specified in Article 2404.05.

Section 2424. Shotcrete

2424.01 DESCRIPTION.

A. Remove unsound concrete, prepare concrete surfaces, and apply and cure shotcrete where indicated in the contract documents and where directed by the Engineer.

B. Shotcrete is mortar or concrete conveyed through a hose and pneumatically projected at high velocity onto a surface. Apply Shotcrete using the Dry Mix Process. This is a process in which the dry cement aggregate mixture is carried by compressed air to the nozzle where water is interjected and the resulting mixture is jetted from the nozzle onto the surface to be shotcreted.

1. Shotcrete Mortar.
Shotcrete mortar is a top or surface layer in which the aggregate is limited to sand with a maximum nominal particle size of 1/4 inch (6.3 mm).

2. Shotcrete Concrete.
Shotcrete concrete contains fine aggregate and coarse aggregate with particle sizes in excess of 1/4 inch (6.3 mm). Procedures and quality of work are, in general, to comply with provisions of the current edition of ACI Standard 506, "Recommended Practice for Shotcreting," subject to approval of the Engineer.

2424.02 MATERIALS.

Use materials for shotcreting that meet the following requirements:

A. Portland Cement.
Meet the requirements of Section 4101, Type I.

B. Water.
Apply Section 4102.

C. Fine Aggregate.
Use natural sand meeting the requirements of Section 4110 or 4111.

D. Coarse Aggregate for Concrete.
Meet requirements of Section 4115 and the gradation requirements of Table 2424.02-1:

Table 2424.02-1: Gradation

Sieve No.	Percent Passing
3/4" (19 mm)	100
1/2" (12.5 mm)	97-100
3/8" (9.5 mm)	40-90
No. 4 (4.75 mm)	0-30
No. 200 (75 µm)	0-1.5
The maximum percent passing the No. 200 (75 µm) sieve may be increased to 2.5%, provided the agreed documented production limit is maintained at 1.0% or less, and any increase up to 2.5% is due to degradation of the parent material and not to contamination by other material.	

E. Wire Mesh.
Apply Article 4151.04. Use mesh that is 3 inches by 3 inches or 4 inches by 4 inches (75 mm by 75 mm or 100 mm by 100 mm) with nominal area of wire between 0.014 and 0.030 square inches (9 mm^2 and 19 mm^2), inclusive. Use mesh that is galvanized with a coating (minimum of 0.15 ounces per square foot (45 g/m^2)) recognized in the industry as a "regular" coating.

F. Concrete Anchors.
Furnish concrete anchors designed for use with 1/4 inch (6.4 mm) anchor bolts. Furnish 1/4 inch (6.4 mm) diameter, galvanized, hooked anchor bolts in lengths suitable for anchoring wire mesh to existing concrete.

G. Burlap.
For curing concrete use burlap that meets the requirements of Section 4104.

2424.03 CONSTRUCTION.

A. Equipment.

1. Power Driven Hand Tools.
Power driven hand tools are allowed, with the following restrictions:

a. Jack Hammers.

1) Do not use jack hammers heavier than a nominal 30 pound (14 kg) class.

2) Do not operate jack hammers or mechanical chipping tools at an angle in excess of 45 degrees measured from the surface of the concrete.

b. Chipping Hammers.
Do not use chipping hammers heavier than a nominal 15 pound (7 kg) class.

2. Hand Tools.
Provide hand tools, such as hammers and chisels, to remove final unsound concrete particles or to achieve the required depth.

3. Sand Blasting Equipment.
Use sand blasting equipment capable of removing rust, oil, and concrete laitance from the existing surface.

4. Proportioning and Mixing Equipment.
Use proportioning and mixing equipment that meets requirements of Articles 2001.20 and 2001.21, C. Use mixing equipment capable of thoroughly mixing the materials in sufficient quantity to maintain placing continuity.

5. Air Supply.
Use a compressor of adequate capacity to maintain a sufficient, constant nozzle velocity for all parts of the work while simultaneously operating a blow pipe for cleaning away rebound. Equip the air hose with a filter to prevent any oil or grease from entering the air stream.

6. Delivery Equipment.
Use delivery equipment capable of delivering a continuous, smooth supply of uniformly mixed material. Equip the nozzle with a water ring and valve to permit adjustment of the water. Maintain the water pressure at the nozzle at least 15 psi (100 kPa) greater than the air pressure. Use a nozzle capable of delivering a conical discharge stream.

B. Qualification of Operators.

1. Certification of Training and Experience.
Provide the Engineer a certified statement of training and experience in shotcreting for each of the individuals proposed to occupy the position of supervisor, shotcrete nozzle operator, and shotcrete gun operator.

2. Qualification Test.

a. Each nozzle operator, working with a certified gun operator, must pass a qualification test prior to undertaking the shotcrete application in the project work. This test serves to qualify the shotcrete operator and is to be performed prior to beginning work. The test measures the percent by weight (mass) of rebound. If the rebound is over the allowable percentage, the operator will be disqualified. Replace with an operator who can pass this test.

b. The Engineer may require additional qualification tests during the progress of the work if the quality of the shotcrete operation declines.

c. The test is as follows:

1) Erect 30 inch by 30 inch (750 mm by 750 mm) plywood board test panels horizontally, vertically, overhead, or any combination of positions depending on the anticipated corresponding shooting positions.

2) Arrange drop cloths around and over the test panel to collect the rebound.

3) The shotcrete operator is to fill the middle 18 inch by 18 inch (450 mm by 450 mm) area of the test panel with shotcrete mortar to a minimum depth of 4 inches (100 mm).

4) Determine the quantities of rebound and applied shotcrete. Compute the percent of rebound by dividing the weight (mass) of rebound by the combined weight (mass) of rebound plus the weight (mass) of the applied shotcrete.

5) The allowable percentage of rebound depends on the position of the surface and is specified in the Table 2424.03-1:

Table 2424.03-1: Maximum Rebound

Position of Surface	Maximum Allowable Percentage of Rebound by Weight (Mass)
Horizontal	15
Vertical	30
Overhead	50

d. Furnish the drop cloths, plywood, and all other material necessary for these tests.

C. Preparation of Surface for Shotcrete Repair.

1. Removals.

a. Remove concrete from each area the Engineer designates. Areas as shown in the contract documents are based on the best information available. The Engineer will determine actual areas.

b. Concrete may be removed with power or hand tools. Use only hand tools for final cleanup.

c. Extend removal at least to the level of reinforcing bars and deeper, as necessary, to remove all unsound concrete. Ensure removal allows for a minimum replacement depth of 2 inches (50 mm). Cut boundaries of removal areas to a 45 degree bevel, with no feather edges or square corners.

2. Cleaning Existing Reinforcement.

a. Use hand methods to remove pack rust.

b. Sandblast to sound metal.

c. Do not damage the reinforcement with tools. To ensure concrete will bond around the periphery of a reinforcing bar, excavate the existing concrete 3/4 inch (20 mm) clear around the bar when:

- More than one-half of an existing reinforcing bar circumference is exposed, or
- A reinforcing bar is loose and unbonded.

3. Anchorage.

The principal anchorage of shotcrete to the existing structure is to be the bond of the shotcrete to the old concrete and to exposed existing reinforcement. Provide supplemental anchorage as follows:

a. Where reinforcement has been exposed and clearance around the periphery of the bar is provided, do not add supplemental reinforcement unless existing reinforcement density and pattern are such that individual open spaces between bars are of 1.5 square foot (0.14 m^2) area or larger. For this situation, install 1/4 inch (6.4 mm) diameter hooked anchor bolts at the rate of one anchor bolt per each 1.5 square feet (0.14 m^2) of area within each open space.

b. Where existing reinforcement is not exposed to provide clearance around the bar periphery, install 1/4 inch (6.4 mm) diameter hooked anchor bolts on an approximate 1 foot by 1 foot (300 mm by 300 mm) grid spacing. For individual areas of 1 square foot (0.1 m^2) or less, install at least one anchor, although mesh will not be required.

4. Reinforcement.

For areas described in Article 2424.03, C, 3 above:

- **a.** Ensure wire mesh is clean and free from coatings which will prevent adequate bond.
- **b.** Fasten mesh to each anchor or to any existing exposed reinforcement, or both. Ensure wire mesh has a minimum of 3/4 inch (20 mm) clearance from the prepared surface.
- **c.** Lap adjacent sheets of mesh at least 1.5 times the spacing of the mesh. Align laps so that parallel wires are staggered, not placed adjacent to each other.
- **d.** Tie sheets together at 1 foot (300 mm) intervals.
- **e.** Bend mesh extending around outside corners or re-entrant corners to template before securing to the anchorage.
- **f.** Position all wire mesh, hook bolts, and existing reinforcement so that they will be covered by the application of at least 3/4 inch (20 mm) of shotcrete.

5. Final Preparation.

Give repair areas a final cleaning by sandblasting followed by air cleaning.

D. Proportioning and Mixing.

1. Storage and Handling.

Store and handle cement and aggregates and measure materials according to Article 2403.02, D.

2. Mix Proportions.

Determine the exact proportions of ingredients on the basis of design mix proportions and a trial application of the design mix. Once the Engineer approves, use the field determined mix in the actual application of shotcrete. Do not vary the mix without the Engineer's written approval.

3. Field Test of Design Mixes.

- **a.** Field test design mixes by shooting one or more test panels. Shoot the first panel in the vertical position. If the first panel is satisfactory, shoot a second panel in the overhead position, if such position is applicable to the work.
- **b.** Conduct a test for percentage of rebound with each test panel. The Engineer will:
  - **1)** Observe production of the test panel.
  - **2)** Approve or reject the mix based on observation of the placement characteristics and appearance of the completed panels.
  - **3)** Direct the testing of a new trial mix if one is necessary.
- **c.** Use 30 inch by 30 inch (750 mm by 750 mm) plain plywood boards for test panels. Install one No. 5 (No. 15) reinforcing bar 1 inch (25

mm) from the surface of the backing board. Place this bar parallel to and 6 inches (150 mm) from one side of the panel.

d. Cover the middle 18 inch by 18 inch (450 mm by 450 mm) area with shotcrete to a minimum depth of 4 inches (100 mm), and finish.

e. Cure the test panels according to Article 2424.03, F.

f. The operator qualification tests specified in Article 2424.03, B may be conducted coincidentally with the field determination of mix for shotcrete.

4. Proportions for Shotcrete Concrete.

Set the design mix proportions for shotcrete concrete at 1 part cement to 3.5 parts aggregate. Proportion the aggregate fraction to be 40% coarse and 60% fine by volume.

5. Proportions for Shotcrete Mortar.

Set the design mix proportions for shotcrete mortar at 1 part cement to 3.5 parts fine aggregate.

6. Proportioning.

a. Proportion dry materials by weight (mass).

b. Ensure the moisture content of fine aggregates is in the range of 3% to 6% by weight (mass) and does not vary more than ± 0.5% during a day's production.

7. Mixing.

a. Do not reuse rebound materials.

b. Mix each batch for at least 1.5 minutes.

c. Clean the mixer as needed to remove all adherent material from the mixing vanes and from the drum.

d. Do not use batches in which the ingredients have been in contact with each other for 45 minutes or more.

8. Admixtures.

a. Admixtures will not be specified.

b. The Contractor may propose specific admixtures for either reducing rebound or improving the workability during finishing.

c. The Engineer may approve such admixtures provided they are incorporated in the field determination of mix.

d. Do not use admixtures containing calcium chloride or polyvinyl acetate.

E. Placing and Finishing.

1. Prewetting.

Saturate the placement area at least 1 hour before the placement of shotcrete, and keep the area damp. However, do not place shotcrete in standing water.

2. Concrete Placement.

a. Apply shotcrete concrete in one or more layers to the total thickness required to restore the repair areas to original lines and section, or to construct a modified section as shown in the contract documents. Ensure each layer is 1 1/2 to 2 inches (40 mm to 50 mm) in thickness.

b. Use ground lines or other suitable devices as necessary to establish true lines and section.

c. Apply a wood float or broom finish to the final surface, subject to the Engineer's approval.

d. The Contractor may use the following procedure in place of surface finishing shotcrete concrete as described above:

1) Follow the procedure described in 1 and 2 above, except stop the concrete filling and strike off the new concrete at about 1/2 inch (15 mm) below the final surface.

2) Change to shotcrete mortar and complete the repair, finishing the surface as described above.

3. Application Sequence.

When shotcreting a vertical face, apply all layers from bottom to top with adequate attention to preventing incorporation of rebound.

F. Curing.

1. Use wet burlap or other approved curing blankets to cover repair areas restored with shotcrete. Apply this cover immediately following finishing and leave in place for at least 7 calendar days. Maintain curing covers in a moist condition throughout this period.

2. The Contractor may submit, for the Engineer's approval, an alternate procedure to provide a wet cure through the minimum period stipulated above. Submit this procedure, together with the schedule for application, to the Engineer for approval before beginning the work.

G. Limitations of Operations.

1. Temperature.

a. Apply shotcrete only when the ambient temperature is at least 40°F (4°C).

b. Do not apply shotcrete to any frozen or frosted surface.

c. Protect shotcrete in place from freezing throughout the curing period.

2. Rain.

a. Do not apply shotcrete during periods of rain without shielding the work, the materials, and the batching and mixing facilities from the weather.

b. Shield shotcrete in place from rain until the curing blankets are in place.

3. **Wind.**
   a. Provide sufficient screening or protection from wind to prevent the cement or fines from being blown out of the jet.
   b. Protect fresh shotcrete in place from rapid cooling or drying out by shielding from the wind or application of fog mist, or both, until curing blankets are in place.

4. **Containment.**
   Screen the work area to:
   a. Contain dust and rebound materials.
   b. Protect nearby structures and vegetation.

5. **Protection of Traffic.**
   Place screening between the work area and nearby traffic, as directed by the Engineer.

2424.04 METHOD OF MEASUREMENT.
Measurement of areas will be based on final surface dimensions to the nearest 0.1 foot (0.1 m). The Engineer will calculate the quantity to the nearest square foot (0.1 m^2) for each area.

2424.05 BASIS OF PAYMENT.

A. Payment for Shotcrete will be the contract unit price per square foot (square meter) for the number of square feet (square meters) placed in a satisfactory manner.

B. Payment is full compensation for:
- Preparing the surface,
- Installing anchors and reinforcement,
- Testing,
- Placing the concrete and mortar,
- Curing and protection, and
- Furnishing all materials, equipment, tools, labor, and incidentals necessary to complete the repair of the areas.

Section 2425. Precast Prestressed Concrete Deck Panels

2425.01 DESCRIPTION.
This specification describes precast prestressed concrete deck panels to be used in the construction of bridge decks. When authorized in the contract documents, these panels may be used in construction of the deck, at the option of the Contractor, in place of the usual removable deck forms. These panels are to remain in place because they are designed to function as part of the deck in the completed structure. When the option is authorized, the contract documents will include details of the panels and their use.

2425.02 MATERIALS.
Produce the panels according to the requirements in the contract documents and Section 2407. Consolidate the concrete for the panels by vibration. Air entrainment will be required. Apply Article 2407.03, B.

2425.03 CONSTRUCTION.

A. Fabricate the panels according to the details shown in the contract documents and the approved shop drawings. Submit shop drawings according to Article 1105.03. On skewed decks, the Contractor may form and cast the skewed portion of the deck, or use individually precast skewed end deck panels. A minimum 2 foot (600 mm) bearing length is required along the edge of the panels.

B. Set the panels in place over strips of preformed joint filler. Place the reinforcement as shown in the contract documents. Place, consolidate, finish, and cure the concrete of the deck. Prior to placement of the concrete, clean the top surface of each panel and beam as designated in the contract documents. Ensure the panel surface is dry and dust free when cast-in-place concrete is placed on the panel.

2425.04 METHOD OF MEASUREMENT.
If the Contractor chooses to use precast prestressed concrete deck panels in the operations, measurement for construction of the deck will be based on the plan quantities for the various items involved.

2425.05 BASIS OF PAYMENT.
If the Contractor chooses to use precast prestressed concrete deck panels in the operations, payment for construction of the deck will be based on the plan quantities and the associated contract prices for the various items involved. No adjustment will be made for using this option.

Section 2426. Structural Concrete Repair

2426.01 DESCRIPTION.

A. Repair spalled or deteriorated structural concrete as specified in the contract documents. This work may include the installation of concrete anchors, reinforcing bars, or wire mesh.

1. Shallow Repair.

a. Repair that:

- Is 3/4 inch to 1 1/2 inch (20 mm to 40 mm) in depth,
- Is placed against sound concrete, and
- Requires a bonding grout, but does not use forms to support the patching material.

b. Forms may be needed in areas of shallow repair where the patching material can not support itself. In these areas bonding grout will not be required.

2. Regular Repair.

a. Repair that:

- Is a minimum depth of 1 1/2 inch (20 mm), or 3/4 inch (40 mm) behind an unbonded reinforcing bar, and
- Is placed against sound concrete.

b. Forms are used, but bonding grout is not required.

B. The Engineer will outline the areas to be repaired.

2426.02 MATERIALS.

A. Use materials meeting the appropriate requirements of Division 41.

B. Mix proportions are as follows:

1. Bonding Grout.
Use equal parts by weight (mass) of Type I cement and sand with enough water to form a slurry with a consistency such that it can be applied with a stiff brush in a thin even coating that will not run or puddle.

2. Concrete.

a. Shallow Repair.

Table 2426.02-1: Proportions

Materials	by weight (mass)
Type I Portland cement	4 parts
Concrete sand (Section 4110)	5 parts
Coarse aggregate (Article 4115.05)	5 parts
Add enough water to the mixture to form a consistency that will permit placement and consolidation by hand compaction without slumping.	

b. Regular Repair.
Furnish Class O concrete. Use 3 inches (75 mm) as the target slump, with a variation not to exceed ± 1 inch (25 mm).

2426.03 CONSTRUCTION.

A. Equipment.
Use equipment that meets the requirements of Article 2413.03, A, 2, to prepare the repair area.

B. Surface Preparation.

1. Remove all loose, disintegrated, and unsound concrete from the repair areas. Outline all repairs with a 3/4 inch (20 mm) deep saw cut. Concrete anchors and wire mesh may be required, as shown in the contract documents. Overhead repairs may require special procedures, as proposed by the Contractor and approved by the Engineer.

2. After removal of loose, unsound concrete, sandblast the repair area and follow with an air blast with oil free air so the substratum is sound, clean and free of all contaminants. Exercise extreme care in concrete removal so that prestressed strands are not damaged. The substrate must be dry prior to concrete placement or bonding grout application, if required.

3. Sandblast exposed reinforcement to remove all rust. Remove and replace damaged or badly corroded reinforcing bars, as directed by the Engineer.

C. Placement Procedure.

1. Shallow Repair.

a. Bonding Grout.
Apply bonding grout to the properly cleaned, dry surface of the old concrete with a stiff bristle brush. Do not prewet the concrete surface before placing grout.

b. Repair Concrete.
Place and compact repair concrete before the grout dries. If the grout dries prior to concrete placement, remove the grout by sandblasting and reapply. Strike off and finish the repair concrete to the correct lines.

2. Regular Repair.

a. Place concrete according to Article 2403.03, C.

b. When repairing a vertical face, place the patch in heights not to exceed 4 feet (1.2 m). Provide access ports at 4 foot (1.2 m) intervals in the forms for placement and vibration. Remove forms according to Article 2403.03, M.

D. Curing.
Apply white pigmented curing compound to the concrete immediately following concrete finishing or immediately after removing forms, if used. Apply curing compound according to Article 2403.03, E, except use an application rate of 100 square feet per gallon (2.5 m^2/L).

2426.04 METHOD OF MEASUREMENT.
The Engineer will determine the square feet (square meters) of Concrete Repair by measuring the surface dimensions of the area repaired to the nearest 0.1 foot (0.1 m). Distinction will not be made between shallow repair and regular repair.

2426.05 BASIS OF PAYMENT.

A. Payment for the number of square feet (square meters) of Concrete Repair completed, measured as provided above, will be the contract unit price per square foot (square meter).

B. Payment is full compensation for:
- Removal of excess concrete from the project,
- Furnishing all materials and equipment, including concrete anchors, wire mesh, and reinforcing bars, if required.
- Sandblasting exposed reinforcement,
- Removing and replacing damaged reinforcing bars,
- Forms, and
- Labor necessary to complete the work according to the contract documents.

Section 2427. Bridge Cleaning

2427.01 DESCRIPTION.

A. Remove all accumulated foreign material from the entire bridge, including the bridge deck, sidewalk, curbs, pier tops, trusses, interior of truss members, and lower flanges of beams or girders.

B. Clean expansion joints, wind links, and drains.

2427.02 MATERIALS.
None.

2427.03 EQUIPMENT, CLEANING, AND TRAFFIC CONTROL.

A. Equipment.

1. Furnish cleaning equipment consisting of hand tools, power brooms, air compressors, water tanks, and water pumps with associated delivery hardware necessary to properly flush, clean, and remove all foreign material from the bridge structure.

2. Other types of cleaning equipment may be used with the Engineer's approval.

3. Ensure air and/or water pressure are sufficient to remove the accumulated material without damaging paint coverage of the structural steel.

4. Equip each self propelled unit used in the cleaning operation with an amber revolving light that:
- Is visible from all directions, and
- Flashes at least 60 times per minute, but not more than 120 times per minute.

5. Other equipment such as high-reach trucks, and under bridge access trucks or movable scaffolds may be necessary to gain access to areas designated for cleaning. It will be the Contractor's responsibility to determine and use whatever method and equipment is best suited for the operation to successfully clean the structure.

B. Cleaning.

1. Ensure areas that have been cleaned are free of all accumulations of sand, gravel, dirt, bird nests and excreta, and other foreign materials.

2. Obtain a source of fresh water free of sediments and salt contaminants, at no cost to the Contracting Authority.

3. Prior to cleaning with water pressure, remove all accumulated foreign material from bridge sidewalks, bridge decks, curb tops, beam flanges, gusset plates, abutment bridge seats, pier tops, truss joints, deck drain systems, and other locations specified and as directed by the Engineer. Remove the accumulated foreign material with hand brooms, hand shovels, scrapers, vacuum cleaners or other methods acceptable to the Engineer. Collect this removed material and dispose of at an approved waste area according to Federal, State, and Local regulations. Do not at any time allow this removed material to fall or be disposed of in the water or on the land below the bridge.

4. Use sufficient water under pressure to remove salt contaminants, dirt, and other detrimental foreign matter without damaging or removing paint from any structural steel. To clean the bridge, use a minimum water flow rate of 5 gallons (20 L) per minute. The maximum water pressure is to be 1000 psi (6900 kPa), but not so high that any paint is removed.

5. Stop the cleaning operation if foreign material has not been removed or if removal of or damage to existing paint coverage occurs. In this situation, adjust the water pressure to remove foreign material without damaging or removing existing paint coverage.

6. Flush all deck drains and scuppers at drains with water under pressure after the accumulated foreign material in them has been properly removed. Drain systems may have to be taken apart to remove large blockages of accumulated foreign material. Should this be necessary, return them to their original configuration immediately after cleaning. Ensure drain systems drain properly after cleaning.

7. Flush out the interior of all truss members with water under pressure. Continue to do so until such time each truss member is draining out clear water.

8. Thoroughly wash down the exterior of all truss members, miscellaneous structural steel connecting truss members, and floor beam ends projecting outwardly from the row of exterior stringers using water under pressure.

9. At the direction of the Engineer, repair or replace all roadway appurtenances damaged during the cleaning operations at no additional cost to the Contracting Authority.

10. Do not soil or damage private or public property during cleaning operations.

C. Traffic Control.

1. Apply Traffic Control according to the traffic control plan.

2. Private vehicles will not be allowed to park on the structure at any time.

3. Furnish, erect, maintain, and remove all signs and traffic control devices made necessary for the work.

2427.04 METHOD OF MEASUREMENT.
Bridge Cleaning will not be measured separately for payment but will be considered as a lump sum.

2427.05 BASIS OF PAYMENT.

A. Payment for Bridge Cleaning will be the lump sum contract price.

B. Payment is full compensation for:
- Furnishing all material, labor, and equipment, and
- Performing of all work necessary to flush, wash, and clean and remove all foreign material and debris, and dispose of according to the contract documents.

Section 2428. Smoothness of Bridge Decks and Bridge Deck Overlays

2428.01 DESCRIPTION.
Test and evaluate smoothness of bridge decks and bridge deck overlays. Perform surface correction if required.

2428.02 TESTING AND EVALUATION.

A. General.

1. Except when specifically excluded in the contract documents, evaluate smoothness for all:
a. Interstate and Primary bridge decks, new approaches and bridge deck overlays, and overlaid approaches.

b. Non-Primary bridge decks, new approaches and bridge deck overlays, and overlaid approaches for projects where the Department is the Contracting Authority.

2. If this specification is required by contract documents on non-Primary projects let by the Department, it will be added in its entirety. Selected portions of the specification will not be deleted.

B. Measurement.

Provide and operate an Ames type or California profilograph or an inertial profiler to produce a profilogram (profile trace) of the surface tested according to Materials I.M. 341.

C. Profilograph Testing.

1. Remove all objects and foreign material from the deck surface, including protective covers, if used, prior to testing by the Engineer. If appropriate, properly replace protective covers after testing.

2. A profilogram will be made by a test in each wheel path of each traffic lane. The profilogram will include a minimum of 16 feet (5 m) beyond the bridge section when there is adjoining pavement. Bridge decks and bridge deck overlays will be treated as one section. The profilogram will include a minimum of 100 feet (30 m) beyond the approach section when there is adjoining pavement.

3. For bridge lengths of 778 feet (240 m) or less, each traffic lane is a segment. For bridges longer than 778 feet (240 m), a segment shall be 0.1 miles (160 m) of the traffic lane. If the remaining segment is 250 feet (80 m) or less in length, it is included in the adjacent bridge segment. If the remaining segment is more than 250 feet (80 m) in length, it is evaluated on its own. When bridge deck overlay expansion joints are not new or replaced, segments begin and end at the expansion joints.

4. Each bridge approach lane is a separate segment.

5. Perform quality control testing and furnish the profilogram results to the Engineer. Ensure:

- Testing and evaluation are done by a trained and certified person, and
- The evaluation is certified according to Materials I.M. 341.

D. Profile Index.

1. Calculate an average profile index for each segment from the two wheel path profilograms, according to Materials I.M. 341, except for:

a. Bridge decks or bridge deck overlays less than 100 feet (30 m) in length.

b. New bridge approach sections or bridge approach overlays less than 100 feet (30 m) in length.
c. Bridge decks for new concrete slab bridges.
d. The 16 feet (5 m) at the ends of the section.
e. The 16 feet (5 m) on each side of the expansion joints that are not new or replaced.

2. Limits for average profile index per 0.1 mile (160 m) are as follows:

New Bridge Deck	less than 22.1 inches/mile (351 mm/km)
Bridge Deck Overlay	less than 15.1 inches/mile (241 mm/km)
Bridge Approach (New or Overlaid)	less than 22.1 inches/mile (351 mm/km)

3. The Engineer will perform verification testing to validate the Contractor's certified quality control testing. If the Engineer's verification test results validate the Contractor's test results, The Contractor's results will be used for acceptance. Disputes between the Contractor's and the Engineer's test results will be resolved according to Materials I.M. 341. The Engineer may test the entire project length if it is determined the Contractor's certified test results are inaccurate. The Contractor will be charged for this work at a rate of $500 per bridge deck. In addition, providing inaccurate test results may result in decertification.

4. On deck placements less than 100 feet (30 m), test and evaluate each lane of placements. Provide the Engineer with the final trace and index and the final evaluation within 14 calendar days of deck completion.

5. On deck placements of 100 feet (30 m) or more, provide the Engineer with the initial profile trace and index for each lane by noon of the fifth working day following each of the first row placements. On subsequent placements, provide the Engineer with the trace and index following every third placement until the deck is completed. On single-pour bridges, provide the Engineer with the final profile trace and index and the final evaluation within 2 weeks of deck completion.

2428.03 SURFACE CORRECTION.

A. Perform surface correction for the full segment width of the paved surface.

B. Obtain the Engineer's approval for all correction work. After all required correction work is completed, determine the final profile index.

C. Accomplish surface correction by grinding or by other methods the Engineer approves. Perform the work as identified in Section 2532.

D. Perform surface correction parallel to lane lines or edge lines as directed by the Engineer. Make each pass parallel to the previous passes. Grind the surface to a uniform texture.

E. Do not overlap adjacent passes more than 1 inch (25 mm) or have a vertical difference of more than 1/8 inch (3 mm) as measured from bottom of groove to bottom of groove.

F. Begin and end smoothness correction at lines normal to the lane lines or edge lines within any one corrected area. Proceed from the center line or lane line toward the edge to maintain cross slope.

G. Maintain cross slope throughout the corrected area.

H. Perform corrective grinding prior to longitudinal grooving.

2428.04 BUMPS AND DIPS.

Bumps and dips, including those at headers, on all surfaces for which smoothness is designated will be evaluated. Correction work will be required according to the criteria in Paragraphs B and C below.

A. Bumps.

1. Correct all bumps exceeding 0.5 inch (12.7 mm) within a 25 foot (7.6 m) span, as indicated on the profilogram, except as stated in Article 2428.04, C.

2. Corrected bumps will be considered satisfactory when profilograph measurement shows that the bumps were 0.3 inch (7.6 mm) or less in a 25 foot (7.6 m) span.

B. Dips.

1. Correct all dips exceeding 0.5 inch (12.7 mm) in a 25 foot (7.6 m) span, as indicated on the profilogram, only when the Engineer requires, except as stated in Article 2428.04, C. The Contractor will be assessed a price adjustment of $900 for each dip exceeding 0.5 inch (12.7 mm) that is not corrected, except as stated in Article 2428.04, C.

2. A dip in both wheel paths at a lane location will be considered a single dip when assessing a price adjustment.

3. Corrected dips will be considered satisfactory when the profilogram shows the dips are less than 0.3 inch (7.6 mm) in a 25 foot (7.6 m) span.

C. Exceptions.

When the Contractor is not responsible for the adjoining surface, bumps and dips in the 16 feet (5 m) at the end of a section will be reviewed by the Engineer. Correct bumps and dips determined to be under the control of the Contractor and resulting from the Contractor's operations. Correction of bumps and dips determined to be beyond the control of the Contractor will be paid according to Article 1109.03, B.

2428.05 SCHEDULE OF PAYMENT.

The cost of certified profilograph testing and associated traffic control is incidental to the contract unit price for the item for which the testing is required.

A. Incentives.

1. New bridge decks or bridge deck overlays which are designated for smoothness will be evaluated for incentives using the initial profile index and the number of segments on the bridge.

2. For each segment of a bridge to be qualified for an incentive payment, the profilogram for that segment before correction must meet the specification requirement so there is no price reduction.

3. For each segment of the bridge deck or bridge deck overlay, the incentive index is 12.0 inches per mile (190 mm/km) for new bridge decks, and 4.0 inches per mile (65 mm/km) for bridge deck overlays. The incentive payment will be according to Table 2428.05-1:

Table 2428.05-1: Incentives

New Bridge Decks		Bridge Deck Overlays	
Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment	Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment
0 - 6.0 (0 - 95)	6000	0 - 2.0 (0 - 32)	2000
6.1 - 12.0 (96 - 190)	3000	2.1 - 4.0 (33 - 65)	1000
12.1 - 22.0 (191 - 350)	Unit Price	4.1 - 15.0 (66 - 240)	Unit Price

B. Price Reduction.

1. New bridge decks or bridge overlays which are designated for smoothness will be evaluated for price reduction assessment using the final profile index and the number of segments.

2. The Contractor may grind the surface of the bridge deck to a final index of 22.0 inches per mile (350 mm/km) or less, or the surface of a bridge deck overlay to a final index of 15.0 inches per mile (240 mm/km) in lieu of a price reduction.

3. Each segment of bridge deck with a final index of 22.1 inches per mile (351 mm/km) or greater or bridge deck overlay with a final index of 15.1 inches per mile (241 mm/km) or greater will be assessed a price reduction according to Table 2428.05-2:

Table 2428.05-2: Price Reduction

New Bridge Decks		Bridge Deck Overlays	
Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment	Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment
22.1 - 30.0 (351 - 470)	2000	15.1 - 20.0 (241 - 315)	1000
30.1 - 35.0 (471 - 550)	4000	20.1 - 25.0 (316 - 390)	2000

35.1 - 40.0 (551-630)	6000	25.1 - 30.0 (391 - 470)	3000
over 40.0 (over 630)	[a]	over 30.0 (over 470)	[a]
[a] Correction is required to an index of 15.0 inches per mile (240 mm/km) for overlays and to an index of 22.0 inches per mile (350 mm/km) for new decks.			

C. Bridge Approach Sections and Overlay of Bridge Approach Sections. Correct bridge approach sections and overlays of bridge approach sections for smoothness as specified in Article 2428.03 in lieu of a price reduction.

Section 2429. Pre-Engineered Steel Truss Recreational Trail Bridge

2429.01 DESCRIPTION.

A. These specifications are for an engineered truss bridge of welded steel construction and are minimum standards for design and construction.

B. Install an engineered truss bridge of welded steel construction manufactured by a company on the approved manufacturer's list in Materials I.M. 557, Appendix D.

2429.02 DESIGN AND MATERIALS.

A. Design.

1. Designer Qualifications.
- **a.** No less than 5 years experience in design and fabrication of engineered bridge trusses. In addition, provide information regarding similar projects that were previously completed, including references.
- **b.** Professional Engineer licensed in the State of Iowa.

2. Design Loads and Related Requirements.
- **a.** Allowable Design Stresses according to the "Standard Specifications for Highway Bridges" adopted by AASHTO.
- **b.** Vertical Loads:
  - Live load: 85 pounds per square foot (4 kPa) applied to the complete width of the deck area shown in the contract documents.
  - Concentrated load: located at mid-span and equal to 10,000 pounds (4.5 Mg) plus 30% for impact loading.
  - Vehicle loads: 20,000 cycles or less.
  - Buoyancy due to submergence.
- **c.** Horizontal Loads:
  - Minimum horizontal wind load: 30 pounds per square foot (1.4 kPa) applied to the entire truss as if fully enclosed.

- Seismic and loads combinations: applied according to the AASHTO Specifications for Highway Bridges noted in this specification.

d. Bridge camber at center of bridge span of 1% of the total bridge span. Camber to offset full dead load deflections.

e. Bridge designed to accommodate a temperature differential of 100ºF (56ºC).

f. Teflon or other approved slip pads placed between the bearing and setting plates provided by the bridge manufacturer. At least 1 inch (25 mm) clearance provided between the bridges and the abutments.

g. Welded Tubular Connection Design: according to the Structural Welding Code from ANSI/AWS D1.1, Chapter 10 Tubular Structures.

h. Shop Drawings (Manufacturer's standard schematic drawings and diagrams):

1) Unique drawings prepared to illustrate the specific portion of the project.

2) All relative design information such as member sizes, bridge reactions, and general notes clearly specified.

3) Accurately prepared to be complete in every respect. Include cross referenced details and sheet numbers. Signed and sealed by a Professional Engineer licensed in the State of Iowa.

4) Submit shop drawings according to Article 1105.03.

i. Maximum deflection due to live load plus impact not to exceed that specified in the contract documents.

j. If intermediate piers are required for the bridge over a railroad, a minimum 25 foot (7.62 m) horizontal and vertical clearance, or a distance as specified elsewhere in the contract documents, from the track is required.

3. Geometry.

a. Low profile (pony truss) half through truss design.

b. Provide one diagonal per panel. Chords, diagonals, verticals, and bracing shall be tube steel.

c. A minimum of 72 inches (1.8 m) from top of bottom chord to top of railing.

4. Railings and Accessories.

a. All railings:

- Located on the inside surface of the trusses.
- Smooth inside surface with no protrusions or depressions.

b. Top railings: a minimum of 54 inches (1.4 m) above the floor for bicycle applications, according to AASHTO.

c. Safety railings: a maximum opening of 4 inches (100 mm). All ends of angles and tubes welded and ground smooth.

B. Materials.

1. Structural Thickness.
- Structural tubing: minimum material thickness of 1/4 inch (6 mm).
- All other structural members: minimum material thickness of at least 5/16 inch (8 mm).

2. Unpainted Bridges.
- Unpainted and fabricated from high strength weathering steel.
- All fabrications produced from high strength, low alloy, atmospheric corrosion resistant ASTM A 606 or ASTM A 242 plate and structural shapes.
- Minimum yield (F_y) greater than 50,000 psi (345 MPa).

3. Field Splices.
- Bolted with high strength bolts according to ASTM A 325.
- Type 3 bolts are required for Weathering Steel bridges, according to ASTM A 325 or A 490.
- Field connection bolts tightened by the “turn-of-nut method” to obtain proper torque. See Article 2408.03, S, 5, b.

4. Welding.
- Materials: according to AWS.
- Welders: certified according to AWS D1.1.

5. Railings and Accessories.
- Railings (except rub rail): fabricated from steel.
- Rub rail: fabricated from 2 inch by 8 inch (50 mm by 200 mm) treated wood.

6. Toe Plates.
Toe plates are required. Use 6 inch x 5/16 inch (150 mm x 8 mm) plate located 2 inches (50 mm) above the floor decks.

7. Anchor Bolts.
Provided by the manufacturer.

2429.03 CONSTRUCTION.

A. Fabrication.
Ensure quality, fabrication, and shop connections comply with AASHTO Specifications for Highway Bridges noted in this specification.

B. Welding.

1. Welding.
- Comply with Article 2408.03, B.
- Use E70 or E80 series electrodes that have the same weathering characteristics as corrosion-resistance steel, or the gas metal arc

welding process (Short Circuiting Transfer) with Carbon Dioxide/Argon shielding gas with ER80-D2 filler material conforming to AWS A5.28.

2. Welding Operators.
Properly accredited experienced operators, each of whom must:
- Submit satisfactory evidence of experience and skill in welding structural steel with the kind of welding to be used in the project, and
- Have demonstrated the ability to make uniform good welds meeting the size and type of weld required.

C. Quality Assurance.
The Manufacturer pays all costs associated with the following inspection requirements for fabrication and finishes:

1. Welded tubular connections qualified per AWS D1.1-94 using short circuited gas metal arc process.

2. All welds to be visually inspected.

3. Base material certifications to be supplied by the material suppliers.

D. Weld Testing.
Have nondestructive weld testing performed by an independent agency. The Manufacturer pays for nondestructive weld testing.

1. Ten percent of all welds are to be magnetic particle tested.

2. Ultrasonic testing is to be performed on all top and bottom chord, full penetration welds.

E. Finishes.
Sandblast unpainted weathering steel bridges according to SSPC Surface Preparation Specification No. 6.

F. Delivery and Erection.

1. Manufacturer's Responsibilities.
- Deliver the bridge by truck to a location nearest to the site accessible by roadways.
- Notify the Contractor in advance of the expected arrival time.
- Provide the Contractor information regarding delays after the truck departs the plant, such as inclement weather, delays in permits, rerouting by public agencies, or other circumstances, as soon as possible.
- Advise the Contractor of the actual lifting weights, attachment points, and all other pertinent information needed to install the bridge.

2. Contractor's Responsibilities.

- Provide proper lifting equipment.
- Unload the bridge from the truck at the time of arrival.
- Splice and bolt the components.

2429.04 METHOD OF MEASUREMENT.

Measurement will be by count for each Pre-engineered Steel Truss Recreational Trail Bridge installed.

2429.05 BASIS OF PAYMENT.

A. Payment for each Pre-engineered Steel Truss Recreational Trail Bridge furnished and erected will be the contract unit price.

B. Payment is full compensation for:

- Designing, manufacturing, delivering, erecting, and assembling the unit complete as shown in the contract documents, and
- All foundations, footings, abutments, piers, pier caps, bearing plates, pads, bolts, anchor bolts, grouting, decking, railing, and any other materials, labor, and equipment necessary to complete the bridge in place.

Section 2430. Modular Block Retaining Wall

2430.01 DESCRIPTION.

Furnish and install modular block retaining wall units, wall fill, and granular backfill material to the lines and grades shown in the contract documents. Modular block retaining walls are defined as systems that usually do not require mesh or strips in the backfill material behind the wall facing to limit backfill material stresses by reinforcing the soil structure.

2430.02 DESIGN AND MATERIALS.

A. Design.

1. Wall Design Engineer.
The Wall Design Engineer is required to be a Professional Engineer licensed in the State of Iowa.

2. Submittals.
Prior to the beginning of the wall construction, submit for approval, according to Article 1105.03, detailed design calculations including soil bearing pressure, construction drawings, and shop drawings prepared and sealed by the Wall Design Engineer. If required, submit a detailed explanation of the design properties and quality control test limits for the geogrid reinforcement with the design.

B. Materials.
Furnish a wall manufactured by a company on the approved manufacturer's list in Materials I.M. 445.04.

1. Concrete Units.
- **a.** Exterior dimensions may vary. Each unit is required to have a minimum of 0.5 square feet (0.046 m^2) of face area and an 8 inch (200 mm) maximum vertical dimension.
- **b.** Block faces are to be straight, with split face texture.
- **c.** Angled sides are to be capable of attaining concave and convex alignment curves of minimum radius of 5.0 feet (1.5 m).
- **d.** Units are to be interlocked:
  - Either with: 1) connector pins of the type, size, and design recommended by the supplier/manufacturer for the type of masonry unit and backfill reinforcement material used in the wall; or 2) by integrally cast shear lugs.
  - To provide minimum of 1/4 inch (6 mm) of setback for each course of wall height.
- **e.** Meet the requirements of Article 2431.02, B, 1.

2. Leveling Pad.
Use supplier/manufacturer recommended leveling pad materials. If granular material is recommended for the leveling pad, use backfill material meeting the requirements of Section 4132. If unreinforced concrete is recommended for the leveling pad, use Class C concrete meeting the requirements of the Materials I.M. 529 and Section 2403.

3. Unit Fill.
Unit fill is the granular material that is within the concrete facing units. Use porous backfill material meeting the requirements of Section 4131.

4. Backfill Material.
When required, use granular backfill material meeting the requirements of Section 4133.

5. Tieback Reinforcement.
When required, use the type, size, and design the supplier/manufacturer recommends.

2430.03 CONSTRUCTION.

A. Excavation.

1. Excavate according to Section 2102. This includes benching of the existing roadway foreslopes and the excavation area under the pad line. Do not disturb existing embankment materials beyond what is needed to construct the wall.

2. At locations where the wall is to be constructed adjacent to a fill section, construct and compact the fill to 95% Standard Proctor Density prior to beginning wall construction. After the fill has been constructed, make

the cut to permit a minimum of 12 inches (300 mm) beyond the wall to be filled with granular backfill materials meeting the requirements of Section 4131. Place and compact the granular backfill material on a course by course basis.

B. Foundation Soil Preparation.

1. Prepare foundation soil as required for the leveling pad.

2. The Engineer will examine the foundation soil to assure that the actual foundation soil strength meets or exceeds the assumed design bearing strength. Remove soils not meeting required strength and replace with soil meeting the design criteria.

3. Ensure the earth foundation has a density equal to or greater than 90% Standard Proctor Density. Step the earth foundation at the required intervals to keep it a minimum 1 foot (300 mm) below the finished grade.

4. Place granular backfill material as replacement material for over excavation in the foundation soil. Compact the replacement material according to Article 2107.03, H.

C. Leveling Pad.

1. Minimum of 6 inches (150 mm) thick.

2. Construct the leveling pad to ensure complete contact of the retaining wall unit with the leveling pad. Gaps will not be allowed between the retaining wall unit and the leveling pad.

D. Unit Installation.

1. Ensure units are in full contact with the leveling pad.

2. Place units side by side for the full length of wall alignment. Alignment may be done by means of a string line or offset from the base line.

3. Install connecting pins and fill units, and tamp the fill.

4. Sweep all excess material from top of units and install the next course. Ensure each course is completely filled prior to proceeding to the next course.

5. Place each course so that pins protrude into adjoining courses a minimum of 1 inch (25 mm) or to tolerances recommended by the supplier/manufacturer. Two pins are required per unit. Repeat the above procedure for each course to the top of wall height.

6. At the end of each course where the wall changes elevation, turn the units into the backfill material. Place units to create the minimum radius possible. Install a minimum of 3 units into the grade. Ensure only the front face of the units is visible from the side of the wall.

E. Backfill Material Placement.

1. Place each course of granular backfill material for the reinforcing following the erection of each lift of wall. At each level for reinforcing, roughly level the backfill material before placing and connecting the reinforcement. Place reinforcing normal to the face of the wall. Place the lifts to closely follow panel erection. Decrease this lift thickness, if necessary, to obtain the specified density.

2. At the end of each day's operations, shape the last level of backfill material to permit runoff of rainwater away from the wall face.

3. Compact granular backfill material according to Article 2107.03, H. Ensure the moisture limits are from 3% under optimum moisture to no more than the optimum moisture content.

4. Place and compact backfill material without disturbing or distorting the tieback reinforcement or the wall. Do not use tamping type rollers or other rollers that may damage the reinforcing. Use light mechanical tampers to achieve the required compaction in a strip 3 feet (1 m) wide adjacent to the backside of the wall; however, compaction within this strip will not be subjected to density testing.

F. Tieback Reinforcement Installation For Retaining Walls, Where Specified.

1. Place the tieback reinforcement horizontally on compacted backfill material, connect it to the concrete wall units, and embed it a minimum of 12 inches (300 mm). Hook reinforcement over pins, pull taut, and anchor before backfill material is placed on the tieback reinforcement.

2. Remove slack in the tieback reinforcement at the wall unit connections.

3. Place tieback reinforcement at the proper elevation and orient it as recommended by the supplier/manufacturer.

4. Correct orientation (roll direction) of the tieback reinforcement, if applicable, as recommended by the supplier/manufacturer.

5. Tieback reinforcement may be secured in place with staples, pins, sand bags, or backfill material depending on the fill properties, fill placement procedures, and weather conditions.

6. Overlaps:

a. Overlapping uniaxial tieback reinforcement in the across-the roll direction is not required, except to contain the fill at the slope face

when wrap around facing is used. Overlap uniaxial tieback reinforcement a minimum of 48 inches (1.2 m) in the roll direction.

b. Spread a layer of compacted backfill material, a minimum of 4 inches (100 mm) in thickness, between uniaxial tieback reinforcement layers in the area to be overlapped.

2430.04 METHOD OF MEASUREMENT.

Measurement for Modular Block Retaining Wall will be in square feet (square meters), determined from the area of the front face of the wall in place. The height will be measured from the top of the leveling pad to the top of the wall, including cap block.

2430.05 BASIS OF PAYMENT.

A. Payment for Modular Block Retaining Wall constructed will be the contract unit price per square foot (square meter).

B. Payment is full compensation for furnishing and erecting the modular block retaining wall according to the contract documents, including:

- Design,
- Excavation,
- Foundation soil preparation,
- Leveling pads,
- Concrete units,
- Connector pins,
- Unit fill for inside the blocks,
- Granular backfill material, and
- Tieback reinforcement if required.

Section 2431. Segmental Retaining Wall

2431.01 DESCRIPTION.

Furnish and install segmental retaining wall (SRW) units, wall fill, and granular backfill material to the lines and grades shown in the contract documents. Segmental retaining walls are defined as systems which usually require mesh or strips in the backfill material behind the wall facing to limit backfill material stresses by reinforcing the soil structure.

2431.02 DESIGN.

A. Design

1. Wall Design Engineer.
The Wall Design Engineer is required to be Professional Engineer licensed in the State of Iowa.

2. Minimum Design Requirements.
The SRW is required to be designed according to ASTM C 90 and recommendations of the National Concrete Masonry Association

(NCMA) Design Manual for Segmental Retaining Walls. The following table summarizes the minimum design criteria and is based upon the structure being critical:

External Stability	Minimum Factor of Safety
Sliding, Fs_{sl}	1.5
Overturning, Fs_{ot}	2.0
Bearing Capacity, Fs_{bc}	2.0

Internal Stability	Minimum Factor of Safety
Tensile Overstress, Fs_{to}	1.2
Pullout, Fs_{po}	1.5

Local Stability	Minimum Factor of Safety
Fs_{sl} (Maximum Unreinforced Height)	1.5
Fs_{ot} (Maximum Unreinforced Height)	2.0
Shear Facing Units, Fs_{sc}	1.5
Facing Connection Strength, Fs_{cs}	1.5
Global Stability	1.5

3. Submittals.

Prior to beginning SRW construction, submit the following for review according to Article 1105.03:

- Detailed design calculations (including soil bearing pressure), construction drawings, and shop drawings, all prepared and sealed by the Wall Design Engineer.
- A detailed explanation of the design properties for the geogrid reinforcement with the design.
- The quality control test limits for the geogrid meeting those design requirements.

B. Materials.

Furnish a wall manufactured by a company on the approved manufacturer's list in Materials I.M. 445.04. Ensure both the supplier of all substantial material components and the Wall Design Engineer have demonstrated experience in reinforced soil-reinforced SRWs for previous projects.

1. Concrete Units.

a. Ensure the following:

- Concrete segmental units and cap blocks comply with the requirements of ASTM C 1372, except with a minimum 28 day compressive strength of 5500 psi (40 MPa) for any one individual unit, and 6000 psi (41 MPa) for the average of three units.
- The 24 hour water absorption rate does not exceed 5%.
- The top surface of cap blocks are sloped 10:1 from front to back or from a crown at the center.

b. Ensure block sampling and testing comply with ASTM C 140.

c. Freeze-thaw durability testing will be required as described in ASTM C 1372 Sections 5.2, 5.2.1, and 8.3. Ensure testing is done according to ASTM C 1262.

d. Ensure specimens meet weight (mass) loss limits for testing in water as required in ASTM C 1372 Section 5.2.1.

e. Ensure specimens are also tested in a 3% saline solution and comply with either of the following:
- The weight (mass) loss of each of five test specimens at the conclusion of 40 cycles does not exceed 1% of its initial weight (mass); or
- The weight (mass) loss of four out of five specimens at the conclusion of 50 cycles does not exceed 1.5% of its initial weight (mass).

f. Ensure testing is continued until one of the following occurs:
- The weight (mass) loss each of five test specimens exceeds 2% of its initial weight (mass), or
- The weight (mass) loss of one of the five test specimens exceeds 2.5% of its initial weight (mass), or
- The specimens have been tested for at least 100 cycles.

g. Submit complete durability test reports for water and saline conditions, including the cycle number at which failure occurred, to the Engineer.

h. Ensure all units are sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the construction.

i. Ensure SRW units dimensions do not differ by more than ±1/16 inch (±1.5 mm).

2. Leveling Pad.

Use supplier/manufacturer recommended leveling pad materials. If granular material is recommended for the leveling pad, use backfill material meeting the requirements of Section 4132. If unreinforced concrete is recommended for the leveling pad, use Class C concrete meeting the requirements of the Materials I.M. 529 and Section 2403.

3. Unit Fill.

If fill is required by the construction drawings for in-place concrete segmental units, place porous backfill material meeting the requirements of Section 4131.

4. Subdrains.

a. Ensure the subdrains are a minimum of 4 inches (100 mm) in diameter and meet the requirements of Article 4143.01, B.

b. Provide Standard Road Plan RF-19F Type A outlets and fit with Standard Road Plan RF-19E rodent guards.

5. Backfill Material.

Use granular backfill meeting the requirements of Section 4133 for fill soil material in the entire reinforced earth zone.

6. Geogrid Reinforcement.

Comply with the following:

- Type, strength, and placement location determined by the Wall Design Engineer.
- Design properties of the reinforcement determined according to the procedures outlined in NCMA Section 3.5.
- Detailed test data (including strength, creep, site damage, and pullout testing) submitted to the Engineer for approval at least 30 days prior to construction.
- Of a type recommended by the block supplier to be compatible with the facing units, with a minimum long term design strength of 1500 pounds per foot (1000 kg/m).
- Regular grid structure having an aperture geometry and rib and junction cross-sections sufficient to permit significant mechanical interlock with the granular backfill material.
- High continuity of tensile strength through all ribs and junctions of the grid structure.
- High resistance to deformation under sustained long term design load while in service, and resistant to: 1) ultraviolet degradation; 2) damage under normal construction practices; and 3) all forms of biological or chemical degradation normally encountered in the granular backfill material.

7. Certifications.

a. Submit a notarized manufacturer's certification to the Engineer at least 14 days prior to the preconstruction conference, stating that the SRW units meet the requirements of this specification.

b. Submit a notarized manufacturer's certification signed and sealed by an officer of the manufacturer, prior to start of work, stating that the geogrid reinforcement meets the requirements of the SRW unit manufacturer and this specification.

2431.03 CONSTRUCTION.

A. Construction Supervision.

1. SRW units and geogrid reinforcement material suppliers shall provide, at no additional cost to the Contracting Authority, a qualified and experienced representative on site at the beginning of wall construction for up to 3 working days.

2. The Contractor is to provide an experienced and qualified field construction supervisor to direct all work at the site.

B. Excavation.

Excavate to the lines and grades shown on the construction drawings as being the reinforced earth zone. Take precautions to minimize over excavation. If required, design a system for excavation support at no additional cost to the Contracting Authority.

C. Foundation Soil Preparation.

1. Excavate foundation soil as required for base course leveling pad dimensions and limits of reinforced earth zone as shown in the contract documents.

2. The Engineer will examine foundation soil to assure that the actual foundation soil strength meets or exceeds the assumed design bearing strength. Remove soils not meeting the required strength and replace with soil meeting the design criteria.

3. Ensure the earth foundation has a density equal to or greater than 90% Standard Proctor Density. Step the earth foundation at the required intervals to keep it a minimum 2 feet (600 mm) below the finished grade.

D. Leveling Pad.

1. Place the leveling pad a minimum of 6 inches (150 mm) in thickness.

2. Construct the leveling pad to ensure complete contact of the retaining wall unit with the leveling pad. Ensure no gaps exist between the retaining wall unit and the leveling pad.

E. Unit Installation.
Install materials at the proper elevation and orientation shown in the contract documents. Install the concrete segmental units and geogrid reinforcement according to the approved submittals in Article 2431.02, A, 2. The plans govern in all conflicts between the two requirements.

F. Subdrains.

1. Install subdrains as shown in the contract documents to maintain gravity flow of water to outside of the reinforced earth zone. Outlet subdrains into a storm sewer access or along a slope at an elevation lower than the lowest point of the pipe within the SRW reinforced earth zone.

2. Place porous backfill material meeting the requirements of Article 2431.02, B, 3, around the subdrain to a minimum cover of 3 inches (75 mm).

G. Backfill Material Placement.

1. Compact the granular backfill material according to Article 2107.03, H. Place the granular backfill material as shown in the contract documents in maximum 8 inch (200 mm) lifts, compacted to a minimum 95% of standard Proctor density (ASTM D 698). Ensure moisture limits are between 3% under optimum moisture to no more than the optimum moisture content. Place the backfill material, spread, and compact in

such a manner that eliminates the development of wrinkles and/or movement of the geogrid reinforcement.

2. Only hand-operated compaction equipment will be allowed within 3 feet (1 m) of the front of the wall face.

3. Do not operate tracked construction equipment directly on the geogrid reinforcement. A minimum backfill material thickness of 6 inches (150 mm) is required prior to operation of tracked vehicles over the geogrid reinforcement. Minimize turning of tracked vehicles to prevent tracks from displacing the fill and damaging the geogrid reinforcement.

4. Rubber-tired equipment may pass over the geogrid reinforcement, if done according to the manufacturer's recommendations. Avoid sudden braking and sharp turning.

H. Geogrid Installation.

1. Overlapping the geogrid in the design strength direction will not be permitted. The design strength direction is that length of geogrid reinforcement perpendicular to the wall face. Use one continuous piece of material. Butt adjacent sections of geogrid in a manner to ensure 100% coverage after placement.

2. Install the geogrid reinforcement under tension. Apply a nominal tension to the reinforcement and maintain it by staples, stakes, or hand tensioning. The tension applied may be released after the geogrid reinforcement has been covered and held in place with soil fill.

2431.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Segmental Retaining Wall.
Square feet (square meters) from measurements of the front face of the wall in place. The height will be measured from the top of the leveling pad to the top of the wall, including coping or cap block.

B. Granular Backfill Material.
Tons (megagrams) or cubic yards (cubic meters) as stipulated in the contract documents.

C. Excavation.
Classed and measured according to Section 2102.

2431.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Segmental Retaining Wall.

1. Per square foot (square meter).

2. Payment is full compensation for furnishing all materials, tools, and labor for the performance of all work necessary to construct the wall, according to the contract documents, including the design, foundation preparation, leveling pad, geogrid fabric, porous backfill material, and subdrains.

B. Granular Backfill Material.
Per ton (megagram) or cubic yard (cubic meter) as stipulated in contract documents for material furnished, hauled, placed, and compacted.

C. Excavation.
Article 2102.05, A, 1, applies for each class of excavation for preparing the reinforced earth zone for construction of the wall. This will normally be included for payment with other excavation required by the contract documents.

Section 2432. Mechanically Stabilized Earth (MSE) Retaining Wall

2432.01 DESCRIPTION.

Construct mechanically stabilized earth (MSE) retaining walls according to this specification and in reasonably close conformity with the lines, grades, design, and dimensions shown in the contract documents or established by the Engineer. MSE walls are defined as large panel retaining wall systems which use mesh or strips in the soil backfill material behind a concrete wall facing to limit backfill material stresses by reinforcing the soil structure.

2432.02 DESIGN AND MATERIALS.

A. Design

1. Wall Design Engineer.
The Wall Design Engineer shall be a Professional Engineer licensed in the State of Iowa.

2. Design Requirements.

a. Consideration is to be given to the internal stability of the wall mass. The wall is to be designed per Section 5, „Retaining Walls', of the AASHTO Standard Specifications for Highway Bridges.

b. Design calculations are to include a summary of all design parameters used, including material types, strength values and assumed allowable soil bearing pressure, assumed load and loading combinations, and factor of safety parameters.

c. Earth reinforcing, and their connections to concrete panels, are to be designed for corrosion over the design life using the following electrochemical criteria:

Requirement	Test Method
Resistivity > 2,000 ohm-cm	AASHTO T 288
Chlorides < 200 ppm	AASHTO T 291
Sulfates < 300 ppm	AASHTO T 290

d. All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown in the contract documents are to be accounted for in the stability design of the wall.

e. Unless noted otherwise in the contract documents, a minimum cover of 4 feet (1.2 m) is to be provided from the top of the leveling pad to finish grade.

f. A special vertical corner element panel (to cover the joint of the panels that abut the corner and allow for independent movement of the abutting panels) is to be used where wall or wall sections intersect with an angle of 130 degrees or less on the backfill side. Corner elements are not to be formed by connecting standard facing panels that abut the acute corner.

g. The face panels are to be designed to accommodate differential settlement of 1 foot in 100 feet (0.3 m in 30 m). The spacing between adjacent panels is to be designed to be at least 3/4 inch (19 mm). Where shown in the contract documents, slip joints are to accommodate excessive differential settlement included.

3. Submittals.

a. MSE Supplier: For Interstate and Primary projects, provide the Office of Design, Soils Design Section with preliminary (non-structural) design calculations, which include estimated maximum applied (required) MSE wall bearing pressures, reinforcing strip or mesh lengths, and random backfill material requirements (if other than Class 10 backfill material), prior to preparation of their final MSE plans.

b. The Contractor: Submit design computations and approved final MSE system construction drawings according to Article 1105.03. Ensure the drawings include all details, dimensions, and cross-sections necessary to construct the wall, and include (but are not limited to) the following:

1) An elevation sheet or sheets for each wall.

2) An elevation view of the wall which includes:

- The elevation at the top of the wall at all horizontal and vertical break points and at least every 15 feet (5 m) along the face of the wall,
- All steps in the leveling pads,
- The designation as to the type of panel,
- The length of soil reinforcing elements,
- The distance along the face of the wall to where changes in length of the soil reinforcing elements occur, and
- An indication of the final ground line and maximum calculated bearing pressures.

3) Details of the architectural treatment. Refer to the contract documents for details and nominal dimensions.

4) All panel details showing all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of soil reinforcing connection devices embedded in the panels.

5) The details for connections between the concrete panel and the soil reinforcements.
6) A typical cross section or cross sections showing the elevation relationship between ground conditions and proposed grades.
7) General notes pertaining to design criteria and wall construction.
8) The details for diverting soil reinforcements around obstructions such as piles, catch basins, and other utilities.
9) Clearly indicated details for construction of walls around drainage facilities.
10) General location of subdrain and outlets of the internal drainage system.

B. Materials.
Install a wall system manufactured by a company on the approved manufacturer's list in Materials I.M. 445.03, Appendix A.

1. Concrete Panels.

a. Concrete.

1) Type I cement meeting requirements of Section 4101.
2) Cement content per cubic yard (cubic meter) of concrete for face panels and precast coping sections no less than 600 pounds (360 kg) nor more than 700 pounds (420 kg).
3) Concrete aggregates meeting the requirements of Sections 4110 and 4115. Class 3 durability crushed stone coarse aggregate. The use of gravel requires the Engineer's approval and is based on past history of deleterious and stain-producing material found in the aggregate source.
4) Air entrainment obtained by addition of an approved air-entraining agent. The air content of fresh, unvibrated concrete, as determined by AASHTO T 152, is to be 6.5% as a target value, with a maximum variation of ± 1.0%. When specified or authorized by the Engineer, approved admixtures for the purpose of improving workability or for retardation may be used according to the Engineer's instructions.
5) Obtain the Engineer's approval for the final mix design.

b. Compressive Strength.

1) Minimum compressive strengths for concrete reinforced face panels:

Strength prior to moving	Strength at 28 days
1800 psi (12.4 MPa)	4000 psi (27.6 MPa)

2) Acceptance of the concrete face panels with respect to compressive strength will be determined on a lot basis. The lot will consist of all production units (batches of concrete or panels) produced within a consecutive 7 day production period. Production units will be randomly selected according to the production day sample sizes of Table 2432.03-1 and tested for compressive strength. Perform compression tests on the test specimens according to Materials I.M. 315.

Table 2432.03-1: Production Day Samples

Production Day Quantities	Sample Size
35 cubic yards (27 m^3) or less (50 panels or less)	1
35-70 cubic yards (27-54 m^3) (50-100 panels)	2
70-100 cubic yards (54-81 m^3) (100-150 panels)	3
Over 100 cubic yards (81 m^3) (150 panels)	5

3) Cast a minimum of six test cylinders for each production unit sampled. Cure all of the specimens according to this specification.

4) Test two specimens at 7 days and two at 28 days. A test will be the average compressive strength of 2 cylinders.

5) Acceptance of the lot will be made:

- If all acceptance tests in a lot are greater than 4000 psi (27.6 MPa), or
- Provided no individual 28 day compressive-strength test result falls below 3500 psi (24.8 MPa), and the average 28 day compressive strength of all test results of the lot equals or exceeds the acceptance limits set forth in Table 2432.03-2.

6) Apply the acceptance limits of Table 2432.03-2 to core compressive strength test results.

Table 2432.03-2: Lot Acceptance Limits

Number of Lot Acceptance Tests	Average of all Lot Acceptance Tests Must Equal or Exceed these Limits
3-7	4000 psi + 0.33R* (27.6 MPa + 0.33R*)
8-15	4000 psi + 0.44R* (27.6 MPa + 0.44R*)
16+	4000 psi+ 0.46R* (27.6 MPa + 0.46R*)
* R is the range (the difference between the highest and lowest acceptance test result).	

c. Reinforcement.

Epoxy coated steel meeting the requirements of Article 4151.03.

d. Casting.

1) Prior to casting, earth reinforcement connections or ties, PVC pipe, and lifting devices are to be set in place to the required dimensions and tolerances.

2) Panels are to be cast on a flat area, the front face of the panel at the bottom, the back face at the upper part. Reinforcement connection guides are to be set on the rear face. The concrete in each unit is to be placed without interruption and consolidated by use of an approved vibrator, supplemented by such hand-tamping as may be necessary to force the concrete into the corners of the forms and to prevent the formation of stone pockets or cleavage planes. Clear form oil from the

same manufacturer is to be used throughout the casting operation.

e. Concrete Finish.

Uniform surface as designated on the formed front face. The rear face of the panel is to be roughly screeded to eliminate open pockets of aggregate and surface distortions.

f. Marking.

The date of manufacture, production lot number, and piece-mark are to be clearly scribed on the rear face of each panel.

g. Fasteners.

Bolts and nuts for fasteners, where required, are to be of type and length recommended by the Wall Design Engineer; high strength, conforming to ASTM A 325 or equivalent, and galvanized.

h. Tolerances.

All units manufactured are to be within the following tolerances:

1) Lateral position of the strips within 1 inch (25 mm).

2) All dimensions within 1/4 inch (5 mm).

3) Angular distortion with regard to the height of the panel not to exceed 1/4 inch in 5 feet (5 mm in 1.5 m).

4) Surface defects on smooth-formed surfaces not to exceed 1/8 inch in 5 feet (2.5 mm in 1.5 m). On textured surfaces, surface defects not to exceed 5/16 inch in 5 feet (8 mm in 1.5 m).

i. Curing.

1) Panels are to be covered with wet burlap as soon as practical after casting, but not later than 30 minutes, and kept wet. Within two hours of the initial covering, water is to be applied to the burlap by means of a continuous, pressure-sprinkling system that is effective in keeping the burlap wet during the initial curing period. The initial curing period is to be continued until the minimum moving strength is obtained.

2) After the initial curing period is complete, panels may be moved from the casting beds to a secondary curing area and covered with one layer of wet burlap and one layer of 2 mil (50 µm) plastic, secured to retain curing moisture. Concrete face panels are not to be uncovered more than 30 minutes during the moving process. Curing is to be continued until the specified strength is obtained.

3) Steam curing procedures may be approved by the Engineer.

j. Removal of Forms.

Forms are to be left in place until they can be removed without damage to the unit.

k. Testing and Inspection.

1) Acceptability of the precast units will be determined on the basis of compression tests and visual inspection.

2) The precast units will be considered acceptable, regardless of age, when compression test results indicate the concrete will meet the specified 28-day strength. Panels will be considered acceptable for placement in the wall when 7-day strengths exceed 80% of 28-day requirements.

l. Rejection.
Units may be subject to rejection because of failure to meet any of the requirements specified above. In addition, any or all of the following defects may be sufficient cause for rejection:
1) Defects that indicate imperfect molding.
2) Defects indicating honeycombed or open-texture concrete.

m. Handling, Storage, and Shipping.
Handle, store, and ship all units in such a manner as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses. Store panels on firm blocking located immediately adjacent to earth reinforcing connections to avoid damage to support panels.

2. Leveling Pad.
This concrete may be any mix the supplier markets as having a nominal strength of 3500 psi (24.1 MPa).

3. Joint Materials.

a. Horizontal and Vertical Joints.
Cover horizontal and vertical joints between panels with a polyester fabric that meets requirements of Article 4196.01, B, 3, and is acceptable to the MSE wall company. Obtain the Engineer's approval for adhesives used to temporarily attach the fabric to the back of the facing panels.

b. Bearing or Filter Pads.
Ensure bearing and filter pads (where required) are of the quality and dimensions recommended by the MSE wall company. Obtain the Engineer's approval.

4. Subdrains.

a. Use one of the perforated, plastic pipes described in Article 4143.01, C. If the size is not designated, use a pipe of nominal diameter no less than 4 inches (100 mm) or more than 6 inches (150 mm).

b. Provide a Standard Road Plan RF-19F Type A outlet fitted with a Standard Road Plan RF-19E rodent guard.

5. Backfill Material.

a. Unless specified otherwise in the contract documents, furnish granular backfill material for the entire reinforced earth zone. Unless specified otherwise in the contract documents, furnish granular backfill material when identified as an MSE wall design requirement in the contract documents for core-outs, other remedial/ ground improvement location, or use behind the reinforced zone. Ensure the backfill material meets the requirements of Section 4133, except that the percent passing the No. 200 (75µm) sieve is not to exceed 5.0%.

b. Use backfill material meeting the following criteria for electrochemical requirements:

Requirement	Test Method
Resistivity > 3000 ohm-cm	AASHTO T 288

pH range 5 to 10	AASHTO T 289
Chlorides < 100 ppm	AASHTO T 291
Sulfates < 200 ppm	AASHTO T 290
Organic content < 1%	AASHTO T 267

c. The Engineer will take two samples from the source of the granular backfill material to determine the electrochemical levels. Obtain the Engineer's approval for the source of backfill material prior to placing.

6. Earth Reinforcing.

Carefully inspect all reinforcement to ensure it is true to size and free from defects that may impair its strength and durability.

a. Reinforcing and Tie Strip.

1) Tie strips shall be shop-fabricated from hot-rolled steel conforming to the minimum requirements of ASTM A 570, Grade 50, or equivalent. Galvanization shall comply with the minimum requirements of ASTM A 123 or equivalent.

2) Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Physical and mechanical properties shall comply with ASTM A 572, Grade 65, or equivalent. Galvanization shall comply with ASTM A 123. Strips shall be cut to lengths and tolerances shown on the plans or recommended. Holes for bolts shall be punched in the locations shown.

b. Reinforced Mesh

Prefabricated from smooth bars meeting the requirements of ASTM A 82 and A 185. Reinforcing mesh shall be galvanized according to ASTM A 123. Mesh connectors are to be galvanized according to ASTM A 153. Mesh is to be cut to lengths and tolerances shown in the contract documents.

2432.03 CONSTRUCTION.

A. Construction Supervision.

1. MSE units and reinforcement material suppliers shall provide a qualified and experienced representative on site at beginning of wall construction for up to 3 working days at no additional cost to the Contracting Authority.

2. The Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site.

B. Excavation.

Comply with the limits and construction stages shown on the contract documents. Prior to start of MSE wall construction, complete and obtain approval for core-outs or other remedial/ground improvement procedures identified in the construction drawing. Temporary or other excavation lines

shown or depicted in the contract documents are for right of way, quantity calculation, and/or other design purposes only.

C. Foundation Soil Preparation.

Grade the foundation for the structure level for a width equal to or exceeding the length of reinforcing mesh or strips, unless shown otherwise in the contract documents. Prior to wall construction, compact the foundation with a smooth-wheeled, vibratory roller.

D. Leveling Pad.

At each panel leveling pad, place an unreinforced concrete leveling pad provided as shown in the contract documents. Cure the footing for a minimum of 24 hours before wall panel placement.

E. Wall Erection.

1. Panels.

For erection, handle the panels using a lifting device set into the upper edge of the panels. Place the panels in successive horizontal lifts in the proper sequence as backfill material placement proceeds. As backfill material is placed behind a panel, maintain the panels in position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall. External bracing may also be required for the initial lift. Ensure vertical tolerances and horizontal alignment tolerance do not exceed 3/4 inch (19 mm) when measured along a 10 foot (3 m) straight edge. Limit offsets in panel joints to 3/4 inch (19 mm) or less. Ensure the overall vertical tolerance of the wall does not exceed 1/2 inch per 10 feet (12.5 mm per 3 m) of wall height.

2. Coping.

Place the coping as shown in the contract documents. Mix, cast, and cure precast coping units with the same concrete mixture and in the same manner as used for construction of the panels. Cast-in-place coping may be constructed in the same manner or Class C structural concrete may be used; however, use aggregates meeting the same quality requirements as are specified in Article 2432.02, B, 1.

F. Subdrains.

1. Install the subdrains behind the bottom course of panels in direct contact with the granular backfill material. Install a second subdrain at the base of the temporary excavation backslope, behind the reinforced earth zone, and at an elevation similar to the subdrain behind the bottom course of panels. Place vertical pipes (if required) as shown in the contract documents. Install the subdrain as shown in the contract documents to maintain gravity flow of water to outside of the reinforced earth zone. The subdrain should outlet into a storm sewer access or along a slope at an elevation lower than the lowest point of the pipe within the reinforced earth zone.

2. The contract documents may require additional subdrain at the base of the granular backfill material in a core-out, if used.

3. Place porous backfill material meeting the requirements of Section 4131 around the subdrain to a minimum cover of 3 inches (75 mm).

G. Backfill Placement.

1. Place backfill material in a manner to closely follow the erection of each lift of panels. At each level for earth reinforcing, roughly level the backfill material before placing and connecting reinforcement. Place reinforcing normal to the face of the wall. Closely follow panel erection with placement of lifts. Decrease this lift thickness, if necessary, to obtain the specified density.

2. At the end of each day's operations, shape the last level of backfill material so as to permit runoff of rainwater away from the wall face.

3. Compact backfill material according to Article 2107.03, H. Place granular backfill material in the reinforced zone and behind the reinforced zone as shown in the contract documents in maximum 8 inch (200 mm) lifts. Compact to a minimum 95% of Standard Proctor density (ASTM D 698). Ensure moisture limits are between 1% under optimum moisture to not more than 2% over optimum moisture content. Perform backfill material compaction without disturbing or distorting earth reinforcing and panels. Do not use tamping-type rollers or other rollers which damage the reinforcing. In a 3 foot (1 meter) wide strip adjacent to the backside of the wall, use light mechanical tampers to achieve compaction. Compaction within this strip will not be subjected to density testing.

4. Compact granular backfill material and/or other materials placed in a core-out or other remedial/ground improvement location to a minimum of 98% of Standard Proctor density or as otherwise defined in the contract documents.

H. Earth Reinforcing Placement.

Place tie strips or mesh in horizontal layers as detailed in the contract documents. When tie strips or mesh can not be placed as detailed in the contract documents, submit a modified placement plan as recommended by the Wall Design Engineer for approval by the Engineer.

I. Surface Water Control

The cross sections in the contract documents will show excavation for any temporary backslope behind the reinforced earth zone. Protect the backslope from surface water which will affect stability of the backslope. Provide positive control and discharge for surface water in the area behind the backslope. If a gravity outlet is available, drain the bases of core-out

excavations by temporary trench outlets or subdrains until granular backfill material is installed in the core-out.

2432.04 METHOD OF MEASUREMENT.

The work involved in construction of Mechanically Stabilized Earth Retaining Walls will be measured as follows:

A. Mechanically Stabilized Earth Retaining Wall.

The Engineer will measure the area of Mechanically Stabilized Earth Retaining Wall in square feet (square meters), from measurements of the front face of the wall in place. The height will be measured from the top of the leveling pad to the top of the wall, including coping.

B. Granular Backfill Material.

The quantity of Granular Backfill Material, in tons or cubic yards (megagrams or cubic meters), that is placed in the reinforced earth zone; identified as an MSE wall design requirement in the contract documents for any core-out or other remedial/ground improvement location; or placed in the temporary excavation zone behind the reinforced earth zone as shown in the contract documents, will be measured in tons or cubic yards (megagrams or cubic meters).

C. Excavation.

Excavation for preparing the reinforced earth zone for construction of the wall and all core-outs or other remediations/ground improvement areas included in the contract documents will be classed and measured according to Section 2102.

2432.05 BASIS OF PAYMENT.

Payment for construction of Mechanically Stabilized Earth Retaining Walls, satisfactorily placed, will be as follows:

A. Mechanically Stabilized Earth Retaining Wall.

For the number of square feet (square meters) of Mechanically Stabilized Earth Retaining Wall constructed, the Contractor will be paid the contract unit price per square foot (square meter). This payment is full compensation for furnishing and erecting the MSE retaining wall including the design, foundation preparation, leveling pad, panels, coping, earth reinforcement placement, and subdrains according to the contract documents. Subdrains within core-out areas, if required in the contract documents, will be measured and paid for separately.

B. Granular Backfill Material.

1. For Contractor furnished Granular Backfill Material for the reinforced earth zone; any core-outs or other remedial/ground improvement locations; and placed in the temporary excavation zone behind the reinforced earth zone as shown in the contract documents, the Contractor will be paid for the quantity of material furnished, hauled, actually placed, and compacted for the contract unit price per ton or cubic yard (megagram or cubic meter) up to the contract quantity.

2. If the slope shown for the temporary excavation zone in the contract documents is not adequate for safety, provide written notification to the Engineer, including a copy of a slope stability analysis, and identification of the additional quantity of Granular Backfill Material that will be needed, before the work begins. The slope stability analysis is to be done by a Professional Engineer licensed in the State of Iowa (at no addition cost to the Contracting Authority). If approved by the Engineer, the additional quantity for Granular Backfill Material will be adjusted according to Article 1109.03, A.

C. Excavation.

1. For the quantity of each class of excavation for preparing the reinforced earth zone and all core-outs or other remediation/ground improvement areas included in the contract documents for construction of the wall, the Contractor will be paid as provided in Article 2102.05, A, 1. This will normally be included for payment with other excavation required by the contract documents.

2. If the slope shown for the temporary excavation zone in the contract documents is not adequate for safety, provide written notification to the Engineer, including a copy of a slope stability analysis, and identification of the additional quantity of excavation that will be needed, before the work begins. The slope stability analysis shall be done by a Professional Engineer licensed in the State of Iowa (at no additional cost to the Contracting Authority). If approved by the Engineer, the additional quantity for excavation will be adjusted according to Article 1109.03, A.

Section 2433. Concrete Drilled Shaft

2433.01 DESCRIPTION.

A. A concrete drilled shaft foundation consists of reinforced concrete placed in a drilled shaft seated in bedrock or soil and may encompass a rock socket as shown in the contract documents. References to “rock” and “rock socket” throughout this section are only applicable to shafts seated in bedrock with rock sockets as specified in the contract documents.

B. Ensure elevations, dimensions, and depth of the drilled shafts and rock sockets are as specified in the contract documents. If bearing strata are encountered at different elevations or are judged to be of a different quality, the Engineer may adjust the socket elevation.

2433.02 MATERIALS.

A. Slurry.

1. Use only mineral or polymer slurries in the drilling process unless the Engineer, in writing, approves other drilling fluids. Ensure the

percentage and specific gravity of the material used to make the suspension is sufficient to maintain the stability of the excavation and to allow proper concrete placement. In the event of a sudden significant loss of slurry to the excavation, stop foundation construction until the Engineer has approved either: 1) methods to stop slurry loss; or 2) an alternate construction procedure.

2. Perform all tests at a slurry temperature of 40°F (4°C) or higher.

3. Thoroughly premix mineral slurry or polymer slurry with clean, fresh water. Mix for the adequate time (as prescribed by the manufacturer) allotted for hydration in slurry tanks. Adequate capacity slurry tanks are required for slurry circulation, storage, treatment, and disposal. No excavated slurry pits will be allowed. Prior to introduction into the shaft excavation, draw sample sets from the slurry tanks and test the samples for conformance with the specified material properties. A sample set consists of samples taken at mid-height and within 2 feet (0.6 m) of the bottom of the slurry tanks.

4. In the Engineer's presence, sample and test all slurry, unless directed otherwise. Record the date, time, persons' names sampling and testing the slurry, and the test results. Submit a copy of the recorded slurry test results to the Engineer at the completion of each shaft, and during construction of each shaft when the Engineer requests.

5. During shaft excavation, take and test sample sets of all slurry, composed of samples taken at mid-height and within 2 feet (0.6 m) of the bottom of the shaft, as necessary to verify the control of the slurry properties. As a minimum, take and test sample sets at least once every 2 hours after beginning slurry use. When the test results show consistent specified properties, take and test sample sets at least once every 4 hours of slurry use. When tests show that the sample sets do not have consistent specified properties, either recirculate the slurry or agitate it with drilling equipment.

6. When samples are found to be unacceptable, either clean, recirculate, desand, or replace the slurry in order to maintain the required slurry properties. Do not begin cleaning the bottom of the excavation and placing concrete until after tests show that the sample sets have consistent specified properties.

7. Demonstrate to the Engineer's satisfaction that stable conditions are being maintained. If the Engineer determines that stable conditions are not being maintained, immediately take action to stabilize the shaft. Submit a revised installation plan which corrects the problem and prevents future instability. Do not continue with shaft construction until receiving the Engineer's approval of the revised shaft installation plan.

a. Mineral Slurry.

Ensure mineral slurry complies with Table 2433.02-1:

Table 2433.02-1: Mineral Slurry Requirements

Property	Test Method	Requirements
Density (lb/ft^3 (kg/m^3))	Slurry Density Materials I.M. 387	64 to 75 (1030 to 1200)
Viscosity (sec/gal (sec/L))	Marsh Funnel and Cup Materials I.M. 387	104 to 201 (27.5 to 53)
pH	pH Paper	8 to 11
Sand Content (%)	Sand Content Test Materials I.M. 387	*
* Sand content of mineral slurry prior to placing the reinforcing steel cage and immediately prior to placing concrete less than or equal to 4.0%.		

b. Polymer Slurry.

1) For polymer slurry use, comply with the manufacturer's recommendations and this specification. Submit to the Engineer the name and telephone number of the manufacturer's representative. The manufacturer's representative is to provide technical assistance in the use of the polymer slurry as needed.

2) Ensure polymer slurry complies with Table 2433.02-2:

Table 2433.02-2: Polymer Slurry Requirements

Property	Test Method	Requirements
Density (lb/ft^3 (kg/m^3))	Slurry Density Materials I.M. 387	62 to 63 (995 to 1010)
Viscosity (sec/gal (sec/L))	Marsh Funnel and Cup Materials I.M. 387	136 to 227 (36 to 60) 231 to 252 (61 to 66.5) (dry sand/gravel)
pH	pH Paper	8 to 11
Sand Content (%)	Sand Content Test Materials I.M. 387	*
* The sand content of polymer slurry prior to placing the reinforcing steel cage and immediately prior to placing concrete less than 2.0%.		

3) Wait 30 minutes after the last drilling and scouring to allow contaminants to settle out before taking and testing a sample set of slurry. After the reinforcing steel cage is placed in the excavation, take and test a sample set of slurry immediately prior to concrete placement.

B. Concrete.
Comply with the following:

1. All materials, proportioning, air entraining, mixing, slump, and transporting of PCC shall be according to Section 2403, except as modified herein.

2. Water/cement ratio: not to exceed 0.45.

3. Drilled shaft construction: use Class D PCC mixture with a slump of 8 inches ±1.5 inches (200 mm ±40mm).

4. Portland cement: meet the requirements of ASTM C 150 Type I / II and Section 4101.

5. Air entrainment: apply Section 2403.

6. Mid-range water reducer is required according to Materials I.M. 403.

7. Retarder is required according to Materials I.M. 403 to maintain workable concrete.

8. Do not use GGBFS.

C. Grout.
Apply Materials I.M. 388.

2433.03 CONSTRUCTION.

A. Construction Tolerances.
Drilled shaft excavations and completed shafts not constructed within the required tolerances will be considered unacceptable. Correct all unacceptable shaft excavations and completed shafts to the Engineer's satisfaction. Furnish materials and work necessary, including engineering analysis and redesign, to complete corrections for out of tolerance drilled shaft excavations (without either cost to the Contracting Authority or an extension of the completion dates of the project).

1. Ensure the drilled shaft is within 3 inches (75 mm) of plan position at the top of shaft.

2. Ensure the vertical alignment of shaft excavation does not vary from the plan alignment by more than 1/4 inch/foot (20 mm/m of depth).

3. Set full depth reinforcing steel cages at no less than 6 inches (150 mm) above the bottom of the excavated shaft prior to concrete placement.

4. Ensure that, after all the concrete is placed, the top of the reinforcing steel cage is no more than 6 inches (150 mm) above and no more than 2 3/4 inches (70 mm) below plan position.

5. Casing dimensions are subject to American Pipe Institute tolerances applicable to regular steel pipe.

6. The top elevation of the shaft may have a tolerance of plus 1 inch (25 mm) or minus 3 inches (75 mm) from the plan top of shaft elevation. Ensure sufficient reinforcement bar splice length for splices above the shaft.

7. Use excavation equipment and methods that ensure the completed shaft excavation will have a planar bottom. Ensure the excavation equipment cutting edges are normal to the equipment's vertical axis within a tolerance of 3/8 inch/foot (30 mm/m) of diameter.

B. Drilled Shaft Installation Plan.

1. Two weeks prior to the pre-construction conference, submit a list containing at least three drilled shaft projects, of similar diameter and length to those shown on the plans, completed in the last three years. In the list of projects include names and phone numbers of owner's representatives who can verify the Contractor's participation on those projects. In addition, submit a signed statement that the Contractor has inspected the project site and all the subsurface information made available in the contract documents.

2. No later than 1 month prior to constructing drilled shafts, submit a drilled shaft installation plan for the Engineer to review. In this plan provide the following information:

- **a.** Name and experience record of firm(s) and associated personnel for the following:
  - **1)** Driller.
  - **2)** Drilled shaft superintendent.
  - **3)** Site exploration.
  - **4)** Confirmation boring.
  - **5)** Crosshole sonic logging (CSL).
  - **6)** Name of load cell testing firm, if applicable.
- **b.** List of proposed equipment to be used, including cranes, drills, augers, bailing buckets, grooving equipment, scouring equipment, final cleaning equipment, core sampling equipment, confirmation boring equipment, tremies or concrete pumps, casing, slurry equipment, airlift pumps, and so forth.
- **c.** Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
- **d.** Details of shaft excavation methods.
- **e.** Details of casing and forms, including installation and removal.
- **f.** Details of the type and methods to mix, circulate, desand, test, and dispose of slurry (if applicable). If polymer slurry is proposed, submit data on load transfer and manufacturer's requirements for slurry control.
- **g.** Details of methods to clean the shaft excavation, including air lift methods and spin bucket methods as applicable.

h. Details of reinforcement placement, including support and cage centering methods.
i. Reinforcing steel cage splicing method, if proposed, including details of dimensions, installation, splice location, support and cage centering methods, and estimated time required for splicing.
j. Details of concrete placement including procedures for tremie or pumping methods and method to prevent slurry intrusion at the discharge end.
k. Concrete mix proposal.
l. Details of methods to control cuttings, water, slurry, and so forth with adjacent traffic conditions (vehicular or railroad if applicable).
m. Details of CSL testing, including location and attachment methods of the steel access pipes.
n. When a load cell test is specified, include details of the test equipment used in the load cell test, and description of load cell test procedures and program according to Materials I.M. 388.
o. Details of methods used to groove the sides of the drilled shaft length within the bedrock supporting stratum and methods of scouring and verification of grooving.
p. Details of final discharge of concrete at top of shaft, of removing contaminated concrete, and verifying concrete uniformity for site specific conditions.
q. When casing is required, include details on casing to be used, including:
- Specific length/depth of all casing proposed, and
- Specific evaluation and determination of casing (size, depth, etc.) required to prevent all shaft installation procedures from having an effect or impact on adjacent structures, railroads, and so forth.

3. The Engineer will evaluate the drilled shaft installation plan for conformance with the contract documents. Within 14 calendar days after receipt of the plan, the Engineer will notify the Contractor of additional information required or changes necessary to meet the contract requirements, or both. Field test the Engineer's procedural approvals. These approvals do not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the contract documents.

4. A pre-drilling conference, in which the Contracting Authority, Contractor, and drilling staff discuss the anticipated shaft process, will be required for this work prior to the start of shaft excavation.

C. Control and Disposal of Materials.
Dispose of excavated material, as well as slurry and/or water removed from the shaft excavation. Collect and properly dispose off site all slurry and water displaced during final cleaning and concrete placement. Open pits for collection of materials will not be allowed. Control all excavated material, slurry, water, and other matter so that at no time it enters or encroaches upon the adjacent travel lanes, railroad, water ways, and so forth.

D. Shaft Excavation.

1. General.

a. Construct drilled shafts by either the wet, dry, or casing method as necessary to produce sound, durable concrete foundation shafts free of defects. These methods are described below.

b. Remove surface and subsurface obstructions. Special tools and/or procedures may be required. No separate payment will be made for removing obstructions.

c. If the Engineer determines that the material encountered during excavation and/or present at tip elevation is unsuitable and/or differs from that anticipated in the design of the drilled shaft, extend the drilled shaft tip elevations.

d. Maintain a drilling log during shaft and socket excavation. In the log, place information such as elevation, depth of penetration, drilling time in each of the strata, material description, and remarks. Furnish two copies of the log (signed by the Contractor) to the Engineer within 1 week after completion of the excavation.

e. After the shaft excavation has been completed, immediately proceed with shaft construction.

2. Wet Method.

a. The wet method consists of:

- Keeping the shaft filled with slurry a minimum of 4 feet (1.3 m) above the highest expected water table during drilling and excavation,
- Desanding of the slurry when required,
- Final cleaning of the excavation by means of a bailing bucket, air lift, pump or other approved device, and
- Placing shaft concrete which displaces the slurry.

b. In the event that layers susceptible to cave-ins are encountered which cannot be controlled by slurry, install temporary removable casing according to Article 2433.03, D, 3.

3. Dry Method.

a. The dry method consists of:

- Drilling the shaft excavation,
- Removing accumulated water and loose material from the excavation,
- Placing the reinforcing cage, and
- Concreting the shaft in a relatively dry excavation.

b. Use the dry method only at sites where:

- The ground water level and soil and rock conditions are suitable to permit construction of the shaft in a relatively dry excavation, and
- The Engineer can visually inspect the sides and bottom of the shaft prior to placing the concrete.

c. The Engineer will approve the dry method only if the shaft excavation demonstrates:

- Less than 12 inches (0.305 m) of water accumulates above the base over a 1 hour period when no pumping is permitted,
- The sides and bottom of the hole remain stable without detrimental caving, sloughing, or swelling between completion of excavation and concrete placement, and
- All loose material and water can be satisfactorily removed prior to inspection and concrete placement (less than 3 inches (75 mm) of water will be permitted in the bottom of the shaft excavation at the time of concrete placement).

d. Use the wet or casing method for shafts that do not meet the dry method requirements.

4. Casing Method.

a. The casing method is used to advance the hole through unstable material. Over-reaming to the outside diameter of the casing may be required. Before the casing is to be removed, the level of fresh concrete must be a minimum of 5 feet (1.5 m) above the bottom of the casing so that fluid trapped behind the casing is displaced upward. As the casing is withdrawn, maintain the concrete level so that fluid trapped behind the casing is displaced upward without contamination or displacing shaft concrete.

b. Determine the appropriate depth to terminate the temporary casing to ensure the stability of the shaft. The purpose of the temporary casing is to stabilize the shaft walls during drilling to prevent cave-ins as the result of potential vibrations. The purpose of the casing is also to prevent shaft installation procedures from having an impact on adjacent structures, railroads, and so forth.

c. Permanent casing, if required, will be specified in the contract documents.

E. Grooving and Brushing Sidewalls.

1. Groove sidewalls of drilled shaft within the rock socket to produce channels with approximate dimensions of 2 inch (50 mm) deep by 3 inch (75 mm) high at intervals of 1 foot (0.3 m).

2. Use a method approved by the Engineer to remove excessive smearing of soft material that may occur on rock socket wall.

3. Clean base of shaft by spin bucket and air lift. Perform grooving and/or brushing prior to final cleaning of base of shaft.

F. Final Cleaning.

1. If a slurry cake builds up on the shaft sidewalls, remove it prior to concrete placement (at no additional cost to the Contracting Authority). If mineral slurry is used, ream the shaft sidewalls above the rock socket reamed prior to placement of reinforcement. Adjust operations so that the maximum time that the slurry is allowed to remain in the shaft is 24 hours.

2. Clean the base of each shaft so that a minimum of 50% of the base will have less than 1/2 inch (15mm) of sediment at the time of concrete placement. Ensure the maximum sediment or debris depth at the base of the shaft does not exceed 1 inch (25mm).

3. The Engineer will visually inspect dry shafts.

4. Use an air lift to clean the bottom of slurry shafts. After a waiting period equal to the time to set the reinforcing steel cage and set up for concrete placement, measure the amount of sediment in the bottom of the shaft. If the amount of sediment meets the requirements in Paragraph 2 above, clean the base of the shaft a second time with the air lift and immediately proceed with shaft construction. If after the described wait period the amount of sediment exceeds the requirements of Paragraph 2, clean the shaft by air lift and repeat the above procedure until the sediment accumulation meets the requirements. The Engineer may approve an alternate method to clean the bottom of the shaft. The Contracting Authority will not provide additional compensation for alternate methods.

G. Excavation Inspection.

Provide equipment for checking the dimensions and alignment of each shaft excavation. Under the direction of the Engineer, verify the dimensions and alignment of the shaft under construction. After final cleaning, use a suitable weighted tape or other approved methods to measure final shaft depths.

H. Reinforcing Steel Cage Construction and Placement.

1. Assemble the reinforcing steel cage (consisting of longitudinal bars, ties, cage stiffener bars, spacers, cage centering devices, and other necessary appurtenances). Place the steel cage immediately after the shaft excavation has been inspected and accepted, and prior to concrete placement. If the Engineer approves, the reinforcing steel cage may be placed as two approximately equal units joined together in the shaft excavation.

2. Ensure the reinforcing steel in the shaft is tied at intersections and supported in such a way that the reinforcing steel will remain within allowable tolerances given in this specification. Use concrete spacers or other approved non-corrosive spacing devices at sufficient intervals near the top and bottom, and at intervals not exceeding 10 feet (3 m) along the shaft, to ensure concentric spacing for the entire cage length. Ensure spacers are:

- Constructed of approved material equal in quality and durability to the concrete specified for the shaft.
- Of adequate dimension to ensure a minimum distance of 3 inches (75 mm) between the cage and the excavated hole.

3. When a full depth reinforcing steel cage is used, support it at the bottom using approved cylindrical feet to ensure that the bottom of the cage is maintained at the proper distance above the base. When a partial depth reinforcing steel cage is used, design and furnish a support system.

4. Check the elevation of the top of the steel cage before and after the concrete is placed. If the reinforcing cage is not maintained within the specified tolerances, make necessary corrections to the satisfaction of the Engineer. Do not construct additional shafts until after modifying the reinforcing cage support in a manner satisfactory to the Engineer.

I. Concrete Placement.

1. General.

a. Place shaft concrete within 24 hours of the start of excavation of the rock socket. Place concrete as soon as possible after placing reinforcing steel.

b. Coordinate concrete batching and delivery with the batch plant the time limits, as stated in the contract documents, between batching and delivery are not exceeded.

c. Place concrete in a continuous manner. Continue concrete placement after the shaft excavation is full until good quality concrete is evident at the top of shaft.

d. Before continuing with column construction, remove a sufficient volume of concrete to ensure elimination of all contaminated concrete at the top of shaft.

e. Place concrete through either a tremie or a concrete pump.

f. Complete placement of the concrete in the shaft within 3 hours. Adjust admixtures, when approved for use, for the conditions encountered on the job so the concrete remains in a workable plastic state throughout the 3 hour placement limit.

g. For construction of shafts larger than 6 feet (2 m) in diameter, the Contractor may propose a placement time in excess of 3 hours provided the Contractor submits trial mix documentation that all concrete in the shaft will retain a minimum 4 inch (100 mm) slump for the entire placement period.

h. Remove all temporary casing.

2. Concrete Placement by Tremie:

a. For the tremie, comply with the following:

- Constructed so that it is watertight and will readily discharge concrete.
- No more than 12 inches (300 mm) in diameter.
- No aluminum parts in contact with concrete.
- Discharge end of the tremie constructed to prevent water or slurry intrusion and permit the free flow of concrete during placement operations.
- Sufficient mass so that it will rest on the shaft bottom before start of concrete placement.
- Sufficient length to extend to the bottom of the shaft.

b. Maintain the discharge orifice between 5 feet and 10 feet (1.5 m and 3.0 m) below the surface of the fluid concrete.
c. Support the tremie so that it can be raised to increase the discharge of concrete and lowered to reduce the discharge of concrete.
d. Maintain a continuous flow of concrete. Ensure the concrete in the tremie maintains a positive pressure differential at all times to prevent introduction of air pockets or contaminants into the concrete.

3. Concrete Placement by Pump.
a. Concrete pumps and lines may be used for concrete placement. Use minimum 4 inch (100 mm) diameter pump lines constructed with watertight joints. Do not begin concrete placement until the pump line discharge orifice is at the shaft base elevation.
b. Use a plug or similar device to separate the concrete from the fluid in the hole until pumping begins. Either remove the plug from the excavation, or use a plug of a material approved by the Engineer which will not be a detriment to the shaft if not removed.
c. Maintain the discharge orifice between 5 feet and 10 feet (1.5 m and 3.0 m) below the surface of the fluid concrete. When lifting the pump line during concreting, temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation.
d. Perform the pumping operation in a manner that prevents introduction of air pockets into the concrete. If breaking the pump line is required, temporarily position the discharge orifice 3 feet to 5 feet (1.0 m to 1.5 m) below the surface of the fluid concrete in the hole. The Contractor may propose additional methods to eliminate introduction of air into the concrete.

J. Crosshole Sonic Log (CSL) Testing.

1. Coordinate with an independent testing agency to perform CSL testing according to ASTM D 6760. Provide analysis and interpretation on each completed shaft.

2. The procedure in ASTM D 6760 will be followed with the exceptions listed below:
a. Plastic access ducts and drilled boreholes will not be allowed unless the Engineer approves.
b. A minimum of 4 access ducts are required.
c. Perform CSL testing after the shaft concrete has cured at least 48 hours but no later than 7 calendar days.
d. Grout the access ducts after the Engineer's approval of the testing results.
e. Include the waterfall diagram (which is a nesting of ultrasonic pulses in an ultrasonic profile) in the report.

3. Furnish and install one access pipe per 1 foot (0.3 m) of shaft diameter, but no less than four per shaft, with external couplings for CSL testing. Furnish access pipes complying with the following:
- 2 inch (51 mm) diameter, Schedule 40 pipe conforming to ASTM A 53, Grade A or B, Type E, F, or S.
- Round, regular inside diameter free of defects and obstructions, including all pipe joints, in order to permit the unobstructed passage of 1 3/8 inch (35 mm) maximum diameter source and receiver probes used for the CSL tests.
- Watertight and free from corrosion with clean internal and external faces to ensure a good bond between the concrete and the access pipes.
- Fitted with a watertight cap on the bottom and a removable, watertight cap on the top to prevent debris from entering the pipes.
- Watertight joints to achieve the specified length.

4. Securely attach the access pipes to the interior of the reinforcing cage such that each pipe is equally spaced within the reinforcing cage. If a partial depth reinforcing cage is specified, design and furnish a support system to secure and properly align the CSL access pipes.

5. Install the access pipes in straight alignment and parallel to the vertical axis of the reinforcing cage. Access pipes shall have 2 inches (50 mm) concrete cover at the bottom of the shaft or extend to the top plate of a load cell placed at the bottom of the shaft. When a load cell is located above the bottom of the shaft, fit the access pipes with watertight slip joints between the load cell bearing plates. Extend the access pipe at least 2 feet (600 mm) above either the top of the continuous concrete placement operation or the top of the shaft. Do not damage the access pipes during the reinforcing steel cage installation.

6. Fill the access pipes with clean water prior to concrete placement. To prevent debris from entering the pipe, reseal each access pipe immediately after water placement. Prior to CSL testing, flush all access pipes containing debris, refill with water of similar temperature, and reseal. Use water of similar temperature to avoid debonding of access pipes with surrounding concrete. Dewater all access pipes and fill with grout after the tests are completed, and the shaft has been accepted by the Engineer. Use grout meeting the requirements of Materials I.M. 388.

7. Submit the test results, analysis, and interpretation for the shafts to the Engineer within 7 calendar days of testing. The Engineer will:
- Determine final acceptance of each shaft, based on the CSL test results and analysis for the tested shafts, and
- Provide a response within 5 working days after receiving the test results and analysis submittal.

8. Do not commence subsequent shaft excavations until receiving the Engineer's approval and acceptance of the first shaft based on the results, analysis, and interpretation of the CSL testing.

9. Do not commence subsequent construction of the structure until receiving the Engineer's approval and acceptance of the supporting shaft based on the results, analysis, and interpretation of the CSL testing.

10. For all shafts determined to be unacceptable, submit a plan for remedial action, including correction procedures and designs, to the Engineer for approval. Do not begin repair operations until receiving the Engineer's approval of the remedial action plan.

K. Demonstration Shaft.

1. Demonstrate equipment and methods, prior to construction of the first production drilled shaft, by installing a non-production drilled shaft. Install on site at a location the Engineer determines.

2. Construct the demonstration shaft in soil as shown in the contract documents or a minimum of 3 feet (1 m) into bedrock. A reinforcing steel cage, designed by the Contractor, to adequately support the CSL tubes will be required.

3. Construct the demonstration shaft according to the requirements of this specification with special emphasis on slurry control and disposal, method of scouring, air lift pump usage, concrete delivery and coordination with the batch plant, concrete slump at the point of delivery, and concrete placement. Include one break of the concrete pump line.

4. If the demonstration shaft installation demonstrates the equipment and methods used to construct drilled shafts to the requirements of this specification are inadequate, the Engineer will require appropriate alterations in equipment or methods, or both, to eliminate the unsatisfactory results. The Contractor may be required to perform additional demonstration shafts until an adequate procedure is demonstrated and approved by the Engineer.

5. Do not begin constructing production drilled shafts until the Engineer approves the methodology and reviews the CSL report. The Engineer will complete the review process within 5 working days.

6. The Demonstration Shaft item will be deleted from the contract if:

- The Contractor has demonstrated sufficient experience in the construction of drilled shaft foundations in soil/rock and under conditions similar to those at this site, and
- Other applicable factors indicate it to be acceptable.

L. Test Shaft.

1. When required in the contract documents, install a test shaft at the location indicated in the plans. Base the final selected depth of the test shaft on the confirmation boring.

a. Confirmation Boring and Sampling.

1) Prior to installation of the test shaft, complete a confirmation boring at the test shaft location to a depth 10 feet (3 m) below the bottom elevation as shown in the contract document or a minimum of 30 feet (10 m) into the bedrock, whichever is greater.

2) Perform standard penetration tests according to ASTM D 1586 in the soil overlying bedrock. Perform the tests on 5 foot (1.5 m) centers.

3) Determine moisture contents on the soil samples. Continue soil sampling and testing with split barrel (spoon) sampling, according to ASTM D 1586, until the top of bedrock is encountered.

4) Core the rock using double barrel diamond coring methods producing a minimum 1.75 inch (44.4 mm) core according to ASTM D 2113, or other approved sampling method. Keep records, including Percent Core Recovery and Rock Quality Designation, according to ASTM D 2113 and D 6032. Preserve rock samples at their natural moisture content and condition. Transport them to the laboratory for classification by a Professional Engineer licensed in the State of Iowa.

5) Test representative samples of intact rock for unconfined compressive strength according to ASTM D 2938, except record stress and strain according to ASTM D 2166, up to 20% strain or failure, whichever occurs first. Prepare a stress-strain plot. In addition, list the unconfined compressive strength.

6) Perform one unconfined compression test for every 3 feet (1.0 m) of rock core. The Engineer will select test samples.

7) Do not install test shafts until the results of the confirmation boring have been submitted and reviewed and incorporated in the proposed load test program to be submitted according to Materials I.M. 388.

8) The Engineer will complete the review of the confirmation boring report within 7 calendar days after submittal and the proposed load cell test program report within 7 calendar days after submittal.

b. Load Cell Test.

1) When required by the contract documents, furnish all materials and labor necessary to conduct a load cell test according to Materials I.M. 388.

2) Install telltale casings to allow measurement of shaft movement during load cell test.

3) Use the utmost care in handling the rebar cage/test equipment assembly so as not to damage the load cell and instrumentation during installation.

4) After the CSL test has been approved and the concrete has reached a minimum required strength of 3500 psi (24 MPa), internally pressurize the load cell creating an upward force on the shaft and an equal, but downward force. The total load for a given internal pressure is found from the load cell's calibration. Ensure this is performed prior to load cell's shipment to the site. During the period required to perform the load cell test, no casings may be vibrated into place or steel piles installed within 200 feet (60 m) of the load test.

5) If the test shaft is a production shaft, monitor the load/deflection curve and halt testing so that the capacity of the shaft is not compromised. Then unload the load cell and reload it to verify that the test shaft has at least the design capacity. If the test shaft is not a production shaft, continue the load cell test until ultimate capacity is reached or the capacity of the load cell is reached.

6) If the test shaft is a production shaft, grout the hydraulic lines and load cell cavities after completion of the load cell test. Use a grout meeting the requirements of Materials I.M. 388.

7) Within 14 calendar days of the test completion, supply four printed copies and one electronic copy of the report for each load cell test, as prepared by the approved firm in Materials I.M. 388. Provide field results after completion of the test. In the report include, at a minimum, the following:

- **a)** Load distributions, skin friction, and end bearing for the various strata instrumented by the strain gauges.
- **b)** Summary of drilled shaft's dimensions, elevations, areas, and masses.
- **c)** Boring logs, test data, and other relevant information from the confirmation boring.
- **d)** Log of the Contractor's installation along with actual mapping of the shaft profile.
- **e)** Load movement for end bearing and upward shear.
- **f)** Equivalent top load movement curve.
- **g)** Side shear creep limit curve.
- **h)** End bearing creep limit curve.
- **i)** Side shear load transfer for each zone/layer identified in the confirmation boring report, where strain gauges were installed, or as modified by the Engineer and the approved firm in Materials I.M. 388.
- **j)** Plots of mobilized side shear load transfer versus vertical displacement for each zone/layer identified in the confirmation boring report, where strain gauges were installed. Layers may be modified in final load test design, if approved of by the Engineer.
- **k)** Tables with test data.

2. If the Engineer determines the test shaft to be unacceptable, submit a plan for remedial action to the Engineer for approval. The Engineer may require another load cell test on another shaft.

3. Do not begin construction of the production shafts until the Engineer approves the methodology, reviews CSL report, and reviews load cell test results.

4. Prior to commencement of the load cell test, repair all cavities or inclusions. Obtain the Engineer's approval for the repairs.

5. The Engineer will complete the review process within 14 calendar days of the load test report submittal.

6. The load test results will be used to evaluate the shaft capacities within the bedrock and to define the final bottom elevation of the remaining productions shafts. The final bottom elevation of the remaining production shafts may vary from what is shown on the plans.

7. Once the load cell test has been completed and the Engineer has approved it, clean up the test shaft site. If the test shaft is a production shaft, clean up the site using whatever measures are required to incorporate the test shaft into the foundation, subject to the Engineer's approval. If the test shaft is not a production shaft, remove it to 3 feet (1 m) below final ground level and clean the area according to Article 1104.08.

2433.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Concrete Drilled Shaft.
Feet (meters), to the nearest 6 inches (0.15 m), constructed.

B. Reinforcing Steel.
Section 2404 applies.

C. Load Cell Test.
By count.

D. Demonstration Shaft
Feet (meters), to the nearest 6 inches (0.15 m), constructed and approved.

2433.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Concrete Drilled Shaft.

1. Per foot (meter).

2. Payment is full compensation for all equipment, labor, and materials (except reinforcing steel) necessary to satisfactorily construct the shafts including:

- Drilling and excavation of shaft and possible rock socket,
- Casing,
- Installation and removal of temporary casing,
- Furnishing and placing concrete,
- CSL pipe and testing, shaft inspection, and
- Disposal of excavated materials and water, and all other materials.

B. Reinforcing Steel.

Section 2404 applies.

C. Load Cell Test.

1. Each.

2. Payment is full compensation for:

- Performing confirmation boring and testing and all costs incurred during the procurement,
- Installation,
- Instrumentation with strain gauges and telltales,
- Conducting of the test,
- Subsequent removal of test apparatus, appurtenances, grouting cell tubes, and
- Reporting.

D. Demonstration Shaft.

1. Per foot (meter).

2. Payment is full compensation for all equipment, labor, and materials necessary to satisfactorily construct the approved shaft including:

- Drilling and excavation of drilled shaft and rock socket,
- Installation and removal of temporary casing,
- Furnishing and placing reinforcing bars,
- Furnishing and placing concrete,
- CSL pipe and testing,
- Shaft inspection, and
- Disposal of excavated materials and water, and all other materials.

Section 2434. Disc Bearing Assembly

2434.01 DESCRIPTION.

A. Furnish, test, and install complete in-place, factory-produced disc bearing assemblies according to details shown on the contract documents and with the requirements of this specification.

B. Ensure disc bearing assembly design, materials, shop drawings and documentation, fabrication, testing and acceptance, packaging, and installation are according to the contract documents and this specification, as well as the most recent edition of the AASHTO Standard Specifications for Highway Bridges.

2434.02 DISC BEARING ASSEMBLY DESIGN, MATERIALS, FABRICATION, AND TESTING.

A. Disc Bearing Assembly Design.

1. Ensure the Manufacturer has designed the disc bearing assemblies for the service loads and movements as shown on the contract documents. Ensure the minimum horizontal load capacity of the bearing is a minimum of 10% of the vertical capacity.

2. Polytetrafluoroethylene (PTFE) sliding surfaces for expansion bearings are designed to translate by the sliding of a PTFE surface across a smooth hard mating surface of stainless steel. Ensure the maximum coefficient of friction within the range of loads and service temperatures is 0.03.

3. Ensure the finished PTFE sheet is no less than 1/8 inch (3 mm) and no more than 3/16 inch (5 mm) thick. Ensure the PTFE sheet is recessed according to Article 18.5.3.2 Div. II of the AASHTO Standard Specifications for Highway Bridges.

B. Disc Bearing Assembly Requirements.

1. Polyether urethane structural element (disc) confined by upper and lower steel bearing plates.

2. Equipped with a shear restriction mechanism to prevent lateral movement of the disc.

3. Adequate provision for the thermal expansion and contraction, rotation, camber changes, and creep and shrinkage of structural members.

4. Supplied as guided expansion or fixed bearings, as designated on the contract documents.

5. Supplier meeting Article 18.7.4.8 Division II of the AASHTO Standard Specifications for Highway Bridges and approved by the Contracting Authority.

6. Sliding bearings stiff in shear (i.e. negligible shear displacements occurs within the load-bearing element).

C. Disc Bearing Assembly Materials.

1. **Steel components:** meet the material requirements as designated on the contract documents.

2. **Anchor bolts:** meet the material requirements as designated on the contract documents.

3. **Stainless steel mating surfaces:** conform to ASTM A 240/A 240M Type 304. Minimum No. 8 mirror finish for mating surface. Minimum 16 gauge thickness for the stainless steel plate.

4. **The PTFE sheets:** manufactured from pure virgin (not reprocessed) unfilled PTFE resin.

5. **Guiding arrangements:** PTFE to stainless steel sliding surfaces.

6. **Structural element (disc):** new and unused polyether urethane, with no reclaimed material incorporated into the finished disc bearing assembly, complying with Article 14.6.8.2 of the AASHTO Standard Specifications for Highway Bridges and tested according to ASTM D 2240.

D. Disc Bearing Assembly Fabrication.
Ensure the following:

1. Fabrication of all parts of the disc bearing assembly is done according to the approved shop drawings.

2. The surface of the stainless steel plates is protected from weld splatter during the welding procedure of the stainless steel plates to the backing plate,

3. PTFE sheet bonding is performed at the expansion bearing manufacturer's factory under controlled conditions and according to the written instructions of the manufacturer of the approved adhesive system.

4. The PTFE surface is smooth and free from bubbles after completion of the bonding operation.

E. Disc Bearing Assembly Shop Drawings and Documentation.
Ensure shop drawings are:

- Prepared according to the requirements of Article 2408.02.
- Certified by a Professional Engineer licensed in the State of Iowa.
- Submitted with design computations for review for conformance with the loads shown on the contract documents.

F. Disc Bearing Assembly Surface Coating.
Ensure that exposed surfaces of steel components of the disc bearing assemblies, except for the stainless steel surface and the masonry plate, are shop primed and painted according to the Standard Specifications. Ensure the masonry plate is galvanized according to ASTM A 123.

G. Disc Bearing Assembly Testing and Acceptance.

1. General.

a. Ensure each manufactured lot of disc bearing assemblies is accompanied by a manufacturer's certificate stating that the steel, neoprene elastomer, and PTFE material meet the requirements of the materials specified above. Ensure certificates show actual test results for the materials used in the manufacture of the disc bearing assemblies.

b. Acceptance of disc bearing assemblies will be based on satisfactory manufacturer's certification, acceptable test results, and inspection at the time of installation.

2. PTFE Sliding Surfaces.
The Manufacturer is to furnish facilities for and perform the testing and inspection of the completed disc bearing assemblies or representative samples in their plant or at an independent test facility according to Article 18.7.4.2 of the AASHTO Standard Specifications for Highway Bridges.

3. Disc Bearing Assemblies.

a. The Manufacturer is to supply the complete disc bearing assembly, including, but not limited to, disc bearing, sole plate, guide bars, slider plate, masonry plate, the 1/8 inch (3 mm) preformed masonry pads, and the anchor bolts.

b. The Manufacturer is to furnish facilities for the Contracting Authority or an independent agency to perform the testing and inspection of the completed disc bearing assemblies or representative samples in their plant or at an independent test facility according to Article 18.7.4.8 of the AASHTO Standard Specifications for Highway Bridges. These tests include those listed below, but do not include a long-term deterioration test (Article 18.7.2.8 of the AASHTO Standard Specifications for Highway Bridges):

- A dimensional check (Article 18.7.2.3 of the AASHTO Standard Specifications for Highway Bridges),
- A clearance test (Article 18.7.2.4 of the AASHTO Standard Specifications for Highway Bridges),

- A bearing horizontal capacity test (Article 18.7.2.9 of the AASHTO Standard Specifications for Highway Bridges), and
- A short-term compressive proof load test (Article 18.7.2.5 of the AASHTO Standard Specifications for Highway Bridges).

c. Disc bearing assemblies represented by the test specimen passing the above requirements will be approved for use in the structure, subject to on-site inspection for visible defects.

2434.03 CONSTRUCTION.

A. Packaging.

Replace disc bearing assemblies damaged during handling, transporting, or storing at no additional cost to the Contracting Authority.

B. Disc Bearing Assembly Installation.

1. The bridge bearings are not designed to accept bending stresses and must be fully supported over the entire area of the bottom and upper surfaces at all times when under load.

2. Set the bearing masonry plate to line and grade. Locate the disc bearing assemblies at the proper elevation and orient them in the proper direction. Obtain the Engineer’s approval for the location and orientation of the bridge disc bearing assembly. Locate the upper part of the disc bearing assembly relative to the base of the disc bearing assembly according to the Engineer's recommendations for the temperature at the time of erection.

3. Do not disassemble disc bearing assemblies without the Engineer’s permission.

4. Exercise care when aligning both the base and upper part of the guided expansion bearing as detailed on the contract documents; otherwise, a wedging action will occur resulting in unsought horizontal forces.

5. Avoid scratching, gouging, or otherwise marking the PTFE or mating stainless steel surfaces of the disc bearing assemblies during handling or erection. Use whatever means necessary to protect the disc bearing assemblies from dirt, grout, or other foreign materials during the construction of other elements of the structure.

6. Modifications required to meet the height of disc bearing assemblies shown in the contract documents are the responsibility of the Contractor, with no additional cost to the Contracting Authority.

2434.04 METHOD OF MEASUREMENT.

The quantity of Disc Bearing Assemblies (each) will be shown in the contract documents.

2434.05 BASIS OF PAYMENT.
Payment for Disc Bearing Assemblies completed and in place will be at the contract unit price. Payment includes the 1/8 inch (3 mm) preformed masonry pad, anchor bolts, work and materials required to drill and fill the anchor bolt holes with approved grout, surface preparation, and painting of steel surfaces as described herein

Section 2435. Sanitary and Storm Sewer Structures

2435.01 DESCRIPTION.
This section was developed in conjunction with Sections 6010 and 6030 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct sanitary and storm sewer manholes to provide access to sewer systems for maintenance and cleaning purposes.

B. Construct storm sewer intakes for collection of surface water and conveyance to the storm sewer system.

C. Modify existing manholes and intakes as necessitated by other improvements adjacent to the manholes or intakes.

D. Clean and inspect sanitary and storm sewer manholes, intakes, and other utility structures. Test sanitary sewer manholes.

2435.02 MATERIALS.
Apply Article 4149.04.

2435.03 CONSTRUCTION.

A. General Requirements for Installation of Manholes and Intakes.

1. Excavation.
Excavate according to Section 2552.

2. Subgrade Preparation.
- **a. Cut Sections (Undisturbed Soil):** Prepare subgrade to accurate elevation required to place structure base or subbase.
- **b. Fill Sections:** Compact to 95% of maximum Standard Proctor Density and hand grade to accurate elevation required to place structure base or subbase, or install stabilization material as directed by the Engineer.
- **c. Unstable Soil:** Install stabilization material as directed by the Engineer.

3. Subbase.
- **a. Cast-in-place Structures:** No subbase material is required.
- **b. Precast Structures:** If precast structure is provided, install 8 inch (200 mm) thick pad of Class I bedding material a minimum of 12 inches (300 mm) outside the footprint of the structure.

4. Installation of Manhole or Intake Structure.
Adjust wall height and depth of base, when necessary, to provide a minimum of 48 inches (1200 mm) between form grade elevation and top of base.
- **a. Cast-in-place:** Apply Article 2435.03, B.
- **b. Precast:** Apply Article 2435.03, C.

5. Pipes.
Install and bed pipes and connect to manhole or intake. Install pipe flush with inside wall of structure. Place bedding and pipe embedment material according to Section 2552.
- **a. Cast-in-place Structures.**
  - **1) Storm:** Form structure walls around pipe.
  - **2) Sanitary:** Form or core circular opening and install flexible watertight gasket according to Article 4149.04, G. Keep void between pipe and manhole section free of debris and concrete.
- **b. Precast Storm Sewer Manholes or Intakes.**
  If annular space between pipe and structure is less than 2 inches (50 mm), fill with non-shrink grout. If annular space is 2 inches (50 mm) or greater, construct a concrete collar around pipe according to Article 2435.03, E, 2.
- **c. Precast Sanitary Sewer Manholes.**
  Connect to structure with flexible watertight gasket according to Article 4149.04, G. Keep void between pipe and manhole section free of debris and concrete.
- **d. Sanitary Sewer Manholes on Existing Pipe.**
  Install waterstop according to Article 4149.04, G.

6. Joint Sealant.
- **a. Sanitary Sewer Manholes.**
  - **1)** Install rubber O-ring or profile gasket (precast structures).
  - **2)** Apply bituminous jointing material or butyl sealant wrap to exterior of all sanitary sewer manhole joints.
- **b. Storm Sewer Manholes and Intakes.**
  - **1)** Apply bituminous jointing material or install rubber rope gasket.
  - **2)** If indicated in the contract documents, apply engineering fabric wrap to joints.

7. Invert.
- **a.** Construct manhole invert up to one half of pipe diameter to produce a smooth half pipe shape between pipe inverts.
- **b.** Shape invert to provide a smooth transition between pipe inverts.
- **c.** Slope invert top toward pipe 1/2 inch per foot (40 mm per meter) perpendicular to flow line.
- **d.** For sanitary sewer, keep void between pipe and structure wall free of debris and concrete.
- **e.** For precast inverts, remove projections and repair voids to provide a hydraulically smooth channel between ends of pipes.

8. Top Sections.
Install manhole eccentric cone or flat top section or install intake top.

9. Adjustment Ring(s).
Bed each concrete ring with bituminous jointing material in trowelable or rope form. Bed each polyethylene ring with the manufacturer's approved product. Do not install more than a total ring stack height of 12 inches (300 mm). For greater adjustment, modify lower riser section(s).

10. Casting.
Install the type of casting specified in the contract documents and adjust to proper grade. Where a manhole or intake is to be in a paved area, adjust the casting to match the slope of the finished surface. When specified in the contract documents, attach a casting frame to the structure with four anchor bolts.

11. Chimney Seal.
For sanitary sewer manholes, install an internal or external rubber chimney seal.
- **a.** Do not use external chimney seal if seal will be permanently exposed to sunlight.
- **b.** Extend seal 3 inches (75 mm) below the lowest adjustment ring.
- **c.** Extend seal to 2 inches (50 mm) above the flange of the casting for a standard two piece casting, or 2 inches (50 mm) above the top of the base section of the casting for an adjustable three piece casting.
- **d.** Use multiple seals, if necessary.
- **e.** Install compression bands (external chimney seal) or expansion bands (internal chimney seal) to lock the rubber sleeve or extension into place and to provide a positive watertight seal. Once tightened, lock bands into place. Use only manufacturer recommended installation tools and sealants.

12. Backfill and Compaction.
- **a.** Place suitable backfill material according to Article 2552.02 after concrete in structure has reached at least 3000 psi (21 MPa) compressive strength or 550 psi (3850 kPa) flexural strength. If concrete strength is not determined, place backfill material at least 14 calendar days after initial concrete placement.
- **b.** Place backfill material simultaneously on all sides of walls and structures so the fill is kept at approximately the same elevation at all times.
- **c.** Compact the 3 feet (1 m) closest to all walls using pneumatic or hand tampers only. Ensure proper and uniform compaction of backfill material around structure.

B. Additional Requirements for Cast-In-Place Concrete Structures.

1. Forms.
- **a.** Apply Article 2403.03, B, 5.

b. Form all cast-in-place manholes and intakes on both the inside and the outside face above the base. Do not form against excavated earthen surface.

2. Reinforcing Steel.

a. Apply Section 2404.

b. Lap bars a minimum of 36 diameters, unless specified otherwise in the contract documents.

c. Provide a minimum of 3 inches (75 mm) of clearance for structure bases and 2 inches (50 mm) of clearance for walls and tops.

3. Concrete Mixing.

a. Apply Article 2403.02, D.

b. When using ready-mixed concrete, comply with ASTM C 94/C 94M.

4. Concrete Placing.

a. Apply Article 2403.03, C.

b. Do not place concrete when the air temperature is less than 40°F (5º C) without the approval of the Engineer. When placement below 40ºF (5ºC) is allowed, apply Article 2403.03, F.

c. Place concrete continuously in each section until complete. Do not allow more than 30 minutes to elapse between depositing adjacent layers of concrete within each section.

d. Apply Article 2403.03, D, for concrete vibration.

e. Form 1 1/2 by 3 inch (38 mm by 75 mm) keyed construction joints at locations shown in the contract documents.

f. Provide a broom finish on portions of structure that are to become part of exposed pavement.

5. Stripping and Cleaning.

a. Remove forms for manhole and intake walls and tops according to Article 2403.03, M. References to culverts include all sanitary and storm structures. When allowed by the Engineer, compressive strengths at six times the stated flexural strengths may be used in determining concrete strength of structure tops.

b. Finish surfaces according to Article 2403.03, P. Give exposed surfaces a Class 2 finish.

6. Curing.

a. Apply Article 2403.03, E.

b. For surfaces visible to the public, use only curing compounds complying with ASTM C 309, Type 1-D or Type 2.

7. Exterior Loading.

a. Restrict exterior loads on concrete according to Article 2403.03, N.

b. When allowed by the Engineer, compressive strengths at six times the stated flexural strengths may be used.

8. Repairs.
After visual inspection of the completed manhole or intake, repair honeycomb areas, visible leaks, tie holes, or other damage areas. Remove concrete webs or protrusions.

C. Additional Requirements for Precast Concrete Structures.

1. Substitutions.
Precast structures may be substituted for designated cast-in-place structures so long as structure is constructed as specified in the contract documents and according to Article 2435.03, B.

2. Cast-in-place Base.
- **a.** Apply Article 2435.03, B, for placement of concrete.
- **b.** Ensure proper vertical and horizontal alignment of base riser section.

3. Precast Base or Base with Integral Riser Section.
Place base or base with integral riser section and ensure proper vertical and horizontal alignment.

4. Additional Riser Sections.
Install additional riser sections as required.

5. Lift Holes.
Install rubber plug in lift holes. Cover plug and hole with non-shrink grout.

D. Adjustment of Existing Manhole or Intake.

1. Casting Extension Rings.
- **a.** Only install casting extension rings when allowed by the contract documents, and only in conjunction with pavement overlays.
- **b.** Install according to the manufacturer's recommendation and adjust for proper alignment.

2. Minor Adjustment (Adding or Removing Adjustment Rings).
- **a.** Remove casting.
- **b.** Modify adjustment ring stack height by one of the following methods:
  - **1)** Add adjustment rings as necessary to adjust existing manhole or intake to finished pavement grade or finished topsoil grade, to a maximum ring stack height of 16 inches (400 mm). Bed each concrete ring with bituminous jointing material. Bed each polyethylene ring with manufacturer's approved product.
  - **2)** Remove one or more adjustment rings, as appropriate, to reduce casting elevation.
- **c.** Install new casting on modified adjustment ring stack. Existing casting may be reinstalled when specified in the contract documents.

d. Replace chimney seal for sanitary sewer manhole using only new materials.

3. Major Adjustment (Adding, Removing, or Modifying Riser or Cone Section).

When adjustment is greater than can be accomplished through adding or removing adjustment rings, a major adjustment will be required.

a. Remove casting.
b. Remove top.
c. Remove and replace or modify existing riser section and/or top section, as appropriate.
d. Install new frame and cover or grate. Existing casting may be reinstalled when allowed by the contract documents.
e. Replace chimney seal for sanitary sewer manhole using only new materials.

E. Connection to Existing Manhole or Intake.

1. General.

a. Remove invert as necessary to install pipe at required elevation and develop hydraulic channel.
b. Insert pipe into structure and trim end flush with inside wall of structure.
c. Place backfill material according to Section 2552.

2. Concrete Collar.

a. For new pipes 12 inches (300 mm) or smaller, install two No. 4 (No. 15) steel reinforcing hoops in collar around pipe. Pour concrete collar around pipe/structure junction to a minimum thickness and width of 6 inches (150 mm), providing a minimum 4 inches (100 mm) of concrete extending beyond pipe opening.
b. For new pipes larger than 12 inches (300 mm), install two No. 4 (No. 15) steel reinforcing hoops in collar around pipe. Pour concrete collar around pipe/structure junction to a minimum thickness and width of 9 inches (230 mm), providing a minimum 4 inches (100 mm) of concrete extending beyond pipe opening.

3. Sanitary Sewer.

a. General.

1) Core openings in existing manholes unless specified otherwise in the contract documents.
2) Divert flow as necessary. Obtain approval of the diversion plan from the Engineer. Maintain sanitary sewer service at all times unless specified otherwise in the contract documents.

b. Cored Opening.

1) Insert flexible watertight connector into new opening.
2) Install and tighten internal expansion sleeve to hold flexible connector in place.

3) Insert pipe through flexible connector and tighten external compression ring.
4) Do not install grout or concrete collar for cored opening with flexible connector.

c. Cut and Chipped Opening (Knockout).
1) Saw opening to approximate dimensions with a masonry saw. Saw to depth sufficient to sever reinforcing steel.
2) Remove concrete and expand opening to a diameter at least 6 inches (150 mm) larger than the outside diameter of the new pipe.
3) Cut off all reinforcing steel protruding from the structure wall.
4) Install waterstop around new pipe centered within structure wall.
5) Fill opening between structure and pipe with non-shrink grout.
6) Construct concrete collar around pipe and exterior manhole opening.
7) Provide pipe joint, non-shear coupling, or other approved flexible coupling within 2 feet (600 mm) of structure wall to allow for differential settlement between the new sewer and the structure.

4. Storm Sewer.
a. Cut opening to manhole or intake to 3 to 6 inches (75 to 150 mm) beyond the outside of the pipe.
b. Fill opening between manhole or intake wall and outside of pipe with non-shrink grout or construct a concrete collar around the pipe according to Article 2435.03, E, 2.

F. Cleaning, Inspection, and Testing of Structures.

1. Cleaning.
a. Clean all manholes, intakes, and structures by removing sheeting, bracing, shoring, forms, soil sediment, concrete waste, and other debris.
b. Do not discharge soil sediment or debris to drainage channels, existing storm sewer, or existing sanitary sewer system.

2. Visual Inspection.
a. Examine structure for:
1) Damage.
2) Slipped forms.
3) Indication of displacement of reinforcement.
4) Porous areas or voids.
5) Proper placement of seals, gaskets, and embedments.
b. Verify that the structure is set to true line, grade, and plumb.
c. Verify structure dimensions and thicknesses.

3. Repair.
Apply Article 2435.03, B, 8.

4. Sanitary Sewer Manhole Testing.

a. General.

1) Use vacuum testing for new sanitary sewer manholes unless exfiltration testing is specified in the contract documents.

2) Conduct final test after manhole construction is complete, all repairs and connections have been made, and invert has been installed.

b. Vacuum Test.

1) Applicable only for new manholes isolated from connecting sewer lines.

2) Use manufactured vacuum test equipment meeting the Engineer's approval. Follow the equipment manufacturer's recommended procedures throughout.

3) Use extreme care and follow safety precautions during testing operations. Keep personnel clear of manholes during testing.

4) Seal all openings except manhole top access using pneumatic plugs rated for test pressures. Install plugs according to the test equipment manufacturer's recommendations.

5) Brace pipe inverts if backfill material has not been placed around connecting pipes.

6) Install the vacuum tester head assembly on the manhole top access, and inflate the seal.

7) Evacuate the manhole to 5 psi (35 kPa). Close the isolation valve and start the test. Record the starting time.

8) Maintain vacuum in the manhole for the time indicated in Table 2435.03-1 below for the diameter and depth of manhole being tested.

9) Test failure is indicated by vacuum loss greater than 0.5 psi (4 kPa) within the minimum test time indicated in Table 2435.03-1 below for the depth and diameter of the manhole being tested.

Table 2435.03-1: Minimum Vacuum Test Times for Various Manhole Diameters

Depth feet (m)	Diameter inches (mm)				
	48 (1200)	54 (1350)	60 (1500)	66 (1650)	72 (1825)
	Time, Seconds				
8 (2.45)	20	23	26	29	33
10 (3.28)	25	29	33	36	41
12 (3.66)	30	35	39	43	49
14 (4.27)	35	41	46	51	57
16 (4.88)	40	46	52	58	67
18 (5.49)	45	52	59	65	73
20 (6.10)	50	53	65	72	81
22 (6.71)	55	64	72	79	89
24 (7.32)	59	64	78	87	97
26 (7.93)	64	75	85	94	105
28 (8.54)	69	81	91	101	113
30 (9.15)	74	87	98	108	121

c. Exfiltration Test.

1) Applicable to new manholes (when specified in the contract documents) or rehabilitated manholes.

2) Testing may be performed in conjunction with sanitary sewer line testing. Apply Section 2504.

3) Do not test by this method if water may potentially freeze during the test.

4) Plug the manhole inlet and outlet.

5) Fill the manhole with water to 2 feet (600 mm) above the outside top of the connecting pipe. If groundwater is present, fill the manhole to no less than 2 feet (600 mm) nor more than 5 feet (1.5 meters) above the groundwater level. Do not fill above the top of the standard barrel sections.

6) Mark the water level.

7) Allow water to stand in the manhole for 1 hour, then refill to the original water level and begin the test.

8) Determine the allowable drop in water level by using the equation given in Article 2504.03, L, 4, b, 3, c. After 1 hour, measure the drop in water level.

9) Test failure is indicated by water loss greater than maximum allowable calculated exfiltration.

5. Test Failure.

If testing fails, reseal the openings, repair the manhole, and retest. An alternate test method complying with these specifications may be used for a retest if desired.

2435.04 METHOD OF MEASUREMENT.

A. Manhole.
Each type and size of manhole will be counted.

B. Intake.
Each type and size of intake will be counted.

C. Drop Connection.
Each drop connection will be counted.

D. Casting Extension Rings.
Each casting extension ring will be counted.

E. Manhole or Intake Adjustment, Minor.
Each existing manhole or intake adjusted to finished grade by addition or removal of adjustment rings or adjustment of adjustable casting will be counted.

F. Manhole or Intake Adjustment, Major.
Each existing manhole or intake adjusted to grade by addition or removal of riser, cone or flat top sections, or the exchange of existing riser sections with sections having different vertical dimensions will be counted.

G. Connection to Existing Manhole or Intake.
Each connection made to an existing manhole or intake will be counted.

H. Cleaning, Inspection, and Testing.
None.

2435.05 BASIS OF PAYMENT.

A. Manhole.

1. Payment will be at the contract unit price for each type and size of manhole.

2. Payment is full compensation for excavation, placing bedding and backfill material, compaction, base, structural concrete, reinforcing steel, precast units (if used), inverts, pipe connections, chimney seals, castings, and adjustment rings.

B. Intake.

1. Payment will be at the contract unit price for each type and size of intake.

2. Payment is full compensation for excavation, placing bedding and backfill material, compaction, base, structural concrete, reinforcing steel,

precast units (if used), inverts, pipe connections, castings, and adjustment rings.

C. Drop Connection.

1. Payment will be at the contract unit price for each drop connection.

2. Payment is full compensation for the connection to the manhole and all pipe, fittings, concrete encasement, and bedding and backfill material.

D. Casting Extension Rings.
Payment will be at the unit price for each casting extension ring.

E. Manhole or Intake Adjustment, Minor.

1. Payment will be made at the contract unit price for each minor manhole or intake adjustment.

2. Payment is full compensation for:
- Removing existing casting and existing adjustment rings,
- Furnishing and installing adjustment rings,
- Furnishing and installing new casting, and
- Installing new chimney seal (sanitary sewer manholes only).

F. Manhole or Intake Adjustment, Major.

1. Payment will be at the contract unit price for each major adjustment.

2. Payment is full compensation for:
- Removal of existing casting, adjustment rings, top sections and risers,
- Excavation,
- Concrete and reinforcing steel or precast sections,
- Furnishing and installing new casting
- Installing new chimney seal (sanitary sewer manholes only),
- Placing backfill material, and
- Compaction.

G. Connection to Existing Manhole or Intake.

1. Payment will be made at the contract unit price for each sewer connection.

2. Payment is full compensation for coring into the existing manhole or intake, pipe connections, grout, and waterstop (when required).

H. Cleaning, Inspection, and Testing.
Cleaning, inspection, and testing of structures are incidental to construction of structures and will not be paid for separately.

DIVISION 25. MISCELLANEOUS CONSTRUCTION

This work consists of various types according to the requirements of the sections listed below. Comply with the lines, grades, and dimensions shown in the contract documents or established by the Engineer.

2501. Piles and Pile Driving.
2502. Subdrains.
2503. Storm Sewers.
2504. Sanitary Sewers.
2505. Guardrail Construction and Removal.
2506. Flowable Mortar.
2507. Concrete and Stone Revetment.
2508. Removal of Paint and Painting Steel Bridge Structures.
2509. Cleaning, Surface Preparation, and Painting of Galvanized Surfaces.
2510. Removal of Pavement.
2511. Removal and Construction of Sidewalks and Recreational Trails.
2512. Portland Cement Concrete Curb and Gutter.
2513. Concrete Barrier.
2514. Curb Removal.
2515. Removal and Construction of Paved Driveways.
2516. Combined Concrete Sidewalk and Retaining Wall.
2517. Railroad Approach Sections.
2518. Safety Closure.
2519. Fence Construction.
2520. Field Laboratory and Field Office.
2521. Certified Plant Inspection.
2522. Tower Lighting.
2523. Highway Lighting.
2524. Highway Signing.
2525. Traffic Signalization.
2526. Construction Survey.
2527. Pavement Marking.
2528. Traffic Control.
2529. Full Depth Finish Patches.
2530. Partial Depth Finish Patches.
2531. Pavement Surface Repair (Milling).
2532. Pavement Surface Repair (Diamond Grinding).
2533. Mobilization.
2534. Delivery of Samples.
2535. Bin Type Crib Walls.
2536. Asbestos Removal.
2537. Underground Tank System Removal and Petroleum Contaminated Soil Remediation.
2538. Salvage, Removal, and Disposal of Obstructions.
2539. Concrete Pavement Undersealing by Pressure Grouting.
2540. Longitudinal Joint Repair.
2541. Crack and Joint Cleaning and Sealing (HMA Surfaces).
2542. Crack and Joint Cleaning and Sealing (Portland Cement Concrete Pavement).
2543. Transverse Joint Repair for HMA Pavements.

2544. Cleaning and Filling Cracks for HMA Surfaces.
2545. Overlay of Type "B" Guide Signs.
2546. Gabions and Revet Mattresses.
2547. Temporary Stream Access.
2548. Milled Shoulder Rumble Strips - HMA or PCC Surface.
2549. Pipe and Manhole Rehabilitation.
2550. Night Work Lighting.
2551. Crash Cushions.
2552. Trench Excavation and Backfill.
2553. Trenchless Construction.
2554. Water Mains, Valves, Fire Hydrants, and Appurtenances.
2555. Deliver and Stockpile Salvaged Materials.

Section 2501. Piles and Pile Driving

2501.01 DESCRIPTION.

A. Furnish and place piles for foundations, trestles, and other exposed work.

B. Furnish and place piling for falsework according to Article 2403.03, L.

2501.02 MATERIALS.

Use piles that comply with the following requirements for the class of pile specified:

A. Untreated Timber Piles: apply Article 4165.03.

B. Treated Timber Foundation Piles: apply Article 4165.04.

C. Treated Timber Trestle Piles: apply Article 4165.05.

D. Concrete Piles: apply Section 4166.

E. Steel Pipe Piles: apply Section 4167.

F. Steel H-Piles: apply Section 4167.

G. Concrete Sheet Piles: apply Section 4166.

H. Steel Sheet Piles: apply Section 4167.

2501.03 CONSTRUCTION.

A. Pile Driving Equipment.
The hammer used for driving piles may be of gravity, steam, air, or diesel type. Use pile driving equipment that complies with the following provisions:

1. Gravity Hammers.
a. When gravity hammers are permitted, use a ram that weighs (has a mass) between 3000 pounds (1350 kg) and 6000 pounds (2750 kg) with a height of drop not exceeding 10 feet (3 m).

b. Equip gravity hammers with hammer guides to ensure concentric impact on the pile cap. Use hammer guides that have some method for visually determining the drop height during driving.

c. For all gravity hammers, apply Article 2501.03, A, 10, of this article.

2. Single or Double Acting Air and Steam Hammers.

a. Use equipment with sufficient capacity to maintain the hammer operation under working conditions as recommended by the manufacturer.

b. Use equipment with accurate pressure gages which are easily accessible to the Engineer.

c. Steam hammers may be air operated if the capacity and pressure of the compressor comply with recommendations of the hammer manufacturer.

d. Ensure the weight (mass) of the striking parts of air and steam hammers is no less than 33% of the combined weight (mass) of the pile cap and pile being driven. In no case allow the striking parts to have a weight (mass) less than 2750 pounds (1250 kg).

3. Diesel Hammers.

For all diesel hammers, apply Article 2501.03, A, 10, of this article.

a. Open End (Single Acting) Diesel Hammers.

1) Equip with a method to visually determine drop height during driving. Examples of measurement devices are as follows:

- A graduated scale (jump stick) extending above the ram cylinder.
- Graduated rings or grooves on the ram.
- An electronic, sound activated, remote measuring instrument.

2) Provide the Engineer with the manufacturer's chart equating stroke to blows per minute for the open end diesel hammer used.

b. Closed End (Double Acting) Diesel Hammers.

1) Equip with an accurate bounce chamber pressure gage mounted in a manner to enable easy access for the Engineer.

2) Provide the Engineer with a current, calibrated chart equating bounce chamber pressure and gage hose length to either equivalent energy or stroke for the hammer being used.

4. Driving Aids.

a. Do not use vibratory hammers, hydraulic hammers, or driving aids such as jets, followers, and prebored holes unless stated in the contract documents or authorized in writing by the Engineer. When permitted, vibratory hammers and hydraulic hammers may be used for installing production piles only after the pile tip elevation is established by load test or by test piles driven with an approved hammer. As condition for approval, perform (at no additional cost to the Contracting Authority) load tests and extra work required to drive test piles as determined by the Engineer.

b. Control production pile installation with vibratory hammers according to power consumption, rate of penetration, specified tip

elevation, or other means acceptable to the Engineer. Assure the pile capacity equals or exceeds the design bearing. Use an approved hammer to retap piles driven to full penetration with a vibratory hammer. Bearing will be determined by an applicable wave equation analysis.

5. Hammer Cushion.

a. Equip all impact pile driving equipment with suitable thickness hammer cushion material to prevent damage to the hammer or pile. In the Engineer's presence, inspect the hammer cushion for condition, composition, and thickness before beginning pile driving at each structure, and regularly during driving.

b. For hammers with internal cushions, check the cushion regularly at 100 hour intervals during driving. Use the hammer manufacturer's recommended beginning cushion thickness and composition. Report this information to the Engineer prior to driving. Replace the hammer cushion when it has less than 70% of the recommended thickness, has burned, or has been broomed.

6. Pile Cushion.

a. Protect the head of all concrete piling with a suitable pile cushion. When requested, provide the pile cushion composition and thickness to the Engineer. Determine the minimum thickness by the wave equation.

b. If alternate pile driving control methods are used, use a minimum thickness of 6 inches (150 mm) of suitable wood.

c. In the Engineer's presence, inspect the pile cushion for condition, composition, and thickness before beginning pile driving at each structure, and regularly during driving. Replace any pile cushion when it has less than 70% of the original reported thickness, has burned, or has been broomed.

7. Pile Driving Cap.

a. Piles driven with impact hammers require an adequate cap to distribute the hammer blow evenly to the top of the pile. Align the cap axially with the hammer and the pile. Guide with leads. Use an appropriate cap for the type and size of pile. Ensure it fits around the top of the pile so that the driving unit is centered during driving.

b. For special types of piles, provide appropriate driving caps, mandrels, or other devices according to the manufacturer's recommendations so that the piles may be driven without damage.

c. Cut all pile tops squarely to ensure proper fit of the driving cap.

8. Followers.

Use followers only with the Engineer's authorization.

9. Water Jets.

Use water jets only with the Engineer's authorization. When jets are used, ensure the size, number, and location of jets, as well as the volume and pressure of water at the jet nozzles, is sufficient to freely erode material from under and adjacent to the pile.

10. Approval of Pile Driving Equipment.

a. On each project, the Engineer's approval is required for all pile driving equipment. Size all pile driving equipment so that the piles can be driven with reasonable effort to the required lengths without damage.

b. Pile driving equipment approval on Interstate and Primary projects will be based on the wave equation analysis. For other projects, the alternate approval method will be used unless specified otherwise.

1) Wave Equation Analysis.

a) For wave equation approval, submit to the Engineer the required data forms detailing equipment to be used on the project. Submit this information to the Engineer at least 20 calendar days prior to driving piles.

b) The Contractor will be notified of the acceptance or rejection of the driving system within 12 calendar days of the Engineer's receipt of the data forms. Modify or replace the proposed methods or equipment (at no additional cost to the Contracting Authority) if the wave equation analysis:

- Indicates pile damage could occur, or
- The pile could not be driven to the required bearing.

c) Ensure the subsequent driving system results in wave equation analysis indicating the piles can be reasonably driven to the desired capacity without damage. The Engineer will notify the Contractor of the acceptance or rejection of the revised driving system within 9 calendar days of receipt of a revised data form or method plan.

d) Equipment meeting the values in Tables 2501.03-1 and 2501.03-2 in the Appendix will be acceptable for wave equation analysis.

2) Alternate Approval Method.

Use the tabulated energy values in Tables 2501.03-1 and 2501.03-2, in the Appendix, as a basis for approval of pile driving equipment for the alternate approval method. Approval will be based on meeting all requirements of this article. This approval does not relieve the Contractor of the basic obligation to provide equipment suitable for driving the specified pile to the required bearing without damage.

11. Pile Driving Equipment.

a. Use an approved system or placement method. Variations in the driving system will not be permitted without the Engineer's approval. If the hammer performance deviates from the manufacturer's recommended specifications, take immediate corrective action. The Engineer will not allow driving to continue until the system is performing to the manufacturer's specifications.

b. Changes in the driving system will be considered after the Contractor has submitted the required data for review. The Contractor will be notified of the acceptance or rejection of the driving system changes within 9 calendar days of the Engineer's receipt of the requested change. Time required for submission,

review, and approval of a revised driving system does not constitute the basis for a contract time extension.

B. Determination of Pile Lengths.

1. When pile length is not specified, the Engineer will determine the length from the results obtained under the procedure specified in the contract documents. Wood pile lengths will be in multiples of:
- 2 feet (0.5 m) for lengths of 20 feet (6 m) and less, and
- 5 feet (1.5 m) for lengths over 20 feet (6 m).

2. Steel H-piles and steel pipe piles will be in multiples of 5 feet (1.5 m). Precast concrete piles may be specified in any length of whole feet (to the nearest 0.5 m).

C. Test Piles.

1. When the contract documents specify that the lengths of piles are to be determined from results of driving test piles, furnish and drive piles:
- Of lengths designated in the contract documents or by the Engineer, and
- In locations designated in the contract documents or by the Engineer.

2. Determine the load carrying capacity of test piles as provided in Article 2501.03, M. Drive these test piles with the same or comparable type of equipment as that which is to be used for driving other piles for the structure. The Contractor may be required to excavate the test pile area to the proposed footing elevation before driving the test pile. Within 10 calendar days, the Engineer will determine the length of piles to be furnished by considering the results of the test pile.

D. Concrete Piles.

1. Use concrete bearing piles of the form and dimensions specified in the contract documents. Place as indicated in the contract documents.

2. Piles may be driven when the concrete compressive strength has reached a minimum of 5,000 psi (35 MPa), but no less than 7 calendar days after casting.

E. Steel Pipe Piles.
Construct steel pipe piles by first driving steel pipe of the specified type and size in the locations specified in the contract documents, and then filling the pipe with concrete. Construct the piles according to the following additional requirements:

1. Inspection.
a. Furnish a light suitable for visual interior inspection of driven pipe piles. This inspection will be conducted before cut off and filling is allowed.

b. Remove and replace, or otherwise correct as directed by the Engineer, all piles which have been improperly driven, broken, or are otherwise defective.

c. Ensure the interior of the pile is clean and free of water at the time of inspection.

2. Cut Off.

Upon completion of driving, inspection, and approval, neatly cut the pile on a horizontal plane at the elevation specified in the contract documents.

3. Filling.

a. After the piles have been cut off, remove water piles.

b. After reinforcement has been accurately placed, fill pile completely with Class C structural concrete meeting requirements of Section 2403. Ensure pile is free of accumulated water at the time concrete is placed.

c. In order to avoid formation of air pockets, place the concrete:

- Using vibratory methods as specified in Article 2403.03, D or
- In small charges of not over 2 cubic feet (0.05 m^3) each.

4. Painting.

After the piles have been filled with concrete, clean the exposed sections using hand methods. Paint with three coats of paint from the cap to the low water elevation or 2 feet (0.5 m) below finished ground line according to the provisions of Section 2508. Apply all three coats of paint in the field.

F. Steel H-Piles.

1. Use steel H-piles of the cross section, size, and weight per foot (mass per meter) specified in the contract documents. The contract documents may allow an option of pipe piles in place of steel H-piles. Pipe piles are also described in Section 4167.

2. When driving is complete, cut the pile off neatly at the elevation specified. The contract documents may require encasement of steel H-piles. The Contractor may increase the diameter of encasements with no additional payment. Limit the increase to 4 inches (100 mm) or less. For a structure, use encasements all of the same diameter. Clean steel H-piles that are exposed to the atmosphere in the finished structure. Paint these piles with three coats of paint as specified in Section 2508.

3. Limit the number of permitted welds used to develop plan specified lengths of steel H-piles to those in Table 2501.03-3:

Table 2501.03-3: Number of Permitted Welds.

Plan Pile Length, feet (m)	Number of Permitted Welds (splices)
0 - 50 (0-15.0)	0
51-100 (15.1-30)	1
101-150 (30.1-45.0)	2

4. Welds (splices) in excess of the number specified above will not be permitted unless required for a pile extension. When steel H-piles are to be spliced, make the last added length the shortest pile length.

G. Steel Sheet Piles.

1. For steel sheet piles that will become a part of a finished structure, use an interlocking type with a:
- Web thickness no less than 3/8 inch (9 mm),
- Section modulus no less than that specified in the contract document.

2. Use an interlock approved by the Engineer.

3. Put used sheet piles in proper condition before redriving.

4. Where steel sheet piles will receive a concrete cap, cut them off neatly in straight lines at the required elevations after driving. Adapt the details at angles in sheet pile walls to the type of pile used. Obtain the Engineer's approval.

5. Steel sheet piles need not be painted unless specified.

H. Foundation Piles.

1. The term "foundation piles" means all piles, whether of wood, concrete, or steel, which support superimposed loads and have no part of their length exposed above ground line.

2. Except as provided otherwise in the contract documents, complete excavation before driving foundation piles. After driving is completed, remove all loose and displaced material forced up during driving from around the piles, leaving a firm surface to receive the footing concrete.

3. After piles have been driven, cut the tops to the plane indicated at the required elevation. Remove all crushed or broomed wood, broken concrete, or deformed steel. Paint the tops of treated wood piles with two coats of treatment material meeting the requirements of Section 4160. Inspect steel pipe piles for damage according to Article 2501.03, E.

I. Trestle Piles.

1. The term "trestle piles" means all piles, whether of wood, steel, or concrete, which support superimposed loads, but will be exposed above the ground level for a part of their length. Bents around which fills may later be constructed are considered trestle piles.

2. Drive wood and steel piles with an accuracy that will permit them to be capped as shown in the contract documents, with only such springing and bending that will not damage the pile. If, in the Engineer's judgment, a pile has been deformed or cracked by springing after being driven, replace it. Perform all springing prior to placing the cap.

3. Drive concrete piles to stand without springing within 4 inches (100 mm) of the intended location, and in no case closer than 3 inches (75 mm), to the faces of the caps as shown in the contract documents. In case it is necessary to move a concrete pile after driving to secure the above accuracy, move it by loosening the soil surrounding the pile with jets until it can be moved and can stand without strain in the correct position. After being moved, drive the pile a sufficient amount to assure the specified minimum bearing value.

4. Cut trestle piles off to be level or at the designed slope at the elevation of cut-off shown in the contract documents. Ensure the length of pile above this elevation is sufficient to permit complete removal of all material damaged by driving.

5. In treated wood piles, apply two coats of an approved treatment material meeting requirements of Section 4160 to all bolt holes, cuts, daps, or chamfers made subsequent to treatment, as well as all abrasions of the surface and the tops of piles after cut-offs. When the tops of treated piles are not to be encased in concrete, protect them as specified in Article 2409.03, D.

J. Preparation of Wood Piles for Driving.
Prepare all wood piles for driving according to the following:

1. Preparation of Pile Heads.
Trim the pile head accurately to make a driving fit into the driving cap. If the head of the pile becomes broomed or crushed before driving is completed, trim off the broomed fibers to provide sound wood accurately fitting the driving cap.

2. Preparation of Pile Points.
Cut the lower end of a pile square. If directed by the Engineer, shape it to a point no less than 4 inches by 4 inches (100 mm by 100 mm). Form the tapered point concentric to the center line of the pile.

K. Protection of Concrete Piles during Driving.
Protect the tops of all concrete bearing and sheet piles from damage by the impact of the hammer. Design, maintain, and use this protection to cause

the minimum absorption of energy consistent with adequate protection of the top of the pile.

L. Accuracy in Placing and Driving Piles.

1. In spotting the points of piles in preparation for driving, use care to locate them as shown in the contract documents or as directed by the Engineer. Limit the deviation from such designated locations to 3 inches (75 mm) or less at the time driving is begun, except as may be made necessary by the presence of unavoidable obstructions.

2. While being driven, hold piles so they deviate the minimum possible amount from the vertical or batter line shown in the contract documents. Firmly and securely hold in place in proper position the leads used in driving piles to assure driving the pile in the line required.

3. Suspend pile driving during and for 12 hours following concrete placement that is within 50 feet (15 m) of the pile driving operation.

M. Determination of Bearing Value of Piles.
When load tests are not specified in the contract documents or are not directed by the Engineer, determine the bearing value of piles determined using one of the following methods:

1. Wave Equation Analysis.
- **a.** Wave equation analysis will be used on all Interstate and Primary projects, on other projects when specified in the contract documents, or as directed by the Engineer.
- **b.** Drive piles to full penetration using approved driving equipment.
- **c.** Retaps or pile extensions may be necessary to obtain the required pile bearing capacity, including potential adjustments for scour or downdrag conditions.
- **d.** Do not continue driving beyond a depth at which acceptable pile stress is exceeded. With the Engineer's approval, driving may be stopped when the rate of driving exceeds 160 blows per foot (0.3 m).

2. Bearing Determinations by Formula.
- **a.** When wave equation analysis is not required, compute the bearing value of piles using the following formulas:

For Gravity Hammers with Wood, Steel H, or Steel Pipe Piles:

English

$$P = \frac{3WH}{S+0.35} \times \frac{W}{W+M}$$

Metric

$$P = \frac{2.5WH}{S+8.9} \times \frac{W}{W+M}$$

For Gravity Hammers with Concrete Piles:

English

$$P = \frac{4.5WH}{S+0.2} \times \frac{W}{W+M}$$

Metric

$$P = \frac{3.7WH}{S+5.1} \times \frac{W}{W+M}$$

Set the height of fall to no less than 5 feet (1.5 m) or more than 8 feet (3 m), and the rate of driving to no less than 8 blows per minute.

Diesel Hammers with Wood, Steel H, or Steel Pipe Piles and (Construction) Steam Hammers for all Piles:

English

$$P = \frac{3E}{S+0.1} \times \frac{W}{W+M}$$

Metric

$$P = \frac{0.25E}{S+2.5} \times \frac{W}{W+M}$$

Diesel Hammers with Concrete Piles:

English

$$P = \frac{7E}{S+0.1} \times \frac{W}{W+M}$$

Metric

$$P = \frac{0.58E}{S+2.5} \times \frac{W}{W+M}$$

Where, for the above equations:

P = The bearing value in tons (kN),

W = The weight (mass) of the gravity hammer, or the ram of an air hammer or diesel hammer in tons (kilograms),

H = The height of free fall of the hammer or ram in feet (meters),

M = The weight (mass) in tons (kilograms) of the pile plus the weight (mass) in tons (kilograms) of the cap plus (for diesel hammers) the weight (mass) of the anvil in tons (kilograms),

E = The energy per blow in foot-tons (joules) (for single acting steam hammers E = W x H (E = 9.81 x W x H)),

S = The average penetration in inches (millimeters) of the pile per blow for the last 5 blows for gravity hammers and the last 10 blows for air or diesel hammers.

b. Apply the following conditions in the use of the above formulas:

1) Unless the hammer has free fall, substitute a value for "W" that is less than the weight (mass) of the hammer by an amount sufficient to compensate for all friction and drag tending to retard its fall.

2) With approval from the Engineer, driving may be stopped when the rate of driving exceeds 160 blows per foot (0.3 m).

3) There is no excessive bounce to the hammer after the blow.

4) For the computation of the bearing value for battered piles driven with gravity hammers, multiply the value obtained from the formulas by the following factor:

(Cosine a) minus (f sine a), where "a" equals the angle the leads make with the vertical and "f" equals the coefficient of friction between the hammer or ram and the surface on which it slides. For gravity hammers sliding on greased steel surfaced leads, assume the value of "f" to be 0.1.

c. The Engineer may modify the above formulas on the basis of load tests. At the Engineer's discretion, the Wave Equation Analysis may be used to evaluate the driving system, as well as determine pile bearing.

3. Static Load Test.

a. When directed by the Engineer, bearing value of piles will be determined by actual load test in which the entire load is applied concentric with the pile.

b. Careful measurements will be made to determine the amount and rate of settlement.

c. Gages reading in thousandths of an inch (0.001 µm) will be used to determine the settlement.

d. The designated test pile(s) shall stand, after being driven, at least 40 hours before the test load may be applied.

e. This method is outlined in Section 5.6 and 6.4 of ASTM D 1143. The procedure in ASTM D 1143 will be followed except as modified below:

1) Apply the test load in increments of 10% of the proposed design load.

2) Apply the load at 2.5 minute intervals. Record readings of time, load, and settlement immediately before and after the application of each load. The test is to continue by adding load increments until continuous jacking is required to maintain the test load (i.e., failure by settlement), or the load limit of the jacking equipment is reached.

3) When the maximum load has been applied, take pile settlement readings immediately, and at 2.5 minutes and 5 minutes, after jacking has ceased. Remove the test load and immediately record pile rebound readings. Take additional rebound readings 2.5 minutes and 5 minutes later.

4) Use the data obtained to plot a load (tons (kilonewtons) versus settlement in inches (millimeters)) curve.

f. The failure load is defined as the intersection between the tangent of the linear portion of the load settlement curve and a line with a slope of 0.05 inches per ton (0.14 mm/kN) from the yield point.

g. The yield point is defined as the intersection between the load settlement curve and a line which is parallel to the linear portion of the load settlement curve at 0.25 inches (6 mm) of settlement.

h. The safe bearing value will be 50% of the load at the failure point.

4. Dynamic Pile Analyzer Tests.

a. The Engineer will take dynamic measurements during the driving of piles designated as dynamic load test piles, or as directed by the Engineer. Instruments for dynamic analysis will be:

- Attached near the top of the pile with bolts placed in approved masonry anchors, or
- Bolted through drilled holes in the web of steel piles, or
- Bolted with wood lag screws for timber piles.

b. The Engineer will furnish the instruments, material, and labor necessary for drilling the holes and mounting the instruments.

c. When specified in the contract documents, or ordered by the Engineer, furnish a shelter to protect the dynamic test equipment from the elements. Maintain the inside temperature of the shelter above 45°F (7°C). Locate the shelter within 100 feet (30 m) of the test location.

d. Pretest, Pile Calibration.

1) Predriving wave speed measurements will be required for concrete or wood piles. Make each designated pile available for this measurement prior to placement of the pile in the leads.

2) When predriving wave speed measurements are required, block the piling up off the ground in a horizontal position and locate it to not contact other piling. Predriving wave speed measurements will not be required for steel piles.

e. Prior to Driving.

1) Prior to placing the designated pile in the leads, provide access to the pile and allow the Engineer time to predrill instrument mounting holes or conduct predriving wave speed measurements, or both, if required.

2) When the designated test pile is placed in the leads and is ready to drive, provide the Engineer reasonable access to the pile for testing purposes.

3) Attach the instruments and associated test cables to the top of the pile as directed by the Engineer, unless there is an acceptable personnel platform (minimum size of 4 feet x 4 feet (1.2 m x 1.2 m) designed to be raised to the top of the pile) provided for the Engineer.

4) Allow time to attach or reattach and check the instruments as needed before beginning to drive.

f. Driving.

1) Drive the designated pile to at least the depth at which the dynamic test equipment indicates that the capacity shown in the contract documents has been achieved, unless the Engineer directs otherwise. The stresses in the pile will be monitored during driving with the dynamic test equipment to ensure that damage, as determined by the Engineer, does not occur.

2) If an over-stress condition is indicated, the Engineer will suspend driving and determine if plan capacity has been achieved. If necessary, in order to maintain monitored stresses below the accepted values, reduce the driving energy transmitted to the pile by:

- Using additional cushion thickness,
- Reducing the energy output of the hammer, or
- Changing hammers.

3) If nonaxial driving is indicated by the dynamic test equipment measurements, immediately realign the driving system.

4) When the Engineer orders, wait a minimum of 24 hours and retap the dynamic load test pile after the instruments are reattached. Do not use a cold hammer for the retap. Warm up the hammer before the retap by applying at least 20 blows to another pile. The maximum amount of penetration required during a retap is 6 inches (150 mm). After retapping, the Engineer will determine if desired bearing has been achieved or if additional pile penetration is required.

5. Retaps.

a. When piles do not achieve the specified driving resistance during driving, the Engineer may require one retap per 10 piles or a minimum of 2 piles in each foundation at no additional cost to the Contracting Authority. Only piles with the lowest driving resistance will be considered for retap.

b. Perform the retap by allowing the pile to set up for 24 hours, or as directed by the Engineer.

c. Warm up hammers (other than gravity) by applying a minimum of 20 blows to another pile before the retap driving begins. Take the bearing for the retap within the first 6 inches (150 mm) of penetration.

d. The first two blows of a retap are for seating the cap and assuring proper operation of the hammer. Do not use the first two blows as part of bearing evaluation.

e. Measure the penetration of the next ten blows, or record the number of blows it takes to drive the pile 6 inches (150 mm). Correct to the appropriate measurement and check for bearing.

1) If bearing is achieved, driving may be halted. However, if the Engineer approves, driving may be continued to cut-off as long as acceptable pile stress is not exceeded.

2) If penetration is less than 1 inch (25 mm) for the first ten blows, discontinue driving. Record the bearing as refusal.

f. Have the Engineer evaluate piles not achieving the specified driven resistance after a retap and, if so ordered, extend as required following the procedures of Article 2501.03, P.

N. Bearing Required.

Unless modified by the Engineer, drive all piles to the design bearing specified in the contract documents. Ensure the specified design bearing is obtained below scour elevation for substructure subject to scour.

O. Penetration.

1. Unless provided otherwise in the contract documents, drive all piles until the design bearing, determined as provided in Article 2501.03, M, is at least equal to that specified in Article 2501.03, N.

2. Drive all piling for piers and abutments of stream crossings, and the piling for piers and abutments of other structures, when ordered by the Engineer, until the following requirements for penetration have been met:

- **a.** The length of all piles specified in the contract documents, or ordered by the Engineer, for any specific structure is to be construed as indicating the desired penetration. Continue the effort to secure this penetration as long as the pile can be driven without damage to the pile.
- **b.** When the pile can not be driven to the required length without damage, the Engineer will determine if additional penetration is required. If full penetration is required, advance the pile by jetting, preboring to a maximum depth of 20 feet (6 m), or other approved methods which will secure the required penetration and bearing without damage to the pile.
- **c.** The driving of wood piling in excess of 40 ton (350 kN) bearing will not be permitted.
- **d.** If soil conditions permit auguring, perform the auguring according to Article 2501.03, Q, except drill the holes to the approximate size of the pile measured at mid length. Do not use Bentonite slurry in prebored holes to gain additional penetration.
- **e.** Drive piles which do not carry superimposed vertical loads, such as wingwall piles, fender piles, wing dam piles, and revetment piles, to the penetration shown in the contract documents without regard to bearing values.

P. Extensions and Splices.

Follow Article 2501.03, M, 5, when piles driven to the specified depth fail to develop the required design bearing. If the Engineer orders pile extensions, driving will continue as long as practical, then the piles will be extended in the manner specified below:

1. Concrete Piles.

- **a.** When a concrete pile is to be extended and the pile does not require further driving, cut away the concrete at the end to expose 24 inches (600 mm) of the existing extension bars cast in the upper end of the pile, as well as 24 inches (600 mm) of the prestressing tendons. To the exposed steel, properly lap and securely wire reinforcing equivalent in cross sectional area to the exposed extension bars.
- **b.** If for any reason extension bars do not exist at the splice, cut the concrete off squarely with at least 24 inches (600 mm) of the prestressing tendons exposed. Use eight No. 7 (No. 25) reinforcing bars, from full lap with the tendons to within 3 inches (75 mm) of the extension top.
- **c.** In the concrete pile extension, use 5 gage (No. W 3.5) spiral reinforcing placed at a 3 inch (75 mm) pitch, and ending with six close turns at the top.
- **d.** After the extension reinforcement is in place, place the necessary forms. Do not allow leakage along the face of the pile.

e. Use the same quality concrete for the extension used to cast the original pile.

f. Just prior to placing concrete for the extension, prepare the joint according to Article 2403.03, I. Coat with a creamy mixture composed of 1 part of water and 1.5 parts of dry cement. The grout may be poured in at the top of the form, depositing it as nearly as possible in the center of the pile.

g. After placement, the forms may be removed after 24 hours, and the extension cured by wrapping with two thicknesses of burlap kept wet for 4 calendar days. Finish the entire surface of the exposed pile to present a uniform color and texture. Splice piles that require further driving as specified in the contract documents or as directed by the Engineer.

2. Steel Piles.

a. For extensions of steel H-piles and steel pipe piles, neatly weld the entire cross section after removing all damaged metal. Ensure the axis of the extension coincides with the axis of the original pile. Perform welding of all steel piles according to Article 2408.03, B.

b. Allow only welders qualified according to Material I.M. 560 to make field extensions of steel piles. Ensure they use an approved welding procedure involving the use of backing plates according to Article 2408.03, B.

c. When designated in the contract documents, the Contractor has the option of extending steel piles by means of mechanical splices approved by the Engineer.

3. Wood Piles.

Splice wood piles as directed by the Engineer.

Q. Prebored Holes as per Plan.

1. When required by the contract documents, bore holes greater than the maximum cross sectional dimension of the pile. Bore holes to the elevations shown and to a minimum diameter 4 inches (100 mm) greater than the maximum cross sectional dimension of the pile 3 feet (1 m) from the butt. Drive piles through the holes to at least the specified design bearing.

2. Use natural bentonite slurry when piling is to be advanced in prebored holes. For holes drilled in noncollapsing soils, the bentonite slurry may be placed after piles are driven. In collapsing soils, place the bentonite slurry at the time the hole is drilled. Cover holes to prevent footing concrete from entering the holes.

3. Use prebored hole filling materials consisting of polymer free sodium bentonite designed for sealing wells and bored holes. Materials may consist of American Petroleum Institute Specification 13A, sodium bentonites, high solids bentonite grout mixes, or granular bentonites composed of approximately 1/4 inch (6 mm) or larger particles.

4. For collapsing soils, make a slurry by thoroughly mixing the bentonite with water according to the manufacturer's recommendation for the product used. In no case use more than 100 gallons (500 L) of water per 80 pounds (50 kg) of bentonite. Place slurry materials by pumping or other applicable methods that assure the hole is filled from the bottom up.

5. For noncollapsing dry holes, coarse 1/4 inch (6 mm) or larger bentonite particles may be poured directly into the hole and hydrated with water after placement.

6. Completely stabilize the hole and fill with bentonite prior to placing footing concrete.

2501.04 METHOD OF MEASUREMENT.

Measurement for the quantities of Wood Piles, Steel HP-Piles (either encased or not), Steel Pipe Piles, Concrete Piles, and Steel Sheet Piles, will be the plan quantity. The quantity may be modified by Article 2501.04, D, F, or G.

A. Wood Piles.

When a wood pile is broken in driving, through no fault of the Contractor, the length measured for payment will be the plan length.

B. Sheet Piles.

The area of walls of sheet piles will be determined from the plan length and the horizontal center line length measured to the nearest 0.1 foot (0.1 m) of wall.

C. Concrete Encasement.

The length of concrete encasement of steel HP-piles constructed will be measured to the nearest 0.1 foot (0.1 m).

D. Extension and Splices.

1. **Wood and Steel Piling.**
   - **a.** For Measurement for extensions of wood, steel HP (either encased or not), or steel pipe piles will be the length of the extension specified by the Engineer. Portions of pile cut-offs used as extensions on the same contract will not be remeasured as additional plan quantity.
   - **b.** Splices (welded or mechanical) are measured by count. Only splices specified by the Engineer to extend piles beyond plan length will be counted.

2. **Concrete Piling.**
   - **a.** Measurement for extensions of concrete piles will be the length of the extension specified by the Engineer, plus the additional length required to be removed for splicing the reinforcement.
   - **b.** Splices are not measured separately.

E. Prebored Holes.

1. The length of prebored holes will be calculated in linear feet (meters) from elevations as shown in the contract documents to the nearest 0.1 foot (0.1 m).

2. Preboring required by Article 2501.03, O, will be measured for payment to the nearest 0.1 foot (0.1 m).

F. Extra Pile.
Extra piles ordered, in addition to the plan quantities, will be measured for payment.

G. Unused Piles.
The quantity of unused piling delivered to the job site without having been placed in the leads or any attempt made to drive it will be subtracted from the plan quantity.

2501.05 BASIS OF PAYMENT.
Payment will be the contract unit price for the quantities of Wood Piles, Steel HP-Piles (either encased or not), Steel Sheet Piles, Steel Pipe Piles, and Concrete Piles measured as provided above. The price bid for piles is full compensation for delivering piles to the site, preparing, driving, cutting, and filling (steel pipe piles only) piles, except as modified in this article.

A. Unused Piles.

1. Return unused piling (either ordered as directed by the Engineer, or specified in the contract documents to the supplier. Unused piles are piles that have been delivered to the job site without having been placed in the leads or any attempt made to drive them. Payment will be made for freight, restocking, and handling charges.

2. The Contracting Authority may purchase unused piles for the invoice cost plus handling and transporting costs.

B. Extension of Concrete Piles.
Payment for the extension will be twice the contract unit price per linear foot (meter) of pile. The length of extension is to be as directed by the Engineer.

C. Extension and Splicing of Steel Piles.

1. Payment for extension will be at the contract unit price for pile.

2. Payment for splice (welded or mechanical) will be at ten times the contract unit price per linear foot (three times the contract unit price per meter) for splices (welded or mechanical) for steel HP-piles or pipe piles required to be spliced to obtain lengths greater than specified in the contract. Payment includes all equipment, labor, and materials necessary to complete the splice.

D. Extension and Splicing of Wood Piles.

1. Payment for extension will be at the contract unit price for pile.

2. Payment for splice will be according to Article 1109.03, B.

E. Pile Cut-Offs.

1. Pile cut-offs not used as extensions on the same contract become the property of the Contractor. Steel pile cut-offs used as extensions on the same contract will not be paid for as additional plan quantity.

2. All piles, or portions thereof, which become the property of the Contractor shall be removed from the project site by the Contractor.

F. Encasement.
Payment will be the contract unit price per linear foot (meter).

G. Test Piles.
The contract may provide a lump sum item for Test Piles. If an item is not provided, Test Piles ordered by the Engineer and driven under the Engineer's supervision will be considered as extra work and will be paid for as provided in Article 1109.03, B.

H. Pile Points.
When the contract documents require that points of piles be protected with metal points, furnish these points without extra compensation. When metal points are not specified in the contract documents, furnish them only upon direction of the Engineer, in which case payment will be made as provided in Article 1109.03, B.

I. Sheet Piles.
When specified to become a part of the permanent structure, payment will be at the contract unit price per square foot (square meter) for steel sheet piles of the specified weight (mass) and cross section for the area of the wall or walls placed.

J. Pile Loading Tests.

1. When required, payment will be the contract lump sum price. Payment is full compensation for all labor, material, and equipment required to comply with the procedure shown in the contract documents, including the test and anchor piles, welding, and placing and removing the test beam.

2. For pile loading tests ordered by the Engineer, payment will be a lump sum price of $3000. When this test is performed within a cofferdam, the lump sum price will be $6000. Payment is full compensation for all labor, material, welding, and equipment, for placing and removing the test beam, and loss of time.

K. Prebored Holes.

1. When required by the contract documents, payment will be the contract unit price per linear foot (meter).

2. Payment is full compensation for all labor, equipment, and materials including bentonite slurry.

3. Prebored holes required by Article 2501.03, O, will be paid for according to Article 1109.03, B.

L. Dynamic Pile Test.

1. When required by the contract documents, or ordered as directed by the Engineer, payment will be a lump sum price of $250 per test pile.

2. Payment is full compensation for all labor, materials, equipment, and time associated with this test as outlined in Article 2501.03, M.

M. Jetting.
When required by Article 2501.03, O, payment will be according to Article 1109.03, B.

N. Payment for Driving Only.
If extensions or extra piles are furnished by the Contracting Authority, payment for driving will be paid according to Article 1109.03, B.

Section 2502. Subdrains

2502.01 DESCRIPTION.
Furnish and install subdrains. Construct trench drains.

2502.02 MATERIALS.

A. Pipe: Meet the requirements of Section 4143.

B. Engineering Fabric: Meet the requirements of Article 4196.01, B, 2.

C. Porous Backfill Material: Meet the requirements of Section 4131.

D. Corrugated Metal Pipe Subdrain Outlet: Meet the requirements of Section 4141.

2502.03 CONSTRUCTION.
Install the size and type of subdrains shown in the contract documents. Install them at the locations and to the grades and elevations shown in the contract documents. Apply the provisions of Section 2403.

A. Standard Subdrains.

1. Unless the Engineer grants permission to construct the drain in sections, begin at the outlet and proceed continuously upgrade. The Engineer will furnish stakes and figures for the grade of the flow line.
- **a.** Accurately place the pipe to line and grade.
- **b.** Lay drain tile ends, when used, as closely together as possible.
- **c.** Use special tile connections for junctions in tile lines.
- **d.** Use a special connection when a pipe diameter change is more than 2 inches (50 mm).
- **e.** Use properly fitting connectors for joints in metal and plastic pipes.
- **f.** Use properly designed fittings for junctions of pipe lines.
- **g.** Take necessary precautions to avoid damaging existing tile lines.
- **h.** Connect such tile lines to the subdrain being installed.

2. Construct inlets to subdrains by filling the full width and depth of the trench with porous backfill material for the length specified.

3. Construct intakes according to design and locations specified. Intake construction includes placing pipe through the intake wall.

4. Allow the Engineer to inspect pipes before covering.

5. Unless porous backfill material is specified, carefully cover (blind) the pipe with soil or other approved material to a depth of approximately 6 inches (150 mm). Do not place sand or boulders directly against pipe. After the drain has been blinded, place backfill in the remainder of the trench using methods and materials approved by the Engineer.

6. When subdrains are placed beneath a highway or driveway or are placed within 5 feet (1.5 m) of the edge of an existing or proposed pavement of base course, place backfill material in layers no thicker than 6 inches (150 mm). Thoroughly tamp each layer with mechanical tampers.

7. The contract documents may also require construction of a granular blanket in connection with subdrains. Construct the granular blanket according to Article 2107.03, K. When installation of a granular blanket is required, place porous backfill material for subdrains prior to construction of the granular blanket.

8. Mark subdrain outlets with steel posts. Use steel posts meeting the requirements of Article 4154.09. Drive the posts 3 feet (1 m) into the ground and install 4 foot (1.1 m) plastic sleeves over the posts. If the Contracting Authority furnishes sleeves, install the sleeves they furnish. Use only one post to mark the location of a double outlet.

9. Use or remove excess excavated project material as directed by the Engineer.

B. Trench Drains.

1. Construct trench drains at locations, depth, and grade shown in the contract documents or as directed by the Engineer.

2. Fill the trench with uncompacted porous backfill material.

C. Longitudinal Subdrains.

1. Place continuous longitudinal subdrains as indicated.

2. Install outlets as shown in the contract documents at approximately 500 foot (150 m) intervals. Provide additional outlets at the low points of vertical sag curves. The Engineer may adjust outlet location. Cover the outlet end of each subdrain with the specific outlet covering. Cap the blind end with a fitting recommended by the manufacturer.

3. Place Class A crushed stone over porous backfill material at piers and at subdrain outlets as shown in the contract documents.

4. Compact material by tamping or vibration.

5. Other outlets may be by special connections which will be shown in the contract documents.

6. Ensure polyethylene tubing elongation does not exceed 5%.

7. Construct longitudinal and lateral shoulder subdrains as shown in the contract documents. Wet the aggregate backfill material prior to installation. The Engineer may require surface application of water. Place the subdrain aggregate backfill material as follows:

a. 24 inch (0.6 m) Depth Subdrain Trench.

1) Place aggregate backfill material in one lift above the sudrain pipe.

2) Compact the lift to maximum consolidation using a vibratory compactor narrower than the trench.

b. 36 inch (0.9 m) Depth Subdrain Trench.

1) Place aggregate backfill material in one lift above the sudrain pipe.

2) Compact the lift to maximum consolidation using a vibratory compactor and an approved trench roller, both narrower than the trench.

c. 42 inch (1.1 m) or Greater Depth Subdrain Trench.

1) Place aggregate backfill material in two lifts of approximately equal thickness above the subdrain pipe.

2) Compact the first lift with a vibratory compactor narrower than the trench.

3) Compact the second lift to maximum consolidation using a vibratory compactor and an approved trench roller, both narrower than the trench.

4) Do not allow compaction to damage the subdrain pipe.

5) When porous backfill material thickness immediately above the pipe is less than 1 foot (0.3 m), place aggregate backfill material in one lift and compact with a vibratory compactor.

8. Maximum consolidation will be determined by an initial trial section approximately 100 feet (30 m) long. Continue compaction on this section until maximum consolidation is achieved.

9. To prevent intrusion of porous backfill material, keep backfill material and engineering fabric (if included in the design) protected during subsequent pavement removal, concrete placement, or other work.

10. Use trench rollers with a maximum trench wheel weight (mass) of 6000 pounds (2700 kg).

11. Restore the shoulder and foreslope area as part of shoulder subdrain work.

a. Unpaved shoulders.

1) Finish unpaved shoulders with a minimum depth of 4 inches (100 mm) of granular shoulder material.

2) Compact granular shoulder material or earth with a minimum of three passes using a single vehicle tire loaded to 6000 pounds (2700 kg).

b. HMA Paved shoulders.

1) Finish HMA paved shoulders and other designated locations with a minimum depth of 6 inches (150 mm) of HMA base.

a) Tack the edges.

b) Place and compact the HMA base mixture in an initial 4 inch (100 mm) lift and a final lift which restores the surface flush with, and no more than 1/4 inch (5 mm) above the adjacent pavement surface.

c) Thoroughly compact each lift with a minimum of three passes using a single vehicle tire that is loaded to 6000 pounds (2700 kg) and is no wider than the trench, or equally compact using an approved trench roller.

2) Proof roll areas that show evidence of paved shoulder settlement before completion of the project. Use a single vehicle tire no wider than the subdrain trench and loaded to 6000 pounds (2700 kg).

3) Correct settlements greater than 1/4 inch (5 mm). Use a 3/8 inch (9.5 mm) mixture described in Section 2303, or a similar commercial mixture approved by the Engineer.

4) Tack the surface, and spread and compact the mixture.

5) Compaction may be accomplished with loaded truck tires.

6) Obtain the Engineer's approval for compaction.

12. If a large boulder or obstruction other than a culvert is encountered, construct the subdrain as shown on the detail for trench repair at culverts, except the engineering fabric and 1 foot (0.3 m) of compacted earth are not necessary. An additional subgrade outlet will be necessary for the interrupted drainage.

13. If culverts and other facilities the Contracting Authority owns are damaged by trenching equipment, repair them as directed by the Engineer.

14. Load excavated material directly onto the transporting vehicle when subdrains are constructed on existing roads and removal of the excavated material is required. The contract documents may designate an area to place this material. If an area is not designated, and the Engineer does not designate one, remove the excavated material from the project according to Article 1104.08.

15. Construct backslope drains as shown in the contract documents. The aggregate may be placed in one lift and with no compaction. Fill and mound the remaining trench in one lift. Compact the earth in place. Level the earth to match the adjacent area.

16. Cover subdrains at piers with granular material described in Article 2502.02, as shown in the contract documents, after the porous backfill material is placed and compacted. Compact the granular material in the same manner as the porous backfill material.

17. Cover subdrain outlets with a rodent guard described in Article 4143.01, B.

18. Mark subdrain outlets, except for medians, with steel posts. Use steel posts meeting the requirements of Article 4154.09. Drive the posts 3 feet (1 m) into the ground. If plastic sleeves are furnished by the Contracting Authority, install over posts.

19. Use only one metal fence post to mark the location of a double outlet.

D. Limitations.

1. When the work is complete, ensure subdrain outlets are open and free of debris.

2. When the road is open to public traffic during construction, work or uncompleted work must be within the limits of a traffic control zone.

2502.04 METHOD OF MEASUREMENT.

Measurement for subdrain construction will be as follows:

A. Standard Subdrain.
To the nearest foot (meter) along the center line of the subdrain.

B. Longitudinal Subdrain.
Computed to the nearest foot (meter) from the following:

1. Longitudinal Subdrain (Backslope).
Lengths of backslope subdrains of each size, including subdrain placed in laterals and outlets, and the extension into the outlet pipe.

2. Longitudinal Subdrain (Shoulders).
Lengths of shoulder subdrains, calculated from centerline stationing for each size of shoulder subdrains and subdrains at piers, including lengths of perforated subdrains in laterals and outlets, and the extension into the corrugated pipe.

C. Subdrain Outlet.
By count of the size specified.

D. Intakes.
By count the number of the size and type specified.

E. Trench Drain.
To the nearest foot (meter).

2502.05 BASIS OF PAYMENT.

Payment for subdrain construction will be the contract unit price as follows:

A. Standard Subdrain.

1. Per foot (meter).

2. Payment will be full compensation for:
- Trenching,
- Removal of excess excavated material from the project,
- Furnishing and placing end caps, elbows, tees, and other necessary connections,
- Furnishing and placing porous backfill material where specified,
- Placing backfill in the trench and finishing the surface as directed by the Engineer, and
- All tools and labor necessary to construct the subdrain.

3. For subdrains built according to the contract documents, no extra compensation will be allowed for overdepth, rock excavation, tamping backfill material, and removal of surplus material from the project.

4. When the contract documents do not indicate the depth of excavation, the first 6 feet (1.8 m) of excavation will be included in the contract unit price. Payment will be made for overdepth excavation as follows:

A deduction of 125% of the delivered cost of pipe per foot (meter) shall be subtracted from the original contract unit price per foot (meter) of pipe. The remainder will be considered the contract unit price for excavation and laying of pipe for subdrain of 6 feet (1.8 m) in depth. The contract unit price for excavation and laying of pipe, determined as provided above, will be divided by 6 and this quotient considered the basic excavation and laying price per foot (meter) of pipe, per foot (0.3 m) of depth.

For overdepth excavation required for the placement of subdrain to elevations greater than 6 feet (1.8 m), measured to the nearest foot (0.3 m) below the original ground profile over the trench, the rate of payment will be as shown in the following table:

Table 2502.05-1: Overdepth Excavation Payment

Overdepth Excavation*	Percentage of Basic Excavation and Laying Price
1st foot (0.3 m)	100%
2nd foot (0.3 m)	120%
3rd foot (0.3 m)	140%
4th foot (0.3 m)	160%
5th foot (0.3 m)	180%
6th foot (0.3 m)	200%

*For depths of excavation greater than 12 feet (3.6 m) below original ground profile, payment will be made as extra work, as provided in Article 1109.03, B.

B. Longitudinal Subdrain.

1. Longitudinal Subdrain (Backslope).
Per foot (meter) of each size placed.

2. Longitudinal Subdrain (Shoulders).
Per foot (meter) of each size placed.

3. Payment for longitudinal subdrains will be full compensation for the following:

- Excavation of the trench and removal of excess trench material from the project,
- Furnishing and placing subdrain pipe, laterals, elbows, tees, special connections, couplings, and adaptors according to the manufacturer's recommendations,
- Furnishing and placing porous backfill material,
- Furnishing and placing engineering fabric as required,
- Restoring the shoulder of shoulder subdrains and covering backslope subdrains with earth, including shoulder outlet locations, and
- Proof rolling as specified.

4. When boulders result from excavation for longitudinal subdrains, the Engineer may order boulder pickup and removal from the project. When ordered, payment for this work will be at 10 (4) times the contract unit price for placing the longitudinal drains on the backslope or shoulder as appropriate, per cubic yard (cubic meter) of boulders.

C. Subdrain Outlet.

1. Each.

2. Payment is full compensation for the following:

- Furnishing and installing corrugated metal pipe, double walled PE, or PVC pipe including the outlet coverings, grouted joints and special connections,
- Drilling or forming into an existing drainage facility,
- Associated excavation,
- Placing specified backfill material,
- Furnishing and installing steel posts and concrete patio block and installing plastic sleeves, and
- Restoration of the site.

D. Intakes.

1. Each.

2. Payment is full compensation for all materials, labor, and equipment necessary for construction of the intakes, as specified, including excavation and removal of excess material from the project.

E. Trench Drain.

1. Per foot (meter).

2. Payment is full compensation for trenching, removal of excess excavated material from the project and furnishing and placing porous backfill material.

Section 2503. Storm Sewers

2503.01 DESCRIPTION.
This section was developed in conjunction with Section 4020 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct storm sewers.

B. Abandon storm sewer.

C. Cleaning, inspecting, and testing storm sewers.

D. Cleaning and inspecting pipe culverts.

E. Cleaning, inspecting, and testing rehabilitated pipe.

2503.02 MATERIALS.
Apply Article 4149.03.

2503.03 CONSTRUCTION.

A. Examination.

1. Verify measurements at site. Make necessary field measurements to accurately determine pipe makeup lengths or closures.

2. Examine site conditions to ensure construction operations do not pose hazards to adjacent structures or facilities.

B. Pipe Installation.

1. **General.**
   - **a.** Clean pipe interior and joints prior to lowering into trench. Keep pipe clean during construction.
   - **b.** Begin at the lowest point in line. Lay groove or bell end pointing upstream unless specifically noted otherwise.
   - **c.** Place pipe with lifting holes at the top of the pipe and fill lift hole with non-shrink grout or manufactured plugs.
   - **d.** Assemble joints as specified by the pipe manufacturer. When specified, wrap exterior of storm sewer pipe joints with engineering fabric.
   - **e.** Use a saw to cut ends of pipe flush with inside wall manholes, intakes, and structures. Do not use hammer or other means to break pipe.
   - **f.** Provide manholes and intakes as specified in the contract documents.
   - **g.** Use watertight stopper, plug, or other approved means to protect the exposed upstream ends of the pipe and prevent soil sediment from entering the storm sewer system.

2. **Trenched.**
   - **a.** Excavate trench and provide bedding and backfill material as specified in Section 2552. If reinforced concrete elliptical pipe is used, provide pipe bedding as specified in the contract documents.
   - **b.** Prepare trench bottom to design line and grade so that only minor movement of pipe is necessary after installation.
   - **c.** Lay pipe to design line and grade. Set field grades to invert of pipe.
   - **d.** Provide uniform bearing for full pipe barrel length. Excavate bell holes as necessary for uniform support of pipe barrel on bedding material.
   - **e.** Do not lay pipe in water or on saturated soil or bedding, or allow water to rise in trench around pipe prior to placing backfill material.
   - **f.** Do not disturb installed pipe and bedding when using movable trench boxes and shields. Block or anchor pipe as necessary to prevent joint displacement.

3. **Trenchless.**
   Apply Section 2553.

C. Storm Sewer Pipe Installed within a Casing Pipe.
Apply Article 2553.03, D, for installation of storm sewer pipe within a casing pipe.

D. Pipe Jointing.

1. General.
- **a.** Clean joint surfaces to remove soil or foreign material prior to jointing pipe.
- **b.** Assemble joints according to the pipe manufacturer's recommendations. Use equipment that does not apply damaging forces to pipe joints.

2. Reinforced Concrete Pipe, Reinforced Concrete Arch Pipe, and Reinforced Concrete Elliptical Pipe.
- **a.** Use cold applied bituminous or rubber rope gasket jointing materials unless specified otherwise.
  - **1)** Apply joint material to entire tongue, or to top half of tongue and bottom half of groove, in sufficient quantity to fill the joint. Close the joint between pipes.
  - **2)** Fill remaining voids in the joint, both inside and outside of pipe, with joint material. Smooth the joint material on the inside of pipes 24 inches (600 mm) and larger.
- **b.** If a rubber O-ring or profile gasket is specified for RCP, coat the rubber gasket and joint with soap based lubricant immediately prior to closing the joint.
- **c.** If wrapped pipe joint is specified, comply with the contract documents. Secure engineering fabric in place to prevent displacement while placing backfill material.
- **d.** Place pipe such that joint openings on the outside or inside of the pipe do not exceed 1/8 inch (3 mm) at the bottom and 5/8 inch (15 mm) at the top.

3. Reinforced Concrete Low Head Pressure Pipe, Polyvinyl Chloride Pipe and Corrugated PVC Pipe, and High Density Polyethylene Pipe.
Coat gasket and joint with soap based lubricant immediately prior to closing the joint.

4. Corrugated Metal Pipe and Corrugated Metal Arch Pipe.
Lap coupling bands to form a tightly closed joint upon installation.

5. Connections between Dissimilar Pipes.
- **a.** Use manufactured adapters or couplings approved by the Engineer.
- **b.** Where adapters or couplings are not available, the Engineer may authorize use of concrete collar as shown in the contract documents.

E. Tolerances.
The following tolerances apply to utilities installed by open trench construction. For trenchless construction, apply Section 2553.

1. Ensure horizontal and vertical alignment of gravity sewer lines does not vary from design line and grade at any point along the pipe by more than 1% of the inside diameter of the pipe or 1/4 inch (6 mm), whichever is larger.

2. Tolerance is allowed only if design line and grade is sufficient to prevent backslope when tolerance limits are reached.

3. Reverse slope on pipe is prohibited. Remove and reinstall to proper grade.

F. Storm Sewer Abandonment.

1. Plug.
a. Prior to placing the sewer plug, the Engineer will verify the sewer line is not in use.
b. Construct sewer plug by completely filling the end of the pipe with concrete. Force concrete into the end of the pipe for a distance of 16 inches (400 mm), or one-half the pipe diameter, whichever is greater.

2. Fill.
a. Prior to filling sewer, Engineer will verify sewer line is not in use.
b. If specified in the contract documents, fill the line to be abandoned with flowable mortar or CLSM, according to Article 2552.02, E, by gravity flow or pumping.

G. Connection to Existing Manhole or Intake.
Apply Article 2435.03, E.

H. Cleaning, Inspection, and Testing.
Apply Articles 2504.03, L, 1, 2, and 5.

2503.04 METHOD OF MEASUREMENT.

A. Storm Sewer.

1. Trenched.
Measurement for each type and size of pipe installed in a trench will be in linear feet (meters) along the centerline of the pipe from center of intake or manhole to center of intake or manhole. Where the end of the pipe discharges to a ditch or waterway, measurement will be to the end of the pipe, exclusive of aprons. Lengths of elbows and tees will be included in the length of pipe measured.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along the centerline of the pipe.

B. Storm Sewer with Casing Pipe.

1. Trenched.
Measurement for each type and size of pipe installed with a casing pipe in a trench will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

C. Removal of Storm Sewer.
Measurement for each type and size of pipe removed will be in linear feet (meters) from end to end.

D. Connection to Existing Manhole or Intake.
Connections to existing manhole intake will be measured according to Article 2435.04, G.

E. Storm Sewer Abandonment.

1. Plug.
None.

2. Fill and Plug.
Measurement for each size of pipe filled and plugged will be in linear feet (meters) from end of pipe to end of pipe.

F. Cleaning, Inspecting, and Testing.
None.

2503.05 BASIS OF PAYMENT.

A. Storm Sewer.

1. Trenched.

a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe.

b. Payment is full compensation for:

- Trench excavation,
- Dewatering,
- Furnishing bedding material,
- Placing bedding and backfill material,
- Joint wrapping,
- Wyes and other fittings,

- Pipe joints and pipe connections, and
- Testing and inspection.

2. Trenchless.

a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe.

b. Payment is full compensation for:

- Furnishing and installing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Pipe connections, and
- Testing, and inspection.

B. Storm Sewer with Casing Pipe.

1. Trenched.

a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe.

b. Payment is full compensation for:

- Furnishing and installing both carrier pipe and casing pipe,
- Trench excavation,
- Dewatering,
- Furnishing bedding material,
- Placing bedding and backfill material,
- Furnishing and installing annular space fill material,
- Casing spacers,
- Pipe connections, and
- Testing and inspection.

2. Trenchless.

a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of carrier pipe.

b. Payment is full compensation for:

- Furnishing and installing both storm sewer pipe and casing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Casing spacers,
- Furnishing and installing annular space fill material,
- Pipe connections,
- Testing, and inspection.

C. Removal of Storm Sewer.

1. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe removed.

2. Payment is full compensation for removal, disposal, and capping (if specified) of pipe.

D. Connection to Existing Manhole or Intake.

Connections to existing manhole will be paid according to Article 2435.05, G.

E. Storm Sewer Abandonment.

1. Plug.
Plugging storm sewers is incidental to other work and will not be paid for separately.

2. Fill and Plug.
Payment will be the contract unit price per linear foot (meter) for each size of pipe filled and plugged.

F. Cleaning, Inspecting, and Testing.
Cleaning, inspecting, and testing storm sewers and pipe culverts is incidental to other project costs and will not be paid for separately.

Section 2504. Sanitary Sewers

2504.01 DESCRIPTION.

This section was developed in conjunction with Sections 4010 and 4060 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct sanitary sewer gravity and force mains.

B. Construct or relocate building sanitary sewer services, stubs, and connections.

C. Clean, inspect, and test sanitary sewer gravity mains, sanitary sewer force mains, and sanitary sewer service stubs.

D. Clean, inspect, and test rehabilitated pipe.

2504.02 MATERIALS.

A. Sanitary Sewer.
Apply Article 4149.02

B. Testing Equipment for Cleaning, Inspection, and Testing Sewers and Drains.

1. General.
Comply with applicable sections of ASTM and other applicable industry standards and codes.

2. Video Inspection.
a. Video Camera:
1) High-resolution color with adjustable iris focus.

2) Pan and tilt capabilities.
3) Integral lighting suitable to provide proper illumination and a clear video image of the entire periphery of the pipe.
4) Capable of operating in 100% humidity conditions.
5) Produce a high quality video image.

b. Provide closed circuit video inspection equipment capable of displaying on-screen footage of distance measured to within 1% of actual distance.

C. Inspection Reporting.
Record the inspection in color in the recording media specified by the Engineer. Forward the recording to the Engineer.

2504.03 CONSTRUCTION.

A. Examination.

1. Verify measurements at site. Make necessary field measurements to accurately determine pipe makeup lengths or closures.

2. Examine site conditions to ensure construction operations do not pose hazards to adjacent structures or facilities.

B. Gravity Sewer Installation.

1. General.
a. Install watertight plug to prevent water from entering the existing sewer system.
b. Clean pipe interior and joints prior to installation. Keep pipe clean during construction.
c. Begin at the lowest point in the line. Lay groove or bell end pointing upstream unless specifically noted otherwise.
d. Assemble joints according to Article 2504.03, D.
e. Use saw to cut ends of pipe flush with walls of manholes and structures. Do not use hammer or other means to break pipe.
f. Provide manholes as specified in the contract documents.
g. Install cap, plug, or bulkhead at exposed ends of pipe upon completion of construction or whenever pipe installation is not in progress.

2. Trenched.
a. Excavate trench and provide pipe bedding and backfill material as specified in Section 2552.
b. Prepare trench bottom to design line and grade so that only minor movement of the pipe is necessary after installation.
c. Lay pipe to design line and grade. Set field grades to invert of pipes.
d. Provide uniform bearing for full pipe barrel length. Excavate bell holes as necessary for uniform support of pipe barrel on bedding material.

e. Do not lay pipe in water or on saturated soil or bedding, or allow water to rise in trench around pipe prior to placing backfill material.

f. Do not disturb installed pipe and bedding when using movable trench boxes and shields. Block or anchor pipe as necessary to prevent joint displacement.

g. Install preformed wye or tee service fitting at each location as specified in the contract documents.

3. Trenchless.
Apply Section 2553.

C. Carrier Pipe Installed within a Casing Pipe.
Apply Article 2553.03, D, for installation of carrier pipe within casing pipe.

D. Gravity Main Pipe Jointing.

1. General.

a. Clean joint surfaces to remove soil or foreign material prior to jointing pipe.

b. Assemble joints according to the pipe manufacturer's recommendations. Use equipment that does not apply damaging forces to pipe joints.

2. Polyvinyl Chloride Pipe and Polyvinyl Chloride Composite Pipe (truss-type).

a. Coat rubber gasket and joint with soap-based lubricant immediately prior to closing joint.

b. Seal ends of PVC composite and closed profile pipe at manholes with the coating recommended by the manufacturer.

3. Reinforced Concrete Pipe.
Coat rubber gasket and joint with soap-based lubricant immediately prior to closing joint.

4. Ductile Iron Pipe.

a. Push-on Joint: Coat gasket and joint with soap-based lubricant immediately prior to closing joint.

b. Mechanical Joint: Wash plain end, bell socket, and gasket with soap solution. Press gasket into socket, set gland, and tighten bolts uniformly.

5. Connections between Dissimilar Pipes.

a. Use manufactured adapters or couplings approved by the Engineer.

b. Where adapters or couplings are not available, the Engineer may authorize use of a Type PC-2 concrete collar as shown in the contract documents.

E. Force Main Installation.

1. General.
Install according to Section 2554.

2. Tracer Wire.
- **a.** Required for all force main installations. Apply Section 2554.
- **b.** Install tracer wire station at each end of the force main and at additional locations specified in the contract documents.
- **c.** Bury end of tracer wire station 2 feet (0.6 m) and compact.

F. Sanitary Sewer Service Stubs.

1. Provide sanitary sewer service stubs at locations specified in the contract documents.

2. Install wye or tee for each service connection.
- **a.** Connection of sanitary service to new sewer main, except RCP:
  - **1)** Use only factory wye or tees.
  - **2)** Install according to the manufacturer's requirements and Articles 4149.02, D, and 2504.03, D, for joints.
- **b.** Connection to existing sewer main and new RCP:
  - **1)** Cut sewer main for service tap with hole saw or sewer tap drill.
  - **2)** Use preformed saddle wye or saddle tee for service tap. Use a gasketed saddle with rigid pipe mains, and a solvent-cemented saddle with PVC mains.
  - **3)** Install according to the manufacturer’s requirements, but always with at least two stainless steel band clamps.

3. Install service stub from sewer main to a location 10 feet (3 m) beyond the right of way line or as specified in the contract documents.
- **a.** Install according to Article 2504.03, B
- **b.** Install service stub with a slope between 2% and 5% for 4 inch (100 mm) pipes, and between 1% and 5% for 6 inch (150 mm) pipes and greater.
- **c.** Terminate end of service stub 10 to 12 feet (3.0 to 3.6 m) below finished ground elevation or as specified in the contract documents.
- **d.** If the depth of the sewer main causes the service to exceed a depth of 12 feet (3.6 m) or a slope of 5%, install a service riser.
- **e.** For undeveloped properties, place watertight stopper, cap, or plug in end of sanitary sewer service. Mark the end of the service line as required by the Engineer or as specified in the contract documents.
- **f.** For reconnection of new service pipe with existing service pipe and new service pipe, comply with the Jurisdiction’s plumbing code.

G. Sanitary Sewer Service Relocation.

1. Relocate existing sanitary sewer services that conflict with new storm or sanitary sewer installations. Existing services located within a conflict zone from 6 inches (150 mm) below the bottom of the proposed sewer

pipe to 2 inches (50 mm) above the top of the proposed sewer pipe require relocation.

2. When a conflicting service is encountered:
- **a.** Determine grades and elevations of the existing service and proposed main.
- **b.** Determine the extent of service replacement necessary to relocate the service outside of the conflict zone while maintaining a minimum 1% slope on the sewer service.
- **c.** If it is not feasible to maintain a minimum slope of 1% on the relocated service, a special design and additional work may be required. Stop work and contact the Engineer. Do not remove sewer service unless directed by the Engineer.
- **d.** If service relocation with a minimum slope of 1% is feasible, proceed with removal and replacement of the existing sanitary sewer service.
  - **1)** Length of replacement varies. Remove the existing service to the extent necessary to move the service out of the conflict zone.
  - **2)** Use new materials complying with Article 4149.02, D.
  - **3)** Re-install the service according to Article 2504.03, B.
  - **4)** Maintain a minimum 1% grade on relocated service.

H. Sanitary Sewer Abandonment.

1. Plug.
- **a.** Prior to placing the sewer plug, the Engineer will verify the sewer line is not in use.
- **b.** Construct sewer plug by completely filling the end of the pipe with concrete. Force concrete into the end of the pipe for a distance of 16 inches (400 mm), or one half the pipe diameter, whichever is greater.

2. Fill.
- **a.** Prior to filling sewer, Engineer will verify sewer line is not in use.
- **b.** If specified in the contract documents, fill the line to be abandoned with flowable mortar or CLSM, according to Article 2552.02, E, by gravity flow or pumping.

I. Connection to Existing Manhole.
Apply Article 2435.03, E.

J. Tolerances.
Apply the following tolerances to utilities installed by open trench construction. For trenchless construction, comply with Section 2553.

1. Gravity Main.
- **a.** Do not allow horizontal and vertical alignment of trenched gravity sewer lines to vary from design line and grade at any point along the pipe by more than 1% of the inside diameter of the pipe or 1/4 inch (6 mm), whichever is larger.

b. This tolerance is allowed for trenched gravity sewer lines only if design line and grade is sufficient to prevent backslope when tolerance limits are reached.

c. Reverse slope on gravity pipe is prohibited. Remove and reinstall pipe to proper grade.

2. Force Main.

Do not allow horizontal and vertical alignment of trenched force mains to vary from design line and grade by more than 3 inches (75 mm).

K. Conflicts.

1. Horizontal Separation of Gravity Sewers from Water Mains.

a. Separate gravity sewer mains from water mains by a horizontal distance of at least 10 feet (3 m) unless:

- The top of a sewer main is at least 18 inches (450 mm) below the bottom of the water main, and
- The sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth at a minimum horizontal separation of 3 feet (1 m) from the water main.

b. When it is impossible to obtain horizontal clearance of 3 feet (1 m) and vertical clearance of 18 inches (450 mm) between sewers and water mains, the sewers shall be constructed of water main materials meeting the requirements of Article 4149.02, B; however, provide a linear separation of at least 2 feet (600 mm).

2. Separation of Sewer Force Mains from Water Mains.

Separate sewer force mains and water mains by a horizontal distance of at least 4 linear feet (1.2 m).

3. Separation of Sewer and Water Main Crossovers.

a. Vertical separation of sanitary sewers crossing under any water main should be at least 18 inches (450 mm) when measured from the top of the sewer to the bottom of the water main. If physical conditions prohibit the separation, the sewer may be placed not closer than 6 inches (150 mm) below a water main or 18 inches (450 mm) above a water main. Maintain the maximum feasible separation distance in all cases.

b. Where the sewer crosses over or less than 18 inches (450 mm) below a water main, locate one full length of sewer pipe of water main material so both joints are as far as possible from the water main. The sewer and water pipes shall be adequately supported and have watertight joints. Use a low permeability soil for backfill material within 10 feet (3 m) of the point of crossing.

L. Cleaning, Inspection, and Testing.

Notify the Engineer at least 24 hours prior to performing testing. The Engineer shall be present to review testing procedures and record results.

1. **Cleaning.**
   - **a.** Clean all sanitary sewers and storm sewers by flushing with high pressure water and removing debris by vacuum extraction, and by removing sheeting, bracing, shoring, forms, soil sediment, concrete, or other debris.
   - **b.** Do not discharge soil sediment or debris to drainage channels, existing storm sewers, or existing sanitary sewer systems.

2. **Visual Inspection.**
   - **a.** Check each section of sanitary sewer and storm sewer by lamping.
   - **b.** Light should be visible through section of pipe lamped.
   - **c.** Visually inspect each run of pipe.
   - **d.** Repair or replace defective pipe or joints, or remove and relay pipe not meeting alignment tolerances, as directed by the Engineer.

3. **Video Inspection.**
   - **a. General.**
     - **1)** Conduct video inspection of all new and rehabilitated sanitary sewers after all backfill and compaction operations are completed, but prior to paving.
     - **2)** Notify the Engineer the day prior to inspection so the Engineer may be present during the inspection.
     - **3)** Low spots holding water in excess of 1 inch (25 mm) or 5% of the pipe diameter, whichever is less, will be considered unacceptable.
     - **4)** If unacceptable low spots exist, as indicated by standing water during video inspection, remove and replace sewer as necessary and re-inspect.
   - **b. Inspection Procedure.**
     - **1)** Prior to video inspection, run sufficient water through the pipe to saturate potential low spots so they may be detected during inspection.
     - **2)** Inspect each pipe segment between manholes or access points in a single, continuous run. Progress through the entire project in a uniform direction.
     - **3)** Inspect all lateral connections and other observations at right angles utilizing the pan and tilt capabilities of the camera.
     - **4)** Center the video camera in the pipe during the inspection.
     - **5)** Do not exceed 30 feet (10 m) of inspection per minute.
   - **c. Inspection Reporting.**
     - **1)** Provide a copy of the video inspection in the recording media specified by the Engineer. Include on screen continuous footage, pipe diameter, direction of viewing, and manhole and street location references in the recording. Affix labels to the recording media to include the name of the project, the date, and the location of the inspection.
     - **2)** Provide a written report of the inspection. In the report, include true to scale drawings of all sewer defects and observation locations. Reference the time stamp on each line item entry on the written report.

4. Sanitary Sewer Leakage Testing.

Perform one or more of the following tests on new sanitary sewer gravity mains and sanitary sewer service stubs. Test sanitary sewer manholes separately as specified in Section 2435.

a. Sanitary Sewer Infiltration Testing.

1) Use only where ground water is more than 2 feet (600 mm) above top of pipe at highest point in section being tested.

2) Provide documented verification of ground water elevations for no less than 24 hours before measurement of infiltration.

3) Measure infiltration in sanitary sewer with a V-notch weir in downstream manhole.

4) The maximum allowable infiltration for new sanitary sewers, including manholes, is 200 gallons per inch of diameter per mile (19 L per mm of diameter per km) of pipe per day.

b. Sanitary Sewer Exfiltration Testing.

1) General.

Use an exfiltration test when ground water level is less than 2 feet (600 mm) above top of pipe at highest point in section being tested. Sectionalize the test section so that the internal pressure in the pipe does not exceed 5 feet (1.5 m) of water.

2) Test Procedures.

a) Install a watertight plug in the inlet of the upstream and downstream manhole of sewer section being tested.

b) Fill the sewer and upstream manhole with potable water until the water elevation in the upstream manhole is 2 feet (600 mm) higher than outside top of pipe in section being tested or 2 feet (600 mm) above existing ground water level, whichever is highest elevation.

c) Allow the water level to stabilize for 30 minutes, then refill the upstream manhole with water to the original level and begin the test.

d) Measure the amount of water lost in the upstream manhole in 1 hour. Use that amount to determine exfiltration in a 24 hour period.

3) Exfiltration Rate.

a) Table 2504.03-1 may be used to determine exfiltration in gallons (liters) per 24 hours by measuring the loss that occurs in 1 hour. The table is applicable only for 48 inch (1200 mm) diameter manholes.

b) The maximum allowable exfiltration for new sanitary sewer, including manholes, is 200 gallons per inch of diameter per mile (19 L per mm of diameter per km) of pipe per day.

Table 2504.03-1: Loss in Gallons (Liters) Per 24 Hours for Drop in Water Level per Hour in 48 inch (1200 mm) Diameter Manhole (table may be interpolated to the nearest 1/4" (6 mm) drop)

Drop	0"	1"	2"	3"	4"	5"	6"	7"	8"	9"
	0	188	376	564	752	940	1128	1316	1504	1692
Drop	**0 mm**	**25 mm**	**50 mm**	**75 mm**	**100 mm**	**125 mm**	**150 mm**	**175 mm**	**200 mm**	**225 mm**
	0	712	1423	2135	2845	3558	4267	4982	5693	6405

c) For manholes larger than 48 inch (1200 mm) diameter, use the following formula:

English

$G = 0.0816(H)(D^2)$

Where:

G = loss in gallons
D = diameter of manhole in inches
H = water level drop in manhole in inches

Metric

$L = 353.25(H)(D^2)$

Where:

L = loss in liters
D = diameter of manhole in mm
H = water level drop in manhole in mm

c. Sanitary Sewer Low Pressure Air Testing.

1) General.

a) A low pressure air test may be used in lieu of an exfiltration test except as noted.

b) Air test is not recommended when ground water elevation is 2 feet (600 mm) or greater above the top of the pipe, and cannot be used when ground water is greater than 6 feet (2 m) above the top of the pipe.

c) Use extreme care and follow safety precautions during testing operations. No one is allowed in manholes during testing.

2) Test Procedures.

a) Clean the entire line of all debris. Flush or wet line to produce consistent results.

b) Plug all inlets and outlets to resist the test pressure. Special attention shall be given to stoppers and laterals.

c) Determine the test duration for the section being tested from Table 2504.03-2. This table ignores pipe length and uses the factor 0.472×d (1.20×d), with d being in inches (mm). Pressure holding time is based on average holding pressure of 3.0 psi (21 kPa) or drop from 3.5 psi (24 kPa) to 2.5 psi (18 kPa).

Table 2504.03-2: Test Duration

Size Pipe, inches (mm)	Test Period Duration (minutes)
8 (200)	4.0
10 (250)	5.0
12 (300)	6.0
15 (325)	7.0
18 (450)	8.5
21 (525)	10.0
24 (600)	11.5
27 (675)	13.0
30 (750)	14.0
36 (900)	17.0
42 (1050)	20.0
48 (1200)	23.0
54 (1350)	25.5
60 (1500)	28.5

d) Add air to the line segment being tested until the internal air pressure of the sewer line is raised to approximately 4.0 psi (28 kPa) greater than the average back pressure of any ground water that may be over the top of the pipe. Pressure in the sewer should not exceed 5.0 psi (35 kPa). Allow at least 2 minutes for air pressure to stabilize.

e) When pressure has stabilized and is at or above the starting test pressure of 3.5 psi (24 kPa), commence the test. Record the drop in pressure for the test period. The test may be discontinued when the prescribed test time has been completed, even though a 1.0 psi (7 kPa) drop has not occurred.

f) If groundwater level at the time of testing is above the pipe invert, add 0.43 psi air per foot (10 kPa air per meter) of water above the invert to the test air pressure range of 2.5 psi (18 kPa) to 3.5 psi (24 kPa) stated above.

g) If the pressure drop exceeds 1.0 psi (7 kPa) during the test period, the test will be considered to have failed. Repair and retest the line.

d. Sanitary Sewer Vacuum Testing.

1) General.

a) Vacuum testing may be used in lieu of other specified test methods.

b) Use extreme care and follow safety precautions during testing operations. Keep personnel out of and away from manholes during testing.

c) Where practical, clean the pipe prior to testing and wet the pipe surface. Isolate the test segment as necessary, including closing service connections.

2) Test Procedures.

a) Determine the test time for the size of pipe being tested using Table 2504.03-3.

Table 2504.03-3: Minimum Test Time

Nominal Pipe Size, inches (mm)	T (time); Minutes/100 feet (30 m) of pipe
4 (100)	0.3
6 (150)	0.7
8 (200)	1.2
10 (250)	1.5
12 (300)	1.8
15 (375)	2.1
18 (450)	2.4
21 (525)	3.0
24 (600)	3.6
27 (675)	4.2
30 (750)	4.8
33 (825)	5.4
36 (900)	6.0

b) Test time is the time required for vacuum to drop from 3.5 psi (24 kPa) to 2.5 psi (18 kPa).

c) Use a vacuum pump with the capacity to evacuate the sewer test section in time equal or less than that shown in Table 2504.03-3 for the size of pipe being tested.

d) Evacuate air until the internal air pressure of the sewer line is lowered by approximately 4.0 psi (28 kPa). Allow the air pressure to stabilize.

e) When the air pressure is stabilized near the starting test vacuum of 3.5 psi (24 kPa), commence the test by allowing gage pressure to drop to 3.5 psi (24 kPa), then commence time recording. Record the drop in vacuum for the test period.

f) If the drop in vacuum is 1.0 psi (7.0 kPa) or less during the test period, the test will be considered successfully passed.

g) If the drop in vacuum is greater than 1.0 psi (7.0 kPa) during the test period, inspect, evaluate, repair, and retest.

5. Deflection Testing.

a. Perform deflection tests on all PVC sanitary sewer mains. Also perform deflection tests on all HDPE storm sewer or culvert pipe 12 inches in diameter or greater.

b. Perform deflection tests after backfill material has been in place at least 30 calendar days and before paving activity takes place, or as per appropriate sections of these specifications.

c. Pull a 9 arm deflection mandrel complying with applicable ASTM Standards through sewer by hand.
d. Ensure pipe deflection does not exceed 5% of average inside diameter as established by ASTM Standards.
e. Remove and replace pipe exceeding deflection limits.
f. Handle and divert existing flows during deflection testing.

6. Force Main Testing.

a. Provide test pumps, test plugs, pipe, and gages. Make necessary piping connections.
b. Fill the force main with potable water and flush before testing to remove entrapped air. Other water sources may be used if approved by the Engineer.
c. Insert taps as required to remove air. Plug taps after the completion of tests.
d. Use a test pressure of 1.5 times the working pressure at the lowest point along the test section, but no less than 50 psi (350 kPa).
e. Pressurize the test section and allow it to stabilize prior to beginning the leakage test.
f. Maintain pressure to within 5 psi (35 kPa) of the test pressure by pumping in potable water as required.
g. Leakage is the quantity of water that shall be supplied into the test section to maintain pressure within 5 psi (35 kPa) of the specified test pressure during a 2 hour test period.
h. The maximum allowable leakage is determined by the following formula:

English Units

$$L = \frac{(S)(D)(P)^{0.5}}{148{,}000}$$

Where:
L = allowable leakage in gallons per hour
S = length of pipe tested in feet
D = nominal pipe diameter in inches
P = average test pressure in pounds per square inch

Metric Units

$$L = \frac{(S)(D)(P)^{0.5}}{794{,}797}$$

Where:
L = allowable leakage in liters per hour
S = length of pipe tested in meters
D = nominal pipe diameter in mm
P = average test pressure in kPa

Table 2504.03-4 assumes an average test pressure (P) of 50 psi (350 kPa) and length of pipe (S) of 1000 feet (300 m).

Table 2504.03-4: Maximum Allowable Leakage Rate

Nominal Pipe Size inches (mm)	Allowable Leakage gallonshour/1000 feet of pipe (liters/hour/300 m of pipe)
4 (100)	0.19 (0.71)
6 (150)	0.29 (1.06)
8 (200)	0.38 (1.41)
10 (250)	0.48 (1.77)
12 (300)	0.57 (2.12)
14 (350)	0.67 (2.47)
16 (400)	0.76 (2.82)

i. Examine exposed pipe and fittings during testing. Repair all visible leaks.

j. If the test indicates leakage greater than allowed, locate, repair, or replace damaged or defective pipe, and repeat tests until the requirements are met.

2504.04 METHOD OF MEASUREMENT.

A. Sanitary Sewer Gravity Main.

1. Trenched.
Measurement for each type and size of pipe installed in a trench will be in linear feet (meters) along the centerline of the pipe from center of manhole to center of manhole.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along the centerline of pipe.

B. Sanitary Sewer Gravity Main with Casing Pipe.

1. Trenched.
Measurement for each type and size of pipe installed with casing pipe in a trench will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

C. Sanitary Sewer Force Main.

1. Trenched.
Measurement for each type and size of pipe installed in a trench will be in linear feet (meters) along the centerline of the pipe from the outside

wall of the pumping station to the center of manhole, or from center of manhole to center of manhole.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along centerline of pipe.

D. Sanitary Sewer Force Main with Casing Pipe.

1. Trenched.
Measurement for each type and size of pipe installed with casing pipe in a trench will be in linear feet (meters) along the centerline of the casing pipe.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe.

E. Sanitary Sewer Service Stub.

1. A sanitary sewer service stub is the portion of the sanitary sewer service from the main to a point 10 feet (3 m) outside of the right-of-way line or as specified in the contract documents.

2. Measurement for each type and size of pipe will be in linear feet (meters) along the centerline of the pipe from the end of the pipe to the centerline of the sewer main.

F. Sanitary Sewer Service Relocation.

1. A sanitary sewer service relocation is the portion of an existing sanitary sewer service in a zone of conflict.

2. Each completed relocation will be counted.

G. Sewage Air Release Valve and Pit.
Each completed installation, including valve, accessories, and pit, will be counted.

H. Removal of Sanitary Sewer.
Measurement for each type and size of pipe removed will be in linear feet (meters) from end to end.

I. Sanitary Sewer Cleanout.
Each sanitary sewer cleanout will be counted.

J. Connection to Existing Manhole.
Connections to existing manhole will be measured according to Article 2435.04, G.

K. Sanitary Sewer Abandonment.

1. Plug.
None.

2. Fill and Plug.
Measurement for each size of pipe filled and plugged will be in linear feet (meters) from end of pipe to end of pipe.

L. Cleaning, Inspecting, and Testing.
None.

2504.05 BASIS OF PAYMENT.

A. Sanitary Sewer Gravity Main.

1. Trenched.
- **a.** Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.
- **b.** Payment is full compensation for trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, wyes and other fittings, pipe joints, pipe connections, testing, and inspection.

2. Trenchless.
- **a.** Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.
- **b.** Payment is full compensation for:
  - Furnishing and installing pipe,
  - Trenchless installation materials and equipment,
  - Pit excavation, dewatering, and placing backfill material,
  - Pipe connections, and
  - Testing and inspection.

B. Sanitary Sewer Gravity Main with Casing Pipe.

1. Trenched.
- **a.** Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.
- **b.** Payment is full compensation for:
  - Furnishing and installing both sanitary sewer pipe and casing pipe,
  - Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material,
  - Furnishing and installing annular space fill material,
  - Casing spacers,
  - Pipe connections, and
  - Testing, and inspection.

2. Trenchless.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.

b. Payment is full compensation for:

- Furnishing and installing both sanitary sewer pipe and casing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Casing spacers,
- Furnishing and installing annular space fill material,
- Pipe connections, and
- Testing and inspection.

C. Sanitary Sewer Force Main.

1. Trenched.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.

b. Payment is full compensation for trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, wyes and other fittings, pipe joints, testing, and inspection.

2. Trenchless.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.

b. Payment is full compensation for furnishing and installing pipe, trenchless installation materials and equipment, pit excavation, dewatering, placing backfill material, pipe connections, testing, and inspection.

D. Sanitary Sewer Force Main with Casing Pipe.

1. Trenched.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.

b. Payment is full compensation for furnishing and installing both sanitary sewer pipe and casing pipe, trench excavation, dewatering, placing bedding and backfill material, furnishing and installing annular space fill material, casing spacers, pipe connections, testing, and inspection.

2. Trenchless.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.

b. Payment is full compensation for:

- Furnishing and installing both sanitary sewer pipe and casing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Casing spacers,

- Furnishing and installing annular space fill material,
- Pipe connections, and
- Testing and inspection.

E. Sanitary Sewer Service Stub.

1. Payment will be made at the contract unit price per linear foot (meter) for each type and size of sanitary sewer service stub.

2. Payment is full compensation for trench excavation, furnishing bedding material, placing bedding and backfill material, tap, fittings, testing, and inspection.

F. Sanitary Sewer Service Relocation.

1. Payment will be made at the contract unit price for each relocation.

2. Payment is full compensation for removal of existing pipe, trench excavation, furnishing new pipe and bedding material, placing bedding and backfill material, connection back to existing service, compaction, testing, and inspection.

G. Sewage Air Release Valve and Pit.

1. Payment will be made at the contract unit price for each sewage air release valve and pit.

2. Payment is full compensation for excavation, furnishing bedding material, placing bedding and backfill material, compaction, and testing.

H. Removal of Sanitary Sewer.

1. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.

2. Payment is full compensation for removal, disposal, and capping (if specified) of pipe.

I. Sanitary Sewer Cleanout.

Payment will be made at the contract unit price for each cleanout. Payment includes the plug at the end of the main, fittings, riser pipe, cap with screw plug, casting, and concrete casting encasement.

J. Connection to Existing Manhole.

Connections to existing manhole will paid according to Article 2435.05, G.

K. Sanitary Sewer Abandonment.

1. Plug.
Plugging sanitary sewers is incidental to other work and will not be paid for separately.

2. Fill and Plug.
Payment will be the contract unit price per linear foot (meter) for each size of pipe filled and plugged.

L. Cleaning, Inspecting, and Testing.
Cleaning, inspecting, and testing sanitary sewers, storm sewers, pipe culverts, and rehabilitated pipes (including video inspection) is incidental to other project costs and will not be paid for separately.

Section 2505. Guardrail Construction and Removal

2505.01 DESCRIPTION.
Construct guardrail. Remove existing guardrail.

2505.02 MATERIAL.
Provide guardrail materials meeting the requirements for the type of guardrail specified. Provide guardrail posts of wood or steel as specified in the contract documents.

A. Formed Steel Beam Guardrail and Low Tension Cable Guardrail.
Apply Section 4155.

B. High Tension Cable Guardrail.

1. Meet the manufacturer's materials requirements. For line post and end anchor foundations, use Class C mix according to Section 2403.

2. Supply spare parts kits for high tension cable guardrail. Deliver them to the Contracting Authority's nearest maintenance office. Spare parts kits consist of the following items, but do not include a tension meter:

- An extra supply of line posts (socketed-type), including post hardware and accessories (caps, reflective sheeting, straps, spacers, and socket covers). This supply is to include enough materials to complete a 300 foot (90 m) installation.
- An extra supply of anchor posts (socketed-type), including post hardware and accessories (caps, reflective sheeting, straps, fittings, spacers, and socket covers). This supply is to include enough materials to complete one end anchor installation.
- Specialized tools necessary to maintain the guardrail, such as a spreader tool.

2505.03 CONSTRUCTION AND REMOVAL OF GUARDRAIL.

Furnish and install posts, beams or cables, end anchors, and special connections and fittings required in the contract documents. Install to the specified line and mounting height. Changes in the installed length require the Engineer's approval.

A. Steel Beam Guardrail and Low Tension Cable Guardrail.

1. Steel Beam Guardrail.

- **a.** Install w-beam or thrie-beam as designated in the contract documents. When not designated, install w-beam.
- **b.** Use steel beam guardrail ready for assembly when delivered to the project. Do not punch, drill, cut, or weld beam in the field.
- **c.** Steel beam guardrail elements may be furnished in either 25 foot (7.62 m) or 12.5 foot (3.81 m) nominal length sections.
- **d.** Straight rail sections may be used to construct radii of 150 feet (45 m) or greater. Shop curve rail sections for radii less than 150 feet (45 m).
- **e.** Install posts for steel beam guardrail at spacing identified in the contract documents. If not defined, use 6.25 foot (1.91 m) spacing.
- **f.** Where necessary, adjust horizontal and vertical alignment of the guardrail to account for road curvature. Use minor adjustments with no abrupt changes.
- **g.** Fully connect beam to all posts as shown in the contract documents. For W-beam guardrail installations with wood blockouts, nail the blockout to the post to prevent blockout rotation. Other methods of preventing rotation may be approved by the Engineer.

2. Low Tension Cable Guardrail.

- **a.** Attach the cables to the posts and end anchors according to the contract documents. Attach compensation devices and turnbuckles so as not to interfere with the function of any part of the installation.
- **b.** Individual cables may be spliced by use of an approved device installed where no interference with any other function will occur. One splice per cable is allowed. Cable may not be spliced within 250 feet (75 m) of another splice in one of the other cables.
- **c.** Tighten individual cables using mechanical means. Stretch cables tight so that no sags occur between posts and so that, in the opinion of the Engineer, the finished installation presents a satisfactory appearance.

3. Posts.

- **a.** Drive posts in a manner that does not damage the post. Place backfill material (consisting of material removed or other suitable soil) around posts required to be set in prebored holes. Place the backfill material in lifts not exceeding 4 inches (100 mm). Thoroughly compact each lift before the next lift is placed.
- **b.** Install the posts to be firm, plumb, and at the location, spacing, and elevation designated.

4. End Anchors and Terminals.

a. Install end anchors and terminals of the type shown in the contract documents. Cast end anchors in place using Class C concrete according to Section 2403, except air content may vary from 4% to 7%. Finish exposed concrete as directed by the Engineer.

b. When bolt holes in concrete bridge end posts or concrete barrier do not align correctly for the steel beam guardrail terminal connection, drill new bolt holes in the locations required for the terminal connection. Use a core bit to ensure correct bolt hole location and alignment.

5. Delineators and Object Markers.

When indicated in the contract documents, install delineators and object markers of the required type meeting the requirements of Articles 4186.11 and 4186.12.

B. High Tension Cable Guardrail.

Furnish high tension cable guardrail from the approved products listed in Materials I.M. 455.01.

1. Installation of High Tension Cable Guardrail.

a. Install high tension cable guardrail according to the manufacturer's recommendations. Prior to construction, provide the Engineer with three copies of the manufacturer’s most current product manuals covering installation and maintenance of the installation. Include signed certification statements that all materials to be incorporated into the installation comply with Materials I.M. 455.01.

b. Tension the cables according to the manufacturer's recommendations at the time of installation, then check and adjust the tension approximately three weeks after installation.

2. Posts.

a. Ensure posts are plumb and at the manufacturer’s recommended location, spacing, and elevation. Spacing is not to exceed 20 feet (6 m).

b. Furnish “socketed” type posts and install in reinforced concrete foundations. Cast the foundations in place according to Article 2505.03, A, 4. Use the dimensions and reinforcement recommended by the manufacturer, except with a foundation depth of at least 42 inches (1.1 m).

3. End Anchors.

a. Incorporate one of the approved end anchors listed in Materials I.M. 455.01. Furnish end anchors produced by the same manufacturer of the high tension cable guardrail.

b. Construct end anchors according to the manufacturer’s recommendations for the site specific soil conditions. Soils testing required is incidental to the cable installation.

4. Delineating High Tension Cable Guardrail.

a. Delineate high tension cable guardrail installations using retroreflective sheeting. Apply the sheeting to the last five posts at each end of an installation and throughout the remainder of the installation at a maximum spacing of 50 feet (15 m). Apply Type III or IV retroreflective sheeting that:

- Meets the requirements of Article 4186.03,
- Provides at least 7 square inches (4500 mm^2) of surface area when viewed from a line parallel to the roadway centerline, and
- Is yellow or white and of the same color as the adjacent edge line.

b. Attach sheeting near the top of the post: 1) in a manner recommended by the manufacturer; and 2) to that side of the post from which vehicle impacts are most likely. For installations where impacts are likely to occur from either side, apply the sheeting to both sides of the post.

C. Guardrail Removal.

1. Remove guardrail, delineators, and object markers as shown in the contract documents. Guardrail materials become the property of the Contactor unless stated otherwise in the contract documents. Deliver salvaged materials to the location stated in the contract documents. Salvaged materials become the property of the Contracting Authority. Remove non-salvaged materials from project site.

2. Carefully remove, disassemble, and clean the salvaged guardrail without damaging the parts. Replace material damaged during removal, disassembly, or cleaning with new material of the same kind (at no cost to the Contracting Authority). Stockpile salvaged materials as indicated in the contract documents. Restore areas disturbed by the removal operation to an acceptable condition.

3. Place backfill material consisting of suitable soil in post holes. Sand or other granular materials are not acceptable for use as backfill material. Place backfill material in lifts not exceeding 4 inches (100 mm). Thoroughly compact each lift before the next lift is placed. Fill and tamp holes within the same working day.

D. Limitations.

1. General.

a. Do not stress attachments to new concrete or to bolts set in epoxy resin until the new concrete or epoxy resin has attained an age of 3 calendar days. Concrete foundations for posts and end anchors may be subjected to cable tensioning after 3 calendar days. These time requirements may be lengthened by the Engineer during cool weather.

b. Complete grading work, if required, prior to removal of existing guardrail or installation of new guardrail.

c. When a roadway is open to traffic during construction, complete guardrail installations within 5 working days from the day the structure, barrier rail, pavement, or shoulder (whichever is the controlling item of work) is sufficiently completed to allow guardrail installation. Each installation exceeding the 5 working day completion requirement will be subject to a contract price adjustment of $100 per working day. For high tension cable guardrail, this price adjustment will be waived when the installation serves as crossover protection only and no guardrail or concrete barrier has been removed.

d. When a roadway is closed to public traffic for construction, complete all guardrail installations before opening the road to traffic.

2. Steel Beam Guardrail and Low Tension Cable Guardrail.

a. In areas where guardrail construction is not restricted by other construction, remove existing guardrail (if any) and construct new guardrail, except for end anchors requiring concrete, on the same working day. Place concrete for the final end anchor no later than the next working day.

b. For steel beam guardrail installations requiring end anchors, use a Type E Terminal Section, a Type II Barricade, and a Type A Warning Light to end the installations until the final anchor is finished.

3. High Tension Cable Guardrail.

a. In case of a discrepancy between these Specifications and the manufacturer's recommendations, these Specifications will govern.

b. At locations where the proposed guardrail installation does not interfere with the functioning of the existing guardrail, do not remove the existing guardrail until the high tension cable guardrail system is fully functional. Once the installation is fully functional, remove existing guardrail within 5 working days.

2505.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Steel Beam Guardrail Installation.

1. Steel Beem Guardrail.
Linear feet (meters) shown in the contract documents.

2. Steel Beam Guardrail Barrier Transition Section.
By count.

3. Steel Beam Guardrail End Anchors.
By count for each type of end anchor constructed. Installations continued across a bridge will not be counted as end anchors.

4. End Terminals.
By count for each type of end terminal constructed.

B. Low Tension Cable Guardrail Installation.

1. Low Tension Cable Guardrail.
a. Linear feet (meters) shown in the contract documents.
b. Length will be calculated using one of the cables of cable guardrail, with no deductions for turnbuckles or compensating devices.

2. Low Tension Cable Guardrail, End Anchors.
By count.

C. High Tension Cable Guardrail Installation.

1. High Tension Cable Guardrail.
a. Linear feet (meters) shown in the contract documents.
b. Length will be calculated as the protection length, not including lengths of end anchors.

2. High Tension Cable Guardrail, End Anchor.
By count.

3. High Tension Cable Guardrail, Spare Parts Kit.
By count for the number of spare parts kits delivered.

D. Removal of Guardrail.

1. Steel beam guardrail: linear feet (meters) to the nearest 0.5 foot (0.1 m) by measuring along the front of the rail from bolt hole to bolt hole.

2. Cable guardrail: in linear feet (meters) to the nearest 1 foot (0.1 m) by measuring along the front of one of the cables with no deductions for turnbuckles or compensating devices.

2505.05 BASIS OF PAYMENT.
Payment for guardrail items will be the contract unit price as described below. Payment includes furnishing all materials, equipment, tools, and labor necessary to complete the removal and installation of the guardrail, including excavation and placing backfill. However, excavation in unexpected rock will be paid for as extra work according to Article 1109.03B. Unexpected rock will be considered as rock encountered during excavation that was not visible from the roadway and was not indicated in the contract documents.

A. Steel Beam Guardrail Installation.

1. Steel Beam Guardrail.
a. Per linear foot (meter).
b. Payment for nested steel beam guardrail will be included in the contract unit price.
c. Posts, spacer blocks, object markers, delineators, guardrail markers, barrier markers, offset brackets, and remaining hardware are incidental.

2. Steel Beam Guardrail Barrier Transition Section.
- **a.** Each.
- **b.** Payment for nested steel beam guardrail will be included in the contract unit price.
- **c.** Posts, spacer blocks, object markers, delineators, guardrail markers, barrier markers, offset brackets, and remaining hardware are incidental.

3. Steel Beam Guardrail End Anchors.
- **a.** Each for the type of end anchor constructed.
- **b.** Payment for nested steel beam guardrail will be included in the contract unit price.
- **c.** Drilling new bolt holes for guardrail connection is incidental.

4. End Terminals.
- **a.** Each for the type of end terminal constructed.
- **b.** Payment for nested steel beam guardrail will be included in the contract unit price.
- **c.** Posts, spacer blocks, object markers, delineators, guardrail markers, offset brackets, and remaining hardware are incidental.

B. Low Tension Cable Guardrail Installation.

1. Low Tension Cable Guardrail.
- **a.** Per linear foot (meter).
- **b.** Posts, spacer blocks, object markers, delineators, guardrail markers, barrier markers, offset brackets, hook bolts, turnbuckles, compensating devices, concrete, and remaining hardware are incidental.

2. Low Tension Cable Guardrail, End Anchor.
Each.

C. High Tension Cable Guardrail Installation.

1. High Tension Cable Guardrail.
- **a.** Per linear foot (meter).
- **b.** Posts and accessories required by the manufacturer, additional hardware and concrete, and grading required to meet cable height tolerance are incidental.

2. High Tension Cable Guardrail, End Anchor.
Each. Grading required to meet the manufacturer's recommendations is incidental.

3. High Tension Cable Guardrail, Spare Parts Kit.
Each. Payment is full compensation for delivering spare parts kit to the location identified in the contract documents.

D. Removal of Guardrail.

1. Per linear foot (meter) for removal of guardrail, including steel beam guardrail, cable guardrail, foundations for socketed posts for cable guardrail, end anchors, and terminal devices.

2. If the guardrail materials are salvaged, payment for hauling and stockpiling the materials shall be according to Section 2555. Placing backfill material around posts and in end anchor footing holes is incidental.

3. Payment for nested steel beam guardrail will be included in the contract unit price.

4. Posts, spacer blocks, object markers, delineators, guardrail markers, offset brackets, end anchors, terminal devices, and remaining hardware are incidental.

5. For low tension cable guardrail, the following additional items are incidental: hook bolts, turnbuckles, compensating devices, and remaining hardware.

Section 2506. Flowable Mortar

2506.01 DESCRIPTION.
Place a flowable mortar fill material. Uses include, but are not limited to, placement under existing bridges, around or within box culverts or culvert pipes, in open trenches, or at other locations as shown in the contract documents.

2506.02 MATERIALS.
Meet the requirements for the respective items in Division 41 with the following exceptions:

A. Cement.
Meet the requirements of Section 4101.

B. Fly Ash.
Meet the requirements of Section 4108. Use fly ash from a source approved by the Engineer.

C. Fine Aggregate.

1. Use natural sand consisting of mineral aggregate particles or foundry sand from the castings of ferrous material. Use the gradation shown in Table 2506.02-1:

Table 2506.02-1: Fine Aggregate Gradation

Sieve Size	Percent Passing
3/4 inch (9.5 mm)	100
No. 200 (75 µm)	0-10

2. It is intended that the sand be a fine sand that will stay in suspension in the mortar to the extent required for proper flow. For the Contractor's information, uniformly graded sand in the gradation range shown in Table 2506.02-2 has generally shown good flow characteristics when using the normal amount of fly ash (300 pounds per cubic yard (180 kg/m^3)). Concrete sand normally does not produce the desired flowability.

Table 2506.02-2: Informational Gradation Limits

Sieve Size	Percent Passing
3/8 inch (9.5 mm)	100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	60-100
No. 30 (600 µm)	45-80
No. 50 (300 µm)	12-40
No. 100 (150 µm)	1.5-25
No. 200 (75 µm)	0-5

3. Fine aggregate meeting the above informational gradation limits may be used in the basic proportions shown in Article 2506.02, E, without initial mix design, provided the flowable mortar is used in noncritical fluidity locations described in Article 2506.02, F. The Engineer reserves the right to reject the intended sand if a flowable mortar cannot be produced using the specified proportions.

4. The Contractor is not responsible for certified aggregate testing. The Engineer will provide appropriate inspection (normally, source approval) followed by visual inspection. If foundry sand is used, ensure it meets the requirements of IAC 567 Section 108. Ensure suppliers of foundry sand submit a processing plan to the District Materials Engineer for review and approval.

D. Admixtures.
Air entraining and water reducing admixtures may be added to increase the fluidity of flowable mortar.

E. Mix Design.

1. Use the basic proportioning for flowable mortar shown in Table 2506.02-1:

Table 2506.02-1: Quantities of Dry Materials Per Cubic Yard (Cubic Meter)

Cement	100 pounds (60 kg)
Fly Ash	300 pounds (180 kg)
Fine Aggregate	2600 pounds (1545 kg)

2. Submit samples of fine aggregate, cement, and fly ash intended for use to the Engineer. Submit the samples before the work begins for mix proportions to produce the required efflux time.

3. The Engineer will determine the mix design. The cement content is not to exceed 100 pounds per cubic yard (60 kg/m^3). The total amount of cementitious material is not to exceed 500 pounds per cubic yard (295 kg/m^3).

4. These quantities of dry materials, with approximately 70 gallons (345 L) of water (mixes utilizing foundry sand may require more water), will yield approximately 1 cubic yard (1 m^3) of flowable mortar of the proper consistency. The quantity of water used for the trial mix or at the project may require adjustment to achieve proper solids suspension and optimum flowability.

5. For information, volume loss during the cure period resulting from surface evaporation, moisture migration away from the flowable mortar unit, and hydration have been observed to be less than 4% of the original volume determined in the fluid condition. In mixes utilizing foundry sand, additional fly ash may be required and the limit of total cementitious material will not apply.

F. Fluidity.

1. Measure the fluidity of the flowable mortar using the method described by Materials I.M. 375. Prior to filling the flow cone with flowable mortar, pass the mixture through a 1/4 inch (6.3 mm) screen.

2. In locations where fluidity is critical, such as inside existing culverts and between the beams under existing bridges, use an efflux time of 10 seconds to 16 seconds. The Engineer will measure prior to placement and at least once every 4 working hours until work is complete.

3. In locations where fluidity is not critical, such as for placement below the beams under existing bridges or for use as backfill material in open trenches, use an efflux time of 10 seconds to 26 seconds. The Engineer will visually monitor.

G. Granular Backfill Material.
For granular backfill material used under flowable mortar, meet the requirements of Section 4133.

2506.03 CONSTRUCTION.

A. Proportioning and Mixing Equipment.
Use equipment meeting the requirements of Articles 2001.20 and 2001.21. Provide mixers with sufficient mixing capacity to permit the intended placement without interruption.

B. Flange Filler Material.
When the flowable mortar is to be placed under a bridge, cover the bridge beams with a filler material, as shown in the contract documents, to fill the flange areas in a manner that will minimize intrusion of the mortar into the flange area of the beams. Construction insulation board or any other suitable material may be used.

C. Placement of Mortar under Existing Bridges.

1. First construct the shoulder area as shown in the contract documents, with the drainage system shown. Complete this work in conjunction with pipe placement, if a pipe culvert is required.

2. If a culvert is required, place engineering fabric meeting requirements of Article 4196.01, B, 2 over all joints in the culvert, within the area where flowable mortar is to be placed as backfill material. Place the fabric from the underlying ground line around the culvert, 1 foot (0.3 m) on each side of the joint.

3. Discharge flowable mortar from the mixer by any reasonable means into the area to be filled.

4. Bring the mortar fill up uniformly to the elevation of the first stage fill line, if specified. Cease mortar placement for a period of 72 hours.

5. If there is only one stage of flowable mortar, place granular backfill material in the lower part of the fill and around the pipe as specified. Compact the granular backfill material according to Article 2402.03, H, or thoroughly and uniformly wet with water in a quantity of approximately 10% of the granular backfill material. Complete flooding may be required. Regardless of the method of consolidation, wait 72 hours to commence flowable mortar placement.

6. Place the flowable mortar in a sequential operation from side to side and longitudinally. Begin with fill in one shoulder area, then proceed through each hole in the deck adjacent to the shoulder until mortar is expelled from the adjacent longitudinal hole. Place the last fill on the opposite shoulder. Place mortar through holes in the deck using a suitable funnel which can create a 3 foot (1 m) head during filling.

7. The locations for holes in the deck will normally be shown in the contract documents. When not shown, drill a hole approximately 5 feet (1.5 m) from each end of the bridge in each area between bridge beams. Drill additional holes as necessary so the longitudinal spacing does not exceed 20 feet (6 m). Limit the size of the holes to that necessary to accommodate filling equipment.

8. When placement of flowable mortar is completed and set, remove the mortar in the holes in the deck and replace with a suitable PCC mixture.

D. Placement of Mortar as Culvert Backfill Material.

1. First construct the shoulder area with suitable soil as shown in the contract documents, with the drainage system shown. Complete this work in conjunction with the pipe placement, if the culvert is a pipe.

2. Place engineering fabric meeting requirements of Article 4196.01, B, 2 over all joints in the culvert, within the area where flowable mortar is to be placed as backfill material. Place the fabric from the underlying ground line around the culvert, 1 foot (0.3 m) on each side of the joint.

3. Place granular backfill material meeting requirements of Section 4133 to approximately mid-height of the culvert. Place the backfill simultaneously on both sides of the culvert so that the two fills are kept at approximately the same elevation at all times. Granular backfill material compaction is not necessary.

4. Discharge flowable mortar from the mixer into the remaining area to be filled. Fill simultaneously on both sides of the structure so that the two fills are kept at approximately the same elevation at all times.

5. If the culvert starts to float, cease the filling operation. Apply an external load to the culvert, sufficient to hold it in place, before the filling is continued. As an alternate, the filling may be suspended until the buoyancy effect of the mortar has ceased.

6. Place the flowable mortar to the elevation shown in the contract documents. When not shown, place the mortar as follows:
- **a.** If the subgrade elevation is not more than 5 feet (1.5 m) over the top of the culvert, place mortar to 1 foot (0.3 m) below subgrade elevation.
- **b.** If the subgrade is more than 5 feet (1.5 m) over the top of the culvert, place the mortar to an elevation 2 feet (0.6 m) over the top of the culvert. Complete the remainder of the backfill operation using soil designated by the Engineer.

E. Limitation of Operations.

1. Do not place flowable mortar on frozen ground.

2. Flowable mortar batching, mixing, and placing may be started when the temperature is at least 34°F (1°C) and rising, if weather conditions are favorable. At time of placement, mortar shall have a temperature of at least 40°F (4°C). Cease mixing and placing when the temperature is 38°F (3°C) or less and falling.

3. Complete each filling stage in as continuous an operation as practical.

4. Do not allow flowable mortar into streams and waterways.

2506.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the volume of Flowable Mortar furnished and placed, from the nominal volume of each batch and a count of batches. The Engineer will estimate and deduct unused mortar; however, deduction will not be made for a partial batch remaining at the completion of the operation.

B. Granular backfill material used in the lower part of the fill area will be based on the contract document quantity.

C. When the flowable mortar elevation for placing backfill around culverts is shown in the contract documents, payment for Flowable Mortar will be based on the quantity shown in the contract documents.

2506.05 BASIS OF PAYMENT.

A. Payment for Flowable Mortar will be the contract unit price per cubic yard (cubic meter).

B. Payment is full compensation for:

- Placing the flowable mortar,
- Flange filler material,
- Engineering fabric as required,
- Drilling and filling the bridge deck holes, and
- Furnishing all materials, equipment, and labor necessary to complete the work.

C. Payment for granular backfill material used in the lower part of the fill area will be based on the quantity shown in the contract documents, and this will normally be included in the quantity of other granular backfill material on the project.

D. Excavation, placing backfill material for construction of the shoulder area, and moisture control if designated necessary for this work, will be paid for separately. These items will be included in the quantities of other similar work on the project. Furnishing and placing the drainage system in the shoulder area will be considered incidental to the payment for Flowable Mortar.

Section 2507. Concrete and Stone Revetment

2507.01 DESCRIPTION.

A. Place a layer of stone or concrete for protection of earth slopes against erosion from stream flow or wave action. Place according to the contract documents for the class of revetment specified. When specified, place a filter course beneath the revetment.

B. When specified furnish, transport, and place concrete grout within the voids of rock revetment as shown in the contract documents. The intent is to fill the voids of the revetment rock placement without over consolidation.

2507.02 MATERIALS.

A. Revetment.
Meet requirements of Division 41 for the material specified.

B. Grout.

1. General.
- **a.** The Engineer may require adjustment of the mix proportions to achieve proper solids suspension and optimum flowability. After the mix has been designated, do not change it without the Engineer's approval.
- **b.** Use proportioning and mixing equipment that meets the requirements of Articles 2001.20 and 2001.21. Provide mixers with sufficient mixing capacity to permit the intended pour to be placed without interruption.

2. Cement.
Use cement complying with Section 4101, at the rate of 10 sacks (940 pounds) per cubic yard (558 kg per cubic meter).

3. Fly Ash.
Meet the requirements of Section 4108. Fly ash may be substituted for cement for up to 25% by weight (mass) of cement.

4. Fine Aggregate.
Meet the requirements of Section 4110. Use 2100 pounds (surface dry weight) per cubic yard (1246 kg (surface dry weight) per cubic meter).

5. Water.
Meet the requirements of Section 4102. Use 45 gallons (375 pounds) per cubic yard (170 L (221 kg) per cubic meter), or enough to provide a thick creamy consistency.

6. Air-entraining Admixtures.
Meet the requirements of Section 4103. 6% to 10%.

7. Liquid Curing Compounds.
Meet the requirements of Section 4105.

C. Filter Blanket.
Apply Article 2107.03, K.

D. Engineering Fabric.
Meet requirements of Section 4196 and listed on Materials I.M. 496.01, Appendix G.

2507.03 CONSTRUCTION.

A. General.

1. For each of the five classes of revetment, begin construction in a trench dug to the elevation shown in the contract documents. Shape the slopes upon which revetment is to be placed and dress them to the extent that, when the revetment is placed to the specified depth, the revetment surface will be in compliance with the lines and grades shown in the contract documents.

2. For control of placement, mark (in a system of grids) those areas designated to receive stone protection. Spot and distribute loads over the surface marked in grids to provide the thickness shown in the contract documents. Control distribution based on the assumed density of 100 pounds per cubic foot (1600 kg/m^3) and the actual weights (mass) delivered.

3. Immediately prior to placing the revetment, the Engineer will inspect the prepared base.

4. After completion of Class A, B, and C revetment, place the excavated material into the trench as backfill.

B. Revetment.

1. Class A Revetment.
- **a.** A layer of the stone specified over the areas indicated in the contract documents.
- **b.** Place this layer so that each stone is firmly bedded against the bank and in close contact with adjacent stones. The stones need not be laid in courses.
- **c.** Drive spalls into openings remaining after the layer of stone is placed.
- **d.** Place this layer to a thickness of approximately 15 inches (0.4 m), with no portion having a thickness less than 12 inches (0.3 m).
- **e.** Chip portions of individual rocks projecting more than 2 inches (50 mm) above the general contour of the surface to within these limits.

2. Class B and C Revetment.
Place by bucket, clam shell or other mechanical means in a manner that will:

- Uniformly distribute the material as shown on the plans,
- Prevent damage to the filter blanket or fabric, and
- Limit disturbance of foundation soils.

3. Class D and Class E Revetment.

a. Meet the requirements of Section 4130. If using recycled PCC, meet requirements of Materials I.M. 210. If filter blanket is required, refer to the contract documents for the material specified.

b. Place revetment stone on the filter blanket. When filter blanket is not required, place revetment stone directly on the prepared slope or area in a manner which will produce a reasonably well graded mass of stone with the minimum practical percentage of voids. Place the entire mass of stone in compliance with the lines, grades, and thicknesses shown in the contract documents. Place revetment to its full course thickness in one operation and in such a manner as to avoid displacing underlying material. Do not place revetment in layers or by dumping into chutes and similar methods likely to cause segregation.

c. Ensure the larger stones are well distributed. The entire mass of stone should comply with the gradation specified in Section 4130. Place the revetment and distribute so that there are no large accumulations of either the larger or smaller sizes of stone.

d. Some roughness in surface is desirable to break up wave action and decrease the velocity of the water, but the mass should be fairly compact with all sizes of material placed in their proper proportions. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the results specified.

e. When the embankment is constantly exposed to erosion, place the revetment protection in conjunction with the construction of the embankment with only sufficient lag to allow for proper stabilization of the embankment. Do not allow embankment materials to mix with revetment materials. When the embankment to be protected is constructed in lifts, revetment can be dumped directly in place from the surface of each lift.

C. Bank Shaping.
When the revetment is to be placed on an existing slope, prepare the foundation for areas on which the revetment is to be placed by shaping, trimming, and dressing. Bring these areas into compliance with the slopes, grades, and cross sections shown in the contract documents. Where such areas are high or low, bring into compliance by cutting and filling, and compact the area so the earth is well compacted.

D. Erosion Stone.
Use erosion stone meeting the requirements of Section 4130. Place the material as shown in the contract documents.

E. Grouting.

1. Placement of Grout.

a. Do not place the grout until the Engineer has inspected and approved the revetment.

b. Flush the rock to be grouted with high pressure water to remove the fines prior to placing the grout. Keep the rock to be grouted wet for at least 2 hours immediately prior to grouting, but do not place the grout in standing or flowing water.

c. Deliver the grout mix to the site and place within 1 1/2 hours after the introduction of cement to the aggregates. Transfer concrete from the mixer to final placement by means which prevent segregation of the aggregate or loss of mortar. Do not allow grout to drop more than 5 feet (1.5 m) vertically unless suitable equipment is used to prevent segregation.

d. Place grout in successive lateral courses starting at the top and progressing to the toe. Discharge the grout directly on the surface of the rock. Direct the flow of grout to prevent it from flowing excessively along the same path and to ensure that all intermittent spaces are filled. Sufficient jarring of rocks may be done to aid penetration of the grout so that all voids are filled and the grout fully penetrates the rock blanket. Work the grout into voids with the use of suitable spades and rods.

e. Do not allow the grouting operation to create a smooth surface. Finish the grout so that face stones are left exposed for one-fourth to one-third of their depth. Finish revetment rock blankets by brooming or other methods to:

- Fill voids caused by sloughing,
- Eliminate runs, and
- Provide a rough surface.

2. Curing and Protection.

a. After completion of any course, do not allow loads on the grouted surface for a period of 24 hours. Protect the grouted surface from injurious action by the sun, rain, flowing water, and mechanical injury.

b. Protect the grouted surface from drying for a curing period of at least 7 calendar days after placement. Keep exposed surfaces moist for the entire period, or until curing compound is applied. Maintain moisture by sprinkling, flooding, fog spraying, or covering with continuously moistened canvas, cloth mats, straw, sand, or other approved material.

c. If compound is used, spray it on the moist finished concrete surface as soon as free water has disappeared. Apply the compound at a uniform rate of no less than 1 gallon per 15 square yards (3 L per 10 m^2) of surface. Form a continuous adherent membrane over the entire surface.

d. Do not apply curing compound to surfaces that will be required to bond to subsequently placed concrete.

3. Limitation of Operations.

a. Do not place grout on frozen ground.

b. Grout batching, mixing, and placing may be started, if weather conditions are favorable, when the temperature is at least 34°F (1°C) and rising. At time of placement, grout shall have a temperature of at least 40°F (4°C). Stop mixing and placing grout when the temperature is 38°F (3°C) or less and falling.

c. Place each course in as continuous an operation as possible.

4. Inspecting and Testing Fresh Grout.

a. The Engineer will inspect materials and processes used in mixing and placing the grout, and will secure samples for air content. Allow the Engineer free entry to all parts of the plant and equipment.

b. When ready-mixed grout is furnished, provide the Engineer with a statement-of-delivery ticket for each batch delivered to the job site. Ensure tickets show:

- Batch weights (mass) of cement,
- Fly ash (if used),
- Water, fine aggregate, and air entraining agent, and
- Time of loading and revolution counter reading at the time of batching.

2507.04 METHOD OF MEASUREMENT.

Measurement for the items associated with concrete and stone revetment will be as follows:

A. Class A Revetment: computed in square yards (square meters) from measurements of the surface as constructed to the nearest 0.1 foot (0.1 m).

B. Class B, C, D, and E Revetment and Erosion Stone: tons (megagrams) to the nearest 0.1 ton (0.1 Mg). Only material placed according to the contract documents will be measured.

C. Material for Filter Blanket: tons (megagrams) to the nearest 0.1 ton (0.1 Mg).

D. Engineering Fabric: computed in square yards (square meters) from measurements of the material placed to the nearest 0.1 foot (0.1 meter).

E. Concrete Grout for Revetment or Gabion (if specified in the contract documents): cubic yards (cubic meters) of concrete grout furnished and placed computed from the nominal volume of each batch and a count of batches. The Engineer will estimate and deduct grout that is unused or wasted; however, no deduction will be made for a partial batch remaining at the completion of the operation.

2507.05 BASIS OF PAYMENT.

A. For the construction of revetment of the class specified, payment will be the contract unit price as follows:

1. Revetment furnished and placed: per square yard (square meter) for Class A Revetment, or per ton (megagram) for Class B, C, D, or E Revetment and Erosion Stone.

2. Material for Filter Blanket placed: per ton (megagram).

3. Engineering Fabric placed: per square yard (square meter).

4. Bank Shaping, if required: lump sum contract unit price.

5. When excavation, placing backfill, and (if required) special compaction are designated in the contract documents, payment will be made according to the type of work specified.

B. Payments are full compensation for all work, including bank shaping, furnishing and placing all material, excavation and placing backfill material, and for furnishing all equipment, tools, and labor necessary to complete the work according to the contract documents.

C. When Concrete Grout for Revetment or Gabion is specified in the contract documents, payment will be paid the contract unit price per cubic yard (cubic meter). Payment is full compensation for placing the grout and for furnishing all materials, equipment, and labor necessary to complete the work.

Section 2508. Removal of Paint and Painting Steel Bridge Structures

2508.01 REMOVAL OF PAINT.

A. Non-Hazardous Paint Removal.

1. General.

a. Apply Article 2508.01, A, only to structures previously painted with "non-lead based" paints and to structures with scratch tests indicating a non-hazardous waste (as identified in 40 CFR 261) is expected to be generated during the project. OSHA may regulate other issues. Take whatever precautions are necessary to comply with Federal and State safety and health regulations.

b. To comply with Iowa Code Section 89 B.8, 1, scratch tests are provided elsewhere in the contract documents for information.

2. Bridge Cleaning.

This work involves removing accumulated foreign material and loose paint. It also involves water washing areas designated elsewhere in the contract documents.

a. Removal of Accumulated Foreign Material.

1) Prior to water washing, remove all accumulated foreign material from:

- Beams, member flanges, and gusset plates,
- Abutment bridge seats, pier tops, truss joints, and deck drains, and

- Other locations the Engineer orders.

2) Remove the accumulated foreign material using hand brooms, hand shovels, vacuum cleaners or other methods the Engineer considers acceptable. Collect the removed material and dispose of at an approved waste area according to Federal, State, and local regulations. Apply appropriate measures to ensure that at no time does removed material fall or be disposed in the water or on the land below the bridge.

b. Loosely Adherent Paint.

Prior to water washing, use hand tool methods, complying with SSPC-SP2, to remove loosely adherent paint in areas designated for painting. All paint removal operations will require containment as specified in Article 2508.01, A, 4.

c. Water Washing.

1) Prior to abrasive blast cleaning, use high-pressure water to wash steel surfaces to be repainted, abutment seats, pier caps, and other surfaces that may be designated elsewhere in the contract documents. Limit water pressure so that no paint is removed.

2) Ensure salt contaminants, dirt, bird excrement, and other detrimental foreign material are removed. Detergents or cleaners and scrubbing may be needed in conjunction with water washing. Use clear fresh water that is free of sediments and salt contaminants. After water cleaning, remove all oily or greasy residues using solvent according to SSPC-SP1.

3) Remove chalking from existing painted surfaces onto which paint is to be applied. Examples are transition zones for spot or zone painting and surfaces that will receive a top coat over an existing prime or top coat. In those areas, remove the chalked pigment by water washing.

4) Detergents or cleaners and scrubbing may be needed in conjunction with water washing. Use detergents or cleaners that are compatible with the existing paint system and pre-approved by the new paint manufacturer. Apply according to the product manufacturer's recommendations.

5) Submit MSDS and any technical field guides for any detergent or cleaner to the Engineer for review and approval before using. If detergents or cleaners are used, thoroughly rinse the surface with water to remove all residue prior to painting.

3. Blast Cleaning and Surface Preparation.

a. Abrasive Blast Cleaning.

1) This work involves preparing all designated surfaces to be painted by either:

- abrasive blasting using conventional equipment, and/or
- vacuum blasting equipment.

2) Some hand-tool and/or power-tool cleaning may be required in areas not fully accessible to the other methods.

3) Use an abrasive blasting system that incorporates abrasive recycling in order to reduce waste volume to the greatest extent possible.

b. Standards For Surface Preparation.

1) Abrasive Blasting.

a) Prepare areas to be painted using a dry abrasive blast method to a level (SSPC-SP6 and/or SSPC-SP10) as designated elsewhere in the contract documents. The current SSPC-VIS1, Visual Standard for Abrasive Blast Cleaned Steel, will be used in conjunction with the appropriate written SSPC Standard for acceptance of final surface preparation. Prepare the surface profile (etched height) to be 1.5 to 2.5 mils (25 µm to 50 µm) as measured by replica tape or surface profile comparator.

b) Use hand-tool or power-tool methods, or both, to prepare small areas that cannot be cleaned using abrasive blasting equipment. SSPC Standards applicable to the method(s) applied will be used to evaluate surface preparation.

c) After blasting or mechanical preparation, thoroughly clean the surface to be painted with either HEPA vacuums or dry, oil free, compressed air, or both, to remove all adhering blast residue. Remove all oily or greasy residues with solvent complying with SSPC-SP1, Solvent Cleaning.

2) Removal of Existing Deteriorated Paint by Mechanical Methods.

a) The contract documents may designate areas to be painted which are to be cleaned by mechanical methods. These will be:

(1) Areas of deteriorated paint where the existing top coat is peeled or deteriorated and the underlying existing primer is in sound condition. In these cases, remove only the existing top coat by manual methods complying with SSPC-SP2 so the underlying existing primer is left in place. Remove the deteriorated top coat back to the boundary of soundly adhering top coat. A soundly adhering top coat is defined as that which cannot be lifted from the primer with a putty knife.

(2) Spot areas deemed too small to be effectively prepared by abrasive blasting.

b) Remove the deteriorated paint back to the boundary of soundly adhering existing primer. Regardless of the method used for cleaning, feather all edges of sites cleaned to a smooth transition between the existing paint and the cleaned area.

c) Use mechanical methods of surface preparation complying with SSPC-SP2 or SSPC-SP3, or both, as modified below.

d) Replace Article 3.5 of SP2, Hand Tool Cleaning, with the following:

3.5 SSPC-VIS3, Visual Standards for Power and Hand-Tool Cleaned Steel, shall be used to evaluate the degree of cleaning.

e) Replace Articles 2.2, 2.3, and 5.3 of SSPC-SP3, Power Tool Cleaning, with the following:

2.2 It is intended that power tool cleaning remove rust, deteriorated paint, detrimental foreign material, and loose mill scale that can be removed by vigorous use of the power tools.

2.3 SSPC-VIS3, Visual Standard for Power and Hand-Tool Cleaned Steel, shall be used to evaluate the degree of cleaning.

5.3 Use power wire brushing, power abrading, power impact, or other power rotary tools to remove rust, deteriorated paint, and loose mill scale. Do not burnish the surface.

f) After mechanical preparation, thoroughly clean the surface to be painted with either HEPA Vacuums or dry, oil free, compressed air, or both, to remove all adhering blast residue. Remove all oily or greasy residues with solvent complying with SSPC-SP1, Solvent Cleaning.

3) Galvanized Elements.

Protect galvanized elements such as deck drain pipes and bearings. Blast clean only if directed by the Engineer. All galvanized elements which are to be cleaned and painted will be paid for as extra work according to Article 1109.03B.

4) Rust Blume or Flash Rust.

Rust blume or flash rust is defined as the development of visible rust on bare metal surfaces after cleaning. Reblast the surface, or brush blast the surface and blow it down, just prior to the application of the first coat of paint if:

- Flash rust or rust blume occurs after removal of existing paint, or
- A surface is cleaned and left unpainted for more than 24 hours

5) Pin Hole Rusting.

a) Pinhole rust areas may be designated for painting in the contract documents. In areas where there is pin hole rusting and associated staining, abrasive blasting may not be required if the existing paint is sound other than at the pin holes. Mechanical cleaning, according to SSPC-SP2, may be used in these areas prior to applying the spot primer.

b) If the mechanical methods do not remove heavy staining of sound paint adjacent to the pinholes, remove the stain to the degree recommended by the manufacturer of the primer. Use methods of removal recommended by the manufacturer. Provide a written copy of the recommendations to the Engineer prior to performing the work.

6) Feathering of Repair Areas.
For spot and zone painting work, feather the existing coating surrounding each repair location. A smooth, tapered transition of 1 to 2 inches (25 mm to 50 mm) onto the existing intact coating is required around each repair area. Roughen the existing coating by hand sanding or a solvent wipe in the feathered area to assure proper adhesion for the new paint. Verify soundness of the existing paint by probing the edges of coating around the periphery of the repair areas with a putty knife, according to the requirements of SSPC-SP3.

7) Protection of Unpainted Surfaces.

a) Use whatever precaution is necessary to ensure vehicular traffic, equipment, hardware, fixtures, concrete, and other surfaces are protected against abrasive impact, paint spillage, over-spray, and other damage during the project.

b) For spot or zone painting work, use protective coverings, shields, or masking as necessary to protect surfaces that are outside the designated painting areas. Maintain protection during the entire period work is being performed which could damage those surfaces.

c) Exercise extra care to avoid over-blast damage to the existing coating in non-designated areas. Correct damage to non-designated areas by cleaning, repairing, and repainting at no additional cost to the Contracting Authority. Repair procedures will be approved by the coating manufacturer's technical representative. Submit the manufacturer's approval to the Engineer for review and approval before the repair work is started.

8) Abrasives.

a) Use steel shot and/or grit, aluminum oxide, or garnet abrasives. This is to ensure hard durable abrasives are used, to encourage abrasive recycling, and to minimize waste generated by the project. Use clean, dry abrasives that are free from contamination. Do not use sand or coal slag.

b) If blasting with previously used or recycled abrasive:

- Obtain a representative sample of that abrasive,
- Have that sample analyzed for TCLP leachable levels of arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver, and
- Submit the laboratory's analytical report to the Engineer for approval prior to use.

c) The Engineer will accept used or recycled abrasives only if the leachable quantity of each metal tested is equal to, or less than, one part per million (1 ppm).

d) Clean and recycle abrasive used during this project to the greatest extent possible. Provide a written abrasive recycling workplan to the Engineer for approval. In this proposal list the equipment and process used for recycling and recovery of the abrasive and monitoring air dispelled from the recycling process.

e) Employ a method to monitor dispelled air from the recycling system that samples and tests for total lead and particulate matter of 0.4 mils (10 µm) and smaller (PM_{10}). Blasting will be suspended immediately if the Engineer deems visible dust or particulate matter is in the air expelled from recycling equipment.

9) Chloride Testing.

a) The Engineer reserves the option to test the blasted surface(s) for residual chloride ions. Chloride ions after blasting and blow down shall be less than 15 µg of chloride per 100 mm^2. Areas that are not equal to, or below, these criteria will need to be re-washed, brush blasted, and retested.

b) The Engineer will measure chloride contamination by using a Surface Contamination Analysis Kit, marketed by KTA-Tator Inc. or an equivalent analytical process.

4. Containment.

a. General.

1) Abrasive blasting using conventional equipment will require a system for total containment of the blast area. Containment includes all containment enclosures (where applicable), monitoring, recovery, and temporary storage of waste. For vacuum blasting, the "contained area" is defined as the area around the blast nozzle and any other connections or equipment where waste, dust, or exhausted air may exit into the environment.

2) Submit to the Engineer a plan for containment enclosures, an analytical report of the abrasives to be used, and a plan for monitoring air quality prior to starting work. A general guideline for containment evaluation abrasive blasting and/or vacuum blasting will be:

No visual or noticeable dust is to be observed escaping into the atmosphere or onto the ground from the contained area during blasting, blow down, or prior to the daily clean-up operations.

3) Suspend blasting if the Engineer determines that air expelled from containment or from the vacuum nozzle has noticeable dust or particulate matter. If the Engineer determines the containment measures are inadequate, alter the removal operation or the containment to meet the Engineer's requirement.

b. Abrasive Blast Cleaning.

1) Use a system which ensures total containment and recovery of the material removed from the structure. Construct bridge containment enclosures over other roadways to allow traffic to be maintained on the bridge being cleaned as well as on the road under the bridge, according to traffic control requirements in the contract documents.

2) Removed material will be defined as paint chips, abrasive particles, and other blasting residues. Ensure the containment

prevents removed material and abrasive from drifting or being deposited, or both, other than within the containment enclosure. The blasting operation will be suspended immediately if the Engineer deems waste cleanup or house keeping measures, or both, to be inadequate. If the Engineer rules the containment measures inadequate, alter the operation or the containment to meet the Engineer's requirement.

3) Use impermeable cover materials, such as tarpaulins, drop cloths, or other approved materials, on or above the ground, waterways, and other surfaces. Recover removed material from the covering materials. Highway pavements and paved surfaces under a structure may be used as a portion of the collection cover for that area providing traffic is maintained on the bridge and on the pavement under the bridge according to traffic control requirements in the contract documents.

4) All areas used for containment and recovery shall be thoroughly cleaned of all debris before work is begun. Close containment areas to the public. If paved surfaces are used for recovery areas, use only areas that are continuous and free of open cracks. Seal cracks to prevent infiltration of blast residue prior to commencing any blasting in that area.

5) Turn the edges of the impermeable cover material upward 1 foot (300 mm) to minimize loss of waste materials. Ensure covers on or over roadways, railways, or waterways do not present a hazard nor remain in place overnight without the Engineer’s written permission. Fasten the edges of the impermeable cover to the vertical drapes to ensure no loss of waste materials. Ensure overlaps of the cover material are a minimum of 3 feet (1 m), securely tied together, and continuously taped to prevent loss of removed material.

6) Extend vertical drapes from above the blasting area to the bottom of the enclosure. Securely anchor them top and bottom and at the laps to prevent spilling or loss of removed material. Use material capable of withstanding wind forces without tearing or having a breach of integrity.

7) Containment enclosures shall be anchored to prohibit enclosure encroachment on open traffic lanes, railroad lanes, and waterways. Ensure removed material will not fall on to surface waters.

c. Monitoring.

1) During abrasive blasting, monitor air quality by conducting air sampling and testing. Perform this work under the direction of a certified Industrial Hygienist. Use a minimum sampling frequency of one sample of 8 hour duration per week.

2) One purpose of the sampling is to allow for the Engineer to determine the effectiveness of the containment. Samples will be obtained from at least two locations outside and immediately down wind from the containment, according to 40 CFR, Part 50.

3) Employ an air monitoring that identifies total lead and total suspended particulate (TSP) to evaluate site compliance with the requirements of Title 40 Code of Federal Regulations. Provide the results of this monitoring to the Engineer as soon as they become available. Abrasive blasting will be suspended immediately if the Engineer determines expelled air quality measures to be above EPA standards for particulate matter.

4) Air quality sampling and testing will not be required for small localized containments when:

- Blasting operations have an expected duration of less than approximately 3 hours, or
- The expected duration of the total amount of blasting on the project is less than approximately 8 hours.

d. Cleaning by Other Methods.

1) At locations where abrasive blasting is not used, use a waste collection system that ensures containment and collection of the material removed from the structure. Removed material will be defined as paint chips and other residues. Ensure the containment prevents removed material from drifting or being deposited, or both, other than on the containment portion provided.

2) Use impermeable cover materials, such as tarpaulins or drop cloths, on or above the ground, waterways, surface waters, and other surfaces. Use these covering materials to recover removed material.

e. Clean-up Contingency.

1) Clean up any spills that result from the operations at no additional cost to the Contracting Authority. Provide a written plan for clean up of spills to the Engineer prior to removing paint.

2) For removal activities over water, have floating boom devices in place during removal operations. Ensure these devices are capable of preventing waste material from moving away from the site in the event of a breach in the containment system.

f. Recovery and Temporary Storage of Waste.

1) Deposit accumulated bridge cleaning waste in appropriately sized clean new or reconditioned containers with securely sealed lids meeting the requirements of Title 49 Code of Federal Regulations. Recover wastes daily and deposit the wastes into these temporary storage containers. Securely seal the containers to shield the contents from the elements at all times. Consolidate all waste material to a minimum number of containers.

2) Recover all residues and carefully transfer, ensuring no release of residues into the air or contamination of surrounding surfaces. Keep all containers containing residue closed and secured, except during the addition of waste. Ensure residues do not remain on bridge surfaces or on the containment material overnight.

3) Clearly mark all bridge cleaning waste containers in no less than 1 1/2 inch (40 mm) block letters stating:

PAINT WASTE
NONHAZARDOUS
(Date)

The date shall indicate when waste was first put into the container.

4) Construct or furnish a secured temporary storage area of sufficient size for the contained waste material. Enclose temporary storage areas with an 8 foot (2.4 m) chain link fence or a roll-off box with a lockable cover. Plans for other secured temporary storage areas may be submitted to the Engineer for approval.

5) Locate the temporary storage area within the right-of-way of the Contracting Authority at a location the Engineer approves. Ensure the base for waste storage is above the extreme high water elevation, if constructed within a flood plain.

6) For projects that will generate less than 55 gallons (208 L) of waste, the fenced temporary storage area or roll-off box will not be required and the Contractor is responsible for securely storing the paint waste containers on-site during the project.

7) At, or prior to the conclusion of the work, obtain one representative sample of the waste material from each container. Combine samples so that one representative composite sample is made for every 5 waste containers. Submit composite sample(s) to a lab for a Toxic Character Leachate Procedure (TCLP) test for the 8 priority metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Provide the results of this analysis to the Engineer upon receipt. Maintain wastes on site and do not dispose of them until the Engineer has reviewed analytical data and approved of the disposal method.

g. Disposal of Removed Material (Waste).

1) Transport waste materials in approved containers from temporary storage to a lined Subtitle D landfill (for non-hazardous wastes) or Subtitle C, Treatment, Storage, and Disposal Facility (TSDF for hazardous wastes) which accepts bridge painting wastes. Transport the wastes to the landfill facility within 5 calendar days of completion of surface preparation operations.

2) Provide the Engineer with copies of delivery tickets and landfill invoices for all waste material generated by this project.

3) Dispose of all bridge cleaning wastes according to Federal, State, and local regulations.

4) This project is based on the best information available that wastes generated will be non-hazardous for disposal per 40 CFR 261. Disposal of hazardous bridge cleaning wastes will be by extra work according to Article 1109.03.

h. Final Clean up.

1) Apply Article 1104.08.

2) In no case allow any foreign material or other painting related wastes to mix with the wastes generated from abrasive blast cleaning or paint cleaning by other methods.

5. Protection and Clean up.

a. For all work, use every reasonable means to protect the environment, human health and safety, adjacent property, and vehicles from damage resulting from the paint removal operations, according to Article 1107.07. Keep the project site in a neat, clean, and safe working condition.

b. At the end of each working day, clean up and properly containerize all waste material. Special attention is drawn to steel abrasive and its preponderancy to rust and stain surfaces where material is allowed to accumulate.

c. Clean up abrasive on a daily basis and remove any staining which occurs.

d. Protection and clean up will not be measured for payment, but will be considered incidental to all other pay items in this specification.

B. Hazardous Paint Removal.

1. General.

a. Apply Article 2508.01, B, only to structures previously painted with lead based paints and for structures with Scratch Tests indicating a hazardous waste is expected to be generated during the project. Scratch tests are provided elsewhere in the contract documents for information per Iowa Code Section 89B.8, Subsection 1.

b. Take responsibility for whatever precautions are necessary, to comply with Federal and State safety and health regulations.

2. Bridge Cleaning.

Apply Article 2508.01, A, 2.

3. Blast Cleaning of Structural Steel.

a. Waste Notification.

1) This structure has previously been painted with coating materials which contained lead pigments or chromium pigments, or both. Analytical results from scrape tests of the existing paint system are provided elsewhere in the contract documents.

2) The waste produced is expected to contain paint chips with heavy metal constituents, spent abrasive, rust, and possible mill scale. Take whatever measures are deemed necessary to assure protection for human health and the environment.

b. Preconstruction Sampling and Testing.

1) Obtain representative waste samples from the existing paint system using the selected production blasting system and equipment. Have an accredited laboratory test waste material with the Toxic Characteristic Leachate Procedure (TCLP) using EPA test method SW-6010B, TCLP; or an approved equal. Laboratories accredited by the American Industrial Hygiene

Association of National Environmental Laboratory Accreditation Program, or any EPA certified laboratory may perform the paint waste testing.

2) Have waste samples analyzed for, at a minimum, the 8 priority metals. These metals are: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. No later than 12 calendar days following the first day of production blasting, provide the Engineer with analytical results of these tests as well as reasonable estimated quantities of waste that are expected to be generated per month.

3) Conduct preconstruction and post-construction soil and river sediment sampling in the areas potentially impacted by blasting activities. At least 3 weeks prior to commencing work, provide a written program for sampling to the Engineer for review and comment. On the program, identify the number of samples proposed, the sampling locations, and sampling procedure to ensure all areas of potential impact are evaluated and that a statistical basis has been developed.

4) All sampling should be tested for total lead and chromium content using EPA Method SW-6010B, Totals, or approved equal. Locations where it is recommended to take samples include:

- At locations under and within the shadow of the structure,
- Storm sewer intakes and curb drains,
- Areas where ditches could carry debris laden storm water run-off to the river,
- Locations of equipment and waste storage, and
- Sediments along the bank and in water less than 5 feet (1.5 m) deep.

5) Preconstruction sampling locations need to be marked and resampled at the same location upon completion of work. Refer to Article 2508.01, B, 6, for additional information.

6) Provide the Engineer with preconstruction analytical results from soil and sediment sampling at least 3 weeks prior to commencing production blasting or other paint removing activities. After final clean up, but before final acceptance of the project, provide the Engineer with post-construction analytical results from soil and sediment sampling.

c. Environmental Regulatory Permits.

1) The Contracting Authority will obtain and provide an EPA hazardous waste identification number for this project if project specific waste sampling and testing indicate a hazardous waste will be generated.

2) The Engineer will use actual waste analytical results and estimated waste quantity data received from the Preconstruction Sampling and Testing to identify which type of identification number, if any, is required.

3) Obtain all other permits including any required for waste disposal. Apply Article 1107.03.

d. Site Working Documents.

Submit to the Engineer, for review and comment, three copies of all site working documents required in this section. Write each site working document to be specific for the issues associated with the blast cleaning alternatives selected. Revise any indicated sections of the site working documents to comply with the Engineer's comments and resubmit, if necessary.

1) Site Work Plan.

A minimum of 3 weeks prior to commencing work, provide a written site work plan to the Engineer for review and comment. On the site work plan include, at a minimum, a complete description of:

a) Paint removal methods selected, refer to Article 2508.01, B, 3, e.

b) The equipment and processes to be used including equipment catalog information from the manufacturers for major pieces of equipment.

c) The environmental protection plan including waste sampling procedures and methods used to control emissions into the air, water, and onto the soil.

d) Waste handling, storage, and disposal plan.

e) A preconstruction soil and river sediment sampling plan, refer to Article 2508.01, B, 3, b.

f) The Site Air Monitoring Plan. In this plan, describe the air sampling protocol and analytical procedures, sampling locations, frequency of sampling, and equipment, refer to Article 2508.01, B, 4, c. Use Title 40 Code of Federal Regulations, Part 50 (40 CFR, 50) as guidance when locating air monitoring equipment. Use a minimum frequency for sampling and monitoring that is in accordance with Federal and State requirements, and this specification.

2) Site Health and Safety Plan.

a) A minimum of 3 weeks prior to commencing work, provide a written Health and Safety Plan (H&SP) to the Engineer for review and comment. In this plan detail the compliance program with regulatory requirements including, but not limited to:

- OSHA 29 CFR, 1910 and 1926,
- Resource Conservation Recovery Act (RCRA) and CERCLA 40 CFR, 261 through 300,
- TSCA 40 CFR, 700 – end, and
- Transportation 49 CFR, 100 through 199.

b) Give attention to 29 CFR, Section 1926.62, Lead in Construction Standard. In addition, ensure the H&SP specifically identifies:

(1) The Project Site Safety Officer who is to be on site at all times when work is in progress, and who has the Contractor's authority to effect an immediate operational change or to shut down production until a specification, regulatory, or safety deficiency is

corrected. The Project Site Safety Officer has continuous site responsibility for assuring that worker health, safety, and U.S. EPA regulatory requirements are being met. This includes the duties of the "competent person" as required by 29 CFR, Section 1926.62.

(2) The compliance program as required by 29 CFR, Section 1926.62 which includes the following at a minimum:

- **(a)** A description of each activity in which lead and/or chromium is emitted including the equipment and processes involved,
- **(b)** Standard operating procedures for activities involving hazardous constituents,
- **(c)** Maintenance schedules of equipment utilized for filtration of potentially hazardous constituents,
- **(d)** Crew size and responsibilities,
- **(e)** Description of engineering controls and processes used to control lead exposure or chromium exposure, or both,
- **(f)** A report of the technology considered in meeting the Personal Exposure Limit (PEL),
- **(g)** Air monitoring protocol which will be used to document personnel exposure,
- **(h)** Schedule for implementing the program,
- **(i)** Work practice program including the personal protective equipment,
- **(j)** Housekeeping and hygiene practices,
- **(k)** An administrative control (job rotation) schedule if used, and
- **(l)** A description of H&SP compliance arrangements made between the Contractor and their subcontractors.

(3) Hazardous substances, that are expected to be encountered, PELs for these substances, and site personnel medical monitoring expected.

(4) The levels of personnel training, protection, and protective equipment required for different tasks performed at the site.

(5) Site control and restricted access policy to ensure unauthorized personnel or untrained personnel, or both, are not exposed to unnecessary risks.

c) The signature of a Certified Industrial Hygienist trained in worker environmental health and safety issues is required on the H&SP.

3) Site Contingency Plan.

a) A minimum of 3 weeks prior to commencing work, provide, for the Engineer's review and comment, a written Site Contingency Plan (SCP). In this plan:

(1) Detail the procedures that will be implemented and corrective action that will be taken, should an emergency or unforeseen situation arise.

(2) Specify procedures to minimize hazards to human health and the environment should there be fires, explosions, vandalism, or any other unplanned sudden or non-sudden release of hazardous waste or hazardous constituents to the air, soil, or surface water.

(3) Detail contingency measures that will be available on site to prevent accidental releases and provide safety to the general public. For example: Security, preventative, and containment measures which will be used to prevent and/or contain:

(a) Spillage or loss of paint wastes.

(b) Spillage of bulk paint, solvents, and thinners during the painting operations,

(c) Spillage or leakage of equipment fuel, oil, or other fluids,

(d) River traffic from encountering floating booms or barge mounted equipment,

(e) Inadvertent public exposure to job site hazards, and

(f) Waste material, or spills on water, from migrating off site and to contain that material until it is cleaned up.

b) Follow current Federal and State regulations in preparing this plan. Have it on file in the locations specified by regulation.

e. Paint Removal.

1) Submit to the Engineer in writing the type of blasting equipment that will be used for the paint removal operations before starting work. Achieve the level of surface preparation specified. In no case will unproven technology or untested technology, or both, be allowed without prior review, testing, and written approval from the Engineer.

2) The blasting process and equipment is required to be part of the Site Work Plan, and the plan shall describe in detail the:

- Method of blasting,
- Work procedures and tasks for this removal method,
- The estimated production rate, in other words, square foot (square meter) per hour,
- Estimated quantity of blasting abrasive utilized per production rate (hour or square foot (square meter)), and
- Procedure and protocols for abrasive recycling.

3) Contain and collect all waste material generated during blast cleaning. Contain any fugitive emissions (solid particulate, fugitive dust). Protect the health and welfare of the public. Protect the environment. Employ adequate administrative and engineering controls to reduce worker exposures to all

hazardous constituents present at the site to levels as low as feasible according to industry standards. Refer to Article 2508.01, B, 4, b for additional details.

f. Standards For Surface Preparation.
Apply Article 2508.01, A, 3, b.

4. Containment.

a. General.

1) This work includes the design, erection, maintenance, and removal of the enclosure or containment used to contain wastes generated during the surface preparation. The work also includes characterizing, collecting, and containing wastes generated during the project.

2) Ensure any enclosure complying with, or comparable to, an SSPC Class 3 or better is designed and sealed by a Professional Engineer licensed in the State of Iowa who is qualified in structures. Ensure ventilation in a Class 2 or better containment is designed and sealed by a Professional Engineer licensed in the State of Iowa who is qualified in ventilation.

3) Work required to decontaminate, clean, and test equipment and non-expendable materials or supplies shall be included in this section. Ensure, at a minimum, decontamination and cleaning do not allow debris or dust, or both, to be dislodged by winds or physical contact during handling and movement of a containment structure. In addition, establish a procedure to ensure all equipment and materials are essentially free from hazardous substances when delivered to and removed from the project site.

b. Enclosure.

1) Perform paint removal activities, except for vacuum blasting, within a full enclosure. Design the full enclosure as a system including:

- The frame work and outer covering,
- Attachments to the structure and supporting foundations,
- Waste handling, and
- Ventilation, if required.

2) Include in the enclosure submittal a method or process to catch, accumulate, and ultimately contain all spent abrasive and all paint waste. Include in the enclosure details a description and catalogue cuts of:

- Containment materials and equipment used,
- Material strengths, permeability, and necessary seam closure details,
- Drawings of attachments to the bridge including abutments, piers, deck, parapet rails, and beams, and
- Calculations of superimposed dead and wind loadings.

3) Submit three copies of this design to the Engineer for review and approval at least 3 weeks prior to erecting the enclosure. Use an enclosure that is:

a) Designed to transfer added wind and static loading safely to the bridge. Analyze the structure for gravity and wind loadings from the containment. Provide a copy of this analysis and all supporting calculations in the submittal. If the Engineer determines that the proposed enclosure could have detrimental effects on the structural integrity of the bridge, modify the design of the enclosure at no additional cost to the Contracting Authority. A copy of the existing bridge plan is available from the Contracting Authority.

b) Designed and constructed to maintain negative pressures inside the enclosure during production blasting and to include an air filtering and dust collection system for all exhausted air, unless site specific data collected during actual blasting operations conclusively show a tight containment with negative air is not required.

c) Designed to employ adequate engineering controls, including ventilation, to reduce airborne contamination to levels as low as feasible.

d) Equal to, or comparable with, SSPC Class 2 or better for Conventional Open Abrasive Blasting.

4) Contamination of the ground, water, or river sediment from project activities is strictly prohibited. Project activities that shall be carefully monitored and controlled to avoid environmental contamination include, but are not limited to:

- The containment,
- Dust collector,
- Abrasive reclaimer,
- Waste accumulation points (storage areas),
- Satellite accumulation points,
- Refueling locations,
- Boat or barge access points, and
- Paint handling, transfer, and mixing operations.

5) Uncontrolled dumping of wastes is strictly prohibited. Immediately clean up spills at no additional cost to the Contracting Authority.

c. Air Emissions and Monitoring.

1) General.

a) Monitor air quality by using high-volume air monitoring equipment. Perform sampling protocol according to the provisions of 40 CFR, Part 50 and its appendices. At a minimum, perform monitoring for total lead and total suspended particulate (TSP) and particulate matter 0.4 mils (10 µm) and smaller (PM_{10}).

b) Use properly calibrated high-volume air sampling equipment at locations of maximum potential impact to the public plus at areas to provide background ambient samples.

c) Identify anticipated monitoring locations and monitoring protocol in the Site Air Monitoring Plan.

d) Have an American Industrial Hygiene Association (AIHA) accredited laboratory analyze all air samples collected.

e) Filter all containment and process air exhausted from air handling equipment or the abrasive recycling process, or both, to remove particulates and regulated constituents to a level below current air quality standards.

f) Capture and contain filtered material using a system designed for this purpose.

g) Establish regulated areas around the dust collector, abrasive reclaimer, containment, and other operations that potentially generate lead emissions or chromium emissions, or both.

h) Properly identify, post, and establish the perimeter of the regulated areas at the OSHA Action Level of 30 $\mu g/m^3$. Limit access within these areas to only those personnel who are properly trained and monitored according to the site Health and Safety Plan.

2) Site Air Monitoring Plan.

a) Ensure compliance with 29 CFR, 1926; 40 CFR, 50; 40 CFR, 60; and 567 IAC, Chapters 22 and 23, by including nomenclature in the plan for:

- Sampling equipment,
- Sampling procedure and protocol,
- Sampling frequency,
- Locating criteria, and
- Laboratory analysis of air samples.

b) Submit analytical results to the Engineer within 1 week of being received from the testing laboratory. An electronically generated version containing, at a minimum, the information on the standard laboratory reporting form will be an acceptable substitute.

3) Containment Efficiency.

a) The Engineer will not routinely use opacity testing to evaluate a containment's efficiency, but will generally use a "no visible dust or blast media is to be observed escaping into the atmosphere or onto the ground from the contained area during blasting, cleaning, or blow down" criteria.

b) The Engineer may conduct random opacity tests or use high volume or personal cassette samplers for verification monitoring. This monitoring, positioning of equipment, and times are at the discretion of the Engineer. Verification monitoring will be outside of the Contractor's regulated areas and involve the Engineer's sampling equipment. The Engineer's sampling equipment will not be made available for the Contractor’s use.

c) Ensure the National Ambient Air Quality Standards for lead or PM_{10} or visible dust are not violated. If it is violated, an issuance of a Suspension of Work notice will be used until appropriate corrective action is taken.

d) Shut downs for noncompliance with environmental regulations or standards will not be cause for extensions in time, or considered for delay costs.

d. Paint Waste.

1) Paint wastes include all wastes generated by the project. These wastes include, but are not limited to:

- Blast waste,
- Material accumulated from filtering exhausted air,
- Spent abrasive,
- Containment material that cannot be decontaminated for reuse,
- Material containers such as paint and solvent containers, and
- Other wastes that fail the TCLP test as modified below and are categorized as a RCRA hazardous waste.

2) Consider all paint wastes as hazardous until after appropriate analytical data or Materials Safety Data Sheets are available showing conclusive evidence that the waste is below any regulated level for hazardous constituents, or is not initially regulated. Further reduce any waste regulatory value listed in the CFRs by a factor of 20%. For example: 40 CFR, 261.24, identifies lead (D008) as a characteristic hazardous waste if the toxic characteristic is equal to, or greater than, 5.0 mg/L. Wastes containing lead that have leachable levels greater than 4.0 mg/L are considered hazardous and are to be disposed of in a Subtitle C landfill.

3) During generation, accumulate all paint wastes and segregate by individual waste stream. Place in properly labeled storage containers. Use containers that comply with Federal DOT 49 CFR requirements. Follow the handling and storage requirements of 40 CFR, 262 and 40 CFR, 265. Waste streams may be combined after each has been sampled, tested, and characterized, provided combining is acceptable to the disposal facility.

4) As required by the Site Contingency Plan, have a designated, responsible, and trained person available for emergency response around the clock any time wastes are stored on the project. It is recommended the Site Health and Safety Officer be so designated. Ensure this person is available during non-working hours and work shutdowns within a reasonable response time whenever wastes are being stored. Post this person and an alternate's name, telephone numbers, and other required information on the accumulation point's fence and list in the Site Contingency Plan.

a) Accumulation Point.

(1) Erect and maintain an accumulation point, or storage area, sized to accommodate the accumulation of wastes awaiting shipment to a disposal facility. Enclose the accumulation point with an 8 foot (2.4 m) high chain link security fence with barbed wire top,

lockable access gates, bermed sides, and properly posted warning signs. Obtain the Engineer's approval for the location of this accumulation point. Construct it within the existing right-of-way at the project, but out of areas prone to flooding.

(2) For projects that will generate minimal quantities of waste, make a detailed written request to modify this storage security requirement. Submit all requests to modify the security requirement to the Engineer a minimum of 3 weeks prior to commencing production blasting. The Engineer will respond to the Contractor within two weeks following the request. The Engineer will evaluate the proposal based on:

- The Contractor's estimated waste quantities,
- The proposal's intent to comply with storage regulations and these specifications,
- Expected waste classification (i.e., hazardous or non-hazardous), and
- Other site specific considerations and details which the Contractor provides.

b) Satellite Accumulation Point.

(1) If the Contractor requests in writing, the Engineer will consider a small satellite accumulation point, or points, in the work zone. Properly label containers stored in any satellite area. Tightly close containers to the elements and secure to prevent accidental spillage or loss. At the conclusion of any working day, remove all containers containing accumulated wastes from any satellite accumulation point and place in the accumulation point storage area.

(2) Equipment which incorporates temporary storage of accumulation of wastes during operation will be considered a satellite accumulation point. As such, the equipment will be subject to proper labeling requirements. Waste materials contained within this type of equipment will not be subject to the requirement for daily transfer to the accumulation point storage area.

(3) Secure all materials stored at the accumulation point and satellite accumulation points to prevent spillage or vandalism. Securely cover to protect from the elements. Ensure the Site Health and Safety Officer maintains a permanent record to account for the accumulation of all waste materials and to report the cumulative weekly volumes at the project's progress meetings. Ensure the volume of materials located in the accumulation points and the condition of the storage containers are recorded weekly in the log.

(4) Remove accumulation point and satellite accumulation points (if used) when the Engineer

orders, or at the end of the project. Apply Article 2508.01, B, 6.

e. Decontamination Plan.

1) Provide the Engineer with a written Decontamination Plan a minimum of 3 weeks prior to commencing work. In this plan, outline procedures to follow to ensure non-expendable materials and equipment have been properly decontaminated prior to arriving on the project and before being demobilized from the site. Prior to in-bound mobilization, provide the Engineer with a written statement which includes the following:

a) Identification of project, location, owner reference, and contact information and type of wastes generated (hazardous or non-hazardous) at the previous project.

b) Certification that all equipment and non-expendable materials have been decontaminated and are clean. In this certification include analytical data verifying items have been decontaminated and are clean.

2) Before off-loading (or allowing in the right-of-way) equipment or non-expendable material, or both, that: 1) is mobilized to the site without being included in the certification; or 2) arrives at the site in an unacceptable condition, ensure it is:

- Decontaminated,
- Adequately sampled and tested, and
- Accepted as clean by the Engineer.

3) Evaluation of equipment and non-expendable material clean-up used on projects that generate hazardous wastes should include sampling (swipe or destructive) and TCLP testing as an integral part of this plan. It is recommended to follow OSHA's Field Operation's Manual, CPL 2.0 - 2.58 and HUD's Clearance Criteria for Post Abatement Clean-up when developing sampling procedures and protocol for a decontamination plan.

4) For projects that generate no hazardous waste, use equipment that is, at a minimum, judged as visually clean. In addition, perform non-expendable material cleanup in a manner that is, at a minimum, judged as visually clean. No special testing will be required. Sample and test, or dispose of, items that cannot be visually evaluated.

5) If a particular waste stream can be identified as the sole source of hazardous materials, in an otherwise non-hazardous project, the Engineer has the discretion to:

- Separate out that process for a higher level of evaluation (for example sampling and testing), and
- Minimize visual evaluation on the other non-hazardous processes.

5. Paint Waste Transport and Disposal.

a. Waste Sampling and Testing.

1) Sample each waste stream during the project to ensure project goals are being maintained and that a disposal facility's need for waste characterization is being met.

2) Obtain all samples properly, prepare for shipment, and offer for transport using Chain-of-Custody procedures and protocol. Have an accredited laboratory, or a laboratory that participates in EPA's Contract Laboratory program, analyze all samples. Refer to Article 2508.01, B, 3, b, for additional information.

3) Provide all laboratory results to the Engineer as soon as they are received. Obtain an adequate number of samples and analyze them to ensure any waste stream generated during this contract is fully characterized.

4) Sample solid wastes and analyze using TCLP test for the 8 priority metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Perform any additional analytical methods required by the disposal facility.

b. Disposal.

1) A minimum of 3 weeks prior to commencing production blasting, provide the Engineer with a written request to approve a designated disposal facility. Determine which of the following options or combinations are applicable to the job and selected removal process, or processes:

a) Permitted, Subtitle C, Treatment, Storage, and Disposal Facility (TSDF) for any hazardous waste generated at the site.

b) Permitted, geosynthetic lined, Subtitle D landfill for non-hazardous waste generated at the site.

c) Treatment and disposal facility for waste water generated from personal decontamination wash water.

2) With this request include a letter of tentative commitment from the facility to accept and dispose of the project's waste or selected waste streams. Dispose of hazardous waste only in a permitted TSDF that has obtained and currently holds an EPA, TSDF identification number. The Engineer will evaluate any facility submitted by conducting an environmental audit, records review, and reference check of that facility.

3) After receiving the Engineer's approval of the facility (or facilities), begin the formal process of obtaining final disposal permits which may be required by that facility. Provide the Engineer with copies of all final documents pertaining to the disposal permit. Obtain a signed contract with the approved TSDF or other facility for wastes produced at the site before accumulating waste (hazardous or non-hazardous) in the amount of 1000 pounds (450 kg) or within 1 month of beginning paint removal operations.

4) Clean all shipping containers for regulated raw materials or consumable supplies received at the project to "RCRA empty". Properly recycle or dispose of at the appropriate disposal facility.

5) The Engineer, on a case-by-case basis, will consider proposals for beneficial reuse, reclamation, or recycling of waste products generated during the course of the project. A minimum of 3 weeks prior to commencing work, provide a written Value Engineering Incentive Proposal, according to Article 1105.15, identifying a waste recycling program to the Engineer for consideration. In the submittal, provide the Engineer with ample detail to thoroughly and completely review and research the proposal.

c. Transportation and Manifesting.

1) Ensure that no waste leaves the site without a properly prepared waste manifest. Manifest all hazardous waste shipments using a Uniform Hazardous Waste Manifest, obtainable from EPA or the approved disposal facility. For all shipments of non-hazardous waste, propose a manifest. Obtain the Engineer's approval for the manifest.

2) Have the Site Health and Safety Officer sign the manifest prior to shipment. Signatures will be on behalf of the Contracting Authority, according to 40 CFR, 262. At the conclusion of each shipment, have the Site Health and Safety Officer deliver to the Engineer and appropriate agencies, copies of the required pages from the Uniform Hazardous Waste Manifests, according to the instructions included on the manifest.

3) When material is being transported or readied for transport, ensure all waste containers are properly labeled and marked according to Federal regulations (40 CFR, 262 and 49 CFR, 172). Ship all wastes with a permitted transporter holding a current EPA transporters identification number. Provide the Engineer with the required emergency response telephone number for the Uniform Hazardous Waste Manifest.

4) Maintain a file of all waste shipped for disposal or recycling. Have the Site Health and Safety Officer immediately notify the Engineer if a waste shipment (hazardous or non-hazardous) does not reach the designated facility. Further, have the Site Health and Safety Officer coordinate with the Engineer to assure that the signed original of each Uniform Hazardous Waste Manifest is received from the designated facility by the Engineer within 35 calendar days of the date the waste was accepted by the initial transporter. For shipments of hazardous waste, if the signed TSDF copy is not received in 10 additional calendar days (45 calendar days total) have the Site Health and Safety Officer immediately:

a) Prepare and submit an Exception Report to the EPA Region VII Administrator, 901 North 5th Street, Kansas City, KS 66101-2728. Provide a copy of this report to the Engineer.

b) Initiate actions to track and locate that shipment (applicable for both hazardous and non-hazardous waste shipments).

5) Provide the Engineer with a photocopy of:

- The signed Generator Copy page from the Uniform Hazardous Waste Manifest on the day of waste shipment, and
- The fully signed Return to Generator page from the Uniform Hazardous Waste Manifest on the day it is received from the disposal facility.

6. Protection and Clean-up.

a. General.

1) For all work, use every reasonable means to protect the environment, human health and safety, adjacent property, and vehicles from damage resulting from the paint removal operations, according to Article 1107.07.

2) Keep the project site in a neat, clean, and safe working condition.

3) At the end of each working day, clean up and properly containerize all waste material. Special attention is drawn to steel abrasive and its preponderancy to rust and stain surfaces where material is allowed to accumulate.

4) Clean up abrasive on a daily basis and remove any staining which occurs.

b. Site Environmental Evaluation.

1) Do not contaminate the soil or bodies of water with lead or other hazardous materials.

2) Soil or river sediments are considered to have been contaminated with lead or chromium from the project if either of the following two conditions occurs. Return the soil or river sediments to back-ground levels by methods acceptable to the Engineer and all applicable regulatory authorities (at no additional cost to the Contracting Authority).

a) If the geometric mean pre-project level is less than or equal to 200 ppm (totals), and an increase in the post-geometric mean total content of 100 ppm or more occurs.

b) If the geometric mean pre-project level is greater than 200 ppm, and the post-geometric mean concentration exceeds the pre-job geometric mean plus two standard deviations, or increases in the post-geometric mean level of 100 ppm occurs, whichever is greater.

c. Final Clean-up.

1) Perform final cleanup of all work on this project according to Article 1104.08 and procedures established in Article 2508.01, B, 4.

2) No separate payment will be made for furnishing protection and cleanup. The costs for protection and cleanup are included in the contract unit prices bid for the various items of work in the contract.

7. Project Submittals and Written Plans.

The Contractor and Engineer shall adhere to the following requirements to ensure appropriate project paper work is submitted in a timely manner. No work will be allowed or progress payments made unless

these items have been submitted, reviewed, corrected, and approved as necessary.

a. Three weeks prior to commencing work.

1) Site Soil and River Sediment Sampling Program, as described in Article 2508.01, B, 3, b.

2) Site Work Plan, as described in Article 2508.01, B, 3, d.

a) Environmental Protection Plan.

b) Waste Handling, Storage, and Disposal Plan.

c) Site Air Monitoring Plan.

3) Site Health and Safety Plan.

4) Site Contingency Plan.

5) Decontamination Plan, as described in Article 2508.01, B, 4, e.

6) Written proposal for Beneficial Waste Reuse, as described in Article 2508.01, B, 5, b.

b. Prior to in-bound mobilization.

Certification of Equipment Decontamination, as described in Article 2508.01, B, 4, e.

c. Three weeks prior to erecting containment.

Containment Design, as described in Article 2508.01, B, 4, b.

d. Three weeks prior to commencing production blasting.

1) Analytical results from soil and river sediment sampling, as described in Article 2508.01, B, 4, b.

2) Request to Modify Accumulation Point Security, if applicable, as described in Article 2508.01, B, 4, d.

3) Written request for Disposal Facility Approval, as described in Article 2508.01, B, 5, b.

e. Twelve calendar days following 1st day of production blasting.

1) Furnish analytical data from project sampling paint waste, as described in Article 2508.01, B, 3, b.

2) Furnish estimated waste production quantities.

f. Prior to painting.

1) Written paint mixing procedure, as described in Article 2508.02, E, 4.

2) Manufacturer's Recommendations, as described in Article 2508.02, B, 2.

3) Written designation of the paint manufacturer's technical representative, as described in Article 2508.02, E, 7.

2508.02 PAINTING OF STRUCTURAL STEEL.

A. General.

This work consists of fully repainting, zone painting, or spot painting (or any combination of these) structural steel at designated locations using a paint system designated elsewhere in the contract documents. The work includes:

- Furnishing the coating system specified,
- Application, protection, and curing of paint coatings,
- Protection of all parts of the structure from paint spatter,
- Environmental protection,
- Final cleanup, and
- Supplying all equipment, scaffolding and rigging, labor, and materials.

B. Material Acceptance.

1. Use paints that:
- Are equal to or less than 3.2 pounds per gallon (5.5 kg/L) for VOC. Calculation of VOC content shall account for thinning necessary for field application, and
- Contain pigments which are free from or have constituents at levels below a threshold that when disposed of would be regulated by the 40 CFR, 261.

2. Furnish three copies of the coating manufacturer's certification document for each shipment intended for use on this project. Ensure the document includes the following information:
- Date of shipment to the project,
- Name of painting Contractor or company to which the shipment was made,
- Brand names and product identification numbers,
- The most current Technical Data sheets and MSDS for coatings, thinners, and tints,
- Batch or lot numbers, and
- Batch or lot numbers and producer mill certificate for any zinc pigment, certifying compliance to at least the purity requirements of ASTM D 520 Type II.

3. Provide the Engineer with three copies of the latest Technical Data Sheets, MSDS sheets, and coating manufacturer's written approval for caulking material to be used on this project.

4. Provide the Engineer with two copies of the certification document prior to starting work. Make an additional copy available on-site.

C. Paint System.
The paint system, Epoxy, Moisture Cured Urethane, or Zinc Silicate, for this project is designated elsewhere in the contract documents. The different systems are as follows:

1. Primer Coat.
- **a.** Use a Zinc-rich Epoxy, Zinc-rich Aromatic Moisture Cured Urethane, or Zinc-rich Silicate applied at a rate that results in a targeted dry film thickness (dft) of:
  - 3 to 5 mils (75 to 125 µm) for Epoxy.
  - 3 to 4 mils (75 to 100 µm) for Moisture Cured Urethane.
  - 3 to 5 mils (75 to 125 µm) for Zinc Silicate.
- **b.** There is no color specified for the primer.
- **c.** Dry film thickness listed assumes a surface profile of 1.5 to 2.5 mils (25 µm to 65 µm). If this is not the case, either because of previous blast cleaning operations or improper quality control on this job, additional dft of primer may be required. In those cases, contact the paint manufacturer to provide a written alternate primer and possible application modifications. Prior to applying additional

alternate primer, provide the written alternative to the Engineer for review and approval. Ensure that in no case do surface peaks project above the primer coverage.

d. The use of penetrating sealer, if required, will be designated elsewhere in the contract documents. A penetrating sealer may be required in any of the following areas:
- Where there are cracks and seams,
- In feathered (transition) areas,
- Areas with surfaces prepared by mechanical methods.

e. Apply the sealer at a rate that results in a targeted dft recommended by the paint manufacturer.

2. Intermediate Coat.

a. Use an Aluminum Epoxy Mastic or Aromatic Moisture Cured Urethane applied at a rate that results in a targeted dft of:
- 5 to 7 mils (125 to 175 µm) for Aluminum Epoxy Mastic.
- 3 to 4 mils (75 to 100 µm) for Moisture Cured Urethane, pigmented with micaceous iron oxide.
- No intermediate coat is required for a zinc-rich silicate system.

b. Tint the intermediate coat to a different color than the primer and finish coats.

3. Finish Coat.

a. Use an Aliphatic Polyurethane, Aliphatic Moisture Cured Urethane, or Waterborne Acrylic applied at a rate that results in a targeted dft of:
- 3 to 5 mils (75 to 125 µm) of Aliphatic Polyurethane for the Epoxy system.
- 2 to 3 mils (50 to 75 µm) of Aliphatic Moisture Cured Urethane.
- 2 to 3 mils (50 to 75 µm) of Waterborne Acrylic for the Zinc Silicate system.

b. For the top coat use Federal Color Number 14223 for highway bridges or the color specified in the contract documents.

D. Acceptable Products.

1. General.

a. Refer elsewhere in the contract documents for the system specified for this project. Acceptable suppliers and products for each system are listed in Materials I.M.s 482.02 through 482.06. Choose material for the paint system specified (including thinners, tinting, etc.) from one of the coating manufacturers.

b. When specified in the contract documents, use a penetrating sealer that is:
- Designated by the paint manufacturer for the system specified, and
- Tinted to a different color than that of the primer.

2. Epoxy System.

Use a three coat epoxy paint system consisting of:

- A Zinc-rich Epoxy primer,
- A High-solids Aluminum Epoxy Mastic intermediate coat, and
- An Aliphatic Polyurethane top coat.

3. Moisture Cured Urethane.
Use a three coat moisture cured urethane paint system consisting of:
- A Zinc-rich Aromatic Moisture Cured Urethane primer,
- A Moisture Cured Urethane - pigmented with micaceous iron oxide intermediate coat, and
- An Aliphatic Moisture Cured Urethane top coat.

4. Zinc Silicate.
Use a paint system consisting of a single coat of Zinc Silicate primer with a Waterborne Acrylic top coat system.

E. Application.

1. General.
Apply paint using brush, roller, or spray methods. Apply paint in strict compliance with the coating manufacturer's latest written recommendations. Regardless of the method of application, ensure the specified minimum dft is achieved. Ensure the manufacturer's recommended maximum dft requirement for each coat is not exceeded without approval of the paint manufacturer's technical representative. Additionally:

a. Ensure product parameters, such as application, thinning, mixing, pot life, ventilation, curing, and so forth comply with the manufacturer's recommendations.

b. Ensure the prime, intermediate, and finish coats have a smooth, uniform appearance free from runs, sags, cracks, dry spray, over-spray, or other defects.

c. Shield concrete and galvanized products so that paint application on steel is full and complete without over-spray.

d. Upon completion, permanently stencil the word "painted" followed by the Contractor's name, the month, year, coating system, and manufacturer of the coating system applied. Stencil this information on an inconspicuous surface in a manner and location the Engineer approves.

e. Provide OSHA compliant access for the Engineer to check the surface preparation before painting and the dft after each coat is applied.

2. Painting.

a. Penetrating Sealer.
Apply penetrating sealer to areas designated in the contract documents. Allow to cure according to the coating manufacturer's recommendations before the prime coat is applied.

b. Prime Coat.

1) Apply a prime coat to all areas blasted clean or mechanically cleaned, or both. Apply this coat to areas of bare metal within

24 hours of being blast cleaned. Brush blast the entire prepared area before paint is applied if:

- The prepared surface shows any sign of flash rust, or
- The prime coat is not applied within 24 hours after blast cleaning.

2) Use methods acceptable to the Engineer to re-prepare areas which were prepared by mechanical methods and are showing flash rust.

3) Pay special attention to all rivets, bolts, edges of connections, areas of pack rust, and areas which may be difficult to access. These areas may require ringing/stripping.

4) Allow the prime coat to cure according to the coating manufacturer's recommendations before the intermediate coat is applied.

c. Intermediate Coat.

1) Apply the intermediate coat to all areas that received a prime coat. Allow to cure according to the coating manufacturer's recommendations before the finish coat is applied.

2) The Zinc Silicate system does not require an intermediate coat.

d. Finish Coat.

Fully cover the intermediate coat with the finish coat. Fully cover other surfaces with the finish coat if designated in the contract documents.

3. Recoating.

a. Surface Condition.

1) Ensure surfaces are free of dirt, oxidation products, oil, and other detrimental material prior to painting. Perform cleaning which may be necessary according to the coating manufacturer’s recommendations.

2) Protect all painted surfaces to prevent soiling or detrimental weather conditions during painting and through the tack-free stage.

b. Minimum Time.

1) No additional coat(s) of paint may be applied until the preceding coat has dried. Recoat according to the coating manufacturer's recommendations for time, temperature (ambient and/or surface), and weather conditions.

2) If minimum recoat times are not given by the coating manufacturer, wait at least 24 hours, and until the previous coat is tack-free, before applying the next coat.

c. Maximum Time.

Do not exceed the coating manufacturer's maximum time between coats. If the maximum recoat time is exceeded for any coat, provide the Engineer with a written correction procedure, or approval to proceed without correction, obtained from the coating manufacturer’s technical representative.

4. Mixing.

a. Mix paint according to the coating manufacturer's recommendations. Do not use previously opened or partially used containers of paint. Partial kit mixing will not be allowed.

b. Together with the coating manufacturer, provide a specific mixing procedure for the Engineer's review prior to performing the work. Follow this procedure unless the Engineer approves a written request to modify it.

5. Dry Film Thickness.

a. The Engineer will determine the dft of each coat and the total paint system using procedures described in SSPC-PA 2. Excessive coating thickness is as equally undesirable as unacceptably thin coating thickness, and both will be sufficient cause for rejection.

b. Targeted dft is specified herein. Touch up areas having less than specified dft to increase dft to at least that specified in this Article for the system specified. Depending on the condition of the steel substrate and paint system being used, it is possible these areas will require reblasting and repainting.

c. Excessive thickness will be evaluated on a case-by-case basis in consultation with the coating manufacturer. Depending on the condition of the steel substrate and paint system being used, it is possible these areas will require reblasting and repainting.

6. Cracks and Seams.

a. Use a best effort combination of blasting and possible hand or power tool cleaning to clean cracks and seams that are formed by junctions of joining members, splices, gusset plates, rivets, bolts, nuts, and similar surface irregularities. After application of any penetrating sealer and prior to application of the prime coat, caulk all cracks and seams that are equal to, or greater than, 3/16 inch (10 mm) wide with a durable caulking compound recommended by the paint manufacturer.

b. Seal cracks and seams less than 3/16 inch (10 mm) wide with the prime coat. Seal cracks and seams that cannot be sealed with the prime coat using caulk before the intermediate coat is applied. In the case of Zinc Silicate, this will be before the top coat is applied.

c. Use lead free caulking compound, supplied with the latest technical data and MSDS sheets. Obtain the paint manufacturer's and the Engineer's approval prior to incorporation into the project.

7. Technical Assistance.

a. Have the coating manufacturer whose products are used on this contract designate a qualified technical representative to support this project. The technical representative shall be available for on-site assistance and project coating consultation as may be required.

b. Difficulties in scheduling on-site technical assistance will not be considered a sufficient reason for approving time extensions to the contract period.

c. Ensure that, in all cases, application parameters are according to the product's Technical Data Sheet or the manufacturer's written recommendations, unless superseded elsewhere in this specification or in the contract documents.

F. Application Conditions.

1. Apply the manufacturer's published weather restrictions for each coating, except as modified below.

2. Paint only when weather conditions are such that the surfaces to be painted are entirely free from moisture, frost, ice, and snow. When painting in an area protected from the above conditions, protect the surface under cover until the paint is dry.

3. If wet paint is exposed to humidity, rain, snow, or condensation, allow it to dry. Remove damaged paint, reclean the surface, and repaint.

4. Moisture Cured Urethane coating may only be applied when:
- Surface temperatures are between 38°F (4°C) and rising and 100°F (37°C).
- Relative humidity is less than or equal to 95%.

5. Bubbling or pinholing which may occur in Moisture Cured Urethane will be evaluated using SSPC-VIS2. Bubbling or pinholing shall be less than 0.1% as defined by SSPC-VIS2, Photographic Standard No. 8.

2508.03 COAST GUARD REQUIREMENTS.

Apply the following for contracts that require work in and over navigable waters.

A. Comply with the following requirements:
- Established by the Corps of Engineers, the U. S. Coast Guard, and others relative to construction work in and over navigable waters, and
- Applicable to this project, but not covered by existing permits.

B. Construction work includes, but not necessarily limited to:
- Bridge washing, paint removal, cleaning structural steel by blasting, and painting structural steel,
- Containment enclosures, safeguards and temporary falsework or platforms, and lighting during construction, and
- Anchorage of barges and construction equipment, temporary restriction of channel width, and the removal of all temporary construction.

C. Ensure operations within or over the river comply with the requirements or directions of the U.S. Coast Guard District Engineer.

D. The following precautionary measures shall be taken during the performance of this work:

1. Perform work so that the free flow of navigation is not interfered with and navigable depths are not impaired.

2. Ensure floating equipment working in the channel displays lights and signals as required by the current Inland Navigational Rules.

3. If scaffolding or nets are suspended below low steel in the navigation span, contact the Coast Guard Office in St. Louis, Missouri, so that the temporary reductions in clearance for river traffic can be checked and appropriate notices can be published. Remove such scaffolding or nets at night, if required by the Coast Guard.

4. Take positive precautions to prevent spark producing, flame producing, lighted, or other damaging objects from accidentally dropping onto barges or vessels passing beneath the bridge. Cease all flame cutting, welding, and similar spark-producing operations over the channel when vessels are passing beneath the bridge.

5. Ensure work does not interfere with displaying navigation lights on the bridge at night.

6. Immediately remove any material, machinery, plant, or appliance which is lost, thrown from the bridge, sunken, or misplaced during the progress of the work, and which in the Engineer's opinion may be dangerous or obstructive to navigation. Immediately notify the Engineer and provide a description and location of the obstruction. When required, mark or buoy such obstructions until the obstruction is removed.

E. The Federal Water Pollution Control act, as amended, prohibits the discharge of oil, including oil based paints, or hazardous substances into the waters of the United States. The law requires any person in charge of a vessel or facility from which oil or a hazardous substance is discharged shall immediately report the discharge to the U.S. Coast Guard National Response Center at 800.424.8802.

F. The owner/operator of a vessel or facility from which the pollutant is discharged is subject to a civil penalty of up to $5000 and is liable for cleanup costs, if any.

G. Inform the U.S. Coast Guard office in St. Louis, Missouri, the status of this work to enable them to issue cautionary notices to mariners. If the Contractor has a marine radio at the job site, furnish the Coast Guard the call sign and operating frequency so that the information can be included in their notices.

H. No changes in channel conditions or in river bank conditions from natural causes or by reason of channel improvements or other construction, nor methods of river control by the United States or the state are to be considered as having any bearing or effect on the obligations of the contract nor justification for any claim for additional payments or extensions of time.

I. In the event that the United States Coast Guard or other constituted authorities should, during the progress of work, issue directions or orders affecting the Contractor's operations or order of procedure, promptly file with the Engineer a copy of such order or restrictions from the Corps of Engineers, U.S. Army, U.S. Coast Guard, and/or other authority having jurisdiction.

2508.04 METHOD OF MEASUREMENT.
Lump sum items. No method of measurement.

2508.05 BASIS OF PAYMENT.

A. Payment for the items below will be the lump sum contract price.

1. Bridge Cleaning for Painting.
Payment is full compensation for furnishing materials, labor, and equipment to perform the work in accordance with contract documents.

2. Blast Cleaning of Structural Steel.
Payment is full compensation for furnishing materials, labor, and equipment to perform the work in accordance with contract documents.

3. Containment.
- **a.** Payment is full compensation for furnishing materials, labor, and equipment necessary to install and maintain the containment during blast cleaning operations or paint removal by other methods.
- **b.** For non-hazardous paint removal, payment is also full compensation for monitoring, sampling, testing, reporting, temporary enclosures, temporary storage of waste, and disposal of waste.
- **c.** For hazardous paint removal, payment is full compensation for:
  - Furnishing all materials, labor, and equipment to perform all work necessary for containment enclosures,
  - Air monitoring, sampling, and testing,
  - Decontamination,
  - Handling, sampling and testing, containerizing, and storage of paint waste, and
  - Installing, maintaining, and removing the waste accumulation points.

4. Paint Waste Transport and Disposal.
Payment is full compensation for furnishing materials, labor, and equipment to perform all work necessary for:
- The proper transport of paint waste,
- The proper disposal of paint waste,
- Analytical testing of paint waste,
- Obtaining all necessary permits and manifests, and
- Preparation of permits and manifests.

5. Painting of Structural Steel.
Payment is full compensation for:
- All materials, labor, equipment,
- Providing material acceptance documents, and
- Providing technical assistance in accordance with contract documents.

B. Coast Guard Requirements will be incidental to the items of work for which they apply.

Section 2509. Cleaning, Surface Preparation, and Painting of Galvanized Surfaces

2509.01 DESCRIPTION

A. For the galvanized steel designated for painting on the plans:

1. Clean the surface.

2. Prepare the surface for painting.

3. Apply an intermediate coat of polyamide epoxy with a coating thickness of 3 mils to 4 mils (75 µm to 100 µm).

4. Apply a topcoat of aliphatic polyurethane which matches the Federal Standard Color number listed in the contract documents.

B. Clean, prepare, and paint the surface in the same shop to ensure single source responsibility of the entire coating system. Submit the sequence of operation to the Iowa Department of Transportation, Attention: Structures Engineer, Office of Materials, 800 Lincoln Way, Ames, IA, 50010. Describe the procedure used in preparing the galvanized surface, the brand names of the paint to be used, and certification that the paint that is used is compatible with galvanized surfaces.

2509.02 MATERIALS

A. One of the two-coat epoxy/polyurethane paint systems listed in Materials I.M. 482.08.

B. Ensure all materials used in the coating system are compatible and from the same manufacturer.

C. Ensure all materials are in unopened, original, dated containers from the manufacturer. Material used shall be within manufacturer's shelf life.

D. Ensure all materials have been and continue to be stored in such a manner as to prevent freezing and/or overheating. Follow the manufacturer recommendations as to maximum and minimum storage temperatures.

2509.03 CLEANING, PREPARATION, AND PAINTING

A. Surface Preparation of Galvanized Surfaces.
Prepare and prime the surface as soon as possible after galvanizing. The surfaces shall be primed within 24 hours of the galvanizing operations. There shall be no visible signs of zinc oxide or zinc hydroxide, which first appear as a fine white powder.

B. Surface Smoothing
Remove zinc high spots by cleaning with hand or power tools as described in SSPC SP2 or SP3. Remove the zinc until it is level with the surrounding area, taking care that the base coating is not removed by the cleaning methods. After cleaning, inspect the surface for conformance to the required zinc thickness according to ASTM A 123 using a magnetic or eddy current type thickness instrument complying with ASTM E 376. Repair all items falling below the required zinc thickness, before or after removal of high spots, according to ASTM A 780.

C. Surface Cleaning

1. Hot dip galvanized surfaces shall be clean and free of oil and grease before they are painted.

2. No water quenching, or chromate conversion coating, of the galvanized surface that is to be painted is allowed. These processes interfere with the adhesion of the paint coatings to the zinc surface.

3. Use one of the following methods, as deemed necessary by the paint manufacturer, for surface cleaning galvanized surfaces:

a. Aqueous Alkaline Cleaning.
An alkaline solution, with a pH of 11 to 13 may be used to remove traces of oil, grease, or dirt. Alkaline cleaner shall not be used for removal of heavy build-up of zinc oxide or wet storage stain. The solution may be applied through immersion in a tank filled with the solution, spraying, or brushing with a soft bristle brush. After cleaning, rinse thoroughly in hot water or water under pressure. Use heat drying to accelerate the complete removal of water from the surface.

b. Solvent Cleaning.
Typical cleaning solvents, such as mineral spirits or high-flash naphtha, may be used to remove oil and grease. The procedure used shall be specified in SSPC SP1. Proper rags or brushes shall be used to wipe the galvanized parts. These rags or brushes shall be cleaned or recycled often since oil can accumulate on their surfaces and be transferred back to the galvanized part. After cleaning, rinse surfaces thoroughly in hot water or water under pressure. Allow to dry completely before proceeding.

D. Surface Preparation
Use any of the following methods, as per the written recommendation of the paint manufacturers, to prepare the galvanized surface for painting:

1. **Sweeping Blasting.**
   - **a.** The purpose of the sweep blasting is to deform, not to remove, the galvanized metal. Repair areas falling below the required zinc thickness, before or after the sweep blasting, according to ASTM A 780. The procedure for this process can be found in SSPC SP7.
   - **b.** Abrasive sweep or brush blasting which uses a rapid nozzle movement will roughen the galvanized surface profile. Ensure the abrasive material provides a stripping action without removing excess zinc layers. Particle size should be in the 8 mils to 20 mils (200 µm to 500 µm) range.
   - **c.** Materials that can be used are aluminum/magnesium silicate, soft mineral sands with a mohs hardness of 5 or less, corundum, limestone, and organic media such as corncobs or walnut shells. Sweep blast zinc at a rate of no less than 130 square yards per hour (110 m^2/h) using these types of abrasives. Substrate should be maintained at a temperature greater than 5ºF (3ºC) above the dew point temperature.
   - **d.** Following abrasive blast cleaning, blow surfaces down with clean, compressed air. The formation of zinc oxide on the blasted surface will begin very quickly so the paint coating shall be applied immediately, and no later than within 60 minutes, after sweep blasting.

2. **Wash Primer Treatment.**
   - **a.** This process involves the use of a metal conditioner to neutralize surface oxides and hydroxides along with etching the surface. One example of a wash primer is SSPC-Paint Specification No. 27. The process is based on three primary components: 1) a hydroxyl-containing resin; 2) a pigment capable of reacting with resin and acid; and 3) an acid capable of making the resin insoluble by reacting with the resin, the pigment, and the zinc surface. The result is a film of approximately 0.3 mils to 0.5 mils (8 µm to 13 µm). Failures can occur if the film exceeds 0.5 mils (13 µm). The film is usually applied by spray, but may be applied by soft bristle brush, dip, or roller coater. Using these latter coating methods, it may be difficult to control film thickness.
   - **b.** For drying time prior to topcoating, follow the manufacturer's instructions.
   - **c.** This wash primer treatment may be better suited to certain types of paint systems. See SSPC-Paint Specification No. 27 for the best match of this treatment to a paint system.

3. **Acrylic Passivation/Pretreatment.**
   - **a.** The passivation/pretreatment process consists of applying an acidic acrylic solution to the newly galvanized surface and then allowing it to dry, forming a thin film coating. When applied, the solution first reacts with the zinc surface forming a passivating conversion coating while simultaneously forming an acrylic coating suitable for painting on top of the passivation layer. The underlying conversion coating provides strong adhesion to the galvanized surface while the thin film acrylic layer provides barrier protection that inhibits

corrosion and provides a highly compatible surface for the application of organic paint films. There are versions of these solutions that contain chrome and versions without chrome.

b. The application methods for these water-based treatments are: dipping, flow coating, spraying, or other appropriate means. Following application, the coating is dried in an oven or in air. In some instances the coating is applied to hot galvanized articles, in which case separate drying is not necessary. Rinsing is not required. The coating is approximately 0.04 mils (1 µm) thick.

c. Painting is possible any time during a period of four months after application if the surface is free of visible zinc oxides or zinc hydroxides. If harmful contaminants such as dust, dirt, oils, grease, or deposits are present, they shall be removed with a mild alkaline degreasing solution (pH 11.5 maximum), followed by a thorough rinse with hot water (140ºF (60ºC) maximum temperature) or a pressure wash, and then thoroughly dried. This treatment is applied in the galvanizing plan or later in the paint shop. When applied in the paint shop, the surface shall first be appropriately cleaned as described above to remove contaminants picked up after galvanizing.

E. Final painting.

1. Apply all materials under conditions within the tolerances listed below. Keep permanent records of the processing conditions during the complete finishing process.

- Air temperature 50ºF (10ºC) minimum and 90ºF (32ºC) maximum.
- Steel surface temperature 50ºF (10ºC) minimum and 100ºF (37ºC) maximum.
- Humidity 85% maximum.
- Steel temperature at least 5ºF (3ºC) above the dew point.

2. Ensure all surfaces are dry and free from dust, dirt, oil, grease, or other contaminants.

3. Ensure total thickness, including epoxy intermediate coat and urethane topcoat, is from 5 mils to 10.5 mils (130 µm to 260 µm) dry film thickness.

4. After the painted galvanized steel has been erected in the field, touch up all areas where the shop paint has been damaged using the same materials from the same manufacturer as specified for shop application.

5. Submit the paint manufacturer's product data sheets to the Engineer prior to the start of work. Follow the requirements as outlined in the data sheets. Apply the intermediate coat of epoxy in two applications.

6. Ensure the coating is packaged in separate containers bearing a label clearly showing the name of the manufacturer, brand name of the product, lot number, and date of manufacture.

7. Ensure the topcoat matches the Federal Standard Color number listed in the contract documents. Submit samples of the topcoat color to Iowa Department of Transportation, Office of Materials, 800 Lincoln Way, Ames, IA 50010.

8. Special handling will be required to prevent damage to the paint system during lifting, shipping, and installation.

9. After completing construction, properly prepare and repaint, according to the manufacturer's specifications, all defects or damage to the paint system. Ensure steel surfaces to be repainted are free of contaminants, including dirt or concrete. For repairs use the same paint from the same manufacturer as was used for the shop painting. Protect adjacent surfaces not to receive paint by masking or other means of protection.

F. Shop Conditions

Ensure surfaces to be painted after surface preparation remain free of moisture and other contaminants. Control the operations to ensure that dust, dirt, and/or moisture do not come in contact with surfaces prepared or painted that day. In addition to the manufacturer's written instructions for surface preparation and painting, apply the following conditions (when in conflict, the most restrictive conditions govern):

- Apply paint only when steel and air temperatures are 40ºF (4ºC) or above. Do not apply paint to steel that is at a temperature that will: 1) cause blistering or porosity; or 2) be otherwise detrimental to the life of the painted surfaces.
- Do not apply paint when the steel surface temperature is less than 5ºF (3ºC) above the dew point.
- Do not apply paint to wet, damp, or frosted surfaces.
- Do not apply paint when the relative humidity is above 85%.
- Work accomplished under unfavorable weather conditions will be considered unacceptable. Complete recleaning and painting of these areas will be required, at no additional cost to the Contracting Authority.

G. Equipment.

Prior to beginning any painting operations, ensure air equipment passes the requirements of ASTM D 4285. This test will be repeated as determined by the Engineer. Comply with the following:

1. **Cleaning and painting equipment.**
   - Includes gages capable of accurately measuring fluid and air pressures.
   - Has valves capable of regulating the flow of air, water, or paint as recommended by the equipment manufacturer.
   - Is maintained in proper working order.

2. **Spray painting and surface preparation equipment.**
   - Utilizes filters, traps, or separators recommended by the manufacturer of the equipment.

- Filters, traps, and separators kept clean using the methods and intervals recommended by the manufacturer of the equipment.
- Paint pots equipped with air operated continuous mixing devices.

3. Pressure type abrasive air blasting equipment.
Capable of providing the minimum required pressure and volume, free of oil, water, and other contaminants.

H. Quality Control.

1. Conduct a quality control program, consisting of the items below, that ensures the work accomplished complies with the contract documents:
- Qualified personnel to manage the program and conduct quality control tests,
- Proper quality measuring instruments,
- Quality Control Plan, and
- Condition and quality recording procedures.

2. Ensure personnel managing the quality control program have experience and knowledge of industrial coatings and the measurements needed to assure quality work. Ensure the personnel performing the quality control tests are trained in the use of the quality control instruments. These personnel are not to perform surface preparation and painting. Have painters perform wet film thickness measurements.

3. Provide necessary equipment to perform quality control testing of shop conditions, equipment, surface preparation, and profile and paint film thickness. Calibrate the equipment according to manufacturer's recommendations.

4. Implement a Quality Control Plan, approved by the Engineer, which includes: 1) a schedule of required measurements and tests as outlined herein; 2) procedures for correcting unacceptable work; and 3) procedures for improving surface preparation and painting quality as a result of quality control findings. Supply and use forms approved by the Engineer to record the results of quality control tests. Make these forms available at the work site for the Engineer to review.

5. The purpose of the quality control program is to assist the Contractor in the proper performance of the work. Quality control tests performed by the Contractor will not be used as the sole basis for acceptance of the work.

2509.04 METHOD OF MEASUREMENT
None.

2509.05 BASIS OF PAYMENT
The cost of cleaning, surface preparation, and painting of galvanized structural steel is incidental to the contract price for the items that have galvanized steel designated for painting as listed in the contract documents. This cost includes:

- Labor, materials, and equipment to complete the cleaning, surface preparation, and painting according to this specification.
- Costs to repaint or repair the paint system after erection.

Section 2510. Removal of Pavement

2510.01 DESCRIPTION.

Remove PCC pavement including reinforcing, pavement widening, HMA pavement, detour pavement, and integral and separate curb. Break up PCC pavement and leave in place. Remove anchor lugs in continuously reinforced PCC pavement.

2510.02 MATERIALS.

None.

2510.03 CONSTRUCTION.

A. Pavement Removal.

1. General.

a. Remove pavement as specified in the contract documents. Within the pavement area, remove utility accesses, intakes, service boxes, integral and separate curb, and junction boxes.

b. Remove pavement to be processed for reuse or stockpiled for salvage or recycling. Do so in a manner that minimizes inclusion of fine material from the shoulder, subgrade, or other underlying course or other foreign material.

c. When a portion of concrete pavement is to be removed and the remaining portion is later abutted at its top surface with new pavement, saw the breakout line of the old slab to full depth.

d. Remove to a new saw line and replace, at no additional cost to the Contracting Authority, all concrete broken or damaged beyond the breakout line designated by the Engineer.

e. When pavement removal results in road closure to public or local traffic, start the removal operation no more than 2 weeks before the succeeding operation is scheduled to begin. Apply the 2 week requirement to each succeeding operation until the closure is no longer necessary.

f. All concrete, reinforcing, or other metal items which are removed and not specified for stockpiling, salvaging, recycling, or any other placement becomes the property of the Contractor. Remove according to Article 1104.08.

2. Portland Cement Concrete.

a. If PCC pavement or other broken concrete is to be placed in fills, cut off protruding steel to within 3 inches (75 mm) of encasing concrete. Place it in alternating layers of broken concrete and soil with a maximum depth of either layer of 2 feet (0.6 m). Do not place broken concrete within 2 feet (0.6 m) of the final cross section. Limit the maximum size of broken concrete to approximately 0.25 square yard (0.2 m^2).

b. For PCC pavement or broken concrete to be used as revetment, meet the requirements of Article 4130.01.

c. When pavement removal is adjacent to a bridge, railroad crossing, or similar structure, do not use heavy breaking equipment within 20 feet (6 m) or within the reinforced section at the bridge approach, whichever is larger or applicable. Apply Article 1105.12, H, to use of this type of equipment.

d. Cut the pavement full depth approximately 2 feet (0.6 m) from the bridge. Use a jack hammer or other hand methods to break up and remove pavement within that area. Beyond 2 feet (0.6 m) and within the bridge approach or 20 feet (6 m), a tractor mounted jack hammer or similar light equipment may also be used.

3. Hot Mix Asphalt.
Remove asphalt pavement as specified in the contract documents.

4. PCC Pavement with HMA Resurfacing (Composite Pavement Section).
The contract documents may specify that the HMA Resurfacing be removed from the PCC pavement as a separate operation. When not specified, the Contractor may remove the composite pavement as a single operation.

5. Removal and Crushing of Pavement.
The contract documents may require the pavement be removed and crushed. When required, the contract documents will specify the size or gradation, or both, to which to crush the pavement. The contract documents will also specify where the crushed material is to be stockpiled or used in the contract.

6. Removal of Intakes and Utility Accesses.
Remove the top and sides of the structure a minimum of 10 feet (3 meters) below the subgrade or 6 feet (1.8 meters) below the finished grade in other areas. Plug all of the pipes in the structure to be removed using Class C concrete. If the structure is more than 10 feet (3 meters) deep, fill the remaining structure with flowable mortar. Place compacted fill over excavation.

B. Breaking Up Old Pavement.
When specified in the contract documents, shatter concrete pavement (maximum size of unbroken concrete to be 0.5 square yard (0.4 m^2)) and leave in place.

2510.04 METHOD OF MEASUREMENT.

Measurement for the items below will be as follows:

A. Removal of Pavement.
Square yards (square meters). This includes areas of utility accesses and intakes within the pavement area, and integral and separate curb. Removal of reinforcing steel will be incidental to removal of pavement and will not be measured for payment.

B. Breaking Up Pavement.
Square yards for the area of pavement broken up and left in place according to the contract documents.

C. Removal of Anchor Lugs.
By count for each traffic lane.

D. Pavement Scarification.
Square yards (square meters) where the HMA Resurfacing has been scarified prior to the removal of the pavement. HMA Resurfacing removed and crushed with the PCC pavement will be included in the area of pavement scarification if the composite crushed material meets the gradation and composition required by the contract documents.

E. Removal and Crushing of Pavement.
Square yards (square meters) removed and crushed according to the contract documents.

F. Removal of Intakes and Utility Accesses.
By count.

2510.05 BASIS OF PAYMENT.

For removal of pavement and breaking up pavement as specified, payment will be the contact unit price as described below. Payment is full compensation for furnishing all tools, equipment, labor, and materials for completion of the work as specified in the contract documents.

A. Removal of Pavement.

1. Per square yard (square meter).

2. When recycling is not mandatory, the cost of recycling pavement removal into granular subbase, granular shoulders, or special backfill material is included into the cost of the items for which the recycled pavement material will be used.

3. The cost of saw cut and integral and separate curb is included in the contract unit price for the Removal of Pavement, Pavement Scarification, or Removal and Crushing of Pavement.

B. Breaking up Pavement.
Per square yard (meter) for the area of pavement broken up and left in place according to the contract documents.

C. Removal of Anchor Lugs.
Each. If removal of anchor lugs is not a bid item in the contract documents, payment will be $600 per lane for each anchor lug removed.

D. Pavement Scarification.
Per square yard (square meter).

E. Removal and Crushing of Pavement.
Per square yard (square meter).

F. Removal of Intakes and Utility Accesses.
Each. Payment is full compensation for the work of plugging pipes, filling remaining structures with flowable mortar, and placing compacted fill.

Section 2511. Removal and Construction of Sidewalks and Recreational Trails

2511.01 DESCRIPTION.

Remove sidewalks and recreational trails or portions of them and/or construct new sidewalks and recreational trails according to the contract documents. For construction of sidewalk with retaining wall, refer to Section 2516.

2511.02 MATERIALS.

A. Portland Cement Concrete.

1. Use Class B Portland cement concrete for sidewalks and recreational trails. Place according to Section 2301.

2. For sidewalk and recreational trail construction included in PCC paving projects, the Contractor may use the approved paving mixture for the project. A Class 2 durability or better aggregate, according to Article 4115.04, will be required.

3. When sidewalk or recreational trail construction is associated with a bridge project, the Contractor may use the concrete approved for the bridge structure with Class C as the minimum.

B. Hot Mix Asphalt.

1. For sidewalks and recreational trails not adjacent to pavement, use 100,000 ESAL, 3/8 inch (9.5 mm) HMA, according to Section 2303.

2. When the recreational trail or sidewalk is adjacent to the pavement and also functions as the pavement shoulder, use 1,000,000 ESAL, 1/2 inch (12.5 mm) base mixture.

3. Use PG 58-28 or PG 52-34 Performance Grade binder as specified in the plans.

C. Subbase.
Use the subbase specified in the contract documents.

D. Detectable Warnings.
Furnish detectable warnings that contrast visibly with adjoining surfaces, either light-on-dark or dark-on-light. Comply with Materials I.M. 411.

2511.03 CONSTRUCTION.

A. Removal of Sidewalks and Recreational Trails.

1. Remove areas of sidewalks and recreational trails shown in the contract documents according to Article 2510.03, A. If only portions of the sidewalks or recreational trails are to be removed, form removal boundaries with a full depth vertical saw cut before breaking the removal.

2. Remove and replace (at no additional cost to the Contracting Authority) any areas of the sidewalk or recreational trail not designated for removal but which are removed, broken, or damaged by removal operations. Perform removal according to Article 2510.03, A.

B. Construction of Sidewalks and Recreational Trails.

1. General.
The contract documents will contain staking diagram sheets for construction of pedestrian ramps, landings, sidewalk, and transitions. If field adjustments are necessary, notify the Engineer prior to construction. Field adjustments shall comply with the following requirements.

a. Construct sidewalks and recreational trails to a longitudinal slope not to exceed 5.0% and a cross slope not less than 1.5% or greater than 2.0%. A cross slope less than 1.5% will be allowed in tie-in areas.

b. Construct ramps as follows:
- 5.0 feet (1.5 m) minimum width, exclusive of curbs or flares.
- Longitudinal slope not to exceed 8.0%.
- Cross slope not to exceed 2.0%.

c. Construct landings as follows:
- 5.0 foot (1.5 m) minimum width by 5.0 foot (1.5 m) minimum length.
- Longitudinal slope not to exceed 2.0%.
- Cross slope not to exceed 2.0%.

d. Install detectable warnings according to manufacturer's recommendations.

2. Preparation of Subgrade.

a. Sidewalks.
Prepare the subgrade by excavating or filling with suitable earth to a depth below the finished grade line so that, when tamped or rolled until smooth, firm, and hard, the subgrade will be uniform and at the required depth below the finished grade line.

b. Recreational Trails.

1) When the recreational trail is to be constructed on natural subgrade, special compaction of subgrade for the recreational trail will be required. Prepare subgrade according to Article 2109.03, C.

2) When the recreational trail surface is to be constructed on an existing granular surface, prepare the subbase (existing granular surface) according to the contract documents.

3. Portland Cement Concrete.

a. Placing.

1) Hand Finished Sidewalks and Recreational Trails.

a) Use wood or steel forms complying with Article 2301.03, A, 3, a, 1, c.

b) Thoroughly moisten the subgrade.

c) Deposit the concrete for the full depth of slab in one operation. Consolidate it by tamping or vibration.

d) Screed the excess concrete off flush with the forms.

e) Thoroughly consolidate edges adjacent to all forms, expansion joints, curbs, or fixtures in the surface.

2) Slip Form Sidewalks and Recreational Trails.

a) Use self propelled slip form pavers that meet the requirements of Section 2301.

b) Other slip form paving machines require the Engineer's approval. Use machines designed for the specific purpose of placing, consolidating, and finishing concrete sidewalk and recreational trail slabs without use of fixed side forms,

b. Finishing.

After consolidating the concrete, finish the surface to a uniform, slip resistant, wet burlap drag or broom finish texture true to the line and grade specified in the contract documents. If a broom is to be used, drag a suitable broom transversely across the surface of the plastic concrete.

1) Sidewalks.

a) After floating the surface, finish the edges of the slabs using a suitable edging tool.

b) For PCC sidewalks set transverse joint spacing to be equal to the sidewalk width. Cut the concrete through for no less than 25% of the depth with a pointed trowel or suitable spading tool. Then edge the concrete on both sides. In place of using a pointed trowel or suitable spading tool, the Contractor may cut these lines within 12 hours after concrete placement using a 1/8 inch (3 mm) blade saw approved by the Engineer.

2) Recreational Trails.

a) For PCC recreational trails set transverse joint spacing to be equal to the pavement width. Saw all transverse joints (tooling will not be allowed). Cut transverse joints 1/8 inch (3 mm) wide and no less than 1 inch (25 mm) in depth. No sealant will be required.

b) Place a longitudinal joint in recreational trails more than 12 feet (3.6 m) wide.

c. Protection and Curing.

After finishing, cure and protect the concrete using one of the methods described in Article 2301.03, K.

d. Isolation Joints.
Construct isolation joints at all points where sidewalks or recreational trails meet other walks, curbs, or fixtures in the surface. Construct them by installing a 1/2 inch (13 mm), full depth strip of approved premolded joint material.

e. Time for Opening Pavement for Use.
Open PCC sidewalks and recreational trails a minimum of 7 calendar days after placement or when flexural strength reaches 400 psi (2.75 MPa) as determined by Materials I.M. 383.

4. Hot Mix Asphalt.
Construct HMA sidewalks and recreational trails according to Article 2303.03 using Class 2 compaction.

5. Smoothness.

a. Ensure sidewalk and recreational trail smoothness comply with Article 2301.03, H, 4, except for the requirements for pavement and bridge approach sections for Primary projects.

b. Areas may be checked by the Engineer with a surface checker and are not to exceed 1/4 inch in 10 feet (6 mm in 3 m). For each bump exceeding these requirements, the Contractor will be assessed $50 or the bump corrected as agreed upon by the Engineer and Contractor.

6. Weight Limits.
Limit construction equipment on both PCC and HMA sidewalks and recreational trails to a maximum of 5 tons (5 Mg).

7. Pavement Markings.
Place pavement markings according to Section 2527.

2511.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Removal of Sidewalk or Removal of Recreational Trail.
Square yards (square meters) shown in the contract documents.

B. Sidewalk or Recreational Trail.
Square yards (square meters) shown in the contract documents. Deductions will not be made for fixtures having an area of 1 square yard (1 m^2) or less.

C. Special Compaction of Subgrade for Recreational Trail.
Stations (meters) shown in the contract documents.

D. Detectable Warnings.
The Engineer will measure in square feet, to the nearest square foot (square meters to the nearest 0.1 square meter), the surface area of Detectable Warnings.

2511.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Removal of Sidewalk or Removal of Recreational Trail.

1. Per square yard (square meters).

2. Payment is full compensation for all equipment, labor, and disposal for removal of the sidewalk or recreational trail as specified in the contract documents.

B. Sidewalk or Recreational Trail.

1. Per square yard (square meter).

2. Payment is full compensation for furnishing all material, equipment, and labor to construct the sidewalk or recreational trail according to the contract documents.

C. Special Compaction of Subgrade for Recreational Trail.

1. Per station (meter).

2. Payment is full compensation for furnishing all material, equipment, and labor to construct the special compaction of subgrade for recreational trail according to the contract documents.

D. Detectable Warnings.

1. Per square foot (square meter).

2. Payment is full compensation for furnishing all material, equipment, and labor to construct the detectable warnings according to the contract documents.

Section 2512. Portland Cement Concrete Curb and Gutter

2512.01 DESCRIPTION.

A. Construct PCC curb and gutter, separate from the construction of a pavement according to the contract documents.

B. Produce, transport, and place concrete according to Section 2403 when curb or curb and gutter construction is associated with a bridge structure.

2512.02 MATERIALS.

Meet the requirements of Division 41 for respective materials. Ensure the consistency of the concrete, as measured by the slump test, does not exceed 3 inches (75 mm).

A. Use Class C concrete for curb or curb and gutter not associated with a bridge structure. Place according to Section 2301.

B. Use Class D concrete when curb or curb and gutter construction is associated with a bridge structure.

2512.03 CONSTRUCTION.

Meet the following requirements for PCC curb or curb and gutter construction:

A. Preparation of the Subgrade.

1. Prepare the subgrade upon which concrete curb or curb and gutter is to be placed by excavating or filling with suitable earth to a depth below finished grade line so that, when tamped or rolled until smooth and firm, the subgrade will be uniform and at the desired depth below finished grade line.

2. When curb or curb and gutter is constructed on a filled section, extend the compacted fill a minimum of 1 foot (0.3 m) outside the form line. Ensure it is no lower than the base of the form at the form line. Thoroughly moisten the subgrade or cover it with a layer of plastic film meeting requirements of Section 4107 before placing concrete.

B. Slip Form Equipment.

Slip form equipment may be used.

C. Forms.

1. Unless slip form equipment is permitted, form all straight sections of curb and gutter with steel forms for the full depth of the concrete. Wood forms may be used on curving sections.

2. Place a steel face, rigidly welded or bolted to the main form, on any extensions used to obtain the required depth of form.

3. Ensure the top face of forms does not vary from a true plane by more than 1/8 inch in 10 feet (3 mm in 3 m). Ensure the upstanding face, including any extension, does not vary from a true plane by more than 1/4 inch in 10 feet (6 mm in 3 m). Remove forms that are bent, twisted, warped, broken, or battered from the work. Allow Engineer to inspect and approve repaired forms before using.

4. Use flexible or rigid forms of proper curvature for curves having a radius of 100 feet (30 m) or less.

5. While concrete is being placed and consolidated, form the front face of the curb with fixed or movable forms. If movable slip forms are used, use forms that are least 6 feet (1.8 m) long with a suitable opening for placing and consolidating concrete. Obtain Engineer's approval for slip forms.

6. Set forms with the upper edge to the correct line and grade. Firmly hold forms in place with adequate stakes and bracing.

7. Forms with height greater than the thickness of the concrete may be used, with no additional cost to the Contracting Authority for extra concrete required, if:
- The upper edge is set accurately to line and grade, and
- The subgrade is excavated to meet the bottom edge of the form in a slope not steeper than one vertical to four horizontal.

D. Placing Concrete.
Place concrete to construct curb and gutter as an integral unit. Consolidate the concrete during placement with internal vibration operating at a frequency between 3,500 vibrations per minute (vpm) and 8,000 vpm.

E. Finishing.

1. After concrete has been consolidated and face forms have been removed, finish the surface to a uniform texture. Use a suitable edging tool to perform edging along all forms and expansion and contraction joints.

2. Ensure the finished surface conforms to the lines and grades shown in the contract documents. Ensure the gutters drain as indicated in the contract documents, with no depressions that trap water.

F. Protection and Curing.
After finishing, cure and protect the concrete using one of the methods described in Article 2301.03, K.

G. Joints.
Construct joints for PCC curb and gutter according to Section 2301 and the contract documents.

2512.04 METHOD OF MEASUREMENT.

The Engineer will measure the linear feet (the length to the nearest 0.1 m) of Curb or Curb and Gutter along the face of the curb at the gutter line.

2512.05 BASIS OF PAYMENT.

A. Payment for Curb or Curb and Gutter will be the contract unit price per linear foot (meter).

B. Payment is full compensation for:
- Furnishing all materials,
- Preparation of subgrade, and
- Placing, compacting, finishing, and curing the concrete curb or curb and gutter.

Section 2513. Concrete Barrier

2513.01 DESCRIPTION.

A. This section describes the production and construction of concrete barrier, both permanent and temporary, as shown in the contract documents.

B. Used temporary barrier rail furnished and placed as temporary barrier rail shall have been manufactured according to the contract documents after December 20, 1988.

C. Used barrier rail shall be included in installations containing units with similar shape and dimensions with compatible connecting loops.

D. Use F-shape temporary concrete barrier rail on roadways with a posted speed limit greater than 45 mph. Use F-shape temporary barrier rail, Type A, as defined in the Standard Road Plans, in all situations requiring the railing to be in place during the winter work period as defined in Article 1108.02, F.

2513.02 MATERIALS.

Use materials for concrete barrier and temporary concrete barrier rail meeting the requirements of Division 41 for the respective materials, and the following paragraphs. Use only approved supports and bedding grout when placing permanent precast concrete barrier.

A. Cement.
Apply Section 4101. Type I or Type III Portland Cement may be used.

B. Aggregates.
Use Class 2 or better durability coarse aggregate, unless otherwise specified.

C. Admixtures.
Apply Section 4103. Use air entrainment. To improve workability or retard hardening, other approved admixtures may be used with Engineer's approval. Those containing more than 1.0% chlorides will not be allowed.

D. Bolts, Anchors, and Other Metal Fastenings.
Apply Article 2407.02, G.

E. Steel Reinforcing.
Apply Section 2404. Unless otherwise specified, use epoxy coated reinforcement for all reinforcement other than temporary concrete barrier.

F. Barrier Markers.
Comply with Article 4186.12.

2513.03 CONSTRUCTION.

Unless otherwise designated, concrete barrier may be cast-in-place, precast in an approved casting yard or plant and hauled to the placing site, or slip formed at the project site. Approved manufacturers of precast barrier are listed in Materials I.M.

571, Appendix A. Use precast barrier produced in a plant for which the District Materials Engineer has approved equipment, procedures, and quality of concrete. Provide, or have the Fabricator provide, technical personnel who are experienced and skilled in the procedures being used. Have these personnel collaborate fully with the Engineer in all technical aspects of the work.

A. Concrete.

1. Precast.

a. Use concrete specified in Section 2407. Proportion, mix, place, and cure the concrete in a manner that will produce the minimum compressive strength at the time designated, as specified in Table 2513.03-1:

Table 2513.03-1: Compressive Strength

	Strength Before Moving From Casting Bed (psi (MPa))	Strength At Age 28 Days (psi (MPa))
Precast	1750 (12)	5000 (34.5)

b. Allow concrete to reach strength at age 28 days before storing in multilayers or shipping.

c. Use 7% as a target value for the air content of fresh, unvibrated concrete, with a maximum variation of plus 1.5% or minus 1.0%.

2. Cast-in-Place and Slip Form.

a. For cast-in-place, use Class C concrete complying with Materials I.M. 529. For slip form, use Class BR complying with Materials I.M. 529.

b. Submit Class BR mix design to the District Materials Engineer for approval at least 7 calendar days prior to placement. Apply Section 2403, except meet the following mix design requirements:

1) Cement for Class BR. Use a minimum cement content of 603 pounds per cubic yard (358 kg/m^3).

2) Water. Do not exceed Table 2513.03-2 for total mixing water and free moisture in the aggregate. Minimum slump is 1/2 inch (12.5 mm).

Table 2513.03-2: Mixing Water and Free Moisture

Class of Concrete	Pounds (kg) of Water Per Pound (kg) of Cementitious Material
BR (Slip Form) C (Cast-in-Place)	0.450 0.488

3) Aggregates for Class BR. Use a well graded combination of aggregates complying with Materials I.M. 532 in Zone II-A or II-B. Meet requirements in Division 41 for each individual aggregate used.

4) **Admixtures.** Use air entrainment. Use 7% as a target value for the air content of fresh, unvibrated concrete, with a maximum variation of plus 1.5% or minus 1.0%. To improve workability and aid in air entrainment, water reducing or retarding admixtures may be used according to Article 2513.02, C.

5) **Fly Ash and GGBFS.** Use the conditions and allowable rates of fly ash and GGBFS substitution in Table 2513.03-3:

Table 2513.03-3: Fly Ash and GGBFS Substitution

Cement Type	Maximum Allowable Substitution[(a)]	Time Period
Type I, II	35% GGBFS 20% Fly Ash	March 16 to October 15
Type IS, IP	20% Fly Ash	March 16 to October 15
Type I, II	20% Fly Ash	October 16 to March 15
Type IS, IP	0%	October 16 to March 15
[(a)] Maximum total mineral admixture substitution is 50%.		

B. Equipment.

Use equipment that meets the requirements of Section 2001 and the following:

1. Forms.

Ensure forms for all concrete barrier are true to dimensions as shown in the contract documents, true to line, mortar tight, and sufficiently rigid to maintain the required shape during placement, vibration, and curing. Ensure inside surfaces are smooth and free of any projections, indentations, or offsets.

2. Bins.

Apply Article 2001.06.

3. Weighing and Proportioning Equipment.

Apply Article 2001.20. A vibrator will not be required on the cement batch hopper.

4. Mixing Equipment.

Apply Article 2001.21. A continuous mixer with volumetric proportioning may be used with the Engineer's approval.

C. Proportioning, Mixing, and Placing Concrete.

1. Apply Article 2407.03, D, except apply the finishing requirements in Article 2403.03, P, 2, b, only to temporary barrier rail.

2. For precast temporary and permanent barrier cast upside down, finish the bottom of the concrete, exposed at the top of the form, as provided in Article 2403.03, P.

D. Curing.

1. Cast-in-Place and Precast.

a. Cure using a method preventing loss of moisture and maintaining an internal concrete temperature of no less than 40°F (4°C) during the curing period. Apply Article 2407.03, D when elevated temperature curing is used.

b. When nonelevated temperature curing is used, keep the concrete barrier damp with wet burlap for a minimum of 12 hours after casting. If forms remain in place during the 12 hours, only the exposed concrete surface will require the wet burlap application. Complete finishing operations after this period in an expedient manner. Once finishing and all necessary repairs have been accomplished, apply clear curing compound to all exposed surfaces as specified.

2. Slip Form.

Cure slip formed concrete barrier by application of a clear curing compound. No moist cure period will be required. Apply clear curing compound to the concrete barrier rail within 15 minutes after final finishing, provided that the free water (sheen) has appreciably disappeared from the concrete surface.

3. Clear Curing Compound.

a. Apply a clear curing compound, when specified, to all exposed surfaces. Use a compound that complies with Article 4105.07. Use a fine spray to form a continuous, uniform film on the surface and vertical edges of the pavement slab. Apply clear curing compound as soon as the free water has appreciably disappeared, but no later than 30 minutes after finishing. Use an application rate of no less than 200 square feet per gallon (5 m^2/L). Use a fugitive dye to ensure uniform application and coverage.

b. Prior to application, thoroughly agitate the curing compound in the supply drum immediately before transfer to the sprayer. After removal of forms following finishing, apply this compound promptly and at the same rate to exposed surfaces. If the coating is damaged within 72 hours after being applied, recoat the affected area without delay. Further sealing is not necessary.

E. Removal of Forms.

For precast and cast-in-place concrete barrier, forms may be removed before the concrete has attained 250 psi (1.7 MPa) in flexure. If form removal interrupts the moist cure process, accomplish form removal without delay and immediately reapply the moist cure process. Ensure form removal does not cause damage to, or deformation of, the barrier.

F. Finish.

1. For permanent precast and cast-in-place concrete barrier, apply Article 2407.03, L, except do not commence the finishing operation until completion of the initial wet cure period.

2. Ensure permanent precast barrier is free from honeycomb or surface defects. When defects develop, evaluate production procedures and make corrections. Patching of such defects is to be very limited.

3. Finish temporary barrier rail according to Article 2403.03, P, 2, b.

4. For slip form concrete barrier, the finish remaining after the steel form passes will not require further surface manipulation. Apply Article 2403.03, P, 2, b. Ensure the finished slip form barrier is free from honeycomb or surface defects. Complete patching operations only as directed by the Engineer and according to Article 2407.03, L.

G. Barrier Markers.

Furnish barrier markers of same color as adjacent edge line. Attach markers to barrier using adhesive as recommended by manufacturer. Locate top of marker 2 inches (50 mm) below top of barrier. Place barrier markers at 100 foot (30 m) increments.

H. Tolerances.

1. Ensure all newly fabricated units of temporary barrier rail are free from honeycomb, surface spalling, and surface defects. Ensure corner breaks and bottom spalls after shipping and placement do not exceed 1 square foot (0.1 m^2) of total surface area, which includes the base.

2. Other than honeycomb, shallow voids, not exceeding 3/4 inch (19 mm) diameter, which appear on the formed surface after proper consolidation will not be considered as surface defects. They need not be filled unless they appear in an abnormal concentration.

3. For concrete barrier, apply the tolerances of Table 2513.03-4:

Table 2513.03-4: Tolerances for Concrete Barrier

Item	Precast Fabrication[(a)] (Permanent or Temporary)	Cast-In-Place or Slip Form Installation
Length	± 3/4 inch (± 19 mm)	
Width	± 1/4 inch (± 6 mm)	[(b)]
Height	± 1/4 inch (± 6 mm)	[(b)]
Horizontal Straightness (Sweep)	1/2 inch maximum in 10 feet (12 mm maximum in 3 m)	3/4 inch maximum in 10 feet (19 mm maximum in 3 m)

Top Straightness (Vertical)	1/4 inch maximum in 10 feet (6 mm maximum in 3 m)	3/4 inch maximum in 10 feet (19 mm maximum in 3 m)
Exposed Ends (Deviation from square)	± 1/4 inch (± 6 mm)	

[(a)] Installation of permanent precast barrier includes shimming and grouting such that adjoining sections match within 1/4 inch (6 mm) on the sides and top, and the finished height is not less than required by the contract documents.

[(b)] The width and depth are not to be less than required by the contract documents.

4. Ensure each unit of temporary barrier rail does not have spalls, corner breaks, and bottom spalls totaling more than 5 square feet (0.5 m^2) of surface area, including the base.

5. Ensure connecting loops on all barriers are not deformed. Ensure they are true to dimensions.

6. Ensure gaps between units do not exceed the dimensions shown in the contract documents.

I. Handling, Storage, and Hauling New and Used Precast Units.

1. Do not lift or stress precast barrier units in any way before they have developed the strength specified. Support units at designated pickup points. Do not use connecting loops as pickup points.

2. Ensure fabrication, storage, handling and transporting will not result in cracking, twisting, or other damage. Minor chips on edges may be patched with the Engineer's approval. Breakage and chipping may be cause for rejection.

3. Ensure tiedowns are not in direct contact with concrete surfaces, which may cause chipping or breakage

4. Do not subject units to excessive impact.

5. Replace at no additional cost to the Contracting Authority units that, in the Engineer's opinion, are damaged in such a way as to impair their appearance or suitability. Mark new barrier units for the proper identification according to Materials I.M. 571.

6. The Engineer will mark temporary barrier rail units that are rejected with an orange painted "R" approximately 12 inches (300 mm) high and 6 inches (150 mm) wide on both ends to show that piece has been rejected for use as a traffic control device.

2513.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Concrete Barrier: linear feet (meters) shown in the contract documents, based on the contract quantity from end to end of the barrier excluding end sections, width transition sections, and height transition sections.

B. End sections, width transition sections, and height transition sections: By count for each type of end section, width transition section, or height transition section.

C. For concrete barrier railing for bridge structures: apply Article 2414.04.

D. Reinforcement in concrete barrier for other than bridge structures will not be measured separately.

2513.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Concrete Barrier, of the type specified: linear feet (meters).

B. End sections, width transition sections, and height transition sections: Each for the type of end section, width transition section, or height transition section specified.

C. For concrete barrier railing for bridge structures: apply Article 2414.04.

D. Reinforcement in concrete barrier for other than bridge structures: not paid for separately.

E. Payment as described above is considered full compensation for all work involved.

Section 2514. Curb Removal

2514.01 DESCRIPTION.

A. Remove curb from PCC pavements which are to remain in place. Remove flumes and construct and shape shoulders as specified in the contract documents.

B. The contract documents may also include granular surfacing of shoulders, seeding and fertilizing, and other additional work.

2514.02 MATERIALS.
None.

2514.03 CONSTRUCTION.

A. Removal of Curb.

1. Remove all integral curb using methods which will not damage concrete that is to remain.

2. When the contract documents do not provide for resurfacing, remove the curb using a grinding machine designed for that purpose.

3. Grind the curb flush with the adjacent pavement surface within a tolerance of ± 1/4 inch (5 mm). Grind the surface to project inside the curb the minimum amount necessary to assure complete curb removal, but not more than 2 inches (50 mm). Ensure the resulting surface has a texture satisfactory to the Engineer.

4. When the contract documents provide for resurfacing, remove the curb by grinding or other methods the Engineer approves. Other methods may include chipping or sawing and breaking. Ensure the method chosen provides complete removal of curb that extends above the pavement surface. Ensure it also provides a safe and smooth surface to accommodate traffic.

5. When removal is by sawing and breaking, perform the work as shown in the contract documents and as follows:

- **a.** Make a vertical saw cut along the edge of the curb nearest the centerline of pavement. At the end of the curb section, extend the saw cut to the extreme end of the curb. At this point make a saw cut at right angles and extend to the pavement edge.
- **b.** Where flumes occur in curb sections, extend the saw cut across the throat of the flume.
- **c.** On resurfaced pavement, locate the saw cut 7 1/2 inches (190 mm) from the pavement edge. Cut to a depth of 3 inches (75 mm) below the surface of the resurfacing.
- **d.** Immediately before breaking the curb, clean the sawed groove free of dirt, stones, or any foreign matter to a depth at least 1 inch (25 mm) below the pavement surface.

6. Remove concrete, including resurfacing concrete and concrete across the throats of flumes, to the dimensions shown in the contract documents. Cut off all reinforcement exposed and loosened.

7. When curb is removed by grinding, remove the ground material from the pavement surface. The ground material may be deposited as an edge fillet or spread on the adjacent shoulder surface.

8. Unless provided otherwise, remove broken concrete according to Article 1104.08.

B. Removal of Flumes.

Removal of flumes includes removal of shoulder basins, slope drains, and discharge basins. Place backfill in the area excavated for flume removal. Compact as directed by the Engineer. Remove flume material according to Article 1104.08.

C. Removal of Posts.

Remove posts as directed by the Engineer. Fill holes resulting from post removal. Compact as directed by the Engineer.

D. Shoulders.

1. Construct shoulders as shown in the contract documents, according to Article 2302.03, F.

2. Fill in depressions resulting from removal of flumes, slope drains, and discharge basins. Use excess shoulder material shaped and compacted with a mechanical tamper or by other methods the Engineer approves.

E. Traffic Control.

1. Traffic control complying with Section 2528 will be required for this work. Work areas will be limited to approximately 1/2 mile (0.8 km) in length.

2. Do not allow traffic in a lane while a drop-off exists at the edge of the pavement in that lane. Schedule work so there are no lane closures or drop-offs at the edge of the pavement overnight.

3. Complete shoulder and fillet or granular surfacing edge treatment on the first side of the pavement at a location before commencing curb removal on the second side of the pavement.

2514.04 METHOD OF MEASUREMENT.

Measurement for curb removal work satisfactorily completed will be as follows:

A. Removal of Curb.
According to Article 2213.04, A.

B. Removal of Flumes.
According to Article 2213.04, B.

C. Shoulders.
According to Article 2302.04, D.

D. Removal of Posts.
The number of posts removed, as specified, will be determined by count.

2514.05 BASIS OF PAYMENT.

Payment for the items involved in curb removal, measured as specified above, will be as described below. Payment is full compensation for all labor, equipment, and materials to remove the curb, posts, flumes, and for the construction of shoulders as specified.

A. Removal of Curb.
According to Article 2213.05, A.

B. Removal of Flumes.
According to Article 2213.05, B.

C. Shoulders.
According to Article 2302.05, D.

D. Removal of Posts.
Contract unit price for the number of posts removed as specified.

Section 2515. Removal and Construction of Paved Driveways

2515.01 DESCRIPTION.

Remove paved drives or portions of drives. Construct new PCC driveways according to the contract documents.

2515.02 MATERIALS.

A. When paved driveways are to be constructed in conjunction with a PCC paving project, the class of concrete being used on the project may be used for driveways. If that class of pavement is not chosen for use, or if the contract contains no item for PCC pavement, pavement widening, or base, then use Class C concrete.

B. For the construction of paved driveways, meet the requirements of Division 41 for the respective materials.

2515.03 CONSTRUCTION.

A. Removal of Paved Driveways.

1. Remove paved driveways as shown in the contract documents.

2. When old concrete pavement is to be removed and later abutted at its top surface with new concrete pavement, saw the designated breakout line to full depth before breaking the pavement. Remove to a new line and replace all concrete broken or damaged beyond the breakout line designated by the Engineer at no additional cost to the Contracting Authority.

3. Apply Article 2510.03, A to the removal of driveways.

B. Construction of Paved Driveways.
Unless specified otherwise, construct new paved driveways to the dimensions shown in the contract documents.

1. Preparation of Subgrade.
Prepare the subgrade by excavating or filling with suitable earth to a depth below the finished grade line so that, when tamped or rolled until smooth, firm, and hard, the subgrade is uniform and at the required depth below the finished grade line.

2. Portland Cement Concrete.

a. Placing.

1) Hand Finish.

a) Use forms complying with Article 2301.03, A, 3, a, 1, c.

b) Ensure the subgrade is thoroughly moistened.

c) Deposit concrete for the full depth of slab in one operation. Consolidate it by tamping or vibration. Screed off the excess concrete flush with the forms. Thoroughly consolidate edges adjacent to all forms, expansion joints, curbs, or fixtures in the surface.

2) Slip Form.
Use self propelled slip form pavers meeting the requirements of Section 2301. For other slip form paving machines, obtain the Engineer's approval. Use machines designed for the specific purpose of placing, consolidating, and finishing concrete driveway slabs without use of fixed side forms.

b. Finishing.

1) After consolidation, finish the concrete surface with a burlap drag.

2) After the surface has been floated, finish the edges of the slabs with a suitable edging tool.

c. Protection and Curing.
After finishing, cure and protect the concrete using one of the methods described in Article 2301.03, K.

d. Joints.

1) Cut through the concrete for no less than 25% of the depth with a pointed trowel or suitable spading tool. Edge the concrete on both sides. In lieu of using a pointed trowel or suitable spading tool, these lines may be cut within 12 hours after placement of concrete with a 1/8 inch (3 mm) blade saw that is approved by the Engineer. Metal dividers will be considered for approval, in lieu of cutting.

2) Construct isolation joints at all points where driveways meet other walks, curbs, or fixtures in the surface. Construct these joints by installing a 1/2 inch (13 mm), full depth strip of approved premolded joint material.

3) Seal contraction joints according to Article 2301.03, P.

e. Time for Opening Pavement for Use.
Open PCC driveways a minimum of 7 calendar days after placement or when flexural strength reaches 400 psi (2.75 MPa) as determined by Materials I.M. 383.

3. Hot Mix Asphalt.
Construct HMA driveways according to Article 2303.03. Apply Class II compaction.

4. Smoothness.

a. Where abutting pavement is to be placed adjacent to the pavement being checked, ensure the surface does not deviate by more than 1/4 inch (6 mm) when checked 1 inch (25 mm) from the edge with a 3 foot (1 m) straightedge used transversely and a 10 foot (3 m) straightedge used longitudinally.

b. Areas may be checked by the Engineer with a surface checker. These are not to exceed 1/4 inch in 10 feet (6 mm in 3 m). For each bump exceeding these requirements, the Contractor will be

assessed $50 or the bump corrected as agreed upon by the Engineer and Contractor.

5. Weight Limits.
Limit construction equipment on both PCC and HMA driveways to 5 tons (5 Mg).

2515.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Removal of Paved Driveway.
Square yards (square meters), to the nearest square foot (0.1 m^2), shown on the contract documents for each paved driveway removed.

B. PC Concrete Driveways.
Square yards (square meters), to the nearest square foot (0.1 m^2), shown on the contract documents for each paved driveway of the thickness specified. This includes areas through sidewalks. No deductions will be made for fixtures having an area of 1 square yard (1 m^2) or less.

2515.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Removal of Paved Driveway.

1. Per square yard (square meter).

2. Payment is full compensation for all equipment, tools, and labor for removal of the driveways as specified in the contract documents.

B. Portland Cement Concrete Driveway.

1. Per square yard (square meter) for the thickness specified.

2. Payment is full compensation for furnishing all material, equipment, tools, and labor to construct the driveway in accordance with the contract documents.

Section 2516. Combined Concrete Sidewalk and Retaining Wall

2516.01 DESCRIPTION.

A. This section was developed in conjunction with Section 9072 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

B. Construct combined concrete sidewalk and retaining wall.

2516.02 MATERIALS.

A. Combined Concrete Sidewalk and Retaining Wall.

1. Portland Cement Concrete.
Comply with Article 2511.02, A.

2. Reinforcing Steel.
Comply with Section 4151.

3. Expansion Joint.
Comply with Article 4136.02. Use resilient filler when type is not specified.

B. Subdrain.

Use minimum 4 inch (100 mm) diameter pipe.

1. Polyvinyl Chloride Pipe and Fittings (Solid Wall PVC):
- **a.** Comply with ASTM D 3034, minimum thickness SDR 35, 46 psi (320 kPa) minimum pipe stiffness.
- **b.** Use PVC plastic conforming to ASTM D 1784, Cell Classification 12454.
- **c.** Integral bell and spigot type rubber gasket joint complying with ASTM D 3212 and ASTM F 477.
- **d.** Slot subdrain pipe according to ASTM F 949 or perforate with four rows of 1/4 to 3/8 inch (6 to 9 mm) diameter holes along the bottom of pipe.

2. Corrugated Polyvinyl Chloride Pipe and Fittings (Corrugated PVC):
- **a.** Use corrugated exterior, smooth interior, PVC.
- **b.** Comply with ASTM F 949, minimum pipe stiffness, 46 psi (320 kPa).
- **c.** Use PVC plastic complying with ASTM D 1784, Cell Classification 12454.
- **d.** Integral bell and spigot type rubber gasket joint complying with ASTM D 3212 and ASTM F 477.
- **e.** Slot subdrain pipe according to ASTM F 949.

3. Corrugated Polyethylene Tubing and Fittings (Corrugated PE):
- **a.** Comply with Article 4143.01, B, 1.
- **b.** Use only fittings supplied or recommended by pipe manufacturer for soil tight service.

C. Porous Backfill Material for Subdrain:

1. Crushed Stone or Processed Gravel.
Comply with Section 4131.

2. Pea Gravel.
Comply with Gradation No. 20 or 21 of Section 4109 and the quality requirements of Section 4131.

D. Suitable Backfill Material.
Comply with Article 2102.02, D, 2.

E. Rodent-Proof Hardware Cloth.
Comply with Materials I.M. 443.01.

2516.03 CONSTRUCTION.

A. Excavation and Embankment.

1. At locations where the wall will be constructed against embankment, compact to a minimum of 90% of maximum Standard Proctor Density prior to beginning wall construction.

2. Excavate to the line and grade specified in the contract documents. Minimize over-excavation. Install sheeting, shoring, or other retention systems as required to ensure the stability of the excavation.

B. Installation.

1. General.
- **a.** Forming the back of the wall is not required. Where the back of the wall is not formed and sloughing occurs, remove loose material, and replace with concrete at no additional cost to the Contracting Authority.
- **b.** Install 3 inch (75 mm) diameter weep holes at 8 foot (2.5 m) intervals. Form weep holes with an approved rustproof device backed with rodent-proof hardware cloth.
- **c.** Install 8 inch (200 mm) wide trench of porous backfill behind the wall. Install subdrain within porous backfill trench. Ensure positive drainage on subdrain.

2. Backfill Material Placement.
- **a.** Place suitable backfill material with adequate moisture content for compaction in maximum 8 inch (200 mm) lifts, spread, and compact.
- **b.** Use hand-operated compaction equipment within 3 feet (10 m) of the front of the wall face.

C. Joints.

1. Form ED joints in wall at no more than 60 foot (18 m) spacing. Affix expansion material to retaining wall.

2. Form C joints in the wall at no more than 20 foot (6 m) spacing.

3. Form E joints in sidewalk to coincide with ED joints in wall. Form C joints in sidewalk at spacing equal to sidewalk width.

4. Form longitudinal joint in sidewalk when sidewalk width is greater than 8 feet (2.4 m).

D. Rustication.
Decorative form liners or inserts may be used when forming the face of the wall with the approval of the Engineer. Form rustications as specified in the contract documents.

2516.04 METHOD OF MEASUREMENT.
Measurement for Combined Concrete Sidewalk and Retaining Wall will be cubic yards (cubic meters) shown in the contract documents.

2516.05 BASIS OF PAYMENT.
Payment for Combined Concrete Sidewalk and Retaining Wall will be the contract unit price per cubic yard (cubic meter). Payment is full compensation for:

- Excavation and foundation preparation,
- Furnishing and placing concrete and reinforcing steel,
- Joint material,
- Subdrain,
- Porous backfill material,
- Suitable backfill material,
- Finishing disturbed areas, and
- Shoring as necessary.

Section 2517. Railroad Approach Sections

2517.01 DESCRIPTION.
Construct pavement sections at junctures of railroad according to the contract documents.

2517.02 MATERIALS.
For construction of railroad approach sections, meet the requirements of Divisions 23 and 41 for the respective material.

A. PCC Paving Projects.
Use either Class C PCC or the same class PCC as specified for the pavement.

B. HMA Paving Projects.
Use an HMA mixture that is one mix level above the approaching surface course. Use PG 64-22 asphalt binder.

2517.03 CONSTRUCTION.

A. PCC Paving Projects.

1. Form, place, finish, and cure the PCC according to Section 2301.

2. The Engineer may require the railroad approach section to be placed one lane at a time for the convenience of the traveling public. When the header slab is constructed in two sections, construct a centerline joint as shown in the contract documents. When the joint is not provided for,

place 1/2 inch (No. 15) tie bars no more than 4 feet (1.2 m) apart and extend them no less than 18 inches (450 mm) into each section.

B. HMA Paving Projects.
Place the HMA according to Article 2303.03, C, 4, with maximum 2 inch (50 mm) lifts. Compact according to Article 2303.03, C, 5, Class II.

2517.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Railroad Approach Section, PCC.
Square yards (square meters) shown in the contract documents.

B. Railroad Approach Section, HMA.
Square yards (square meters) shown in the contract documents.

2517.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Railroad Approach Section, PCC.

1. Per square yard (square meter).

2. Payment is full compensation for:
- Excavation for modified subbase and subdrain,
- Furnishing and installing subdrain,
- Furnishing and installing subdrain outlet,
- Furnishing and placing porous backfill material,
- Furnishing and placing modified subbase backfill material, and
- Furnishing and installing reinforcing steel, tie bars, and dowel assemblies.

B. Railroad Approach Section, HMA.

1. Per square yard (square meter).

2. Payment is full compensation for:
- Asphalt binder and tack coat,
- Excavation, modified subbase, and subdrain,
- Furnishing and installing subdrain,
- Furnishing and installing subdrain outlet,
- Furnishing and placing porous backfill material,
- Furnishing and placing modified subbase backfill material,
- Furnishing and installing fiber board barrier, and
- Furnishing, placing, and compacting HMA.

Section 2518. Safety Closure

2518.01 DESCRIPTION.

This section concerns Safety Closures erected as specified in the contract documents. Two types of safety Closures will be specified: Road Closures and Hazard Closures.

2518.02 MATERIALS.

Use orange mesh safety fence meeting the requirements of Article 4188.03.

2518.03 CONSTRUCTION.

A. Erection.

1. Road Closures.

- **a.** Place a fence meeting the requirements of Article 2518.02 across the roadway from outside edge of shoulder to outside edge of shoulder. Securely support the fence so it is in a vertical position without sagging.
- **b.** Place a Type III barricade, described in Part 6 of the MUTCD, immediately in front of the fence at the approximate roadway centerline. Mount a ROAD CLOSED (RII-2) sign on the Type III barricade.
- **c.** Erect road closures as specified in the contract documents. Erect them on the mainline of the roadway where public traffic is diverted onto an on-site detour and where public traffic is prohibited from entering the work area.
- **d.** Erect road closures beginning with the start of the contract period as specified in the contract documents, or when the work commences.

2. Hazard Closure.

- **a.** Place a fence meeting the requirements of Article 2518.02 across the roadway from outside edge of shoulder to outside edge of shoulder. Securely support the fence so it is in a vertical position without sagging.
- **b.** Place a Type III barricade, described in Part 6 of the MUTCD, immediately in front of the fence at the approximate roadway centerline.
- **c.** Erect hazard closures as specified in the contract documents. Erect them at locations within a work area when construction involves major hazards on existing or relocated roadways. Such hazards may be located at streams, gullies, railroads, bridge approaches, and driveway locations. Through public traffic should not normally encounter a hazard closure.
- **d.** Erect hazard closures beginning with the start of the contract period as specified in the contract documents, or when the work commences.

B. Responsibility.

1. Maintain the location and condition of the safety closures. Any Contractor who temporarily moves the safety closure for equipment or delivery of materials, shall replace it in its original position and is responsible for the restriction of public traffic into the closed area.

2. If a safety closure placed by the Contractor is required for an area after the Engineer's approval of completed work for that specific area, maintenance of that safety closure will become the responsibility of the Contracting Authority. The Engineer will document in writing the transfer of authority.

3. The Engineer will notify the Contractor of the date of removal of safety closures. The safety closure remains the property of the installing Contractor. If the safety closure is not removed by the date specified in the notification, it will become the property of the Contracting Authority and the Contractor will be charged for any removal costs.

2518.04 METHOD OF MEASUREMENT.
The Engineer will count each Safety Closure (either road closure or hazard closure) erected.

2518.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price for each Safety Closure counted.

B. Payment is full compensation for furnishing all material, labor, and equipment necessary to erect, maintain, and remove the Safety Closure, unless indicated otherwise in the contract documents.

Section 2519. Fence Construction

2519.01 DESCRIPTION.
Furnish all material, set posts, and erect the fence according to the contract documents.

2519.02 MATERIALS.
Meet requirements of Section 4154 for the type of fence specified.

2519.03 CONSTRUCTION.
Furnish and erect field fence, deer fence, or chain link fence of the type and dimensions shown in the contract documents and according to the provisions below. Do not disturb right-of way-markers.

A. Field Fence and Deer Fence.

1. General.

a. Prior to placement, provide a smooth ground profile free of all tall grass and debris in the area the fence is to be placed.

b. When rock is encountered, employ the appropriate means of excavation to the bottom of post elevation. Place backfill using suitable material placed and thoroughly compacted by tamping until the post is firmly embedded, plumb, and true to alignment.

c. When removing and reinstalling field fence, make arrangements with adjacent property occupants for restraining livestock from entering the right-of-way.

2. Brace Post Assembly.

a. Locate brace posts so the horizontal brace will make contact with both posts while posts are in the vertical position. Set all posts as shown in the contract documents.

1) Angle posts will be required where vertical alignment of fence changes 30 degrees or more.

2) Corner posts will be required where horizontal alignment of fence changes by 10 degrees or more.

3) When required in the contract documents, install pull post assemblies at right-of-way breaks of less than 10 degrees, horizontal alignment changes less than 30 degrees, and property corners.

4) An end post assembly will be required where a fence begins or ends.

b. Place and tamp backfill material, consisting of a well graded crushed stone meeting requirements of Section 4120 or a PCC mix approved by the Engineer, around angle, corner, end, gate, and brace posts. Ensure backfill material contains sufficient moisture to be readily and thoroughly compacted by tamping at the time backfill material is placed.

c. Posts may be driven if demonstrated that driving can be done in a manner that will not damage the post. Drive the post plumb and true to alignment. Place backfill material in voids around driven posts that require straightening. Thoroughly compact backfill material by tamping.

d. Install metal braces as shown in the contract documents. Place them so they will not hold water on top of the brace. At installations with two brace wires, maintain tension in both directions.

3. Pull Post Assemblies.

a. Pull post assemblies are for the purpose of tightening fence wire by mechanical means. Use mechanical means to tighten fence fabric from both directions to the middle post. Use a staple to secure each line wire of the fence fabric and barbed wire at pull posts. Drive the staples so they are not parallel with the wood grain and are tight.

b. Set posts to comply with the provisions in Article 2519.03, A, 1, above.

4. Line Posts.

a. In each run of fence between brace posts, set line posts at the interval designated in the contract documents. Use wood posts no smaller than 4 inch (100 mm) top diameter.

b. In runs of fence 1,000 feet (300 m) or less, use steel line posts that are all of the same type. Set steel line posts by driving. Do not damage posts while driving.

c. Set wood line posts in bored holes no smaller than 9 inches (225 mm) in diameter or by driving in a manner which will not damage the post. Thoroughly tamp soil removed from bored holes back into the hole.

d. Set all posts plumb and true to line. Reset all posts that are:
- Out-of-plumb more than 1 inch (25 mm).
- Out-of-line more than 2 inches (50 mm).

e. At each steel post, secure each line wire of the fence fabric and barbed wire to the post by a wire tie or clip. Wrap the clip around the wire on each side of the post, holding the wire tightly to the post to preventing slipping up or down the post.

5. Stretching Fence Fabric.

a. Cut and tie off fabric at all pull posts. Pass each line wire to the pull post. Secure the wire with no less than four wraps tight around itself. Stretch the wire until:
- All slack is taken up,
- All longitudinal wires are taut, and
- Approximately 50% of the factory fabricated fence crimp is removed.

b. Apply tension in the fabric by mechanical means using equipment designed for such use. Hold the fabric until the end of each line wire has been tightened around the pull post and securely wrapped on itself. From the pull post around the angle or corner post to the other pull post, hand tension the fabric at the angle or corner post assembly.

c. For pull post assemblies, extend the fence fabric past the brace post and attach to the pull post. Cut and wrap each line wire of the fabric around the pull post. Secure line wire by no less than four wraps tight around itself.

6. Stretching Barbed Wire.

a. Secure each strand of barbed wire at pull posts by wrapping around the post with no less than four wraps tight around itself.

b. Apply tension to each individual strand of barbed wire by mechanical means using equipment designed for such use.

c. Hold the wire until the end of each wire has been tightened around the pull post and the end is secured on itself before the tension is released.

7. Splices.

a. Fabricate splices in fence fabric, as detailed in the contract documents by one of the following methods:
- Attaching the fabric to pull posts according to Article 2519.03, A, 3, or by wire splice,
- Approved fence splice,
- Crimp connector, or

- Rod method.

b. Fabricate splices in barbed wire, as detailed in the contract documents, by either:
- Attaching the wire to pull posts according to Article 2519.03, A, 6, or
- Approved fence splice or crimped connector recommended for barbed wire which develops a strength of at least 85% of the wire strength.

c. Fabricate splices in brace wire by approved splice or crimped connector recommended for brace wire which develops a strength of at least 85% of the wire strength, as detailed in the contract documents.

8. Gates.

a. Mount gates so that they swing fully and do not sag or drag on the ground. Provide them with a galvanized, welded chain:
- Long enough to completely encircle the post and the end frame of the gate.
- With chain links large enough to use with a padlock.

b. Drive a 4 inch (100 m) diameter wood post in the ground to provide an adequate stop to prevent the gate from opening to a point that would damage the gate.

9. Electrical Grounds.

Field fence will not be required to be grounded except as required in the contract documents.

10. Channel Crossing Fence.

a. Construct channel crossing fence complying with, and at locations indicated in, the contract documents.

b. Channel crossing fence, of the type specified in the contract documents, will be required when:
- A stream or ravine is to be crossed and it is impractical to fit the line fence to the existing ground line, and
- More than two additional barbed wires are required below the normal line fence to adequately close the opening.

c. Set the posts and stretch the barbed wire and secure as specified for field fence.

d. Use barbed wire with a spacing of no more than 6 inches (150 mm).

e. For Type A channel crossing fence, use extra length wood posts and additional field fence materials to close the opening satisfactorily. For Type B channel crossing fence, construct a floodgate as shown in the contract documents, in addition to extra length wood posts and additional field fence materials needed to close the opening satisfactorily.

11. Flood Plain Fence.

Use materials specified for field fence. Use wood line posts only, spaced as shown in the contract documents, and with the fence fabric

on the downstream side of the posts. Otherwise, construct flood plain fence to meet requirements for field fence.

B. Chain Link Fence.

1. General.

Unless indicated otherwise in the contract documents, use chain link fence steel posts connected with pipe rails at the top and tensioned stretcher wire at the bottom.

2. Posts.

a. The Engineer will designate the location of each end, angle, corner, and gate post.

b. Set posts with the required brace post assembly at each end, angle, corner, and gate. Brace post assemblies will not be paid for separately. Set posts plum and true to line. Reset posts that are:

- Out-of-plumb more than 1 inch (25 mm).
- Out-of-line more than 2 inches (50 mm).

c. Fill the hole around each post with PCC meeting the requirements of Section 2403.

d. Ensure dirt or other foreign material is not mixed with concrete as it is placed. Forms will not be required if, in the opinion of the Engineer, the earth around the hole is dry and firm enough to permit satisfactory placement. Fill the hole around the post completely with concrete. Neatly finish the concrete to slope up to the post approximately 1 1/2 inches (38 mm) above the ground surface. Protect the concrete from drying by covering with soil or burlap kept wet for 24 hours or by applying white curing compound.

e. Set posts a minimum of 24 hours before fence is stretched.

f. Instead of drilling holes for posts and filling with concrete, other equivalent means of securely anchoring the posts into the ground may be used if the Engineer approves.

g. So that no section of fence longer than 500 feet (150 m) is constructed with line posts only, place pull posts, constructed according to the contract documents, between end, angle, corner, and gate posts, as necessary.

3. Chain Link Fabric.

Construct as shown in the contract documents. Uniformly smooth ground surface along the line of fence for a width of 2 feet (600 mm) so fabric will conform to ground surface.

4. Gates.

Erect gates as shown in the contract documents.

5. Electrical Grounds.

a. Properly ground chain link fence that crosses beneath any primary electrical power transmission line, other than a secondary feeder line for individual customer service. Ground the fence at the point of transmission line crossing and at a distance of 25 to 50 feet (7.5 m

to 15 m) in each direction from the crossing. Construct the grounding installation as detailed in the contract documents.

b. Ground chain link fence erected adjacent to and within 50 feet (15 m) of a primary power line by placing ground rods at no more than 500 foot (150 m) intervals.

c. Include at least one ground in each applicable straight section of fence. The Engineer may require the installation of an additional ground at the terminus of a section of fence or at other locations near areas of pedestrian traffic. Connect the ground rod to the fence as shown in the contract documents.

2519.04 METHOD OF MEASUREMENT.

Measurement for the items associated with fence construction will be measured as follows:

A. Field Fence, Deer Fence, or Chain Link Fence: linear feet (meters) constructed, of the height and type specified, measured along the fence at the bottom of the fabric, excluding the length of gates or fence otherwise measured for payment.

B. Field Fence and Deer Fence Brace Panels: by count of the metal braces properly installed for the various units.

C. Channel Crossing Fence: linear feet (meters) of the type specified and constructed according to the contract documents, measured along the fence at the bottom of the fabric between end posts for the channel crossing fence.

D. Flood Plain Fence: linear feet (meters) constructed, measured along the fence at the bottom of the fabric between end posts for the flood plain fence.

E. Gates: by count of each type and size installed.

F. Removal and reinstallation of fence: Linear feet (meters) for each type of fence, including gates, as shown in the contract documents.

G. Removal of fence: Linear feet (meters) for each type of fence, including gates, as shown in the contract documents.

2519.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price as follows:

1. For the various types of fence: Per linear foot (meter).

2. Field Fence and Deer Fence Brace Panels: each. Payment is compensation for brace wires and metal braces.

3. Gates: each.

4. Removal and reinstallation of fence: Per linear foot (meter) for each type. Payment will be full compensation for removing and reinstalling

fence, including removing and reinstalling gates (if required) and replacement of any fence parts that are not able to be salvaged and reinstalled.

5. Removal of fence: Per linear foot (meter) for each type. Payment will be full compensation for removing fence fabric, gates, posts, and footings and for filling and consolidating resulting holes to finish grade to prevent future settlement.

B. Payment is full compensation for furnishing all material and for construction of fence as provided herein, including clean up after the work is complete. Excavation will not be paid for separately, but excavation in unexpected rock will be paid for as extra work. Unexpected rock will be considered as rock encountered during post installation, but not visible from the roadway nor indicated in the contract documents.

C. Electrical grounds required in the contract documents will not be paid for separately. Payment for additional electrical grounds required by the Engineer will be according to Article 1109.03, B.

D. Where a new terminus is required at an intersection with new fencing, work and materials to install an "End Post Assembly" for existing field fence will not be paid for separately.

Section 2520. Field Laboratory and Field Office

2520.01 DESCRIPTION.

Furnish and maintain field office space or laboratory space, or both, to be used for project testing of:

- Earthwork where moisture control or moisture density control is required,
- Subbase, base, and pavement, and
- Any other designated use.

2520.02 MATERIALS.

None.

2520.03 FIELD LABORATORY AND FIELD OFFICE.

A. Field Laboratory.

1. General.

Meet the following requirements. Items a through h are meant as a guide rather than minimum requirements. The Engineer may approve suitable alternative facilities.

a. Weather tight field laboratory space with minimum inside dimensions of 7 feet by 18 feet (2 m by 5.5 m) with 7 feet (2.1 m) of head room.

b. Two doors: one at least 32 inches (800 mm) wide with screens, and one for emergency.

c. Outside walls with screened windows which can be used for ventilation.
d. Desk with drawers, three chairs, a closet, and a suitable work table space.
e. Splinter free and solid floor.
f. A floor broom and fire extinguisher.
g. Anchor bolts firmly attached to accommodate a mechanical sieve shaker (template furnished upon request).
h. Lockable laboratory space (with appropriate number of keys) that is set level and stable for minimum vibration. The laboratory space may be independent or dependent on other space, but is for the exclusive use of the Contracting Authority.
i. Adequate lights and heavy duty, 110 volt electrical outlets, suitably placed.
j. An exhaust fan or fans.
k. A laboratory stove or stoves with hoods vented to an exhaust fan
l. A sink with potable water supply to sink faucet.
m. Air conditioning and heat to maintain a temperature approximately between 70°F (20°C) and 80°F (27°C).
n. Wireless connectivity. Provide a device to allow multiple inspectors to access the internet wirelessly, such as a mobile hotspot. Provide a minimum of 3 GB of data usage monthly. This device will be considered a part of the field laboratory and shall stay with the field laboratory. If the field laboratory and field office are located adjacent to each other, one device may be adequate to cover both, so long as the signal can be accessed from both trailers. The Contracting Authority will pay data charges for usage above the monthly minimum.
o. Suitable sanitary facilities located within 75 feet (25 m) of the laboratory for use by the inspection forces.

2. Furnishing Field Laboratory.

A field laboratory will be required as follows:

a. Field Laboratories.

1) Field laboratories will be required for acceptance testing when specified on the proposal. The items for which the field laboratory is intended will be designated. If base and pavement are of similar types which require similar plant and testing facilities, only one field laboratory will be shown on the proposal for both items.

2) Furnish the field laboratory before all work is started. Keep the field laboratory on the project at all times regardless of work being performed or testing required. Duplicate field laboratories may be required when the plant facilities are duplicated or dispersed so that plant operation of base or pavement work cannot be monitored from one field laboratory.

3) Relocate laboratories used to control asphalt binder or Portland cement proportioning as the plant facilities are relocated. Field laboratories used primarily to test densities of base, subbase, or earthwork may be required to be relocated

once for each 4 miles (6.5 km) or fraction thereof in the length of the project.

b. Field Laboratories for Materials Inspection.

1) Materials will be inspected at the project site if prior inspection has not been made, and a materials laboratory may be required for this purpose. If inspection prior to shipment to the project site is necessary, in the opinion of the Engineer, or agreeable to the Engineer and Contractor, furnish inspection facilities near the location for inspection.

2) Inspection facilities will be necessary at the site of production or warehousing of:

- Pipe,
- Cement,
- Asphalt,
- Structural steel and other metal items,
- Precast concrete,
- Aggregates,
- Other materials requiring or utilizing approved warehousing, and
- Proportioning and mixing plants for concrete and bituminous mixtures at permanent facilities.

3) Ensure inspection facilities are suitable for the use intended, including testing space or office space for record keeping, or both. Facilities may vary from designated or separate space in a shared building for occasional inspection, to a materials laboratory (defined below) for continuous and full time use.

4) Material laboratories will be required for any inspection for individual or combinations of projects involving more than:

- 5,000 tons (5000 Mg) of aggregate from an individual source for use in pavement, base, or subbase, or
- 10,000 tons (10,000 Mg) of aggregate for other purposes.

5) Ensure laboratories are located close to production operations. For facilities furnished jointly, ensure the laboratory is within a driving distance of 5 miles (8 km) from each source.

6) For the materials laboratory, furnish facilities similar to those specified in Article 2520.03, A, 2, a. Equip the laboratory for testing the type of material to be produced according to an equipment listing available upon request. The Engineer may modify parts of this specification to allow for:

- Facilities furnished prior to first use of this specification,
- Small amounts of material to be furnished from widely separated sources, or
- Unusual testing procedures.

B. Field Office.

1. General.

Meet the following requirements. Items a through i are meant as a guide rather than minimum requirements. The Engineer may approve suitable alternative facilities.

a. Office space separate and apart from any building occupied by the Contractor and for the exclusive use by the Contracting Authority.
b. Conveniently located near the work, as may be directed by the Engineer.
c. Weather tight, insulated, and painted, and of a size as to enclose a nominal area of 192 square feet (18 m^2) of floor space.
d. At least five windows having a total sash area no less than 30 square feet (3 m^2).
e. Windows fitted with locking devices and hung to open and close.
f. Outside door fitted with a cylinder lock, and all keys turned over to the Engineer.
g. Fit the windows and door with screens.
h. A plan table, a plan storage rack, a desk, three straight chairs, a drafting stool, a water cooler dispenser, a floor broom, and a 10 pound (4.5 kg) rated capacity carbon dioxide fire extinguisher.
i. Non-furnished area partitioned from the larger area for use as storage.
j. Heating and air conditioning to maintain an approximate temperature between 70°F (20°C) to 80°F (27°C).
k. No less than two wall power outlets and sufficient ceiling lighting fixtures in the office to provide a minimum of 70 foot-candles (750 luxes) of light on all working surfaces.
l. Wireless connectivity. Provide a device to allow multiple inspectors to access the internet wirelessly, such as a mobile hotspot. Provide a minimum of 3 GB of data usage per month. This device will be considered a part of the field office and shall stay with the field office. If the field laboratory and field office are located adjacent to each other, one device may be adequate to cover both, so long as the signal can be accessed from both trailers.
m. Suitable sanitary facilities within 75 feet (25 m) of the office for the use of the inspection forces.
n. An all weather access road and parking area (both maintained) for not less than five vehicles at the field office for the use of the inspection forces.

2. Furnishing Field Office.

a. Furnish the field office before all work is started. For the duration of this contract, maintain the building in a satisfactory state of repair and supply all heating fuel, electricity, and drinking water. The Contractor is responsible for paying all installation charges. The Contracting Authority will pay data charges for usage above the monthly minimum.
b. Notify the Engineer 3 calendar days before removing a field office.

C. Limitations.

Contractor's maintenance of these facilities does not include normal housekeeping.

2520.04 METHOD OF MEASUREMENT.
The Engineer will count the Field Laboratories or Field Offices, or both, furnished according to this specification, as required by the contract documents. Field laboratories furnished for materials inspection will not be counted for payment.

2520.05 BASIS OF PAYMENT.

A. Payment for each Field Laboratory or Field Office, or both, will be the contract unit price.

B. Payment is full compensation for furnishing, moving, and maintaining the field laboratory or field office, or both, and for furnishing the utilities and sanitary facilities.

Section 2521. Certified Plant Inspection

2521.01 DESCRIPTION.
Certified plant inspection will be required for Interstate, Primary, state park, and institutional projects. It will apply to other projects only when designated. When this specification applies, furnish or oversee certified plant inspection for the work, as specified herein.

2521.02 REQUIREMENTS.

A. For certified plant inspection, comply with Materials I.M. 213, using personnel certified for the type of inspection to be accomplished and using prescribed test equipment the Contractor furnishes. Ensure the equipment is also available for use by the Engineer for monitoring purposes.

B. When a field laboratory or office is furnished, as provided in Section 2520, exclusive use by the Engineer for inspection purposes is intended. Additional field laboratory space and equipment and/or office space for use by the Contractor to fulfill the requirements of Certified Plant Inspection are incidental to the contract unit price for the item for which this inspection is required.

C. Delivery of samples to the District Materials Laboratory may also be required. Comply with the provisions in Section 2534.

2521.03 APPLICATION.

A. This specification applies to all HMA, HMA patching material, PCC, structural concrete, and flowable mortar, except where excluded by a note in the contract documents.

B. The Engineer may waive aggregate gradations, moisture, and specific gravity tests based on previous satisfactory experience with the plant for PCC which is furnished at a maximum rate of 25 cubic yards (25 m^2) per day, whether from one or more sources. This may be based on quantities planned by the Contractor several days ahead of placement.

2521.04 METHOD OF MEASUREMENT.
Certified plant inspection will not be measured.

2521.05 BASIS OF PAYMENT.
Certified plant inspection will not be paid for separately and is to be included in the contract unit price for the item for which this inspection is required.

Section 2522. Tower Lighting

2522.01 DESCRIPTION.

A. This specification is for fabrication and construction of tower lighting systems, consisting of footings, towers, luminaires, and associated appurtenant items required by the contract documents. Apply Section 2523 to other components of this system.

B. Each individual installation consists of:
- A reinforced concrete footing,
- A tubular steel tower of circular or other approved cross-section of the length indicated in the contract documents,
- Approved luminaires of the proper number,
- An approved lowering device, and
- The electrical system described in the contract documents.

2522.02 MATERIALS.

A. Submit copies of the following to the Office of Materials for review for compliance before these materials are shipped to the project:
- A certified mill analysis for each heat of steel used in the pole and pole assembly, and
- Certified test results for support cables.

B. Refer to Article 2522.03, D for welding requirements.

C. Notify the Office of Materials of the shop fabrication schedule.

D. Verify one copy of a mill certification accompanies each shipment to the project and two copies are sent to the Office of Materials to:
- Identify materials included in each shipment, and
- Ensure that materials and fabricated materials may be used in the work promptly after delivery.

E. Final approval of all materials and fabricated materials will be based on:
- A certification that methods and materials used in fabrication comply with the contract documents,
- Satisfactory reports from random monitoring inspections performed during fabrication, and
- Verification of satisfactory compliance at the time of final inspection of the construction site.

2522.03 CONSTRUCTION.

A. Shop Drawings.

1. Submit drawings according to Article 1105.03.

a. Tower lighting equipment (if applicable):

1) Tower design data.

2) Lowering device, showing wiring diagram and materials.

3) Luminaires, including photometric data.

b. Additional drawings may be required on a project specific basis according to the contract documents.

2. Along with the shop drawings, include a statement that methods and materials to be used in fabrication comply with the contract documents. Note and identify all materials or methods for which specific requirements have not been previously stipulated.

3. Provide the Engineer with an appropriate certification of compliance with all design requirements. Along with the certification, include copies of all calculations necessary for proper design of the tower shaft and component features of the tower assembly.

4. Have a Professional Engineer licensed in the State of Iowa perform the structural design. The Contractor's certification is to appear on the drawings. Provide the Engineer with the base shear, base moments, and vertical loads on the bottom of the base plate.

5. Obtain the Engineer’s written concurrence for the various items involved prior to fabricating or assembling parts.

B. Footings.

1. Construct footings as required in the contract documents at the specified locations. Unless specifically stated otherwise, construct footings using methods and materials complying with current specifications.

2. Place anchor bolts according to Article 2405.03, H, 3. Place conduit and all other appurtenant or optional features of the footing as shown in the contract documents.

C. Transporting Towers.

1. When transporting towers over the highways of the State of Iowa, comply with all applicable laws, rules, and regulations governing such movements. Obtain all required permits for such movements.

2. Limit the overall length of the hauling unit and tower to 120 feet (35 m) or less.

D. Welding.

1. Weld and fabricate steel structures according to Article 2408.03, B except that gas, metal arc, and flux cored arc welding processes will be permitted.

2. A list of approved brands of electrodes may be obtained from the Office of Materials.

3. Examine all fillet welds accessible for inspection using magnetic particle inspection according to ASTM E 709 (at no additional cost to the Contracting Authority).

4. Use ultrasonic inspection, according to the requirements of Article 2408.03, B, to perform a 100% examination of all transverse butt welds and all specified 100% penetration longitudinal butt welds on the pole. Perform a 100% visual inspection of all longitudinal butt welds. Supplement the visual inspection with magnetic particle inspection on all areas of questionable visual results. If defects are found in the area tested, perform additional inspection for a minimum of 5 feet (1.5 m) on each side of the defect (at no additional cost to the Contracting Authority). The cost of these inspections is incidental to other items in the contract.

E. Lighting Tower.
Ensure the structural design of the tower and its appurtenances meet the requirements of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," with the following clarifications:

1. Wind Velocity.
Use a design wind velocity (V) of 90 mph (145 km/h).

2. Total Wind Force.
Calculate the total wind force on luminaires on the basis of the sum of projected areas for each individual luminaire. Base the projected area of individual luminaires on manufacturer's recommendations.

3. Steel Tubular Shape.
Use a compact section.

4. Anchor Bolts, Washers, and Nuts.
Ensure galvanizing for anchor bolts, washers, and nuts meets the requirements of ASTM F 2329; or ASTM B 695, Class 50, Type I Coating.

a. Furnish each anchor bolt with one leveling nut and two anchoring nuts. Use anchor bolts that:

- Meet the requirements of ASTM F 1554, Grade 105 (724 MPa),
- Are full-length galvanized,
- Are high-strength low alloy steel, and

- Unless specified otherwise, are Unified Coarse Thread Series with Class 2A tolerance.

b. Color code, in red, the end of each anchor bolt intended to project from the concrete to identify the grade.

c. Use galvanized washers that meet the requirements of ASTM F 436.

d. Use heavy hex, galvanized nuts that meet the requirements of ASTM A 563, DH. Nuts may be over-tapped according to the allowance requirements of ASTM A 563.

5. Pole Base.

a. Use a solid plate. Keep the holes cut out in the base plate for utility lines to a minimum, subject to the Engineer's approval.

b. Design the pole base and anchor bolt system to resist both tension and compression resulting from bending moments and direct loads.

6. Poles.

The poles may be furnished in single welded units or in telescoping sections.

a. Single Welded Units.

1) Fabricating the tower by welding two or more shaft sections together is permitted. If the pole sections are welded together, butt weld all transverse pole splices with full penetration welds.

2) Use a method for connecting the sections that results in a smooth joint with no projections on the exterior of the shaft.

3) Unless specifically authorized otherwise, all welded connections of shaft sections are to be made in the fabricator's shop.

4) If hauling length restrictions do not allow the tower shaft to be shop fabricated in one piece, furnish a telescoped pole.

b. Telescoping Sections.

1) If the pole sections are telescoped together, ensure the overlapped splices:

- Are equal in strength and rigidity to that of welded splices, and
- Do not exceed four sections for poles up to and including 120 feet (35 m) in length and do not exceed five sections for poles between 120 feet (35 m) and 160 feet (50 m) in length.

2) Ensure the telescoping sections overlap a length which is the larger of the following, and the overlap has full contact between faying surfaces:

- 2 feet (0.6 m), or
- 1.5 times the nominal diameter of the shaft at the splice level.

3) Ensure pole sections to be telescoped together are factory test fit to verify straightness of the pole and accuracy of the mating surfaces. Ensure the sections are match marked for accurate field assembly. In the field, mechanically fit the telescoping sections using factory supplied equipment. Submit field

assembly procedures for the Engineer's review and concurrence.

7. Longitudinal Seam Welds.

a. Minimum 60% penetration, except for the following areas where complete penetration welds are required:

1) Within 6 inches (150 mm) of circumferential welds which are complete penetration butt welds.

2) For a distance of the nominal splice length plus 6 inches (150 mm) on both sections of telescopic (slip type) field splices of high level lighting (pole type) supports.

b. When designated in the contract documents:

- Radiographically inspect 100% of the full penetration sections of longitudinal seam weld, and
- Use the magnetic particle method to inspect a random 10% of the partial penetration section of the longitudinal seam welds.

8. Poles with Welded Transverse Splices.

Bevel all backing plates for transverse welds.

9. Poles with Telescoped Lab Joints.

Bevel the lower section of the joint. The beveling is required to prevent possible interference with the operation of the lowering device.

10. Hand Hole.

a. Ensure the pole provides an opening for a minimum 10 inch by 30 inch (250 mm by 750 mm) handhole to allow for servicing and maintenance of the lowering devices. Ensure the handhole is reinforced to maintain the design strength of the pole.

b. Install a neoprene or rubber gasket to make the handhole weatherproof. Obtain the Engineer’s acceptance for the gasket prior to installation. Foam adhesive-back rubber gaskets are unacceptable.

c. Ensure the door is hinged and is fabricated from the same type of steel as the poles. Ensure the securing hardware is stainless steel and provisions have been made to allow for the door to be bolted securely shut.

11. Pole Base Plate.

a. Prior to welding, ultrasonically test the pole base plate using a Straight Beam Search Unit, meeting requirements of the current AWS D1.1, Structural Welding Code, to determine the extent of laminar type discontinuities in the plate.

b. After welding the pole to the base plate, use the same ultrasonic testing described above to ensure there are no laminar tears in the base plate.

12. Shaft, Base Plate, and Integral Shaft.

a. Ensure the shaft, base plate, and integral shaft components are fabricated with steel meeting the requirements of ASTM A 709 Grade 50 (345 MPa), with a minimum yield strength of 50,000 psi

(345 MPa). All steel required to be ASTM A 709 Grade 50 (345 MPa) shall meet impact requirements specified for main members in Article 4152.02. If the Engineer approves, certain components of the tower assembly may be fabricated from steel meeting requirements of ASTM A 709 Grade 36 (250 MPa).

b. Ensure that after fabrication pole shafts, anchor bolts, base plate, washers, nuts, and all steel items are:

- Fully galvanized inside and outside according to ASTM A 123 or ASTM A 153 as appropriate, and
- Are of uniform color and appearance.

F. Tower Lighting Luminaire.
Meet the following provisions:

1. Luminaire Assembly.
Rain tight aluminum housing and slipfitter with an internally mounted ballast designed for operation with the specified lamp.

2. Optical System (when required).
Specular aluminum or prismatic glass reflector and a prismatic glass refractor or a clear lens.

3. Luminaires with open bottom optical systems.
Prismatic glass reflectors and refractors.

4. Luminaires with horizontal burning lamps
Totally enclosed optical systems with prismatic glass refractors.

5. Specular aluminum reflectors.
Protective coating of oxide applied by the anodic oxidation process. The manufacturer's certification that the coating is not less than 6 milligrams per square inch (0.01 mg/mm^2) and that the reflectivity of the specular surface is not less than 82% is required.

6. Lamp Socket.
Mogul multiple and porcelain enclosed. Lamp gripping device for vertical burning lamp sockets.

7. Glassware.
Annealed, thermal-shock-resisting, borosilicate glass.

8. Slipfitter.
Accommodate a standard two-inch (50 mm) pipe bracket and provide for leveling of the luminaire.

9. Light source.
High pressure sodium lamp of the size shown in the contract documents.

10. Ballast.
Regulated high-power-factor type with starting current lower than operating current. Maintains lamp wattage within ± 10% with a line voltage regulation of ± 10%, with no less than 90% power factor.

G. Luminaire Lowering Device.
Consists of a luminaire frame and head frame, support cables, winch, and electrical cable, along with associated appurtenant devices. Ensure the lowering device properly lowers the luminaires to a position within 5 feet (1.5 m) of the ground for maintenance, and maintains their alignment when raised to the operational position.

1. Luminaire Frame and Head Frame.

a. Ensure the luminaire frame and head frame assembly meet the requirements of ASTM A 709 Grade 50 (345 MPa). For the purpose of Charpy V-notch toughness requirements, all steel required to be ASTM A 709 Grade 50 (345 MPa) will be considered main members. Miscellaneous appurtenant steel components may be constructed using ASTM A 709 Grade 36 (250 MPa) steel. Ensure all steel and the head frame dome are galvanized.

b. Attach the luminaire frame to two or three lift cables. Attach a multiple conductor electrical cable to the luminaire frame with a double weave, stainless steel, grip type, strain relief connection. Pass all cables through a head frame assembly mounted at the top of the tower shaft, as shown in the contract documents. Ensure they pass freely through the shaft during raising and lowering operations.

c. Ensure the luminaire frame is designed to accommodate the specified number of luminaires on mounts consisting of 2 inch (50 mm) slipfitters.

d. Ensure the head frame assembly is enclosed and shielded from the elements by means the Engineer approves.

e. Install three or more spring loaded centering arms with rubber or nylon rollers (or other approved means) to control lateral movement of the luminaire frame during raising or lowering operations. Ensure the centering arms interlock with each other so the tower is centered within the luminaire frame.

2. Support Cables.

a. Install support cables of anti-rotational aircraft type stainless steel with a minimum diameter of 3/16 inch (4.8 mm) and having a safety factor of 5. Space them 120 degrees apart where attached to the luminaire frame. Attach them to a terminating device which is located within the tower shaft and provides a means of equalizing tension of the lift cables.

b. Ensure the terminator and attached components are shaped to prevent interference to the raising or lowering operation caused by irregularities on the interior surface of the tower shaft.

3. Winch.

a. Install and securely anchor a winch assembly that:

- Consists of a worm gear speed reducer with either one or two output shafts with cable drum attached.
- Is capable of supporting five times the maximum lifted load.
- Includes an integral drag brake to prevent unwinding, slipping, or free spooling of the winch cable.
- Includes a drum provided with keepers to ensure that the cable will properly wrap onto the drum.
- When powered by the internal power unit, raises the luminaire ring at a minimum rate of 12 feet (4 m) per minute.

b. Install a stainless steel, anti-rotational aircraft type winch cable with 1/4 inch (6.4 mm) minimum diameter and a safety factor of 3 to be used to raise and lower the luminaire frame. Attach the cable to the terminator. Include a safety device that is capable of stopping upward motion of the terminator at any time, in case of winch cable failure. Include a torque limiting device with the winch or power unit.

c. Install a top-latching system. Do not install non-latching systems. Ensure the following:

- Latch barrels are cast, high strength, copper-free aluminum or cast stainless steel.
- Latching is accomplished by the alternate raising and lowering of the luminaire ring assembly using the winch and hoisting assembly.
- There are no moving latch parts or springs attached to the head frame assembly.
- The latch mechanism is not impaired by the formation of ice and does not require adjustment after the original installation.
- Indicator flags are used to show when the luminaire supporting ring is in the latched or unlatched position.

d. Install pulleys that are:

- Stainless steel type designed for the respective types and sizes of cables used, and
- Equipped with permanently lubricated, sealed bearings or oil impregnated bronze bushings mounted on stainless steel shafts.

4. Electrical Cable.

a. Install a multiple conductor cable complying with the requirements for flexible cord. Ensure it is designed to meet all physical requirements for satisfactory operation of the lowering device. Ensure all provisions for electrical disconnects are accessible from ground level.

b. Attach the electrical cable to the terminator with a strain relief device as used at the luminaire frame. Ensure electrical connectors for the power and control circuits are rigidly attached to the terminator.

c. Ensure conductors for connections from the power cable to the luminaires are protected by suitable raceways or are made with weatherproof cables securely anchored to the luminaire frame. A luminaire frame of hollow cross section may be used as a raceway.

Ensure all connections are made in weather tight boxes or within the luminaire housings.

H. Erection.

1. After testing has been accomplished to the satisfaction of the Engineer, the tower may be erected on the foundation.

2. Precise aligning and erecting of all components of the tower lighting system is essential. Plumb towers during full cloud cover, prior to sunrise or after sunset, as approved by the Engineer, to prevent thermal expansion effects on the steel tower due to heat from sunshine. Verify in at least two directions, 90 degrees apart, with a transit. Plumb all towers within a tolerance of 50% of the pole top diameter. Tighten anchor bolt nuts, after the tower has been plumbed, using the following procedure:

- **a.** Perform this work only on days with winds less than 15 mph (25 km/h). Tighten all of the nuts in the presence of the inspector. Once the tightening procedure is started, it shall be completed on all of the base plate nuts without pause or delay.
- **b.** Use properly sized wrenches or sockets, or both, designed for tightening nuts or bolts, or both, to avoid rounding or other damage to the nuts. Do not use adjustable end or pipe wrenches.
- **c.** Ensure base plates, anchor rods, and nuts are free of all dirt or debris.
- **d.** Apply stick wax or bees wax to the threads and bearing surfaces of the anchor bolt, nuts, and washers.
- **e.** Tighten top nuts so they fully contact the base plate. Tighten leveling nuts to snug tight condition. Snug tight is defined as the full effort of one person on a wrench with a length equal to 14 times the bolt diameter but not less than 18 inches (460 mm). Apply full effort as close to the end of the wrench as possible. Perform tightening by leaning back and using entire body weight to pull firmly on the end of the wrench until the nut stops rotating. Perform a minimum of two separate passes of tightening. Sequence tightening in each pass so that the nut on the opposite side, to the extent possible, is subsequently tightened until all of the nuts in that pass have been tightened.
- **f.** Tighten top nuts to snug tight as described for the leveling nuts.
- **g.** Match-mark the top nuts and base plate using paint, crayon, or other approved means to provide a reference for determining the relative rotation of the nut and base plate during tightening. Further tighten the top nuts tightened in two passes, as listed in the Table 2522.03-1, using a striking or hydraulic wrench. Follow a sequence of tightening in each pass so that the nut on the opposite side, to the extent possible, is subsequently tightened until all nuts in that pass have been turned. Do not allow the leveling nut to rotate during the top nut tightening.

Table 2522.03-1: Bolt Tightening

Anchor Bolt Size	First Pass	Second Pass	Total Rotation
Less than or equal to 1 1/2 inch (38 mm) diameter	1/6 turn	1/6 turn	1/3 turn
Greater than 1 1/2 inch (38 mm) diameter	1/12 turn	1/12 turn	1/6 turn

h. Lubricate the jam nuts, place, and tighten to snug tight.

3. Cover the void between the base plate and top of the foundation as shown in the contract documents.

4. Construct and test all other components of this system according to Section 2523.

I. Miscellaneous.

1. Have a manufacturer's service engineer present, on site, to advise during the installation of at least one complete lowering system. Duties of the manufacturer's service engineer include directing all adjustments to the lowering system to insure positive latching and unlatching (a minimum of three complete raising and lowering cycles) and other necessary work.

2. Provide three complete raising and lowering operations for the other towers, providing the same adjustment and commissioning as demonstrated by the manufacturer's service engineer on the first tower.

2522.04 METHOD OF MEASUREMENT.

Measurement for the various items of work involved in tower lighting, satisfactorily completed, will be as follows:

A. Towers.
By count for the various lengths specified in the contract documents.

B. Luminaires.
By count.

C. Footings.
As outlined in the following sections:

Piling	Section 2501
Structural Concrete	Section 2403
Reinforcement	Section 2404
Excavation	Section 2402

2522.05 BASIS OF PAYMENT.

A. Payment for the various items of work involved in tower lighting will be the contract unit price as follows:

1. Towers.
Each for the various specified lengths.

2. Luminaires.
Each.

3. Footings.
As outlined in the following sections:

Piling	Section 2501
Structural Concrete	Section 2403
Reinforcement	Section 2404
Excavation	Section 2402

B. Payment for towers is full compensation for furnishing all materials, equipment, tools, and labor for construction of the towers complete, including an approved lowering device, and related equipment, anchor bolt assembly, and responsibility during the testing period.

C. Payment for other components of the tower lighting system will be as provided in Article 2523.05.

Section 2523. Highway Lighting

2523.01 DESCRIPTION.
Furnish all work, apparatus, and materials to construct, install, and place in operation, to the Engineer's satisfaction, a complete highway lighting system as shown in the contract documents.

2523.02 MATERIALS.

A. Install lighting materials that meet the requirements of Division 41.

B. Use cast-in-place concrete that meets the requirements of Section 2403.

2523.03 CONSTRUCTION.

A. General.

1. Furnish and install all components of the lighting system not furnished by the utility company serving the installation, including all incidental items appurtenant to the operation of the system.

2. Ensure all apparatus, materials, and work comply with the contract documents and with standards, practices, and codes of the electrical industry. Particular attention is directed to the following:
- NEC, latest edition, including amendments.
- IEEE Standards and Practices.
- ANSI Standards and Practices.
- NEMA Standards.
- UL Standards.

3. Ensure the completed lighting installation complies with all local and special laws, codes, or ordinances of all Federal, State, and municipal authorities with due jurisdiction.

4. The Contracting Authority will be responsible for the cost of electric power used during installation and testing of lighting equipment and prior to final acceptance of the work. Do not put the installation into use prior to final acceptance without the Engineer's approval.

B. Shop Drawings.

1. Before any items are ordered or installation is started, the following list of shop drawings shall be submitted for approval according to Article 1105.03:

a. Required Shop Drawings:

1) Lighting poles and mastarms.
2) Transformer bases.
3) Slip bases.
4) Roadway luminaires with lamps.
5) Iowa DOT Standard Road Plan RM-41, Underdeck Lighting (High Pressure Sodium Luminaire).
6) Control cabinet components.
a) Enclosure.
b) Door latch mechanism.
c) Contactor.
d) Circuit breaker (main).
e) Circuit breaker (branch).
f) Photoelectric control.
g) Test switch(es).
h) Breather drain.
i) Wiring diagram, showing wire type and size
j) Component placement drawing.
k) Control fuse holder.
l) Surge suppressor.
7) Iowa DOT Standard Road Plan RM-40, Cable Splices and Connectors.
8) Insulated wire and cable.
9) Additional drawings may be required on a project specific basis in accordance with the contract documents.

b. Shop Drawings Not Required:

1) Wood pole.

2) Concrete.
3) Reinforcing steel.
4) Anchor bolts, nuts, and washers.
5) Other bolts, nuts, and washers.
6) Ground rods and clamps.
7) Iowa DOT Standard Road Plan RM-42, Type 1 Handhole.
8) Rigid steel conduit and fittings.
9) Rigid aluminum conduit and fittings.
10) Plastic conduit and fittings.
11) Plastic warning tape.
12) Bare copper ground wire.

2. Meet the following provisions for shop drawings:
- **a.** Submit all drawings simultaneously for each project.
- **b.** Include catalog cuts, diagrams, drawings, brochures, or other descriptive data required by the Engineer.
- **c.** Include a schematic diagram and a component placement diagram of the control cabinet and panel.
- **d.** Ensure all wire and cable sizes, placement of components, and dimensions are shown on the diagrams.
- **e.** Ensure all drawings are completely legible and contain adequate information to identify that the described components comply with the contract documents.
- **f.** Ensure identification markings on the described items correspond to like markings shown on the drawings to provide easy identification of the item.
- **g.** Ensure apparatus or materials are not installed until the Engineer has reviewed and concurred with descriptive data.
- **h.** Ensure each sheet or bound pamphlet is imprinted with the county and project number.
- **i.** Ensure each set is assembled and contains one copy of the required data for each item listed on the schedule.

3. Incorrect or incomplete submittals will be returned to the Contractor for correction. The Engineer may require certified test results and samples of materials for consideration of all items including those described by reviewed drawings.

C. Cooperation with Utility Companies.

1. The utility company is to provide secondary service to the project in the vicinity indicated. Consult and cooperate with the utility company in locating the distribution lines and service poles so lines will be as short and direct as possible. If the utility company is unable to perform the required work, furnish and install the service poles (payment will be according to Article 1109.03). The Contracting Authority will be responsible for the cost for extension of power lines and for furnishing and installing meter sockets and meter loops as required in the contract documents.

2. The entire transformer pole installation, when required, including all accessories and appurtenances, is to be installed by the utility company that is to supply service according to their agreement for service. Cooperate with the utility company so that connections may be made in the proper manner and at the proper time.

3. Furnish all apparatus and material for the pole mounted control station, as shown in the contract documents. Upon acceptance of the project, they will become the Contracting Authority's property.

4. If pad mounted transformers and control stations are specified, ensure they are furnished and installed as specified in the contract documents. Ensure they are approved by the designated utility company.

D. Excavation.

1. Drill the holes for pole footings and direct embedded poles.

2. Details of trenching for underground circuits will be shown in the contract documents.

3. Pile the excavated material away from the trench to prevent cave-ins.

4. Accurately grade the trench bottom to provide for placement of cable or duct work at a uniform depth.

5. Ensure surface water does not enter the trench. Remove water that is present before duct work is installed, unless directed otherwise by the Engineer.

E. Placing Backfill.

1. After inspection of the completed trench, duct work, and cables, place backfill consisting of the material that was removed into the trench, unless stated otherwise in the contract documents or directed by the Engineer. Place backfill material in layers with the first layer not exceeding 2 feet (0.6 m) of loose thickness and each succeeding layer not exceeding 1 foot (0.3 m) of loose thickness. Compact each layer using hand or mechanical tampers. Do not use material containing glass, metal, concrete, brick, cinders, or any other abrasive material for backfill within 6 inches (150 mm) of the cable or conduit. Install approved plastic warning tape in all trenches.

2. Use the removed material to place backfill around direct embedded poles and handholes. Place the material in layers not exceeding 6 inches (150 mm) of loose thickness. Compact using hand or mechanical tampers.

3. Shape excess material to original contours as directed by the Engineer.

4. Shape all other disturbed areas to the original contours as directed by the Engineer.

F. Seeding and Fertilizing.
In locations where erosion control work has been completed or turf has been established, restore the areas disturbed by application of seed and fertilizer as indicated in the contract documents.

G. Footings.

1. Construct cast-in-place concrete footings for all lighting units not located on structures or barriers. Form and pour the top portion of all footings in form work to at least 6 inches (150 mm) below the finished ground level. Ensure the footings conform in all respects to the details, including reinforcement and alignment to provide the correct overhang, as indicated in the contract documents.

2. Ensure finished surfaces are smooth and free from stains and foreign material.

3. Construct an alternate footing, as directed by the Engineer, when shale, sandstone, broken and shattered rock, solid rock, or other similar materials are encountered.

4. Place anchor bolts to provide for placement of nuts and washers on the top and bottom of the transformer base or pole flange, leaving ample room for adjustment and plumbing the pole. When slip bases are used, position anchor bolts so that they do not interfere with the operation of the slip base. Place anchor bolts according to Article 2405.03, H, 3.

H. Breakaway and Slip Bases.

1. Furnish and install breakaway bases or slip bases of the size and type specified in the contract documents for each light pole not mounted on a roadway bridge. Use the same type and manufacturer for all bases for a project. Install a commercially available product. Comply with the details of bases shown in the contract documents.

2. Ensure each breakaway base has a nonmetallic spacer impervious to galvanic action placed between the breakaway base and pole base mounting flange.

I. Aluminum Transformer Bases.
Ensure the bottom flange of aluminum transformer bases are painted on the inside and outside surfaces with two coats of zinc-rich paint.

J. Poles and Mastarms.

1. Furnish and install poles at all locations indicated in the contract documents. Install poles of the lengths shown in the contract documents.

2. Carefully erect all poles and mastarms. Check for vertical alignment, mounting height, and overhang, after installation, with mastarm and luminaire installed.

3. Rake single mastarm poles so the side of the shaft opposite the mastarm is plumb. Erect poles without mastarms, or with more than one mastarm, so the center line of the pole shaft is plumb within a tolerance of 1/32 inch per foot (3 mm/m).

4. Check the pole posture at no less than three radial locations on the shaft. For poles required to have plumb shaft center lines, space the checking positions approximately 120 degrees apart, as viewed from above. For raked poles required to have one side plumb, space the check points on the side to be plumbed at 90 degrees in either direction, as viewed from above.

5. Plumb the poles using double nuts on each anchor bolt. Locate the nuts:

- Above and below the bottom mounting flange of the breakaway base, or
- Above and below the pole base or slip base mounting flange where breakaway bases are not required.

6. Install anchor bolt washers according to the details in the contract documents.

7. Base leveling shims or alternate pole mounting methods will be permitted only when indicated.

8. After the erection has been inspected and approved, fill the space between the mounting flange and the concrete footing with an approved non-shrink grout and finish as detailed.

9. Install mastarms of the type and length specified. Unless shown otherwise in the contract documents, mastarms greater than 8 feet (2.4 m) in length are to be Type B, and all others Type A. Use the same type and material for all lighting poles and mastarms on a project.

10. Install insect barriers in the ends of all mastarms at the point of luminaire attachment.

11. Install wood poles of the length and class specified. Set them plumb in drilled holes as directed by the Engineer. Embed the poles no less than 8 feet (2.5 m). Additional embedment may be required by the Engineer if warranted by soil conditions.

K. Luminaires.

1. Furnish and install luminaires of the type and rating specified.

2. All roadway luminaires shall be leveled after installation unless a tilt is specified.

3. When light distribution is specified, ensure the luminaire has the necessary components and is adjusted properly.

4. Provide the Engineer with printed instructions regarding luminaire components and adjustment.

L. Circuits.

1. Unless specified otherwise, install an underground, multiple system roadway lighting circuit that is totally encased in conduit. Construct circuits and control stations according to the contract documents.

2. Ensure circuits are complete with all necessary accessories for proper operation. Thoroughly coordinate disconnecting devices, protective devices, and all other equipment to secure a safe operating lighting system. If any changes in arrangement of the circuit system are considered necessary by the Contractor, submit details of changes and reasons to the Engineer for approval. Obtain the Engineer's approval prior to making changes.

M. Grounding.

1. General Requirements.

a. A component of the lighting system will be defined to be grounded when it is electrically bonded to a driven ground rod or a multiple system of ground rods producing a resistance to ground of 25 ohms or less when installed and tested according to the contract documents.

b. Use ground rods and connections described in Article 4185.04 to ground major components of the lighting system, such as control stations, lighting units, and sign structures, and all metal duct work in exposed locations or installed on roadway bridges. Refer to the contract documents for details of these and other locations to be grounded.

2. Grounding Installations.

a. Whenever the ground rod installation does not have a resistance to ground of 25 ohms or less, couple additional rods to the first, and drive to the full depth until the required resistance is obtained. If a maximum depth of 50 feet (15 m) is reached, or if obstacles to further driving are encountered, install additional ground rods until the required resistance to ground is obtained.

b. Permissible grounding installations are as follows:

1) Ensure that in no case is any portion of the ground rod closer than 18 inches (0.5 m) to the finished earth surface. Drive all rods as nearly vertical as possible. Whenever possible, drive a full length ground rod.

2) When rock or other obstructions prevent driving the rod to full depth, two half-length sections may be driven, with the Engineer's approval. The two half-length sections are considered as a minimum length rod when additional rods are required to obtain the specified resistance to ground.

3) Where two half-length rods can not be driven to the required depth, place full length rods horizontally at a depth of no less than the adjacent trench depth.

4) The minimum horizontal clearance between all rods in a multiple ground installation is to be 6 feet (2 m).

N. Electrical Ducts.

1. General Requirements.

a. Refer to the contract documents for details of duct installations. Ensure the completed duct systems are watertight. Use expansion fittings where duct runs cross structural expansion joints and elsewhere as direct by the Engineer.

b. Thread metal conduit joints. Treat the mating threads with pipe joint compound. Treat all other threads with an approved rustproofing compound. For plastic conduits, use solvent welded, socket type joints.

c. After the duct runs are installed, demonstrate that the runs are clear by pulling an approved brush or conduit swab through the entire length of each run. Ensure no deleterious material remains in the duct. Securely cap terminal ends until cable is installed. Before the wire and cable is installed, fit terminal ends of metal conduit with threaded insulating bushings. Fit terminal ends of plastic conduit with socket type, bell end fittings.

d. Do not embed aluminum conduit in concrete.

2. Underground Ducts.

a. Lighting Circuit Ducts.
Fabricate lighting circuit ducts using Schedule 40 plastic conduit. As field conditions permit, install the runs to avoid adding bends or total bend angle to the design layout. Limit the total bend angle between pulling points to no more than 360 degrees.

b. Crossing Ducts.
Unless shown otherwise in the contract documents, use Schedule 80 PVC conduit for crossing ducts. If crossings are to be placed without disturbing the existing surface, install by jacking or boring methods approved by the Engineer. Do not use jetting.

c. Primary Service Ducts.
Apply installation requirements for lighting circuit and crossing circuit.

3. Exposed Exterior Ducts.

a. Unless shown otherwise in the contract documents, use rigid steel conduits for all ducts for exposed installations.

b. When not shown in the contract documents, support exposed ducts at intervals of 6 feet (1.8 m) or less. Anchor the hangers or clamps

to be attached to concrete structures by means of expanding anchors in drilled holes. The use of driven or explosive set anchors will not be permitted.

O. Handholes.

1. Construct handholes of the size and type and at locations shown in the contract documents, unless the Engineer specifies otherwise. Do not construct handholes in the following areas:
- Ditch bottoms,
- Low areas where ponding of water may occur, or
- Where they will be subject to normal vehicular traffic.

2. Provide access ducts for each general direction of the circuit branch run. Position them for ease of cable installation.

3. Position handholes so that the top is at the same inclination as the adjacent grade.

P. Junction Boxes.
Furnish junction boxes of the type specified and install as indicated in the contract documents.

Q. Wire or Cable.

1. Furnish and install wire or cable of the size and type specified. When installing wire or cable in a conduit system, provide equipment to demonstrate to the Engineer that at no time will a pulling tension of 0.008 pound per circular mil (70 N/mm^2) of conductor be exceeded.

2. Ensure unreeled wire or cable is not left on the ground surface or exposed to mechanical abrasion. Replace all wire or cable that is stressed or damaged in any way at no additional cost to the Contracting Authority. Do not install wire or cable with dirt or any other abrasive material adhering to it.

3. Use a lubricant when pulling wire or cable. Use a UL listed lubricant designed for use with the specified cable and conduit. The use of graphite or petroleum lubricants will not be permitted. Ensure the pulling device is attached to each conductor and all wire or cable within a single duct is pulled simultaneously.

R. Connectors.
Furnish and install connectors of the type specified at the locations shown in the contract documents. Ensure connector assemblies are supplied with a disposable mounting pin, when required, and sufficient silicone compound to lubricate the metal parts and rubber housings. Ensure complete instructions are supplied with each connector.

S. Splices.
Use approved connector assemblies to make splices. Splices in the system will only be allowed in pole shafts, handholes, pull boxes, breakaway bases, and other specified locations.

T. Control Station.
Furnish the components specified and construct the control station as indicated in the contract documents.

U. Final Acceptance.

1. Perform electrical tests of all systems after the circuit installation work is complete, and at any other stage of construction when directed by the Engineer. Include the following tests:
- Insulation resistance measurement for all underground circuit cable,
- Voltage measurements, and
- Ground resistance test for each individual grounding installation.

2. Perform insulation resistance measurements with all lamps or ballasts disconnected from the circuit and all neutral lines properly grounded. Measure with a properly calibrated 500 volt megaohmmeter. Ensure insulation resistance is no less than 100 megaohms.

3. Measure and record the voltages in the cabinet from phase to phase and phase to neutral at no load and at full load. Measure and record the voltage readings at the last termination of each circuit.

4. Measure ground resistance with the ground rod, or system of ground rods as described in Article 2523.03, K, disconnected from the circuit neutral wire. Measure with a Wheatstone bridge type ground resistance tester according to the manufacturer's instructions. Ensure the ground resistance of each individual grounding installation is no greater than 25 ohms.

5. Perform electrical tests and demonstrate to the Engineer that the lighting system complies with requirements of the contract documents.

6. Provide the Engineer with a written report of all test results for a permanent record.

7. In the insulation resistance report, include measurements from each insulated line to ground, and between all combinations of lines in a given circuit or contained in a single duct.

8. In the voltage measurement report, include measurements for each cabinet and each circuit.

9. In the ground resistance report, include measurements for each grounding installation identified by a lighting unit number and at other grounding locations by a means approved by the Engineer.

10. All components of the lighting system shall be in satisfactory operation according to the ratings and requirements specified.

11. After satisfactory completion of required testing, the complete lighting system is to be placed in operation for a 30 calendar day trial period, and final approval of the installation will not be made until the trial period ends. During the trial period, service and maintain the installation and make all necessary adjustments or replacements as are required, at no additional cost to the Contracting Authority. The Contractor will not be required to pay for energy consumed by the system, and working days will not be charged, during this trial period.

12. Where the existing ground has been disturbed by the Contractor, reshape to original contours or as directed otherwise by the Engineer.

13. Final acceptance of all lighting installations will be based on:
- Satisfactory results of electrical tests the Contractor has performed, and
- Satisfactory completion of the 30 calendar day trial period.

2523.04 METHOD OF MEASUREMENT.
Measurement for the quantities of the various items involved in the construction of highway lighting will be as follows:

A. Lighting Poles.
By count.

B. Electrical Circuits.
Linear feet (meters) shown in the contract documents.

C. Handholes and Junction Boxes.
By count.

D. Control Cabinet.
By count.

E. Under Deck Lighting.
By count.

2523.05 BASIS OF PAYMENT.
Payment for the quantities of the various items involved in constructing highway lighting will be the contract unit price as follows:

A. Lighting Poles.

1. Each.

2. Payment is full compensation for materials, equipment, excavation, and installation of the pole, luminaire, mastarm, footing, base, ground rod, wiring within the pole, and connectors within the pole, according to the contract documents.

B. Electrical Circuits.

1. Per linear foot (meter).

2. Payment is full compensation for materials, equipment, excavation, and installation of the conduit and the wiring/cables between the connectors in the poles, including switches.

C. Handholes and Junction Boxes.

1. Each.

2. Payment is full compensation for materials, equipment, excavation, and installation of the handholes and junction boxes.

D. Control Cabinet.

1. Each.

2. Payment is full compensation for materials, equipment, excavation, meter socket, meter loop, control cabinet pole, and installation of control cabinet and all internal circuitry.

E. Under Deck Lighting.

1. Each.

2. Under Deck Lighting luminaires shall be complete including lamps, ballast, and mounting device.

Section 2524. Highway Signing

2524.01 DESCRIPTION.
Erect traffic signs and delineators according to the contract documents.

2524.02 MATERIALS.

A. Signing Materials: Apply Section 4186.

B. Wood Posts: Apply Section 4164.

C. Class A Crushed Stone: Apply Article 4120.04.

D. Concrete Footings: Apply the provisions of Section 2403.

2524.03 CONSTRUCTION.
Ensure all parts used in construction of traffic signs and delineators are able to withstand a wind load of 30 pounds per square foot (1.4 kPa) on the sign surface.

A. Fabrication of Signs.

1. Traffic Signs.

a. Except as modified by the contract documents, fabricate signs according to the standards established in the Standard Highway Signs, 2004 edition, as published by the U.S.D.O.T.

b. All traffic signs, except milepost markers and 6 inch by 6 inch (150 mm by 150 mm) route markers, are classified into two groups, Types A and B, as indicated in the contract documents.

1) Type A Signs.

a) Comply with the following:

- Aluminum, galvanized steel, or when specifically specified, plywood sheets mounted on wood or steel breakaway posts.
- Sign face material fabricated from reflective sheeting.
- Sign legends accomplished with either the direct or reverse silk screen process, or with black nonreflective sheeting that is direct applied.

b) Ensure the finished signs comply with the details specified in the contract documents.

2) Type B Signs.

a) Comply with the following:

- Extruded aluminum highway sign panels mounted on either wood or steel breakaway posts as specified in the contract documents.
- Sign face material fabricated from reflective sheeting.
- Sign legends accomplished through use of reflectorized or nonreflectorized letters, numerals, symbols, and borders that are direct applied.

b) Ensure the finished signs comply with the details specified in the contract documents.

c) Prior to fabrication, submit shop drawings for each Type B sign according to Article 1105.03. Each drawing is to be a scale drawing of the sign face, showing the size, arrangement, and spacing of all letters, numerals, symbols, and borders.

2. Milepost Markers.

a. Comply with the following:

- Green reflectorized sheeting on flat aluminum or galvanized steel sheets as for Type A signs.
- Reflectorized white message applied directly to the face material.
- Dimensions as specified in the contract documents.

b. Mount milepost markers on posts of the type specified for delineators.

3. Route Markers, 6 Inch by 6 Inch (150 mm by 150 mm).
Comply with the following:

- Reflectorized sheeting on flat aluminum or galvanized steel sheets as for Type A signs.
- Details as specified in the contract documents.

4. Delineators.

a. Install a hermetically sealed, acrylic plastic, prismatic, reflex reflector, appropriately housed and contained on Materials I.M. 486.07.

b. Mount above milepost markers on the same delineator post.

B. Erection of Signs, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.

1. Type A and B Signs.

a. Accurately erect all Type A and B signs to comply with the dimensions and details shown in the contract documents. Obtain the Engineer's approval for all deviations from the contract documents before starting the work.

b. After installation, modify each 4 inch by 6 inch (100 mm by 150 mm) wood sign post by field drilling holes as shown in the contract documents. All labor and equipment necessary for this modification is included in the price bid for the post and no separate payment will be made.

c. Set wood posts in 12 inch (300 mm) diameter holes of the proper depth.

d. Set posts to full depth at the required spacing. Align posts accurately both vertically and horizontally. Place backfill consisting of Class A crushed stone meeting the requirements of Article 4120.04 into the post holes. Place material in layers no more than 6 inches (150 mm) in depth. Thoroughly compact each layer taking care to preserve the alignment of the posts.

e. Where steel breakaway posts are specified in the contract documents, carefully drill or dig footing holes to the required size at the proper location. Spread the excavated earth within the right-of-way to blend uniformly with the existing surface to the Engineer's approval.

f. Immediately before placing concrete, remove all loose and uncompacted material from the bottom of the hole. Some of the holes will be located in the bottoms of drainage ditches. In these cases conduct construction operations so that water will not enter excavated holes.

g. For the breakaway base, tighten all bolts to maximum using a 12 inch to 15 inch (305 mm to 308 mm) wrench to bed washers and shims, and to clean bolt threads. Loosen each bolt in turn and retighten in systematic order to the torque specified in the contract documents. For the fuse plate assembly, tighten fuse bolts to the torque specified in the contract documents.

h. Preposition stub posts and reinforcing to the proper depth as shown in the contract documents. Ensure stub posts and reinforcing are properly aligned and secured, complying with Article 2405.03, H, 3. Cast the footing to the elevation shown in the contract documents.

Rod the concrete in place to fill all the voids. Form the exposed portion of the footing as shown in the contract documents. Shape the cap of the footing so that drainage is away from the base plate of the post. Apply the provisions of Section 2403.

i. After the concrete has developed the strength required by Article 2403.03, N, 2, attach the post and adjust for correct alignment and elevation. Remove all excess concrete from around the holes.

j. Erect extruded panels according to the details in the contract documents. Take necessary measures to prevent damage to sign faces. Repair (at no additional cost to the Contracting Authority) any mars, scratches, dents, or other damage to sign faces visible at a distance of 5 feet (1.5 m). Tighten locknuts on the post clip bolts by means of a torque wrench to 225 inch-pounds (25 Nm) when using dry, clean, unlubricated threads. Draw the nuts on panel bolts tight.

2. Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.

a. Drive the posts for delineators, milepost markers, and 6 inch by 6 inch (150 mm by 150 mm) route markers. Provide a suitable driving cap. Attach signs and delineators after driving.

b. Erect markers and delineators so that the signs and delineator reflectors will be at elevations called for in the contract documents. Ensure they are true to line and grade and are truly vertical. Where a milepost marker is designated, attach the marker in place of a delineator. Where a 6 inch by 6 inch (150 mm by 150 mm) route marker is designated, attach it above the milepost marker on the same post.

c. Ensure delineator posts for these signs are plumb and firm in the ground, spaced as shown in the contract documents, and driven to the required lines and grades. Ensure that after driving, the top of the post has substantially the same cross section dimensions as the body of the post. Battered heads will not be permitted. Remove from the site and replace (at no additional cost to the Contracting Authority) all posts which are bent or otherwise damaged to the extent that they are, in the Engineer's opinion, unfit in the finished work.

C. Sign Positioning.

The glossy surface on sign faces may produce specular reflection. Position signs to eliminate or minimize specular reflection in the following manner:

1. Overhead Signs.

a. Adjust the sign face in the following manner, where the road grade approaching the sign is plus 2.0% or greater:

- Vertical axis to be parallel to a plumb line.
- Horizontal axis to be at right angles to the road.

b. Adjust the sign face in the following manner, where the road grade approaching the sign is less than plus 2.0%:

- Vertical axis inclined to face upward at the rate of 1/8 inch per foot (10 mm/m) of vertical sign surface for each 1% the road grade differs from plus 2.0%.
- Horizontal axis to be at right angles with the road.

2. Ground Installations.

a. Ground installations will be shown in the contract documents.

b. After installation of signs is complete, the signs will be inspected at night by the Engineer. If specular reflection is apparent on any sign, adjust its positioning to eliminate or minimize this condition.

D. Sign Identification.

Identify the signs as specified in Section 4186, with the following additions:

Sign No..... (Filled in by Sign Fabricator)
Erection Date..... (Filled in by Sign Contractor)

2524.04 METHOD OF MEASUREMENT.

Measurement for signing, satisfactorily erected according to the contract documents, will be as follows:

A. Type A Signs.

1. Calculated in square feet (square meters) of sign area completed in place based on the nominal dimensions of the signs.

2. The area of all regular, rectangular, triangular, octagonal, and circular shaped Type A signs will be measured from the nominal given dimensions. Cutouts for rounded corners, and so forth, will not be deducted. The area of all irregularly shaped Type A signs, such as U.S. and Interstate route markers, will be measured from the dimensions of a circumscribed rectangle around the route marker.

B. Type B Signs.

Calculated in square feet (square meters) on the basis of area of the vertical, front face of the signs specified in the contract documents. Measurement will not be made for area in excess of this area.

C. Wood Posts for Type A or B Signs.

Each to the nearest foot (0.3 m) for the various post sizes installed. When posts are placed to depths greater than the minimum depth specified, the measured length does not include any parts placed to depths greater than 1 foot (0.3 m) more than the specified minimum.

D. Steel Breakaway Posts for Type A or B Signs.

1. Each to the nearest 0.1 foot (30 mm) for the various post sizes installed.

2. Unless specified otherwise in the contract documents, the measured length of steel breakaway posts includes no more than 1 foot (0.3 m) over the length necessary to meet specified minimums.

E. Concrete Footings for Breakaway Posts for Type A or B Signs.
Each will be counted by the various sizes installed.

F. Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.
Each will be counted by the various types installed.

2524.05 BASIS OF PAYMENT.

Payment for signing, satisfactorily erected according to the contract documents, will be at the contract unit price as follows:

A. Type A Signs.

1. Per square foot (square meter) of sign area.

2. Payment is full compensation for furnishing, fabricating, and erecting the signs complete, including furnishing of the blank, application of reflective sheeting, application of the screened message, and all mounting hardware.

B. Type B Signs.

1. Per square foot (meter) of sign area.

2. Payment is full compensation for:

- Furnishing, fabricating, and erecting the complete signs, including furnishing aluminum extrusions or formed steel panel,
- Applying reflective sheeting,
- Furnishing and applying all letters, numerals, symbols, and border to the sign
- Applying the sign to the post,
- Furnishing all labor, and
- Furnishing all other details necessary to provide signs complete and erected in place, except for the required footings and posts.

C. Wood Posts for Type A or B Signs.

1. Per linear foot (meter).

2. Payment is full compensation for furnishing and erecting the posts, including treatment and other details necessary to provide the sign posts complete and erected in place.

D. Steel Breakaway Posts for Type A or B Signs.

1. Per linear foot (meter) for the various post sizes.

2. Payment is full compensation for furnishing, fabricating, and erecting the posts, including galvanizing and other details necessary to provide the sign posts complete and erected in place.

E. Concrete Footings for Breakaway Posts for Type A or B Signs.

1. Each for the various sizes.

2. Payment is full compensation for:
- Excavating the hole,
- Furnishing and placing concrete, stub post, reinforcing bars, and so forth,
- Finishing, and
- All other details necessary to provide a complete concrete footing.

F. Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.

1. Delineators and Milepost Markers:
a. Each for the various types.
b. Payment is full compensation for:
- Furnishing, fabricating, and erecting the delineators or milepost markers complete, including posts, reflector units, and frames for delineators, posts and milepost marker signs,
- Furnishing all necessary fittings and attachments, and
- All labor necessary to complete the work.

2. 6 inch by 6 inch (150 mm by 150 mm) Route Markers:
a. Each.
b. Payment is full payment for furnishing, fabricating, and erecting the route marker to a milepost marker post previously measured for payment, including all necessary fittings and attachments and all labor necessary to complete the work.

G. Excavation in Unexpected Rock.
Excavation in unexpected rock for wood posts for Type A or B signs, steel posts for Type A or B signs, concrete footings for Type A or B signs, delineators, and milepost marker posts will be paid for as extra work in Section 1109.03, B. Unexpected rock will be considered as rock encountered during post erection, but neither visible from the roadway nor indicated in the contract documents.

Section 2525. Traffic Signalization

2525.01 DESCRIPTION.
Furnish all work, apparatus, and materials to construct, install, and place in operation, a complete traffic signal system as shown in the contract documents. Furnish and install all components of the system not furnished by the utility company serving the traffic signal system, including all incidental items appurtenant to the operation of the system.

2525.02 MATERIALS.
Furnish materials of new stock unless the contract provides for the relocation or the use of fixtures furnished by others.

A. Power Cable.
Comply with Article 4185.12. UL listed for type "USE".

B. Signal Cable.
Meet the requirements of IMSA Nos. 19-1 or 20-1.

C. Loop Detector Wire.
Single conductor meeting standard requirements for THHN. Meet the requirements of IMSA No. 51-5.

D. Detector Lead-In Cable.
Meet the requirements of the IMSA No. 50-2.

E. Tracer Wire.

1. Single conductor, stranded copper, Type THHN, with UL approval and orange colored jacket.

2. Splice tracer wires in the handholes, cabinet, and pole bases to form a continuous network.

F. Communications Cable (Conductive).
Meet the requirements of the IMSA No. 39-2 or 40-2.

G. Bare Copper Ground Wire.
Meet the requirements of Article 4185.12.

H. Conduit.

1. General.
Meet the requirements of Article 2523.03, N and Article 4185.10.

2. Rigid Steel Conduit.
Use conduit fittings meeting the requirements of ANSI C80.4.

3. Polyvinyl Chloride Conduit.
Use rigid PVC conduit meeting the requirements of NEMA TC-2, Type 2, and applicable UL Standards.

4. Innerduct.
For innerduct conduit (IDC), use Schedule 40, high density polyethylene. Conduit shall provide nominal conduit size as indicated in the contract documents, be orange in color, and longitudinally ribbed on the inside wall. Conduit shall be purchased in continuous reel lengths to minimize splicing.

2525.03 CONSTRUCTION.

A. General.

1. Furnish equipment and materials of new stock unless the contract provides for the relocation or the use of fixtures furnished by others.

2. Submit to the Engineer, for review, a list of equipment and materials to be furnished before they are ordered. Replace, at no additional cost to the Contracting Authority, any part that fails in any manner by reason of defective materials within a period of 1 year from the date that the equipment was placed in operation and accepted. Provide the standard industry warranties for all equipment at the date of final acceptance of the work by the Engineer.

3. Shop drawings will be required for the poles and mastarms. Submit shop drawings according to Article 1105.03.

4. Prior to acceptance of the work, the Contractor will be required to furnish the Engineer with:
- Five copies of the manufacturer's instructions for maintenance and operation of all signal equipment,
- Wiring diagrams of the installation or system, and
- A parts list sufficient for the ordering of parts.

B. Handholes.

1. Build handholes in place or furnish precast units. When forms are used, use forms that are set level and are of sufficient thickness to prevent warping or other deflections from the specified pattern. Provide a means for holding them rigidly in place while the concrete is being placed.

2. Use concrete meeting the requirements of Section 2403.

3. Extend the ends of all conduit leading into the handhole approximately 2 inches (50 mm) beyond the inside wall.

4. Construct a drain in the bottom of the handhole. Furnish frames and covers for handholes made of cast iron.

5. Furnish handhole covers with the words "TRAFFIC SIGNAL" cast on the top of the cover. Set them flush with the sidewalk or pavement surface.

6. When installed in an earth shoulder away from the pavement edge, install so the top surface of the handhole is approximately 1 inch (25 mm) above the surface of the ground. When constructed in unpaved driveways, install so the top surface of the handhole is approximately level with the surface of the driveway.

C. Conduit System.
Apply Article 2525.02, H.

1. Installation.

a. Accomplish change in direction of ducts by:
- Bending the conduit uniformly to a radius which will fit the location (minimum radius 6 times the internal diameter of the conduit), or

- The use of standard bends or elbows.

b. When it is necessary to cut and thread steel conduit, no exposed threads will be permitted.

c. Ensure all ducts and fittings are free from burrs and rough edges.

d. Use standard manufactured elbows, nipples, tees, reducers, bends, couplings, unions, and so forth of the same materials and treatment as the straight duct throughout the duct system. Tightly connect all fittings to the duct. Provide a bushing to all duct ends to protect the cable from abrasion, except for open ends of conduit being placed for future use. Cap or plug open ends intended for future use.

e. When the contract documents require that ducts be placed without disturbing the existing pavement, the term "pushed" is used. Place pushed conduit by jacking, pushing, boring, or any other means necessary to place the ducts without cutting or removing pavement.

f. Slope all ducts to drain. Furnish crushed stone drainage sumps at all handhole locations.

2. Excavation.

a. Excavate trenches to the depth necessary to provide 18 inches (0.5 m) of cover over the ducts. Remove all cinders, broken concrete, or other hard or abrasive materials. Do not use these materials as backfill materials. Ensure the trench is free of these materials before the conduit is placed.

b. Do not place ducts prior to the Engineer’s inspection of the trench. Place backfill material in all trenches as soon as possible after duct installation. Place backfill material in the trench in layers not to exceed 6 inches (150 mm) deep. Thoroughly compact each layer before placing the next layer.

c. Whenever excavation is made across parkways, driveways, or sodded areas, replace or restore the sod, topsoil, crushed stone, and gravel as nearly as possible in its original position. Leave the whole area involved in a neat and presentable condition.

d. Replace concrete sidewalks, pavements, base courses, and bituminous surfaces with new materials.

D. Wire and Cable.

Apply Articles 2525.02, A through G.

1. Install all cable runs so they are continuous from connections made in the handhole compartments of signal pole bases to the terminal compartment in the controller cabinet. Splicing will not be allowed. Install one signal cable from each signal head to the base of the pole. Use a 5-conductor cable in the poles for 2-section, 3-section, or 4-section signal heads. Use a 7-conductor cable for 5-section signal heads.

2. Install service cable runs so they are continuous from the service point to the terminal compartment on the controller cabinet. Connect loop detectors to the controller using a 14 A.W.G. 2-conductor shielded cable. Install these cables to be continuous from the terminal compartment in the controller cabinet to a splice made with the detector

leads in the first handhole or pole base junction box provided adjacent to the detector.

3. Pull cables through conduit by means of a cable grip designed to provide a firm hold upon the exterior covering of the cable or cables, with a minimum of dragging on the ground or pavement. Use reels mounted on jacks or other suitable devices. Use frame mounted pulleys or other suitable devices to pull the cable out of conduit into handholes. Use lubricants which are approved for cable lubrication to facilitate the pulling of cable. Provide slack for each cable by the use of a 4 foot (1.2 m) loop in each handhole.

E. Controllers, Cabinets and Associated Equipment.

1. General Design Requirements.

a. Purpose.

The purpose sets forth minimum design and operating requirements for controllers, cabinet and associated equipment. Furnish controllers, cabinets, and associated equipment complying with NEMA TS-1, except as modified by the contract documents.

b. Cabinet.

1) Furnish controller units and associated equipment that are completely housed in a cabinet of clean-cut design and appearance. The cabinet shall be constructed from 5052-H32 sheet aluminum alloy which has a nominal 0.12 inch (3 mm) thickness.

2) Furnish a hinged door that meets the following requirements:

- Permits complete access to the interior of the cabinet.
- When closed, fits the gasketing material making the cabinet weather resistant and dust tight.
- Includes a strong Corbin #2 lock and key, or approved equal.

3) Ensure the outside of the main controller door includes a small, hinged and gasketed door-in-door that:

- Does not allow entrance to the controller mechanism or to exposed electrical terminals,
- Provides access to a small switch panel and compartment which contains a signal shutdown switch, manual/stop time, and a flash control switch, and
- Is equipped with a strong lock utilizing keys of a different design from those provided for the main cabinet.

c. Wiring.

1) Furnish panels that have mounted on them at least the following short circuit protection devices and suitably identified field terminals:

a) Terminals for the conductors of the signal light cable. One for each signal circuit.

b) Terminals for common return conductors of the signal light cable. At least one for each three signal circuits for which the controller is equipped.

c) Terminal grounded to the cabinet or an equipment grounding conductor.

2) The grounded side of the power service is to be carried throughout the controller in a continuous circuit, but do not ground it to the controller cabinet.

3) Furnish controllers that withstand without failure a high energy transient (1000 volts, both positive and negative, applied three times for each polarity at a rate of once every two seconds from a 15 microfarad oil filled capacitor) applied to the incoming power supply line.

d. Contacts.

For all contacts, meet the following requirements:

- Fabricated from coin or fine silver or material of similar conductivity,
- Sufficient cross section to perform their normal functions with minimum pitting or burning under maximum current, and
- No fine adjustment and readjustment required for satisfactory and continuous operation.

e. Mechanical Requirements.

Meet the following requirements:

1) All mechanism, motors, operating coils, bearings, contacts, relays, flashers, and similar components sufficiently large, rugged, and accessible to ensure reliability and minimum maintenance.

2) All equipment neatly and systematically arranged and mounted to allow thorough inspection while the controller is operating normally, and to permit easy removal of components without interfering with other portions of the controller.

3) Components securely fastened in place, if necessary to prevent accidental contact with moving parts or electrical power and to permit the cabinet door to be opened and closed without interference or damage to the controller and wiring.

4) The opening and closing of the flashing circuit accomplished in such manner as to avoid undue pitting or burning or other damage of signal load switches at 10 amperes of tungsten lamp load at 120 volts, 60 hertz AC, for 50 million times.

a) Each equipped with additional terminals which are wired so that, by an interchange of jumpers, flashing operation may be arranged to display either flashing yellow or flashing red on each.

b) Cabinet constructed so that flashing operation can be obtained by operating the flash control switch even if the controller unit malfunctions or is removed from the cabinet.

c) Each cabinet equipped with adequate means to suppress or prevent radio interference from flashing of vehicular and pedestrian signal indications.

f. Uninterrupted Timing.

Ensure changes in operation of traffic control signal lights as described in Article 2525.03, E, 1, b, 2, and Article 2525.03, E, 1, e, do not interfere with the continued in-time operation of the cycle timer in each controller. A transfer from these special operations

back to normal automatic operation is to immediately re-establish the normal cycle length and subsequently the in-time relation.

2. Preemption Features.

Furnish controllers equipped to provide special preemption sequences upon remote control from railroad track circuit, emergency vehicle preemption, mass transit equipment, or other similar device which may connect either through a master controller or directly to the interconnected controller.

3. Actuated Signal Controllers.

a. Description.

Furnish NEMA TS-1 or TS-2 controller units that:

- Are of completely solid state modular design,
- Incorporate digital timing, and
- Are capable of expanding to accommodate up to eight phases.

b. Electrical Requirement.

1) Over-current Protection.

Furnish controllers that contain a front-panel-mounted AC power input fuse of suitable size to provide adequate over-current protection.

2) Automatic Reorientation.

Furnish controllers that in the event of a power interruption are capable of automatic reorientation upon power resumption and require no manual initiation or switching.

c. Constancy of Intervals: Minimum Requirements.

Ensure the length of any interval or timing setting does not change by more than 100 milliseconds (±) so long as the voltage and frequency of the power supply and the ambient temperature inside the controller cabinet remain within the tolerances specified in these specifications.

d. Interval Sequence.

Ensure that at the end of the green interval of the terminating phase, if neither vehicle nor pedestrian memory indicates a need for the next traffic phase, the intervals which comprise that phase are omitted from the interval sequence. This does not preclude the use of recall causing the phase to be displayed even though no detector actuations have been received.

e. Interval Setting and Functions.

1) Provision for Setting.

Furnish controls that meet the following requirements:

- Calibrated in seconds and fractions of seconds, when applicable.
- Provide a clear visual indication of the value of each interval or function.
- Timing and function values capable of being set without the use of special tools or wiring changes.

2) Location of Controls.
Furnish controllers with the interval and function controls located on the front of the controller and properly designated as to the function each control performs.

3) Interval and Function Indication.

a) Indication.
Furnish controllers with indication provided and appropriately labeled on the controller to facilitate the determination of operation and termination of the intervals and functions contained therein. Indication shall include, but not necessarily be limited to, the following:

- Phase(s) next.
- Phase(s) in service.
- Status indicators.
- Initial interval.
- Vehicle interval.
- Yellow change interval.
- Maximum/gap termination.

b) Call Indication.
Furnish controllers on which indication is provided to display presence of vehicle call, including memory and detector actuations and presence of a pedestrian call when pedestrian timing functions are included.

4) Vehicle Detector Non-Lock Memory Switch(es).
Ensure a switch is provided for each actuated vehicle phase which, when placed in the nonlock position, causes the vehicle detector memory circuit for that phase to be disabled.

f. Signal Circuits.

1) General.
Furnish cabinets with load switches, external to the controller, for closing and opening signal light circuits.

2) Closing and Opening of Circuits/Minimum Capacity.
Ensure closing or opening of signal circuits is positive without objectionable dark intervals, flickering of lights or conflicting signal indications. Ensure each switch has a capacity of no less than 10 amperes of incandescent lamp load at 120 volts AC.

3) NEMA Triple Signal Load Switch(es).
Furnish external jack-mounted load switches according to Part 5, "Solid-State Load Switches", Section TS-5.01, NEMA Traffic Control Systems Standards.

g. Conflict Monitor.
Furnish a separate external signal monitoring device complying with Part 6, NEMA TS-1 that monitors the occurrence of conflicting Green or Walk indications and causes the signals to go into flashing operation should such conflicts be sensed.

1) Control of Flasher Mode.
Meet the following requirements:

a) Operation of flash mode from police panel does not interrupt operation of controller and associated units.

b) An "auto-off-flash" mode switch is provided inside the cabinet.

2) Flashing of Vehicular Signals.
Meet the following requirements:

a) Flashing of vehicular signal indications is obtained from one or more flashers, each of which is a self-contained device designed to plug into a panel in the controller cabinet.

b) If the flashing is provided by two flashers, they are wired to assure that the flashing of all lenses on the same approach is simultaneous.

3) Flashing of Pedestrian Signals (Pedestrian Clearance).
When pedestrian interval timing functions are included, ensure means are provided to permit flashing of the DON'T WALK pedestrian signals during the pedestrian clearance interval.

4) Solid State Flasher.
Furnish solid state flashers that:

- Contain no contact points or moving parts, and
- Comply with Part 6, NEMA Traffic Control Systems Standards TS-1.

h. Manual Control Enable.
Ensure, when specified, manual commands:

- Place vehicle calls and pedestrian calls (when pedestrian timing is included in the controller's sequence of operation) on all phases and stop controller timing in all intervals except vehicle clearances, and
- Inhibit the operation of interval advance during vehicle clearances.

i. Coordination.

1) Minimum Requirements.
Furnish controllers with the means to permit its interconnection into a coordinated traffic signal system when coordinating devices are added. As a minimum, this should include the provision of Yield circuit or Hold circuit, accessible to interruption by command external to the controller.

2) Coordination Requirements.
Ensure controllers, in addition to the minimum coordination requirements specified above, contain the coordination features for the applicable configuration included in NEMA Traffic Control Systems Standard TS-1.

j. Cooling/Heating Devices.
No heating or cooling devices other than standard vent fan(s) are required for proper operation of the controller.

k. Cabinet.

1) Size.
Furnish cabinets of a size to adequately house the controller, all associated electrical devices and hardware, and other auxiliary equipment herein specified.

2) Mounting.

a) Ensure the cabinet is arranged and equipped for mounting as shown in the contract documents. Also ensure

sufficient clamps, nuts, hardware, etc., as required for the specified mounting type, are furnished with each cabinet.

b) Seal all conduit openings in the controller cabinet with a sealing compound that meets the following requirements:
- Readily workable, soft plastic,
- Workable at temperatures as low as 30ºF (-1ºC), and
- Does not melt or run at temperatures as high as 300ºF (150ºC).

c) Install the controller cabinet on preplaced caulking material on the concrete base. After the cabinet is installed in place, also place caulking material around the base of the cabinet.

3) Door Stop.
Ensure the controller cabinet door is provided with a stop and catch arrangement to hold the door open at angles of both 90 degrees and 180 degrees, ±10 degrees.

4) Mounting Shelves.
Furnish cabinets containing strong mounting facilities to:
- Accommodate the mounting of the controller and all auxiliary equipment, and
- Permit the controller and/or auxiliary equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting operation of the controller.

5) Mounting Screws.
Do not allow screws used for mounting shelves or other mounting purposes to protrude beyond the outside wall of the cabinet.

6) Outlet and Lamp.
Furnish and locate an electrical outlet with a Ground Fault Interrupter and lamp receptacle in an accessible place near the front of the cabinet.

7) Plastic Envelope.
Furnish a heavy-duty clear plastic envelope (minimum dimensions of 12 inches by 18 inches (300 mm by 450 mm)), securely attached to the inside wall of the cabinet or cabinet door, for stowing cabinet electrical prints, and so forth.

8) Ventilation.

a) Vents.

(1) Furnish cabinets containing a suitably designed rain tight vent or vents that:
- Are equipped with screens or filters, and
- Allow the release of excessive heat and/or any explosive gases which may enter the cabinet.

(2) Ensure when filters are utilized, positive retainment is provided on all sides to prevent warpage and entry of foreign matter around the edges.

b) Vent Fan.
Meet the following requirements:

- A thermostatically controlled vent fan is furnished to provide air circulation within the cabinet.
- The thermostat controlling the fan is manually adjustable to turn on between 90ºF and 150ºF (32ºC and 66ºC) with a differential of not more than 10ºF (6ºC) between automatic turn on and turn off.
- The fan is located with respect to the vent holes to direct the bulk of the air flow over the controller and auxiliary equipment.

9) Connecting Cables, Wiring, and Panels.

a) Connecting Cables.

Fabricate electrical connections from the controller (and auxiliary devices when included) to outgoing and incoming circuits in a manner that the controller (or auxiliary device) can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wires leading therefrom. This can be accomplished by means of a multiple plug, a spring connected mounting, or approved equivalent arrangement.

b) Panels and Wiring.

Furnish each cabinet with suitable, easily accessible wiring panel(s). Ensure all panel wiring is neatly arranged and firm, and all incoming cables are clearly identified by use of plastic numbered tags.

(1) Wiring Terminals.

Furnish terminals, as a minimum, for the following:

- Terminal with NEC approved cartridge fuse receptacle, fuse, power line switch, or magnetic circuit breaker, with integral power line switch, for the incoming power line,
- Terminal, unfused, for the neutral side of the incoming power line,
- Terminals and bases for signal load switches, flasher, and outgoing signal field circuits,
- Terminals for detector cables, and
- Terminals for all required auxiliary equipment.

(2) Clearance between Terminals.

Ensure adequate electrical clearance exists between terminals. Also ensure the controller, auxiliary equipment, panel(s), terminals, and other accessories are arranged within the cabinet so that they will facilitate the entrance and connection of incoming conductors.

(3) Signal Circuit Polarity.

Ensure the outgoing signal circuits are of the same polarity as the line side of the power service, and the common return is of the same polarity as the grounded side of the power service.

(4) Grounding Conductor Bus.
Ensure an equipment grounding conductor bus is provided in each cabinet, and is grounded to the cabinet in an approved manner.

10) Fusing and Surge Protection.

a) Incoming AC Line.
Furnish suitable over-current protection, utilizing one of the methods described in Article 2525.03, E, 3, k, 9, b, 1.

b) Lightning.
Furnish suitable protection from lightning with lightning arresters, preferably of the gas filter type.

11) Painting.
Do not paint the aluminum exterior surface of the cabinet.

4. Multi-Phase Traffic Actuated Controllers.

a. Operational Requirements.

1) Mode of Operation.
Furnish controllers meeting the following requirements:

- Provide two to eight phase operation and are fully actuated with means for receiving actuations on all phases.
- Permit a nonactuated mode of operation on any of its phases by assertion of the vehicle recall function or pedestrian recall on the desired phase.

2) Call to Nonactuated Mode.
Furnish controllers that feature an input which, when asserted, permits the selection of nonactuated mode of operation on any of its phases.

3) Operation with Auxiliary Functions/Devices.
Furnish controllers capable of having their basic operation expanded or augmented by the addition of auxiliary functions or devices.

4) Minimum Green.

a) Actuated Phase.
The minimum green is to be the first timed portion of the green interval which is set in consideration of the storage of vehicles waiting between the sensing zone of the approach vehicle detector and the stop line.

b) Nonactuated Phase.
In the nonactuated mode of operation, the minimum green on the nonactuated phase is to be equal to the values described for Actuated Phases in the preceding paragraphs or equal to a separately set Minimum Green function.

5) Unit Extension.
Ensure the actuation of a vehicle detector during the extendible portion of an actuated traffic phase having the right-of-way causes the retention of right-of-way by that traffic phase for one Unit Extension portion from the end of the actuation, but subject to the Maximum (extension limit).

6) Maximum (Extension Limit).
Ensure the Maximum (extension limit) determines the maximum duration of time the right-of-way can be extended for a phase having successive detector actuations spaced less than a Unit Extension portion apart.

7) Initiation of Maximum or Extension Limit.

a) Ensure the timing of the maximum or extension limit commences:
- With the first actuation or other demand for right-of-way on a traffic phase not having the right-of-way, or
- At the beginning of the Green interval if an actuation or other demand for right-of-way has been previously registered on a traffic phase not having the right-of-way.

b) Alternatively, the maximum may commence at the end of the Initial portion of the Green interval if an actuation or other demand has been previously registered on a traffic phase not having the right-of-way.

8) Transfer of Right-of-Way.
Ensure the actuation of any detector on a traffic phase not having the right-of-way causes the transfer of the right-of-way to that traffic phase at the next opportunity in the normal phase sequence, provided there has been an expiration of:
- A Unit Extension portion with no continuing actuation, or
- The Maximum (extension limit) timing on the preceding phase having the right-of-way.

9) Rest in Absence of Actuation.
Ensure in the absence of detector actuation or assertion of recall switch(es), the right-of-way indication remains (rests) on the traffic phase on which the last actuation occurred.

10) Memory Feature.
Unless precluded by the operation of the nonmemory feature, the following memory retention is to be provided in the controller:

If the right-of-way is transferred by the operation of the Maximum or extension limit, the traffic phase losing the right-of-way is to again receive it without further actuation at the next opportunity in the normal phase sequence.

11) Pedestrian Timing Operation.
Ensure the following pedestrian function operation is provided:

a) Condition in Absence of Pedestrian Call.
In absence of pedestrian actuation or assertion of pedestrian recall function, pedestrian signals remain in a DON'T WALK condition.

b) Pedestrian Actuation Memory.
Pedestrian actuations received by a phase during steady or flashing DON'T WALK indications of that phase are remembered and cause the controller to provide pedestrian timing functions for that phase at the next opportunity in the normal phase sequence.

c) Nonextension of Pedestrian Intervals.

Successive pedestrian actuations do not cause extension of the pedestrian intervals.

12) Other Operations Features.

Ensure, in addition to specified functions, the following additional features are provided:

- All phase detector inputs are supplied with detector delay disable capability.
- All signal load outputs are individually fused with 10 ampere fuses.
- Detector test switches and pedestrian (if specified) test switches are provided for each phase.
- The permissive and force-off features are fully conditionable.

b. Functional Requirements.

Ensure, in addition to the basic functional requirements specified above, the controller provides the functional features for the applicable configuration included in NEMA Traffic Control Systems Standard TS-1.

5. Coordination of Traffic Actuated Controllers.

a. Requirements.

Furnish controllers with a means to permit their interconnection into a coordinated traffic signal system when coordinated devices are added. As a minimum, this should include the provision of yield circuit or hold circuit accessible to interruption by commands external to the controllers.

1) Hold Feature.

Ensure controllers contain a hold feature which, when asserted for a particular phase, holds that phase in a rest condition. Upon release from hold, the phase is to immediately advance into the appropriate clearance interval or other unexpired portion of the Green, provided there is an actuation or an opposing phase.

2) Force-off Feature.

Ensure controllers contain a force-off feature which, when asserted, causes termination of the current phase, provided that phase is in the extension portion. In no case is assertion of force-off to cause termination in a clearance interval or during a minimum Green for vehicles or pedestrians.

3) Additional Features.

Ensure the controllers and coordination devices are capable of, but not limited to, the additional coordination features, including:

- Three cycles,
- Four splits per cycle,
- Three offsets per cycle,
- Four permissible periods per split,
- Four force-offs per split,
- One pedestrian permissive period per vehicular permissive period, and

- One dwell period per cycle.

b. NEMA Coordination Requirements.
Ensure, in addition to the coordination requirements specified above, controllers contain tab coordination features for the applicable configuration included in NEMA Standard TS-1.

6. Master-Secondary Controller.

a. Purpose.
The purpose sets forth functional requirements which apply to an interconnected actuated controller which is also equipped to serve as a master controller. For this, the master controller shall be located as designated in the contract documents.

b. Design Requirements.
The general design requirements in Article 2525.03, G, 1 and 2 apply, in addition to specific functional requirements described below.

c. Equipment.
Ensure the master-secondary controller consists of a complete interconnected controller equipped with the necessary apparatus to provide supervisory functions for operation of a system of interconnected actuated and pretimed controllers.

d. Supervisory Functions.
Ensure the master controller is equipped with a solid state programmable plug-in module or controller accessory unit with time-based coordination capabilities. This unit is to provide as a minimum, but not limited to, these capabilities:

1) Synchronization pulse generation for offsets.
2) An offset interrupter or equivalent device for decreasing the disruption to interval timing caused by large offset changes.
3) Hand operated flash control switch for transfer of traffic control signal lights at each interconnected controller to give flashing indications.
4) Complete compatibility with actuated controller coordination units specified in Article 2525.03, E, 3.
5) Programming capability as a minimum, but not limited to, time of day, day of week, week of year, with daylight savings selection.

F. Inductive Loop Vehicle Detector.
Provide wiring and schematic diagrams, descriptive parts lists, and instruction and maintenance manuals for all items furnished under these specifications. Equipment or unit modifications as approved shall be accompanied by revised diagrams with the first shipment of the modified units. Provide tables, charts, or equations for use in designing loops of various sizes and configurations. Provide five complete sets of diagrams, manuals, and so forth to the Engineer with each order.

1. Design Requirements.
Meet the following requirements:

a. Operation.

1) General.

a) Detectors shall be designed to meet requirements of NEMA Traffic Control Systems Standard TS-1.

b) The detector shall provide reliable detection and maintain an output indication for a period of not less than 3 minutes for a vehicle that causes a 0.02% change in the total inductance of the loop and lead-in system, as measured at the detector loop input terminals.

c) The detector shall provide operation as above with a loop system having any or all of the following characteristics:

(1) A shunting resistance of 10,000 ohms or greater to a common or circuit ground bus.

(2) A loop system quality factor (Q) of not less than 5.0, when connected to the detector being tested. Q is defined as the ratio of the resonant operating frequency over the half-power band width.

(3) A total or equivalent inductance within the range of 40 microhenrys to 700 microhenrys at the detector loop input terminals.

d) A sensitivity adjustment or selector is to be provided to allow selection of a high, medium, or low sensitivity adjustment. Increments are to include: High, 0.02%; Medium, 0.06%, 0.01% (±); Low, 0.125%, 0.025% (±).

2) Loop Energizing and Detector Sensing Circuits.

a) The detector is to:

- Provide reliable detection of licensed motor vehicles,
- Provide an output (switch closure) only when vehicles are passing or stopped over the loop,
- Detect all vehicles passing over the loop at speeds up to 80 mph (130 km/h).

b) When first turned on, while tuning or being tuned, the detector shall provide a continuous output pulse (switch closure), plus a visual indication, in both the presence and pulse modes of operation. On power failure, or loop failure that would cause the inductance to exceed the tuning range, the detector shall place a continuous call.

c) To prevent mutual interference "cross-talk," the detectors shall be provided with a three-position frequency mode switch on the front panel.

d) The detector is to be designed to be initially tuned to the loop and provide for automatic drift compensation.

e) The operation of the detector shall not be affected by changes in the inductance of the loop caused by environmental changes, such as rain, hail, snow, temperature, and humidity, nor is the sensitivity to be markedly affected.

3) Accuracy.

The detector shall be able to detect all licensed vehicles, including motorcycles, accurately.

b. Detector Output.

The detector output (switch closure) to the associated traffic control equipment shall be provided by means of a relay. The relay shall

have a mechanical life of at least 1,000,000 operations. The contacts are to have a rating of at least 1.0 ampere at 120 volts AC or DC.

c. Power Supply.

The primary of the power supply transformer shall be fused with a 1/4 inch (6 mm) diameter, 1 1/4 inch (32 mm) long, 250 volt fuse of suitable current rating. Provide an extractor-post fuse holder. The fuse rating shall be marked by the fuse holder.

d. Visual Indicator.

1) A LED shall be used to provide a visual indication of each vehicle detection. The indication shall be readily visible in indirect sunlight.

2) The LEDs are to have a minimum design life of 20,000 hours at rated voltage.

e. Dielectric Strength.

The detector shall withstand a dielectric strength test of 1250 volts, 60 hertz, AC applied between the 120 volt AC line-supply circuit and the terminals for the external loop, for a period of 1 minute.

f. Interchangeability and Design Life.

All modules and components of the same type shall be interchangeable. The design life of all components, under conditions of normal operation, is to be no less than 5 years.

g. Marking.

Each detector is to be marked with the manufacturer's name, model, catalog, or type number, and serial number. The electrical input rating (voltage, frequency, and wattage) is to be included in the marking.

2. Input/Output Receptacle.

a. Function Assignment.

Complete input and output connections for the detector to a type MS-3102-A-18-1P box receptacle using 10 male contacts. Place a plastic cover on the receptacle. Assign the pin positions of the input/output connector as follows:

Pin No.	Function
A	120 vac (-)
B	Output Relay Common
C	120 vac (+)
D	Input from Loop
E	Input from Loop
F	Output Relay N.O.
G	Output Relay N.C.
H	Chassis Ground
I	Spare
J	Spare

b. Plug and Cable.

Furnish a plug, type MS-3108-B with type 18-1S insert, with 10 female contacts, wired with leads of No. 18 AWG stranded, color-coded wire with 300 volt insulation. Furnish a type MS-3057-10 cable clamp and boot for strain relief. Fabricate the leads to be 10 feet (3 m) long, with the first 16 inches (0.4 m) of leads, from the

plug, enclosed in cotton braiding. No terminals are required on the leads.

3. Components.

a. Inductors and Transformers.
Ensure all inductors and transformers have their windings insulated and are impregnated to exclude moisture. Ensure all wire leads are color coded.

b. Resistors and Capacitors.
Ensure all resistors and capacitors are insulated and marked with their resistance or capacitance value. Resistance and capacitance values may be indicated by the Radio Electronics Television Manufacturer's Association (RETMA) color codes. Ensure all electrolytic capacitors are marked to indicate polarity and voltage.

c. Printed-Circuit Boards.
Ensure the following:

- All printed-circuit boards are at least 1/16 inch (1.5 mm) thick and made of glass-cloth silicone NEMA type G-10 glass epoxy, or equivalent.
- The conductor material is copper, 0.0027 inch (70 µm) thick, having a weight of 2.0 ounces per square foot (610 g/m^2), with a protective solder coating.
- All printed-circuit board connectors (male and female) are gold plated over the copper base.
- The printed circuit-boards are securely mounted to prevent flexing or bending of the boards, and are easily removable for servicing or replacement.

d. Wiring.
Use No. 22 AWG, or larger, insulated interconnecting wires, suitable for 180ºF (82ºC) operation.

e. Solid State Circuitry.

1) Meet the following requirements:

a) Transistors, integrated circuits, or semiconductor diodes shall be used for all amplifying, detecting, rectifying, counting logic, and regulator circuits. No vacuum or gas tubes are to be used except for pilot lights. Transistors, integrated circuits, and diodes are to be marked with their type number and are to be types listed by the RETMA.

b) No electro-mechanical timers, synchronous motors, or relays shall be employed, except as specified in Article 2525.03, A.

c) All electronic and electrical components shall be of standard manufacture and available from a source other than the manufacturer of the loop detector unit.

2) No modifications to the circuit, parts substitutions, or changes in the function or form from the original equipment list will be allowed without prior approval of the Engineer.

4. Detector Loop Installation.

a. Insert the detector loop wire into a flexible plastic tubing for the full length of the wire from the point of splicing. Prefabricated loops

installed under new paving consist of loop wiring encased in a watertight plastic tubing assembly. The field loop conductors installed in the pavement are to run continuously from the terminating service box or base with no splices permitted. At the time of placing the loop wire in the sawed slots, seal the ends of the tubing to prevent moisture from entering the tubing.

b. Twist all lengths of loop wires and tubing not imbedded in the pavement with at least 5 turns per foot (16 turns per meter), including lengths in conduit and service boxes.

c. Solder the electrical splice between the loop and lead-in cable to the controller and the loop wire using resin core solder. Furnish a water tight protective covering for the spliced wire, the shielding on the loop lead-ins and the end of the tubing containing the loop wires. Using an open flame to heat the wire connection will not be permitted. Use a soldering iron, gun, or torch equipped with a soldering tip. Complete the splice using the following method:

1) Remove all lead-in cable coverings leaving 4 inches (100 mm) of insulated wire exposed.

2) Remove the insulation from each conductor of a pair of lead-in cable conductors and scrape both copper conductors with knife until bright.

3) Remove the plastic tubing from the loop wires for 1.5 inches (40 mm).

4) Remove the insulation from the loop wires and scrape both copper conductors with knife until bright.

5) Connect conductors by a soldered “Western Union” type splice, wrapped with water proof tape and coated with a water tight protective covering.

6) Cover the exposed shielding, ground wire and end of any unused loop lead-in where the sheathing was cut with liquid silicone rubber. Apply Butyl Rubber Polymer Tape sealant between the wires and completely cover the silicone rubber. 3M Company Scotchcast Kit, or approved equal, is an acceptable alternate for splices.

d. Mark the location of each loop on the pavement with crayon or spray paint. Obtain the Engineer’s approval prior to cutting the saw slots.

e. Use a saw equipped with a depth gage and horizontal guide to assure proper depth and alignment of the slot. Use a blade for the saw cut that will provide a clean, straight, well defined 3/8 inch (10 mm) wide saw cut, without damage to adjacent areas. Make cuts 1.5 inches to 2 inches (40 mm to 50 mm) deep. Where the loop changes direction, overlap the saw cuts to provide full depth at all corners. Do not use right angles or corners less than 90 degrees.

f. Before installing the loop wire, check the saw cuts for the presence of jagged edges or protrusions. If they exist, remove them. Clean and dry the slots to remove cutting dust, grit, oil, moisture or other contaminants. Clean by flushing with a stream of water under pressure, followed by an air blast using oil free compressed air.

g. Install loop detector conductor using a nominal 0.2 inch (5 mm) thick wood paddle. If the wire does not lie close to the bottom of the

saw cut, hold it down using a material such as tape or doubled over pieces of the plastic tubing.

h. Coil each loop clockwise (or according to the manufacturer's recommendations) and band the beginning conductor in the terminating handhole or base with a symbol "S" to denote the start of conductor. Use durable tags to further identify each loop by phase or function as shown in the contract documents.

i. Connect the “S” conductor of the loop to the unbanded conductor of the adjacent loop for situations where multiple loop configurations, spliced to a single lead-in loop, are to be connected in series.

5. Detector Loop Sealing.

a. After obtaining satisfactory test results, seal the loop with a flexible embedding sealer listed in Materials I.M. 491.18. Use the sealer according to the manufacturer's instructions.

1) Pour the sealer into the slot to half depth.

2) When both the loop and lead-in slots are half filled, check for air bubbles and material pileup, and then proceed to fill the slots to roadway level. The sealer, when poured into a saw cut, should completely surround the wires, displace all air and completely fill the area of the slot, except for that portion filled with the wire hold down material.

3) Remove excess sealant using a squeegee. Ensure neither a trough or a mound remains.

4) Allow sufficient time for the sealer to harden, according to manufacturer's instructions, before allowing traffic to move over the area.

b. After completion of the sealing, test the loop individually at the handhole and as a group at the control cabinet. The completed sealed loop is required to pass continuity, inductance, and resistance testing prior to being accepted.

6. Detector Loop Testing.

Test all loops and document by using the following procedures:

a. Determine the insulation resistance of the loop wire using a "megohmmeter" with 500V applied to either loop wire to earth ground. The resistance is to be greater than 100 megohms.

b. Determine the inductance of the loop using a loop inductance meter.

G. Signals.

1. General.

a. Furnish traffic signals manufactured in polycarbonate sections that are interchangeable and fit so they can be combined in a tier. Follow the requirements as shown in the contract documents for mounting devices, lens indications, and other modifications. Ensure the reflector is parabolic in design and made of specular alzak aluminum. Other parts of the optical system, including the lens, lamp socket, reflector, and reflector holder, are to be manufactured

as a whole system so as to eliminate the return of outside light rays which enter the unit.

b. During the course of construction and until the signals are placed in operation, cover signal faces or turn them away from approaching traffic. When ready for operation, secure them in position facing toward approaching traffic.

c. Ensure the optical assembly of the vehicle signals is in substantive compliance with the latest version of ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads.

d. Apply one prime coat of metal primer and two coats of high quality Federal yellow enamel to mounting accessories. Dipping will not be permitted for any part of the enameling process. Ensure mounting accessories for mast-arm mounted signal fixtures are galvanized in accordance with the latest revision of ASTM A 123. The body of the signal sections is to be Federal yellow, and the door, backplate, if required, and visors are to be dull black. The color shall be completely impregnated in the polycarbonate material, and scratches are not to expose uncolored material.

2. Vehicle Signals.

Meet the following requirements:

a. All lenses shall be of the prismatic, long range type. The lenses shall have a nominal diameter of 12 inches (300 mm). All lenses shall be made of vandal resistant polycarbonate or acrylic plastic meeting the light transmitivity and chromaticity standards established by latest version of ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads.

b. Each signal lens, with the exception of lenses for optically programmed sections, shall have a visor of a type normally described as a tunnel visor, which encloses 75% of the lens circumference for the entire length of the visor. Cut-a-way type visors shall be provided for each lens of optically programmed sections only where specifically required as indicated in the contract documents.

c. Mastarm mounted vehicle heads shall be equipped with a backplate. The backplate shall provide a minimum of 5 inches (125 mm) of black field around the assembly.

3. Pedestrian Signals.

Meet the following requirements:

a. Pedestrian signals shall consist of two signal sections with rectangular lenses and mounting attachments as shown in the contract documents. The upper section shall display a DON'T WALK symbol, and the lower shall display a WALK symbol. The two sections are to be of such design and construction as to fit rigidly and securely together with or without a spacer. Any space shall be no more than 0.5 inch (13 mm) thick. These signals are intended to operate with incandescent lamps.

b. The lenses shall be either sanded or prismatic lenses of nominal 9 inch or 12 inch (225 mm or 300 mm) size, as indicated in the contract documents. The lenses shall be made of vandal resistant

polycarbonate or acrylic plastic. The symbols on these lenses shall be designed to produce maximum legibility both day and night. The WALK symbol shall be Lunar White, and the DON'T WALK symbol is to be Portland Orange. Both messages shall be screened on the lenses with a material which will not crack or peel. The background or field around both messages is to be black.

c. Each signal lens shall be equipped with a visor which encloses the top and both sides of the lens.

4. Traffic Signal Lamp.

All traffic signal lamps shall have a standard, medium brass screw base and a clear glass envelope. The light center length (L.C.L.), or the dimension, in inches (millimeters), from the center of the filament to the tip of the base, is to be in compliance with the following design requirements:

a. 67 Watt series (9 inch (225 mm) pedestrian heads)

- Light center length 2 7/16inch (62 mm)
- Rated life hours 8000 hours
- Rated initial lumens 665 lumens
- Minimum initial lumens 595 lumens
- Rated voltage 120 volts

b. 150 Watt series (for 12 inch (300 mm) traffic and pedestrian heads)

- Light center length 3 inch (75 mm)
- Rated life hours 6000 hours
- Rated initial lumens 1950 lumens
- Minimum initial lumens 1745 lumens
- Rated voltage 130 volts

5. Optically Limiting Signals.

a. General.

Ensure the signal permits the visibility zone of the indication to be determined optically without a need for hoods or louvers. The projected signal may be visible or selectively veiled anywhere within 15 degrees of the optical axis. No indication is to result from external illumination, nor is one indication to illuminate a second.

b. Optical System.

Meet the following requirements:

1) The components of the optical system are to consist of:

Lamp
Circlet Reflector
Optical Limiter-Diffuser
Objective Lens

2) The lamp shall be a nominal 150 watt, 120 volt AC, three prong, sealed beam having an integral reflector and an average rated life of 6,000 hours.

3) A circlet reflector with a specular inner surface is to mate the lamp to the diffusing element.

4) The optical limiter-diffuser combination shall provide an imaging surface, at focus on the optical axis for objects 900 feet to 1,200 feet (270 m to 370 m) distance. It is also to permit an effective veiling system to be variously applied as

determined by the desired visibility zone. The optical limiter-diffuser shall be provided with positive indexing means and to be composed of heat resistant glass.

5) The objective lens shall be a high resolution planar incremental lens, hermetically sealed within a flat laminate of weather resistant acrylic. The lens shall be symmetrical in outline and may be rotated to any 90 degree orientation about the optical axis. Lens colors shall comply with ITE transmittance and chromaticity standards.

c. Castings.
Ensure cast aluminum parts comply with ITE alloy and tensile requirements and have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be finished with a high quality flat black enamel prime and finish system. The lens cover and the interior of the case shall be optical black. Hinge and latch pins shall be stainless steel. All access openings shall be sealed with weather resistant rubber gaskets.

d. Visors.
Ensure visors are 9 1/2 inch (240 mm), cut-a-way visors, are optical black, and are attached to all optically limiting signals for this project.

e. Installation.
Install, direct, and veil the signal according to published instructions and the Engineer's approval. Mask each section of the signal as required with prescribed materials in an acceptable and competent manner.

6. Pedestrian Push Button Detectors.
Furnish pedestrian push button detectors of the direct push contact type without levers, handles, or toggle switches. Meet the following requirements:

a. Each detector shall consist of a removable contact assembly mounted in a durable metal case.

b. The contacts shall be entirely insulated from the case and operating button with terminals for making connections.

c. The case shall have one outlet for 0.5 inch (13 mm) pipe.

d. The operating button is to be made of brass or other nonrusting metal alloy and be of sturdy design.

e. This button shall be weatherproof and is not to protrude out from the case.

f. The entire assembly shall be weather tight, secured against electrical shock and of such construction to withstand continuous hard usage.

g. The contacts shall be normally open, with no current flowing except at the moment of actuation.

H. Signal Supports (Single Tubular Mastarms and Poles).

1. General.
Meet the following requirements:

a. Furnish mastarms and support poles that are continuous tapered, round steel poles of the anchor base type as shown in the contract documents. The poles and mastarms shall be fabricated from one length of steel sheet with one continuous arc welded vertical seam, unless approved otherwise by the Engineer.

b. Unless specified otherwise, the poles and mastarms shall be fabricated from low carbon steel (maximum carbon, 0.30) of U.S. standard gage The base and flange plates shall be of structural steel complying with AASHTO M 183 (ASTM A 36/A 36M) and cast steel complying with ASTM A 27/A 27M, Grade 70-36 or better.

c. When specifically required, the poles and mastarms shall be fabricated from corrosion resistant steel meeting requirements of ASTM A 595, Grade C, and A 606, Type 4 sheets (with minimum chemical requirements of ASTM A 588/A 588M, Grade D). The base and flange plates shall be fabricated from A 588/A 588M structural steel.

d. After manufacture, poles and mastarms shall have a minimum yield strength of 48,000 psi (330 MPa).

e. It may be permissible to fabricate poles and mastarms by welding two sections together. The method used for connecting the sections shall result in a smooth joint and be factory welded.

- **1)** Longitudinal butt welds, except within 1 foot (0.3 m) of a transverse butt-welded joint, shall have a minimum 60% penetration for plates 3/8 inch (10 mm) and less in thickness, and a minimum of 80% penetration for plates over 3/8 inch (10 mm) in thickness.
- **2)** Longitudinal butt welds on poles and arms within 1 foot (0.3 m) of a transverse butt-welded joint shall have 100% penetration.
- **3)** Transverse butt welds for connecting sections shall have 100% penetration achieved by back-up ring or bar.
- **4)** Transverse butt welds and all specified 100% penetration longitudinal butt welds on poles and mastarms shall be examined 100% by ultrasonic inspection.

f. In addition, welding, fabrication, and inspection shall comply with Article 2408.03, B.

g. Personnel performing nondestructive testing are required to be qualified according to the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A and applicable Supplements B (Magnetic Particle) and C (Ultrasonic). The welding consumables used shall comply with Materials I.M. 559.

h. The poles and mastarms shall be designed to support traffic signals, luminaires, and/or signs as shown in the contract documents. They shall be certified by the fabricator that the poles and mastarms are capable of withstanding winds up to 100 mph (160 km/h) without failure.

i. The poles and mastarms shall be galvanized inside and out according to ASTM A 123.

j. Erect all poles vertically, unless otherwise specified.

- **1)** Securely bolt bases to the cast-in-place concrete foundations.
- **2)** Perform leveling using two nuts on each anchor bolt. One nut shall be turned on each anchor bolt and the pole placed in

position on these nuts. The top nut shall then be turned into place loosely and the pole adjusted to the vertical position by adjusting both the upper and lower nuts.

3) After leveling the poles, trowel mortar between the pole base and the foundation. Use expansive type mortar. Neatly finish exposed edges of mortar.

4) Ground each pole by installing a No. 6 AWG bare copper ground wire between the pole and the ground rod according to Article 2523.03, M.

5) Perform electrical tests according to Article 2523.03, U.

2. Concrete Bases for Poles.

a. For the forms, use material of sufficient thickness to prevent warping or other deflections from the specified pattern.

b. Set the forms level, and provide means for holding them rigidly in place while the concrete is being deposited.

c. Rigidly install all conduit, ground rods, and anchor rods in place before concrete is deposited in the forms.

d. Place anchor bolts according to Article 2405.03, H, 3. Set anchor bolts for the signal poles in place by means of a template constructed to space the anchor bolts according to the manufacturer's requirements.

e. The center of the template and the center of the concrete base are to coincide.

f. For concrete, apply Section 2403.

g. Finish the top of the base to be level and round the top edges with an edger having a radius of 0.5 inch (13 mm).

h. Set the top of pole bases flush with the sidewalk or pavement surface. When installed in an earth shoulder away from the pavement edge, set the concrete base so the top is approximately 4 inches (100 mm) above the surface of the ground. Finish the exposed surface of the base with a wood float.

3. Hardware.

Ensure mastarms and poles are equipped with all necessary hardware, shims, and anchor bolts to provide for a complete installation without additional parts. The fabricator shall submit drawings for anchor bolts and base design. All hardware shall be steel, hot-dipped galvanized according to ASTM F 2329; or ASTM B 695, Class 50, Type I coating, or shall have an electro deposited coating of the same coating thickness, and so designed for this purpose.

a. Anchor Bolts.

- Full-length, full-body diameter, hot-dip galvanized meeting the requirements of ASTM F 1554, Grade 105 (724 MPa).
- Threaded a minimum of 6 inches (150 mm) at one end, with a 4 inch (100 mm) long, 90 degree bend at the other end.
- Unified Coarse Thread Series with Class 2A tolerance.
- The end of each anchor bolt shall project from the concrete color coded in red to identify the grade.

b. Nuts.
- Heavy hex meeting the requirements of ASTM A 563, DH.
- May be over-tapped according to the allowance requirements of ASTM A 563.

c. Washers.
Meet the requirements of ASTM F 436.

4. Aluminum Traffic Signal Pedestal.
Meet the following requirements for the pedestal shaft:

a. Fabricated from tubing with a wall thickness of no less than 0.125 inches (3 mm).

b. Equipped with a cast aluminum base with a handhole. The size of the handhole shall be at least 4 inches by 6 inches (100 mm by 150 mm). It shall be equipped with a cover which can be securely fastened to the shaft with the use of hand tools.

c. The top of the shaft shall have an outer diameter of 4.5 inches (115 mm).

I. Testing of Signal Equipment.

1. After the project is open to traffic, notify the Engineer in writing of the date the signal or signal system will be ready for testing. Upon concurrence of the Engineer, place the signal or signal system in operation for a consecutive 30 calendar day test period. If the signal is to operate independently of other signals or signal systems, test it as a single installation. If the signal is part of a system, do not start the test period until all signals in the system are ready to be tested. Test a system as a unit. Correct all failures or malfunctions of the equipment during the test period at no additional cost to the Contracting Authority. The Contractor will not be required to pay for energy consumed by the system, and working days will not be charged during this testing period.

2. Secure the services of an authorized factory representative of the controller manufacturer to check out the system and to make all necessary adjustments at the time the equipment is turned on in order to get all specified functions of the equipment working properly. The factory representative shall have on hand, at the time the equipment is turned on, the necessary tools, test equipment, spare modules, spare detector amplifiers, and other miscellaneous parts and equipment to check out the system and make all necessary adjustments. Notify the Engineer at least two business days prior to turn on so the Engineer may be present at the turn on.

J. Certification of Equipment.
Supply certification from the manufacturers of all electrical equipment, signal supports, conduit, and cable stating the materials comply with the specifications.

K. Documentation.

1. With each signal system, provide file documentation packages which consist of the following:
- **a.** Complete schematic diagram, accurate and current for units supplied.
- **b.** Complete physical description of units.
- **c.** Controller printout or equal documentation of initial controller settings installed in the field or in the office.
- **d.** Complete installation procedure and performance specifications, both electrical and mechanical, for loop detector amplifier units.
- **e.** Complete maintenance and trouble-shooting procedures.
- **f.** Standard industry warranties on units supplied.
- **g.** Complete parts list identifying full names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA, or EIA.
- **h.** Pictorial of components layout on chassis or circuit board.

2. Include at least one full package in each controller cabinet and provide the Engineer with one full package.

2525.04 METHOD OF MEASUREMENT.
None. Plan quantities are for estimating purposes only, and these quantities will not be paid for separately.

2525.05 BASIS OF PAYMENT.

A. Payment for Traffic Signalization will be made at the lump sum contract price.

B. Removal of the existing traffic signal installation will be paid for at the lump sum price for Removal of Traffic Signalization. The lump sum price for Removal of Traffic Signalization will be full payment for the removal of all traffic signal poles, signal pole footings, overhead wires, handholes, and controllers. Removal of underground wire, cable, and conduit will not be required.

Section 2526. Construction Survey

2526.01 DESCRIPTION.
Perform survey for construction projects.

2526.02 MATERIALS.
None.

2526.03 SURVEY.

A. Furnish all survey necessary for construction of the project before work begins in the area. Do not apply the provisions of Article 1105.06 to this work, except to preserve the original stakes set by the Engineer. If, in the

opinion of the Engineer, the Contractor has destroyed or disturbed any of the original survey stakes or benchmarks, the cost of replacing will be charged to the Contractor. Bring design errors discovered to the Engineer's attention for review prior to staking. Construction survey includes qualified personnel, equipment, and supplies required for, but not limited to, the following items:

1. Project Control.

a. Primary Control Monuments.

A primary control monument is a survey point the Contracting Authority establishes prior to project commencement. These are shown in the contract documents. The point will be established by placing a monument in the ground.

b. Secondary Control Monuments.

A secondary control monument is a survey point the Contractor establishes on grading or other projects specified in the plans, and preserves on all other projects.

1) The Engineer will provide monuments, similar to those the Department uses for Global Positioning System (GPS) control.

2) Place secondary permanent horizontal control monuments, under the Engineer’s direction, at locations likely to survive project construction and at intervals not to exceed 2640 feet (0.8 km). Place the monuments in the ground along the project corridor. Place at higher elevations along the corridor to provide a view of the immediate project topography and to provide for visible clear line of sight to the nearest secondary permanent control monument in either direction. Primary project monuments may be substituted if appropriate.

3) Plant secondary control monuments 1 to 4 inches (25 mm to 100 mm) below existing ground. Drive a metal fence post within 1 foot (0.3 m) to mark their location.

4) Carefully determine project coordinates relative to the nearest primary project control monument using project coordinate values the Engineer has provided. Ensure the resulting error radius of the secondary monument does not exceed 0.10 feet (30 mm) ±2 ppm relative to the primary control. Provide the Engineer with all the field data of the survey. The data may be either unedited printed or electronic formatted field data, or both. Provide the Engineer with an ASCII comma delineated file of the coordinates formatted as (Point Number, Northing, Easting, Elevation, Point Description, Feature).

5) Perform an independent traverse check between the secondary control monuments by observing distance and angular measurements or by use of GPS. Provide the Engineer with all the field data for the traverse check. The data may be either unedited printed or electronic file, or both. Provide the Engineer with a diagram indicating horizontal ground distances to nearest 0.01 foot (3 mm) and angles to at least the nearest 10 seconds between each secondary control monument. Ensure inverses between the coordinate pairs as determined in the previous paragraph do not exceed 0.10 feet (30 mm) of the direct measurements.

6) Replace secondary control monuments disturbed during construction activities using procedures outlined above, at no additional cost to the Contracting Authority.

c. Durable Physical Objects.

1) Using measurements to the nearest 0.10 foot (30 mm), reference each control monument to a minimum of three durable physical objects located 20 to 100 feet (6 m to 30 m) away from the monument. Durable physical objects could include trees, poles, fence posts, station marks in new roadway pavement, or metal fence posts.

2) Provide the Engineer with either a printed or electronic reference image (for example JPEG, TIFF, etc), or both, including each reference and project coordinate.

d. Benchmarks.

1) Establish permanent vertical control benchmarks at all bridges and reinforced concrete box culverts within the project. Use an Iowa DOT brass plug on bridge barrier rail or headwall of reinforced concrete box culvert to indicate the benchmark. If the Engineer approves, a sawn “X” on bridge barrier rail or headwall of reinforced concrete box culvert may be used.

2) Transfer all benchmark elevations from construction plan benchmarks to the permanent benchmarks using the three-wire method or by trigonometric leveling. Use temporary benchmarks of reasonable stability to preserve the plan benchmarks.

3) Provide the Engineer with all field benchmark elevation data. The data may be either unedited printed or electronic formatted, or both. Provide the Engineer with the project x and y coordinates of all benchmarks along with an ASCII comma delineated file of the coordinates formatted as (Point Number, Northing, Easting, Elevation, Point Description, Feature).

4) Ensure benchmark level loops do not exceed an error of 0.05 feet (15 mm) times the square root of the loop’s length in miles (kilometers). Distribute the error equally along the loop on all intermediate traverse/benchmark points.

2. Grading.

a. Survey right-of-way line between permanent right-of-way corners at 100 foot (20 m) intervals, or less if needed, including borrows, temporary easements, and right of entry. Mark these points by placement of a metal pin or wood hub, flat, and lath at the same location as the slope stakes. Clearly mark the flat with the station number, distance from centerline, and elevation (cut or fill) to subgrade.

b. Set slope stakes at 100 foot (20 m) intervals, or less if needed, for all embankment and excavation work including roadway, channel changes, and borrow areas. Interpolations may be necessary to match the cross-sections. Set the stakes at the toe of the foreslope or the top of the backslope, or both. Mark slope stakes with a flat and lath. Clearly mark the flat with the station location, distance, slope, and cut/fill information.

c. Set grade check stakes at 100 foot (20 m) intervals for bottoms of subgrade treatments. Set the stakes on centerline for two-lane roads and in the median for four-lane roads. Mark grade check stakes with a lath. Clearly mark the lath with the station location and cut or fill information.

d. Set finish grade stakes (blue tops) at 100 foot (20 m) intervals, or less if needed. Set the blue tops at each shoulder line and at each point where there is a change in cross slope. Mark blue tops with a wood hub and a stake chaser or similar type tassel.

e. Take original and final elevations of all borrows. Provide original and final graphical cross sections at 100 foot (20 m) intervals, or less if needed, suitable for use by the Engineer to calculate excavation quantities.

f. Set bridge berm slope stakes to establish all transitions, including the face of the berm. Set finish grade stakes (blue tops) on all roadway shoulder lines and roadway centerlines to project down the face of the bridge berm at the top, face of berm bench, and toe.

g. When Class 12 excavation is an item, take cross section elevations at 100 foot (20 m) intervals, or less if needed, and plot cross sections for use by the Engineer to calculate the excavation quantities.

h. Use a lath to locate, on each side of roadway at the right-of-way line, agricultural drain tile shown in the contract documents. Clearly mark lath to show station location, distance from centerline, tile size and type, and flowline elevation.

3. Bridges.

a. Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark flat with the pier/abutment station location, design number, and offset distance from centerline of the approach roadway.

b. Establish a minimum of three temporary benchmarks.

c. Mark location of test pile with a wood hub.

d. Perform an independent check of the above stakes.

e. Submit elevations of all completed substructure beam seats to the Engineer for review prior to installation of bearings and superstructure elements.

f. Take elevations of beams as erected. Provide the elevations to the Engineer for computation of finish elevations for deck construction. Locations for determining beam elevations are to be according to the plans.

g. Provide the Engineer with a copy of the staking diagram prior to commencing work.

4. Reinforced Concrete Box Culverts.

a. Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, design number, cut/fill elevation, and offset distance from the centerline of the culvert and back of parapet.

b. Perform an independent check of the above stakes.

c. Provide the Engineer with a copy of the staking diagram prior to commencing work.
d. Report to the Engineer questionable flow lines and alignments that do not match existing drainage.

5. Pipe Culverts.
a. Mark locations and elevations with metal pin or a wood hub, flat, and lath. Clearly mark the flat with the station location, cut/fill elevation, and offset distance to both ends or centerline of pipe.
b. Report to the Engineer questionable flow lines and alignments that do not match existing drainage.

6. Sanitary and Storm Sewers.
Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, pipe number, cut/fill elevation, and offset distance to centerline of pipe.

7. Water Mains.
Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, pipe number, cut/fill elevation, and offset distance to centerline of pipe.

8. Intakes and Utility Accesses.
Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, intake or utility access number, cut/fill elevation (including bottom of well and form grade), and offset distance to the Station Location.

9. Pavements (PCC & HMA).
a. Mark locations and elevations with metal pin or tack in a wood hub (only tack one side), flat, and lath. Mark elevations on both sides of the pavement at 50 foot (10 m) intervals on straight and level sections and at 25 foot (10 m) intervals on horizontal and vertical curves. Clearly mark the flat with the station location, cut/fill information, and offset distance to the edge of pavement. Include pavement cross slope information in superelevated curves.
b. Take elevations of pavement centerline and both edges at bridges and existing pavement at 10 foot (3 m) intervals for 100 feet (30 m). Submit final elevations to the Engineer for approval.
c. When a new profile grade is not included in the contract documents:
1) Obtain elevations of the existing shoulders and/or pavement as stated in Article 2526.03, A, 9.
2) Design a smooth profile grade line based on these elevations to provide the required pavement or shoulder thickness as detailed in the contract documents. This grade line shall tie into existing bridges, adjacent pavement and ramps, and provide the required pavement crown. Submit this proposed grade line to the Engineer for approval.

10. HMA Overlays

a. Reference and preserve existing control points located at each Point of Intersection (P.I.).

b. Obtain the Engineer's approval for the method used to reference points.

c. Reset Control Points after the work is complete.

11. PCC Overlays

a. Mark locations and elevations with metal pin or tack in a wood hub (only tack one side), flat, and lath. Mark elevations on both sides of pavement at 50 foot (10 m) intervals on straight and level sections and at 25 foot (10 m) intervals on horizontal and vertical curves. Clearly mark flat with the station location, cut/fill information, and offset distance to edge of pavement. Include pavement cross slope information in superelevated curves.

b. Take elevations of pavement centerline and both edges at bridges and existing pavement at 10 foot (3 m) intervals for 100 feet (30 m). Submit final elevations to the Engineer for approval.

c. When a new profile grade is not included in the contract documents:

1) Obtain elevations of existing pavement at centerline and both pavement edges for bonded overlays and projects including mainline stress relief course and/or pavement scarification.

2) Obtain elevations of existing pavement at centerline, quarter points, and both pavement edges for unbonded overlays and whitetopping projects when a stress relief course and/or pavement scarification are not included.

3) Obtain elevations at 100 foot (30 m) intervals on straight and level sections and at 50 foot (10 m) intervals on horizontal and vertical curves.

4) Design a smooth profile grade line based on these elevations to provide the required pavement or shoulder thickness as detailed in the contract documents. This grade line shall tie into existing bridges, adjacent pavement and ramps, and provide the required pavement crown. This proposed grade line shall be submitted to the Engineer for approval.

d. Reference and preserve existing control points located at each Point of Intersection (P.I.).

e. Obtain Engineer's approval for method used to reference points.

f. Reset Control Points after work is complete.

12. Structural Walls.

a. Survey requirements for structural walls includes the following work types:

1) Mechanically Stabilized Earth (MSE) Walls.

2) Cast in Place (CIP) Retaining Walls.

3) Soil Nail Walls.

4) Tie Back Walls.

5) Noise Walls.

6) Modular Block Retaining Walls.

7) Segmental Retaining Walls.

b. Mark locations and elevations with a metal pin or a wood hub, flat, and lath. Clearly mark the flat with the station location, cut/fill elevation, and offset distance to face of wall.

B. Submit the method used to preserve project control to the Engineer for approval. Format the survey work documentation in a manner acceptable to the Engineer. Ensure survey work is completed by a Professional Engineer licensed in the State of Iowa in responsible charge or a Professional Land Surveyor licensed in the State of Iowa in responsible charge, according to the provisions of Chapter 542 B, Code of Iowa. Submit a resume to the Engineer identifying the field survey personnel and their capabilities to perform the intended requirements.

C. Obtain the Engineer's approval for the method of determining alignments and elevations and the method of preserving control points. This approval does not act to relieve the Contractor of the responsibility for the correctness of the survey work. Do not use plan cross-sections for vertical or horizontal control.

D. The Engineer will provide bench mark elevations, right-of-way corners, and reference control points on the original survey as shown in the contract documents. A GeoPak alignment will be provided if available.

E. Check tie-ins with existing roadways for correctness of alignment prior to construction staking.

F. When survey work is done under traffic, detail sheets in the contract documents will establish the required signing.

G. Establish benchmarks in the adjacent area before installing settlement plates in accordance with Article 2526.03, A, 1, d.

1. Obtain Engineer's approval for method of determining alignments and elevations and the method of preserving control points. This approval does not relieve Contractor of the responsibility for correctness of survey work.
2. Do not use plan cross-sections for vertical or horizontal control. The Engineer will locate and determine elevations of settlement plates.

H. Replace land corners and permanent reference markers unless stated otherwise in the contract documents.

I. All survey work documentation becomes the property of the Contracting Authority. The work of this specification will be considered finished when the documentation is furnished to and accepted by the Engineer.

J. For the purpose of subcontracting, this item will be considered a specialty item.

2526.04 METHOD OF MEASUREMENT.
None. Lump sum item.

2526.05 BASIS OF PAYMENT.

1. Payment for Construction Survey will be paid for at the lump sum contract price.

2. Payment is full compensation for the survey work required for the project as let, including any interpolations that may be necessary between cross-section and field staking.

3. Payment for revisions after the letting will be paid for according to Article 1109.03, B.

Section 2527. Pavement Marking

2527.01 DESCRIPTION.

A. Furnish, install, maintain, and remove permanent or temporary pavement markings, temporary delineators, and raised pavement markers, such as for:

1. Diversions and on site detours where the need for this work is anticipated as part of the traffic control plan to accommodate traffic during construction.

2. Replacing markings obliterated during construction activities on roads open to public traffic.

3. Changing markings on roads open to public traffic where the necessary changes result from staged construction.

4. Replacing markings that are obsolete.

5. Marking completed pavement surfaces.

B. Permanent pavement markings are those intended to remain in place after the project is completed. Temporary markings are those that are designated for removal, those that will be obliterated during construction, or those that require changes during construction.

C. Diversions are installations or modifications for the transfer of traffic on four lane or wider roadways to lanes which would normally carry traffic in the opposite direction. Diversions provide for continuous but restricted traffic flow from both directions for divided highways. Diversions usually include crossovers.

D. On site detours are temporary roadways specifically constructed to accommodate traffic during construction.

2527.02 MATERIALS.

A. Use pavement marking materials that provide markings readily visible when viewed in daylight and with vehicular headlights at night.

B. The marking materials used for temporary pavement marking include removable marking tape, traffic paint, temporary delineators, and raised pavement markers. Unless specified otherwise, the marking materials used for permanent pavement marking include regular marking tape, traffic paint, and preformed polymer pavement marking material.

C. Other marking materials, such as: epoxy, polyester, or thermoplastic, etc.; may be specified in the contract documents.

D. Materials for pavement markings are described below:

1. Removable Marking Tape.

a. Meet the requirements of Article 4183.06, A. and prequalified for use according to Materials I.M. 483.06.

b. Complying with the following:

1) Nominal width of 4 inches (100 mm).

2) Yellow or white, weather and traffic resistant film, precoated on one side with a pressure sensitive adhesive.

3) Flexible and formable.

4) Capable of remaining in place during its useful life.

5) Easily removed from the pavement at any time.

2. Traffic Paint.

a. General.

1) Use painting equipment complying with the following:

a) Capable of placing two lines simultaneously with either line in a solid or intermittent pattern in yellow or white.

b) Capable of applying glass beads at the required rate.

c) All guns in full view of the operator at all times.

d) Equipped with a metering device to register the accumulated length for each gun, each day.

e) Designed so that the pressure gages for each proportioning pump are visible to the operator at all times during operation to monitor fluctuations in pressure.

2) Apply reflectorizing spheres meeting requirements of Section 4184 to the painted lines. Apply the paint without dilution using mechanical equipment intended for that purpose. Apply the reflectorizing spheres immediately to the wet paint with a pressurized system.

b. Waterborne and Solvent-based Paint.

1) Meet the requirements of Section 4183 for fast dry paint.

2) Use the nominal application paint and glass bead rates shown in Tables 2527.02-1 and 2527.02-2:

Table 2527.02-1: Waterborne Paint

Line Width	Wet-Film Thickness	Paint	Spheres
4" (100 mm)	14 mils (0.35 mm)	343.7 ft. of solid line per gallon of paint. (27.68 m of solid line per liter of paint.)	9.0 lb./gal. (1.08 kg/L)

Table 2527.02-2: Solvent-based Paint

Line Width	Wet-Film Thickness	Paint	Spheres
4" (100 mm)	16 mils (0.41 mm)	300.8 ft. of solid line per gallon of paint. (24.22 m of solid line per liter of paint.)	9.0 lb./gal. (1.08 kg/L)

c. Durable Paint Pavement Markings.

1) Meet requirements of Article 4183.04.

2) Provide the Engineer with a copy of the manufacturer's recommendations for applying the marking material. Install the marking material according to the product manufacturer's recommendations. Use the same binder thickness as applied on the National Transportation Product Evaluation Program (NTPEP) deck with a tolerance of 10%. The bead application rate, bead gradation, and bead coating is at the discretion of the Contractor. Use an appropriate bead package to consistently meet or exceed the minimum retroreflectivity requirements.

3) Demonstrate to the Engineer at the start of the project the ability to meet the retroreflectivity requirements of these specifications when tested according to Materials I.M. 483.04. The Engineer may also require the Contractor to demonstrate the ability to meet the initial retroreflectivity requirements if there is a change in equipment, materials, or a delay of more than 2 months in completing the project.

4) Final acceptance will be based on compliance with these specifications. Ensure the markings meet the following retroreflectivity requirements.

Minimum Coefficient of Retroreflected Luminance mcd/sq.ft./ft.-cdl. (mcd / m^2 / lux)	
White line, symbols, and legends	300
Yellow line	200

d. High-Build Waterborne Paint Pavement Markings.

1) Provide high build waterborne paint listed in Materials I.M. 483.03, Appendix C.

2) Supply Engineer with a copy of paint manufacturer’s recommendations for applying marking material. Include in recommendations minimum pavement temperature required for painting. Install paint according to manufacturer’s recommendations. Provide binder thickness of 0.022 inches ± 0.0025 inches (0.56 mm ± 0.06 mm). Bead application rate,

bead gradation, and bead coating is at the discretion of the Contractor. Provide a bead package that will ensure initial retroreflectivity requirements consistently at or above the minimum.

3) Demonstrate to Engineer at start of work the ability to meet initial retroreflectivity requirements.

4) Final acceptance will be based on compliance with these specifications. Ensure markings meet the following retroreflectivity requirements.

Minimum Coefficient of Retroreflected Luminance mcd / sq. ft. / ft.-cdl. (mcd / m^2 / lux)	
White longitudinal lines	300
Yellow longitudinal lines	225

The Engineer will use the procedure in Materials I.M. 386 to determine retroreflectivity.

3. Regular Marking Tape.

a. Meet the requirements of Article 4183.06, B. and prequalify regular marking tape for use according to Materials I.M. 483.06.

b. Comply with the following:

1) Nominal width of 4 inches (100 mm).

2) Yellow or white, weather and traffic resistant film on a conformable, metallic foil backing precoated with a pressure sensitive adhesive.

3) Flexible and formable, and following application, remains conformed to the texture of the pavement surface.

4. Temporary Delineators.

Meet the requirements of Article 4186.07. Mount on posts meeting the requirements of Article 4186.10 for delineator posts.

5. Raised Pavement Markers.

a. These markers are intended for temporary use to provide retro-reflective pavement markings. Place in addition to other pavement markings, when specified. Use markers for which the reflective surface or surfaces:

- Have a minimum area of 1/2 square inch (320 mm^2),
- Are of the color required, and
- Provide reflectance from approaching headlights.

b. Ensure markers that will be continually exposed to traffic, when installed, do not extend more than 3/4 inch (20 mm) above the pavement surface. Use markers that comply with Materials I.M. 483.07.

6. Channelizer Markers.

Use channelizer markers that comply with Materials I.M. 483.08.

7. Preformed Polymer Tape.

a. Use preformed polymer tape that:

- Consists of glass beads imbedded in a white or yellow polymer film,
- Is precoated with a pressure sensitive adhesive, and
- Has a nominal width of 4 inches (100 mm).

b. The contract documents will specify precut symbols and legends or tape to be made of preformed polymer marking material.

c. Use marking material that:

- Is capable of adhering to asphalt and PCC surfaces,
- Meets the requirements of Article 4183.06, C., and
- Is prequalified as a preformed polymer tape according to Materials I.M. 483.06.

8. Removable, Nonreflective, Preformed Tape.

Comply with the following:

a. Nominal width of 6 inches (150 mm).

b. Dark grey or black, weather and traffic resistant film.

c. Precoated on the bottom with a pressure sensitive adhesive.

d. The top of the tape embedded with skid resistant particles.

e. Flexible and conforming to the pavement surface.

f. Capable of remaining in place during its useful life.

g. Easily removed from the pavement at any time.

h. Does not damage or discolor the underlying pavement or pavement markings.

9. Profiled Pavement Marking Tape.

a. Use profiled pavement marking tape that:

- Consists of reflective beads imbedded in a white or yellow polymer film, which is precoated with a pressure sensitive adhesive,
- Is capable of adhering to asphalt and PCC surfaces,
- Meets the requirements of Article 4183.06, E., and
- Is prequalified as a profiled pavement marking tape according to Materials I.M. 483.06.

b. This marking tape has raised profiles which gives the tape higher initial retroreflectivity than the preformed polymer marking in Article 2527.02, D, 6.

c. The contract documents will specify precut symbols and legends or lane stripes to be marked with profiled pavement marking tape. Use lane stripes with a nominal width of 4 inches (100 mm).

10. Intersection Marking Tape.

a. Use intersection marking tape that:

- Consists of reflective beads and ceramic anti-skid particles embedded in a polymer film that is precoated with a pressure sensitive adhesive,
- Is capable of adhering to asphalt and PCC surfaces,
- Meets the requirements of Article 4183.06, E., and
- Is prequalified as a profiled pavement marking tape according to Materials I.M. 483.06.

b. This marking tape is intended for use in high wear and high shear areas such as cross walks, gore lines, and turn symbols at intersections.

c. The contract documents will specify precut symbols and legends or lane stripes to be marked with intersection marking tape. Use lane stripes with a nominal width of 4 inches (100 mm).

2527.03 CONSTRUCTION.

A. General.

1. The contract documents will specify the quantity, locations, and type of pavement markings required.

2. Table 2527.03-1 shows the minimum atmospheric and surface temperatures for application of pavement markings. Follow the manufacturer's written recommendations for other details of application.

Table 2527.03-1: Minimum Atmospheric and Surface Temperatures

Type of Marking	Oct. 23 to Apr. 7	Apr. 8 to Apr. 22	Apr. 23 to Oct. 7	Oct. 8 to Oct. 22
Waterborne Paint	not allowed	45°F (4°C)	45°F (4°C)	45°F (4°C)
Low Temperature Waterborne Paint with Rohm & Haas XSR Resin	35°F (2°C)	35°F (2°C)	35°F (2°C)	35°F (2°C)
Solvent Based Paint	no restrictions	no restrictions	(a)	no restrictions
(a) Solvent-based paint may be used only if temperature requirements can not be met.				

3. Follow the manufacturer's temperature restriction recommendations for tape and durable paint.

4. For all pavement markings, ensure the pavement surface is dry and free from dirt, dust, oil, curing compound, and other contaminates which may interfere with markings properly bonding to the surface. Ensure the clean surface is at least 1 inch (25 mm) wider than the anticipated marking. Shoot an air blast on the pavement surface immediately prior to placing the new marking. The air blast is not intended to remove large amounts of dust, but only a very small amount of residue that might be left from the removal and cleaning operation.

5. Ensure the following for all painted and taped pavement markings:

- Uniform thickness,
- Uniform distribution of glass beads throughout the line width,
- Line widths as specified, with a tolerance of ± 1/4 inch for 4 inch (± 6 mm for 100 mm) lines and ± 1/2 inch (13 mm) for wider lines,

- Symbols and Legends are visually proportional to contract documents with an out-to-out tolerance of ± 6 inches (150 mm), and
- Markings have sharp edges and cutoffs at the ends.

6. For tape products, follow the manufacturer's recommendations for surface dryness, primers, adhesives, and other surface preparation requirements. Unless specified otherwise by the tape manufacturer, meet the following test for determining surface dryness before applying the tape:

a. In an area of direct sunlight where the tape will be applied, place an 18 inch x 18 inch (450 mm x 450 mm) piece of polyethylene (a green or black garbage bag may be used). There should not be any holes or tears in the polyethylene.

b. Tape down all the edges of the polyethylene sheet to seal all the edges and not allow any air movement to get under the polyethylene.

c. Firmly tamp the tape using the tamper cart or by foot tamping.

d. Allow 20-25 minutes for the polyethylene to be exposed to the direct sunlight.

e. Remove the polyethylene from the road surface. If no moisture is present on the under side of the polyethylene or on the road surface, the tape can be applied.

f. If any moisture is present, allow another hour to pass and repeat the test until no moisture is found.

B. Traffic Control.

Apply the provisions of Section 2528 to traffic control for removing and placing painted and taped pavement markings, along with the following additional requirements:

1. Place traffic control devices on the roadway before removal operations have commenced. Leave traffic control devices in place through the completed curing time of the newly applied pavement markings.

2. Do not close any longer length of lane than can be adequately removed and replace in a single working day.

3. For painted pavement markings, do not remove traffic control devices until the newly applied pavement markings are tack free.

C. Removal of Pavement Markings.

1. Promptly remove, on the same day new lines are placed, all existing pavement markings in the newly marked traffic lanes that are confusing, conflicting, or misleading to traffic. The Engineer may designate other pavement markings for removal to maximize the effectiveness of the traffic control plan.

2. Upon completion of the project, remove all new pavement markings which are applied according to this specification and would change the

color or placement of existing standard pavement markings. Removal may also be required during progress of the work if lines that are no longer needed cause confusion in traffic delineation.

3. Remove existing painted pavement markings so that 90% or more of the pavement is visible. Tightly adhering markings may remain in the bottom of the tining and other depressions on the pavement surface but shall not be visible to the motorist during daytime or night time. Remove tape markings according to the manufacturer's recommendations. Ensure removal processes do not cause functional damage to the transverse or longitudinal joint sealant materials.

4. Conduct pavement marking removal operations in a manner so that the finished pavement surface is not damaged or left in a pattern that may mislead or misdirect the motorist. When the operations are completed, power broom the pavement surface. Remove all marking removal debris from the pavement surface before the pavement is open to public traffic.

5. Perform pavement marking removal to a width no less than the width of the existing or new pavement markings plus 1 inch (25 mm). When symbols or legends are removed, remove the entire area of the existing symbol or legend; in a rectangular shape so no directionality may be observed from the removed symbol or legend.

6. Removal will not be required prior to being covered by a construction process unless specified in the contract documents. Removal of pavement markings may be by vacuum blasting, vacuum dry grinding, wet grinding, shot blasting, or high pressure water blasting. Open abrasive blasting or dry grinding without containment will not be allowed.

7. In lieu of physical removal, existing pavement markings may be covered by removable, nonreflective, preformed tape that is prequalified according to Materials I.M. 483.06 and meets the requirements of Articles 2527.02, D, 7, and 4183.06, D.

8. Ensure pavement marking removal equipment:
- **a.** Operates without the release of dust,
- **b.** Recovers all removed material, and
- **c.** Includes a waste collection and transfer system and for dry wastes, ensure the system incorporates HEPA methods and equipment.

9. Removal operations may be halted if the process and final result is not acceptable to the Engineer.

10. Remove collected material and dispose of according to applicable Federal and State regulations.

11. Remove temporary delineators, posts, and raised pavement markers when their need no longer exists or when directed by the Engineer.

D. Permanent Pavement Marking.

1. When permanent marking is required, place:
- Center lines, lane lines, no passing zone lines, and edge lines,
- Barrier lines and transverse lines,
- Symbols and legends, and
- Other markings required by the contract documents or by the Engineer.

2. Permanent marking will normally be required, according to this specification, for all projects on which public traffic is allowed during construction.

3. Accurately place all lines to a close tolerance using a guide extending at least 3 feet (1 m) ahead of the machine. The location of edge lines may be referenced to the pavement edge. The locations of other longitudinal lines may be referenced to accurately located longitudinal joints. Where such references do not exist or are not reliable, locate the lines as follows:
- **a.** For straight or nearly straight lines, reference the locations to a stringline set between marking line points.
- **b.** For curves, reference the locations to closely spaced marking line points. For sharp curves, a spacing of 10 feet (3 m) may be required.
- **c.** Other equally effective systems the Engineer approves.

E. Temporary Pavement Marking.
The location of temporary pavement marking will be shown in the contract documents or as directed by the Engineer. Temporary pavement marking includes:

1. Diversions.
Temporarily mark roadways as follows:
- **a.** Mark the traffic lane or roadway for traffic that is not diverted with a continuous yellow inside edge line in the approach taper, continuing as a no passing zone line through the diversion along the existing lane line.
- **b.** For traffic that is to be diverted:
  - **1)** Place a continuous yellow line as a left edge line through both crossovers, continuing as a no passing zone line through the diversion.
  - **2)** Place a white edge line on the right pavement edge through the diversion and both crossovers.

2. On Site Detours.
- **a.** Mark on site detours for two way traffic with two continuous no passing zone lines near the center of the roadway and two continuous white edge lines, one at each pavement edge.
- **b.** Mark on site detours for one lane traffic with two continuous white edge lines, one at each pavement edge.

3. Marking Changes Resulting from Stage Construction.
On all sections of Primary Road open to traffic during construction activities, place center lines, lane lines, no passing zone lines, and edge lines necessary for the construction stage as shown in the contract documents or as directed by the Engineer.

4. Temporary Delineators.
Erect temporary delineators (when required) as shown in the contract documents. Temporary delineators will usually be single, white reflectors which are to be placed:

- 2 feet (0.6 m) beyond the outside edge of the shoulder, and
- 4 feet (1.2 m) above the edge of the pavement on delineator posts.

5. Raised Pavement Markers.

a. Place raised pavement markers parallel to the line being marked at that location. Place according to the manufacturer's recommendations, subject to the Engineer's approval.

b. For pavement crossovers, supplement the white and yellow edge line with raised pavement markers, spaced at 10 feet (3 m) on center, from the beginning of the lane reduction taper through the reverse curves of the crossover.

F. Markings Obliterated during Construction.

1. On sections of pavement open to traffic, place pavement markings where operations have obliterated existing markings.

2. Replace pavement markings before the lane or road is opened to traffic in the following situations:

a. Multi-Lane Roads:

1) Divided.

a) Lane lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated for 50 feet (15 m) or more.

2) Undivided (Three or More Lanes) or Road with Continuous Two-Way Left-Turn Lane.

a) Lane lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated for 50 feet (15 m) or more.

c) Center lines obliterated for 50 feet (15 m) or more.

b. Two Lane Roads:

1) Paved Shoulder More Than 2 Feet (0.6 m).

a) Center lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated for 50 feet (15 m) or more.

c) No Passing Zone lines obliterated.

2) Paved Shoulder 2 Feet (0.6 m) or Less.

a) Center lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated on curves with a radius of 1,000 feet (300 m) or less.

c) Edge lines obliterated at bridge approaches, or other obstructions within 3 feet (1 m) of the roadway, for 300 feet (90 m) or more.

d) No Passing Zone lines obliterated.

3. Within 3 working days from the day the pavement and shoulder work are completed for the project, place edge lines that are not required to be placed before the lane or road is opened to traffic. Place remaining pavement markings within 3 working days from the day the road work is completed for the project.

4. Place symbols and legends within 5 working days from the day the road is open to traffic.

G. Defective Pavement Markings.

1. Markings that are low on initial retroreflectivity up to 20% may, at the discretion of the Engineer, be accepted with a price adjustment.

2. Repair, at no additional cost to the Contracting Authority, all pavement markings which, after application and curing, the Engineer determines to be defective and not in conformance with these specifications. Remove the defective markings completely and clean to the underlying pavement surface according to the requirements of Article 2527.03, C. Remove the defective area plus all adjacent marking material extending 1 foot (300 mm) in any direction. After surface preparation work is complete, finish the repair by reapplying new marking material over the cleaned pavement surface according to the requirements of these specifications.

H. Grooving for Pavement Markings.

1. When specified, place pavement markings in a groove cut into the pavement surface. Dry or wet cut the groove in a single pass, using stacked diamond cutting heads mounted on a floating head with controls capable of providing uniform depth and alignment. If dry cutting, use equipment that is self vacuuming. Use the equipment according to the manufacturer's recommendations.

2. Ensure the groove meets the following specifications:

a. Groove width.
Marking width plus 1 inch (25 mm) with a tolerance of minus 0.0 inches (0 mm) and plus 0.2 inches (5 mm).

b. Groove depth.
For profiled marking tape, a grooved depth of 0.080 inches + 0.010 inches (2.0 mm + 0.03 mm). For all other markings, a groove depth as recommended by the pavement marking manufacturer.

c. Groove length.
Full length of tape plus 3 inches (75 mm) minimum grooving transition on either end. Do not use a continuous groove for dash markings. When replacing existing dash markings, start cycle so most of the existing marking is removed with the groove. No additional removal of existing markings is required.

d. Groove position.
Minimum of 2 inches (50 mm) from edge of the longitudinal joint.

e. Finished surface.
The bottom of the groove should have a fine corduroy-like texture. The maximum allowable rise between the high and low points across the width of the groove is 0.010 inch (0.25 mm).

f. Groove cleaning.
Vacuum and broom dry cut grooves using a high pressure air blast for the final cleaning. If wet cutting is used, immediately flush the groove with water and recover the removed material. Allow the surface to dry to a visibly dry condition. Ensure the surface to receive the tape is free from dust, dirt, or other contaminates that may interfere with the tape properly bonding.

I. Limitations.

1. When pavement markings are required, coordinate their application with other construction work and associated traffic control changes.

2. Use removable tape for temporary pavement markings which extend diagonally across a final traffic lane.

3. When the installation of preformed polymer pavement marking material or profiled pavement marking tape is in conjunction with placement of HMA, inlay the tape by positioning it on the HMA prior to the final rolling. Perform the installation of the tape according to the manufacturer's recommendations. If grooving is specified, do not inlay the tape into hot HMA.

4. When pavement markings are placed on newly completed PCC pavements, remove the existing curing compound film from horizontal surfaces in these locations. Curing compound film need not be removed from curbs or other vertical surfaces. Remove the curing compound in a manner that does not damage the underlying PCC pavement.

5. Complete the placement of pavement markings before the lane, road, on-site detour, or diversion is open to traffic.

6. If unavoidable circumstances result in not being able to complete the pavement marking placement or removal specified for that day, provide traffic control until the pavement marking placement or removal work is completed.

J. Maintenance.

Maintain in good condition all pavement markings, symbols and legends, temporary delineators, and raised pavement markers for which the Contractor is responsible. Replace, if necessary, for the period of their intended use. Their condition is subject to review by the Engineer.

2527.04 METHOD OF MEASUREMENT.

A. Measurement for pavement markings, symbols and legends, temporary delineators, and raised pavement markers, satisfactorily placed or approved, will be as follows:

1. **Painted Pavement Markings.**
   Stations (meters) of the type specified placed with traffic paint. This includes both permanent and temporary pavement marking.

2. **Permanent Tape Markings.**
   Stations (meters) placed of the type specified in the contract documents.

3. **Removable Tape Markings.**
   Stations (meters) placed. Removing removable tape will not be measured separately for payment.

4. **Painted Symbols and Legends.**
   By count for the type specified complete as a unit placed with traffic paint.

5. **Precut Symbols and Legends.**
   By count for each complete unit placed with the marking tape specified in the contract documents.

6. **Temporary Delineators.**
   By count.

7. **Raised Pavement Markers.**
   By count.

8. **Pavement Markings Removed.**
   Stations (meters). Pavement markings obliterated during construction, that are of removable marking tape, or removed by the Contractor on the Contractor's own accord, will not be measured separately for payment.

9. **Symbols and Legends Removed.**
   By count. Symbols and legends obliterated during construction or removed by the Contractor on the Contractor's own accord, will not be measured separately for payment.

10. **Removable, Nonreflective, Preformed Tape.**
    Stations (meters) of Removable, Nonreflective, Preformed Tape placed. Removal of the tape will not be measured separately for payment.

11. **Grooves Cut for Pavement Markings.**
    Stations (meters). This quantity will be equivalent to the number of stations (meters) measured for the Pavement markings. Additional width and transition length will be incidental.

12. Grooves Cut for Symbols and Legends.
By count for grooves cut for profiled marking tape. Each symbol or legend groove will be counted as a complete unit.

B. The Engineer will measure the number of stations (meters), based on a single 4 inch (100 mm) width, of painted, taped, and/or removed line. The length of each type of markings will be determined using beginning and ending points, and adjusting for breaks at side roads, median crossings, station equations, or other locations shown in the contract documents. The measurement for dashed and dotted lines will be adjusted to exclude skips. Measurement of lines wider than 4 inches (100 mm) will be adjusted by the quantity factor to a 4 inch (100 mm) line.

2527.05 BASIS OF PAYMENT.

A. Payment for pavement marking, symbols and legends, temporary delineators, and raised pavement markers, satisfactorily placed or removed, will be at the contract unit price as follows:

1. Painted Pavement Markings.
Per station (meter) of the type specified, placed with traffic paint, including both temporary and permanent marking.

2. Permanent Tape Markings.
Per station (meter) placed for the type of marking tape specified in the contract documents.

3. Removable Tape Markings.
- **a.** Per station (meter) placed.
- **b.** Payment includes removing the removable marking tape, when required.

4. Painted Symbols and Legends.
Each.

5. Precut Symbols and Legends.
Each.

6. Temporary Delineators.
Each.

7. Raised Pavement Markers.
Each.

8. Pavement Markings Removed.
Per station (meter).

9. Symbols and Legends Removed.
Each.

10. Removable, Nonreflective, Preformed Tape.
- **a.** Per station (meter) placed.

b. Payment includes removal of the tape and repairing damage to the existing pavement markings caused by the tape.

11. Grooves Cut for Pavement Markings.
Per station (meter).

12. Grooves Cut for Symbols and Legends.
Each.

B. Payment is full compensation for:

- Cleaning and surface preparation,
- Application of temporary and permanent pavement markings, symbols and legends,
- Maintenance of pavement markings,
- Removal of pavement markings or symbols and legends,
- Installing or removing temporary delineators,
- Installing or removing raised pavement markers, and
- Furnishing all materials, equipment and labor, and disposal of material generated from the removal operations.

Section 2528. Traffic Control

2528.01 DESCRIPTION.

A. General.

1. This section describes various materials, equipment, and procedures involved in traffic control during construction. The Contractor and the Contracting Authority have certain responsibilities, whether public traffic is allowed or is prohibited during construction. Apply Article 1107.09.

2. The contract may include an item for traffic control. In this case furnish, erect, operate, maintain, move, and remove all traffic control devices required by the contract documents.

3. The contract may indicate that traffic control is incidental. In this case the Contracting Authority will furnish all signs and traffic control devices, except pilot car and flaggers' signs, and all Type III barricades, and associated mounting devices. Furnish all other traffic control devices required. Erect, operate, maintain, move, and remove all traffic control devices. Signs and barricades to be furnished by the Contracting Authority will be made available at a nearby maintenance site. Return the signs and barricades when no longer needed.

4. The contract documents may specify orange mesh safety fence be used in conjunction with other traffic control devices as part of the project traffic control requirements. Use orange mesh safety fence meeting the requirements of Article 4188.03. Securely support the fence so it is in a vertical position without any sagging. Locate and place the safety fence supports so they are not a safety hazard.

5. Ensure all traffic control complies with the current edition of the MUTCD, Part 6 as adopted by the Department.

6. On Interstate and Primary Road projects, use crashworthy Category I and Category II traffic control signs and devices that meet NCHRP Report 350.

7. Upon request provide the following to the Engineer for the purpose of documenting the crashworthiness of Category I and Category II signs and traffic control devices:
- **a.** The vendor's self-certification for Category I traffic control devices.
- **b.** FHWA NCHRP Report 350 approval memos for Category II signs and traffic control devices.

8. A list of approved Category II traffic control devices is found on the World Wide Web at the following URL: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/wzd/.

9. Gender specific signs, such as FLAGMAN and MEN WORKING, will not be allowed. Use neutral gender signs, for example FLAGGER, or equivalent symbol signs.

10. Provide ten calendar days advance notification of a pedestrian path closure to the following:
- Iowa Department of the Blind: Program Administrator of Field Operations and Access Technology, telephone: 515.281.1361, website: www.blind.state.ia.us.
- National Federation of the Blind of Iowa: President, telephone: 515.771.8348, website: www.nfbi.org.
- Engineer

B. Monitoring With Incident Response.

1. Provide 24 hour per day continuous monitoring of traffic control devices and incident response for emergency situations on projects during complex traffic situations as defined in the contract documents. The contract documents will identify projects requiring monitoring with incident response. Ensure a vehicle and operator traverses the project throughout the entire traffic control zone at all times, except for refueling and short rest breaks no greater than 15 minutes in duration.

2. Furnish this work according to the contract documents any time that signs, barriers, barricades, or other traffic control devices are in place during complex traffic situations.

3. Provide a vehicle and operator for this work as follows:

a. Equipment.

1) Meet the following requirements:

a) 3/4 ton (or metric equivalent) pickup truck or another similar vehicle.

b) Contractor's insignia on the vehicle.
c) Adequate weight and power and suitably equipped to move stalled automobiles or pickup trucks.
d) Equipped with an amber revolving light or amber strobe light visible in all directions and a cellular telephone or similar type of mobile phone.
e) Capable of carrying traffic signs, tools, traffic control devices, and other necessary equipment.

2) When used on projects where more than one lane in one direction is maintained at all times, ensure this vehicle is also be equipped with a Type C arrow panel as described in Article 2528.03, G, mounted to be visible to traffic approaching from behind.

b. Operation.

1) Furnish an operator for the vehicle. Ensure the operator re-erects, repairs, or replaces defective devices immediately upon discovery.

2) Have the operator:
a) Be available to assist persons with vehicle problems and move automobiles, pickup trucks and other obstructions so as to keep all travel lanes and shoulders available for public traffic.
b) Continue assistance to motorists and involvement with obstructions until they are no longer an impediment to traffic and further assistance can be provided safely by others.
c) Assist motorists or remove obstructions promptly and safely when a vehicle or anything else is obstructing a travel lane or shoulder intended to be clear.
d) Summon further assistance if needed.
e) Keep a report of any events that restrict the normal traffic flow during complex operations, including responses to emergency situations, on forms provided by the Engineer. Provide the Engineer with a copy of this report daily.

3) The Engineer may request to operate project related Portable Changeable Message Signs (PCMS) according to Article 2528.03, B, for advance traffic notification and warning. Authority to operate PCMS units will be under the direction of the Engineer according to the contract documents. Only the Engineer may add or modify any preprogrammed messages. The Contractor may only operate the CMS to display one of the preprogrammed messages.

4) During anticipated peak traffic times, the Engineer may direct the Contractor to provide additional monitoring personnel for PCMS operation and other traffic monitoring functions.

C. Traffic Quality Control.

1. Maintain a Traffic Control Technician on staff, even though the traffic control portion of the contract may be subcontracted. The Traffic Control Technician is required to have attended and passed the exam in an

ATSSA Traffic Control Technician, IMSA Work Zone Traffic Control, or Minnesota DOT Traffic Control Supervisor training class. This Traffic Control Technician is responsible for overall management of the Contractor's quality control program for traffic control.

2. On a daily basis as the project is constructed, perform the following quality control work associated with monitoring and documenting traffic control conditions:

a. Review all traffic control operations for compliance with contract documents and maintain a project traffic control daily diary in a format provided by the Contracting Authority. Submit this diary to the Engineer. It will become a part of the Contracting Authority's permanent project records. The Engineer may require submission of completed portions of the daily diary at routine intervals during construction of the project. In the diary include:

- Listing and station location of traffic control used each day referenced to the appropriate Standard Road Plan, project plan sheet, etc.,
- All reviews of traffic control devices and operations, whether satisfactory or unsatisfactory, and corrections made,
- Approved changes to the contract document's traffic control,
- Incidentals affecting the efficiency and safety of traffic, and
- A daily list of trained flaggers used, including hours worked.

b. Monitor traffic operations and submit proposed Traffic Control Plan changes to the Engineer for approval.

c. Coordinate all changes to the Traffic Control Plan.

d. Coordinate all traffic control operations, including those of subcontractors and suppliers.

2528.02 MATERIALS.

Use materials meeting the requirements of Part 6 of the MUTCD and Division 41 for the respective traffic control signs and devices.

2528.03 SIGNS AND DEVICES.

A. Signs.

1. Furnish signs that are of the size and type shown in the contract documents and use retroreflective sheeting meeting the requirements of Article 4186.03.

2. For Interstate and Primary projects, furnish diamond shaped warning signs that are 48 inches (1200 mm) by 48 inches (1200 mm) unless specified otherwise in the contract documents.

3. For traffic control zones in duration for 4 calendar days or more, mount signs on fixed posts.

4. Signs for traffic control zones in duration for less than 4 calendar days may be mounted on moveable skids or fixed posts.

5. Meet the following requirements for fixed post mounted signs:
- **a.** Sign sheeting applied to rigid wood or metal.
- **b.** Mounted at a height of at least 7 feet (2.2 m), measured from the bottom of the sign to the near edge of the pavement. A secondary sign on the same post may be mounted 1 foot (0.3 m) lower than specified above.
- **c.** A clear distance 2 feet (0.6 m) behind a curb or beyond the edge of the shoulder.

6. Meet the following requirements for moveable skid mounted signs:
- **a.** Flexible roll-up sheeting or other skid mounted sign systems that meet NCHRP 350 requirements.
- **b.** Mounted at a height of at least 1 foot (0.3 m) above the roadway.

7. Ensure mounting devices are not so substantial as to be a hazard to vehicles. Meet the following requirements for posts mounted in existing soil:
- **a.** Wood sign supports meeting the materials requirements of Article 4164.04.
- **b.** 3.0 pounds per foot (4.5 kg/m) U-shaped rail steel posts.
- **c.** 2 1/4 or 2 1/2 inch (60 mm or 65 mm) square 12 gage perforated steel tubing.

8. Dual-post and triple-post configurations using these sign supports are acceptable provided that no more than two posts occupy any 8 foot (2.4 m) wide path. Bracing of these posts will not be permitted. Posts exceeding these requirements shall have breakaway features approved by the Engineer.

9. Ensure signs are in a condition so they are effective for the intended purposes when viewed from a vehicle. For nighttime installations, ensure the reflectance is adequate so that the message is clearly readable. Ensure signs are maintained in a near vertical position.

10. When indicated in the contract documents, use supplemental sign flags in conjunction with work zone signing. Use sign flags 16 inches (400 mm) square and sheeted with red Type III or Type IV retroreflective sheeting meeting requirements of Article 4186.03.

11. On projects where two new lanes are being constructed adjacent to an existing two lane highway, place TWO WAY TRAFFIC (W6-3) signs. Place them off the right shoulder of mainline: 1) after each public side road for each direction of travel for traffic that may enter from all intersecting side roads; or 2) at 1/2 mile (0.8 km) intervals, whichever is less. Install these signs when grading activities start and leave in place until the entire four lane divided highway is opened to traffic. If the pavement is constructed under a separate contract, leave these signs in place after the grading contract is completed. They become the property of the Contracting Authority. The paving contractor then takes over these signs and removes them when the four lane divided highway is opened to traffic. Payment will be according to Article 2528.05, A.

12. When directed by the Engineer, cover or remove permanent signing that conveys a message contrary to the message of the temporary signing and not applicable to the working conditions.

13. The END ROAD WORK (G20-2) sign may be eliminated for mobile or short duration (less than 1 hour) temporary traffic control zones.

B. Portable Changeable Message Signs

Furnish, place, operate, and maintain PCMS at the locations shown on the plans. The Contractor maintains possession of the PCMS upon completion of the project.

1. Sign Design.

a. Trailer mounted signs. Message panel mounted at a height of at least 7 feet (2.2 m), measured from the bottom of the sign to the near edge of the pavement. Sign presents a level appearance. Sign is capable of displaying three lines of up to eight characters at one time. Character height is 18 inches (450 mm) and configured using a 7 pixel tall by 5 pixel wide font.

b. Message panel visible from 1/2 mile (800 m) under both day and night conditions. Letters legible from 750 ft (225 m). Message sign shall include automatic dimming for nighttime operation and a power supply capable of providing continuous 7 days (24 hours per day) service.

c. Message panel consisting of a line matrix or full matrix design controlled by an onboard computer capable of:

- Storing a minimum of 99 programmed messages for instant recall.
- Being programmed to accept messages created by the operator via an alpha-numeric keyboard.
- Being programmed by remote.

d. Physical access to the onboard computer protected by a padlock (using a key). Electronic access to the onboard computer protected by a username and password.

2. Operation of Signs.

a. Provide preventive maintenance efforts necessary to achieve uninterrupted service. If service is interrupted and not restored within 24 hours, the Engineer will cause such work to be performed as may be necessary to provide this service, at no additional cost to the Contracting Authority.

b. The Engineer may request the Contractor to operate PCMS for advance traffic notification and warning. Authority to operate PCMS will be under the direction of the Engineer. The Contractor may only operate the PCMS to display messages authorized by the Engineer.

c. Promptly program and/or reprogram the computer to provide the messages as directed by the Engineer.

d. Provide the Engineer with the username and password and two keys.

3. Internet Operation for Long Term Duration.

a. This section describes Internet operations for use of PCMS for long term duration. PCMS hardware and software that are required for Internet operation under this article will be considered extra work according to Article 1109.03, B.

b. Communication equipment at the sign, a web server at a central communications hub, and communications from the sign to the Internet are required.

c. Make an Internet web page available as the method for the Engineer to control the sign from the office. Choose software to control the signs that is not required to be installed on the Engineer's computer. Ensure the Internet web page performs the following functions:

- Displays the name of the sign.
- Shows the current display on the message board.
- Puts up a message using free text.
- Puts up a message by calling the onboard library of stored messages.
- Removes the current message.
- Displays the current voltage of the sign's batteries (if solar).

C. Channelizing Devices.

1. Use Channelizing Devices that are of the type shown in the contract documents. Use reflective sheeting meeting the requirements of Article 4186.03.

a. Barricades.

1) A 2 foot (0.6 m) minimum length barricade may be used when Type I or Type II Barricades are furnished as one of the options for channelizing devices in lieu of vertical panels, 42 inch (1050 mm) channelizers, cones, or drums.

2) Ensure Type III barricades have a minimum length of rail of 6 feet (1.8 m). When traffic is permitted in each direction around a Type III Barricade, ensure the Type III Barricade used has fully reflectorized faces on both sides of the rails.

3) Erect barricades in essentially a horizontal position perpendicular to the direction of approaching traffic. Ballast them so as not to cover any striped rail.

b. Cones, Vertical Panels, 42 Inch (1050 mm) Channelizers, Drums, and Tubular Markers.

1) Ensure cones, vertical panels, 42 inch (1050 mm) channelizers, drums, and tubular markers meet the current requirements of the MUTCD, and Section 4188.

2) When used to separate two way traffic, separate temporary no passing lines approximately 16 inches (400 mm), with the marker to be installed between these lines.

3) Ensure tubular markers meet the following:

a) Between 28 inches (710 mm) and 34 inches (865 mm) in height.

b) Diameter facing traffic at least 2 inches (50 mm) in width.

c) Completely faced with reflectorized white and orange sheeting that is in two bands 4 inches (100 m) wide with 6 inches (150 mm) between bands, with the top band no more than 2 inches (50 mm) from the top of the tubular marker.

4) Cones may be used as channelizing devices in tapers and along lane lines during daylight hours only.

5) 42 inch (1050 mm) channelizers may be used in place of drums in work areas remaining in place for up to three days. Spacing of channelizers shall be half the spacing required for drums or double the number of drums required.

2. Channelizing devices may be placed up to 2 feet (0.6 m) beyond centerline or lane line at specific locations where actual work activity is taking place. Return channelizing devices to the original position when the work activity has passed.

3. Individual channelizing devices may be omitted during working hours in areas where placement interferes with the work. Channelizing devices on tapers are required at all times.

4. Do not intermix channelizing devices of different types.

5. For pedestrian path closures, use Type III Barricades to block the full width of the pedestrian path. Mount a SIDEWALK CLOSED (R9-9) sign to at least one of the Type III barricades at each closure.

D. Pilot Cars.

1. Pickup trucks or automobiles displaying the Contractor's company insignia, equipped with G20-4 signs reading: PILOT CAR - FOLLOW ME. Ensure two signs are mounted on the vehicle so as to be clearly visible from both directions of traffic. Mount the signs so the bottoms are at least 1 foot (0.3 m) above the top of the vehicle's roof.

2. Operate pilot cars such that they maintain a uniform speed through the work area, no greater than 40 miles per hour (65 km/hr).

E. Temporary Barrier Rail.

Use temporary barrier rail as shown in the contract documents. Unless shown otherwise, use precast concrete units. Tie the units together as specified or as approved by the Engineer.

F. Modular Glare Screens.

1. When specified in the contract documents furnish, install, and maintain a modular glare screen system on the top of concrete barrier rail according to the contract documents and the modular glare screen system manufacturer's instructions. Furnish a system consisting of modular base units attached to the top of concrete barrier rail with

blades evenly spaced and securely mounted to the base units. Ensure the following:

- Modular base units and glare screen blades are compatible so the base unit and blades can be securely attached to each other.
- Base units and blades supplied are manufactured by the same manufacturer.
- The length of individual modular base units is no longer than the nominal length of individual temporary concrete barrier rail sections.
- The width of the modular base units is no wider than the top width of the concrete barrier rail.
- Glare screen blades are FHWA highway green in color and made of impact resistant non-metallic high density plastic material.
- Blade height is from 24 inches to 30 inches (600 mm to 750 mm) and width is from 6 inches to 9 inches (150 mm to 225 mm).
- The same uniform sized blades are used throughout the work.
- The modular glare screen system is manufactured by a company on the approved manufacturer's list in Materials I.M. 486.06, Appendix A.

2. Install the modular glare screen system according to the manufacturer's instructions and the approval of the Engineer. Install the system so that:

- It is centered along the longitudinal axis length of the top of the concrete barrier rail.
- The overhang of the base units, blades, and associated assembly over the edges of the top of the concrete barrier rail is kept to a minimum.
- The modular base units are flush with the top of the concrete barrier rail and they do not extend over the joints between concrete barrier rail sections.

3. Install glare screen blades so the combination of blade width and spacing provide for a minimum 22 degree sight cut-off angle.

4. At 10 foot (3 m) intervals along the glare screen installation, apply (appropriate to the direction of traffic) 3 inch by 6 inch (75 mm by 150 mm) yellow or white strips of Type III or IV retroreflective sheeting meeting the requirements of Section 4186 to the appropriate glare screen blades. Apply each strip at the vertical midpoint of the glare screen blade and to the side of the blade nearest to traffic. Apply the strip with the longer dimension vertical.

5. Maintain the modular glare screen throughout the work. Replace or repair damaged parts of the modular glare screen system, as soon as practical, at no additional cost to the Contracting Authority.

6. When moving temporary barrier rail with a modular glare screen system, the Contractor may temporarily remove base units and glare screen blades, if necessary, to assist in the moving. Reinstall the removed base units and glare screen blades as soon as the temporary concrete barrier rail has been moved to its new location.

7. Perform final removal of the modular glare screens from the concrete barrier rail when directed by the Engineer. Upon removal, ensure there are no protrusions on the top of the concrete barrier rail.

8. Upon completion of the work, the Contractor retains ownership of the modular glare screen system.

G. Lighting Devices.

1. Furnish lighting devices as required by the contract documents. Type A barricade warning lights will normally be required for nighttime installations. Type B warning lights will normally be required for 24 hour operation.

2. Use barricade warning lights that comply with the ITE Standard for Flashing and Steady Burn Barricade Warning Lights and are identified as such. In addition, use Type A barricade warning lights that:

- Operate on a 12 volt battery system, unless the ITE identification specifically indicates that the rating is based on a different system, and
- Are visible to both directions of traffic.

3. When arrow displays are used, furnish Type C arrow displays described in the current edition of the MUTCD, Part 6, and operate them in a sequential chevron mode when indicating a lane change.

H. Temporary Traffic Signals.

1. General.

a. Set up and operate temporary traffic signals as shown in the contract documents. Ensure the temporary traffic signal system meets the physical display and operational requirements of conventional traffic signals as specified in Part 4 of the MUTCD. Unless stated otherwise in the contract documents, either a span wire or trailer mounted temporary traffic signal system may be provided.

b. In the event any part of the temporary traffic signal system malfunctions or a continuous red flash mode is encountered, furnish flaggers on a 24 hour/7 day a week basis until repairs are made and the signals are fully functional. For temporary traffic signals at intersections, install stop signs on all approaches until the signals are fully operational, at no additional cost to the Contracting Authority.

2. Equipment.

a. Trailer or Span Wire Mounted Systems.

1) Furnish actuated signal controllers complying with NEMA and ITE standards. Ensure the temporary traffic signal system complies with the following:

a) Includes a solid state digital traffic signal controller capable of operating the signals according to MUTCD

requirements and NEMA Standard TS1. A copy of the manufacturer's certificate of compliance is to be posted in the control cabinet (in a weatherproof folder) and made available to the Engineer upon request.

b) Has conflict monitoring complying with NEMA Standard TS1 and the following:

- Detects the presence of conflicting signal indications, absence of proper voltages, and proper operation of the controller.
- Upon detection of a conflict or loss of communication, all signals enter into flashing red mode.

2) Apply Article 2525.03, E, 4, with the following exceptions for one lane two way traffic control:

a) **Green Revert.**
If during an All Red clearance interval a call occurs on the phase losing the right-of-way prior to a call on any other traffic phase, the right-of-way reverts to the previous traffic phase, initiating the initial green interval. The transfer is to be immediate without completing the All Red clearance interval.

b) **Rest in Absence of Actuation.**
In the absence of detector actuation of assertion or recall switch(es), the right-of-way indication dwells in All Red.

3) Comply with the following:

a) Clearance for overhead wiring is a minimum of 18 feet (5.5 m).

b) A detection area is located near the stop line with the downstream edge positioned 6 feet (2 m) from the stop line. A second detection area is located 100 to 150 feet (30 to 45 m) in advance of the stop line. The size of detection areas is 6 feet by 10 feet (2 m by 3 m). A single above-ground detector may be used to provide detection for both areas.

c) Signal heads have 12 inch (300 mm) lenses and comply with ITE Specification "Vehicle Traffic Control Signal Heads". All signal heads are equipped with visors and back plates. The backplate provides a minimum of 5 inches (125 mm) black field around the signal assembly and has a dull black finish.

d) A minimum of two traffic signal heads per approach. All signal heads mounted over the road surface are mounted a minimum of 15 feet (4.6 m) from the bottom of the signal head to the top of the road surface. One signal head mounted over the center of the travel lane. All far right signal heads mounted a minimum of 8 feet (2.45 m) from the bottom of the signal head to the top of the ground surface. Required signal heads for through traffic on any one approach located no less than 8 feet (2.4 m) apart measured horizontally perpendicular to the approach between the centers of the signal faces.

b. Trailer Mounted Systems.
Provide a system consisting of two or more self-contained trailer mounted units each containing two signal heads.

c. Span-Wire Mounted Systems.
Ensure posts meet the requirements of Article 2528.03, A.

3. Operational Requirements.

a. Locate signals, stop bars, and signs exactly as identified in the contract documents. Secure and level temporary traffic signal installations in a manner approved by the Engineer.

b. Program all temporary traffic signals for red flash upon startup, conflict, or power failure. Program the temporary traffic signal system to dwell in All Red.

c. For one lane two way traffic control operations, when an additional phase is used for a side road movement, only one long all red interval is to be used between active phases on each side of the work area.

d. Set signal timing as identified in the contract documents.

4. Equipment Crossings.

a. For equipment crossings, use a signal operator to control the signal system. Position this operator with good sight distance for both the mainline and haul road.

b. Program the signal system with fixed yellow and all red time periods so the operator can only activate the beginning of the yellow interval for mainline traffic.

c. When the equipment crossing is not in use, set the signal to yellow flash mode. If hauling operations are suspended for more than one week, cover the signal heads, or if portable trailer units are used, remove the trailers.

I. Temporary Floodlighting.

1. Ensure floodlighting is installed and in service before work is started that requires nighttime traffic control by the traffic control plan.

2. Ensure temporary floodlighting meets the following:

a. Pole-mounted luminaire or a luminaire mounted on portable equipment.

b. Mounting height of luminaires is no less than 35 feet (11 m) above the roadway, and as shown in the contract documents. Pole length determined by field measurement to obtain specified mounting height.

c. Clearance for overhead wiring a minimum of 18 feet (5.5 m). Auxiliary poles used to furnish power to floodlighting offset 30 feet (9 m) from the traveled way unless there are right-of-way restrictions.

d. Poles placed outside the normal shoulder line at the approximate locations shown in the contract documents.

e. Above ground lighting circuits are aluminum or A.C.S.R. triplex.

f. Underground lighting circuits are type U.S.E. or U.F.

3. Meet the following requirements for luminaires used for floodlighting:
   a. Standard roadway types with totally enclosed refractors.
   b. IES glare control rating of "cut off".
   c. The lamps with an initial output rating of 19,000 lumens or greater.
   d. Photoelectric controlled for dusk to dawn operation.
   e. Approval of the Engineer.

4. Exercise reasonable care to avoid interruptions during the hours of darkness, promptly repair damage to the system, and replace all burned out lamps as soon as possible.

J. Temporary Crash Cushions.
Apply Section 2551.

K. Flaggers.

1. Prior to flagging operations, ensure the flaggers are trained in safe flagging operations that comply with Iowa DOT Flagger's Handbook, Part 6 of the MUTCD, and the Standard Specifications. Ensure training of flaggers includes the following:
   a. Issuing and reviewing the current Iowa DOT Flagger's Handbook,
   b. Presentation of the current Iowa Professional Flagging Video,
   c. Issuing flagger training cards including the information below. Ensure the flaggers carry their flagger training card at all times and show it upon request.
      1) Employee name,
      2) Date of training,
      3) Name of Instructor, and
      4) Expiration date of December 31 of the year following the training date.

2. Maintain a list of the flaggers trained and the date of the training.

3. Training is not required for short time, emergency, or relief assignment of employees to flagging operations. Payment will not be made in accordance with Article 2528.05, I.

4. Ensure flagger operations, equipment, and apparel comply with the current Iowa DOT Flagger's Handbook.

5. When nighttime flagging is required, provide auxiliary lighting to illuminate the flagging stations according to the current Iowa DOT Flagger's Handbook. Set up this lighting in such a manner to minimize glare to motorists. The cost of furnishing nighttime flagging stations is included in the lump sum price bid for Traffic Control.

L. Limitations.

1. Use sandbags to anchor all traffic control devices subject to movement by wind.

2. When a two way road is open to public traffic during contract work, do not control one way traffic through the work area by means of a carry through flag or other token, except during equipment failure or emergency. Use other means when voice or signal communication between flaggers at control points is difficult or not effective because of distance, sight, or noise. Other means may be two way radio, pilot cars, or traffic signals.

3. Use pilot cars when the normal work area exceeds 1/4 mile (0.4 km) on Primary projects. Where necessary for short durations, the distance may be extended to 1/2 mile (0.8 km) for better sight distance or to clear intersections or other safety considerations with approval of the Engineer, provided a two way radio is used for communication between flaggers.

4. During non-working hours, remove, cover, or turn down traffic control devices intended for working hours only, unless a drop-off or physical obstruction remains within 15 feet (4.5 m) of a lane open to traffic. Signs or barricades are not required for work beyond 15 feet (4.5 m) of a lane open to traffic. When traffic control devices are no longer needed, remove them.

5. All personnel in the highway right-of-way are required to wear ANSI 107 Class 2 apparel at all times when exposed to traffic or construction equipment.

6. The Engineer may require traffic control devices to be recleaned by washing. Use a brush and water, and detergent or solvent as necessary. Include the entire target area or sign face, supplemental or auxiliary signs, if any, all reflectors, and faces of warning lights which are part of that device.

7. Ensure entry to and exit from work areas is in the direction of public traffic and does not cross open traffic lanes at other than designated locations.

8. During hours of darkness, operate equipment in the traffic control zone facing in the direction of traffic flow unless specified otherwise in the Traffic Control Plan. Darkness will include the period from sunset to sunrise and other times when conditions such as fog, snow, sleet or rain provide insufficient lighting to clearly identify persons and vehicles on the highway at a distance of 500 feet (150 m) ahead.

9. Unless stated otherwise in the traffic control plan, provide for a minimum of 2 miles (3 km) between traffic control zones on rural roadways. The Engineer will determine minimum distances between traffic control zones on urban roadways.

10. Submit Traffic Control Plan modifications to the Engineer for review and approval prior to any changes being made. The Engineer may modify

sign spacing to meet existing field conditions or to prevent obstruction of the motorist's view of permanent signing.

11. Ensure vehicles (except ready mix trucks) hauling soil, aggregate, and paving material to or from work area display a minimum 16 inch by 48 inch (400 mm by 1200 mm) sign with the legend "DO NOT FOLLOW - INTO WORK AREA" as shown in the contract documents. Comply with the following requirements for the sign:

- Orange with black lettering using Type VII (Iowa) sheeting.
- Keep clean to maintain its visibility.

12. For lanes closed to traffic, place two drums meeting the requirements of Article 2528.03, C, every 1000 feet (300 m). For full depth excavations in a closed lane, place two drums in front of each location. Additional drums need not be placed for full depth excavations spaced closer than 150 feet (45 m).

2528.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Traffic Control.
Lump sum.

B. Portable Changeable Message Signs.
The Engineer will count the number of days each PCMS is required to be in a location to display potential messages to the traveling public.

C. Temporary Barrier Rail.
The Engineer will calculate the length of temporary barrier rail used based on count and the nominal length of each unit. The length of temporary barrier rail measured will be the length required per setup. Measurement will also be made for temporary barrier rail moved within, or added to, an existing setup when required by the contract documents. Measurement of temporary barrier rail, after its initial placement, will not be made unless it is required by the contract documents to be moved.

D. Modular Glare Screen.
Measurement for Modular Glare Screen System will be in liner feet (meters).

E. Temporary Crash Cushions.
Article 2551.04 applies.

F. Temporary Traffic Signals.
By count for each group installation of temporary traffic signals operated by a common control unit. A group installation is normally four signal heads at the same traffic conflict area.

G. Temporary Floodlighting Luminaire.
By count.

H. Pilot Cars.

1. By count for the number of pilot cars used during each work shift. A shift is a scheduled period of work for the Contractor's operations.

2. For a pilot car to be counted:
- **a.** Use of the pilot car is necessary and it is used as part of preplanned work that is started that shift and is intended to proceed for a major part of the shift. If used less than 4 hours during a shift, one half pilot car will be counted.
- **b.** Use of other pilot cars is necessary and they are used for at least 1 hour during the shift, perhaps intermittently, and this shall be the primary duty of the employee. If used less than 4 hours in a shift, one-half pilot car will be counted.

3. Short time, emergency, or relief assignment of employees to pilot car operations will not be counted separately.

I. Flaggers.

1. By count for the number of flaggers used during each work shift. A shift is a scheduled period of work for the Contractor's operations.

2. For flaggers to be counted:
- **a.** Use of the flaggers is necessary and they are used as part of preplanned work that is started that shift and is intended to proceed for a major part of the shift. If used less than 4 during a shift, one-half flagger will be counted.
- **b.** Use of other flaggers is necessary and they are used for at least 1 hour during the shift, perhaps intermittently, and this shall be the primary duty of the employee. If used less than 4 hours in a shift, one-half flagger will be counted.

3. Short time, emergency, or relief assignment of employees to flagging operations will not be counted separately.

J. Monitoring with Incident Response.
Calendar days based on the contract quantity. Additional personnel required by the Engineer to provide additional traffic monitoring of CMS operation will be measured in calendar days per person needed.

2528.05 BASIS OF PAYMENT.
Payment will be at the contract unit price as described below. When the Engineer requires recleaning of reflectorized surfaces of traffic control devices, payment will be made as extra work according to Article 1109.03, B. All traffic control devices furnished by the Contractor remain the Contractor's property at the completion of the work and are to be removed from the site when no longer needed.

A. Traffic Control.

1. Lump sum when there is a contract item for Traffic Control.

2. Payment is full compensation for:
- Erecting, maintaining, moving, and removing all traffic control devices required by the contract documents, including warning lights,
- Furnishing all materials, labor, and equipment, and
- Traffic quality control.

B. Portable Changeable Message Signs.

1. Payment will be the contract unit price per calendar day for each PCMS that is required to be in a location to display potential messages to the traveling public.

2. Payment is full compensation for furnishing, placing, operation, and maintenance of PCMS. Payment includes the cost of communication, software, hardware, and power supply.

C. Temporary Barrier Rail.

1. Linear feet (meters) of Temporary Barrier Rail measured.

2. Maintenance of temporary barrier rail is incidental to Temporary Barrier Rail.

D. Modular Glare Screen.

1. Per foot (meter) of Modular Glare Screen System measured.

2. Payment is full compensation for:
- Material,equipment, and labor to furnish and install the system on the top of the temporary concrete barrier rail,
- Furnishing and applying retroreflective strips,
- Maintenance of the system,
- Repairing or replacing damaged parts of the system,
- Removing and reinstalling the system if necessary when moving the concrete barrier rail, and
- Final removal of the system from the top of the concrete barrier rail.

E. Temporary Crash Cushions.
Article 2551.05, A, applies.

F. Temporary Traffic Signals.

1. Each, for individual group installations operated by a common control unit, normally four signal heads at the same traffic control area.

2. Payment is full compensation for furnishing, installing, maintaining and servicing the controller, signal heads, traffic detection system, signal operator, costs for electrical energy, and the cost of removing temporary traffic signal materials from the construction site. The Contractor shall

supply their own breaker box and power meter and shall not connect to existing Contracting Authority owned circuits to supply power for temporary traffic signals.

G. Temporary Floodlighting Luminaire.

1. Each.

2. Payment is full compensation for:

- Furnishing, installing, maintaining and servicing the temporary floodlighting units,
- All costs for electrical energy,
- The cost of removing all lighting materials from the construction site, and
- The Contractor shall supply their own breaker box and power meter and shall not connect to existing Contracting Authority owned circuits to supply power for temporary floodlighting.

H. Pilot Cars.

Predetermined contract unit price per each for the number of shifts each pilot car was operated.

I. Flaggers.

1. Predetermined contract unit price per each for the number of shifts each flagger was used.

2. Payment is full compensation for providing trained flaggers according to Article 2528.03, K.

J. Monitoring with Incident Response.

1. Per calendar day for the number of calendar days used.

2. This payment is full compensation for:

- Furnishing the necessary vehicle (including operation, maintenance, and supplies),
- Furnishing the operator,
- Documentation of any events that restrict the normal flow of traffic including responses to an emergency situation,
- Re-erecting, repairing, or replacing traffic control devices,
- Providing assistance to persons with vehicle problems,
- Moving stalled vehicles, and
- Summoning further assistance when needed.

3. Payment for the number of calendar days that additional personnel, such as for CMS operation required by the Engineer, will be the contract unit price per calendar day. Payment is full compensation for furnishing the required personnel and necessary support vehicles.

Section 2529. Full Depth Finish Patches

2529.01 DESCRIPTION.

A. Remove pavement in areas designated by the Engineer to be patches. Restore the subbase and/or subgrade and furnish and place subbase aggregate, furnish and place patching material, and restore the shoulder area. Construct a new finished traffic surface in the patch area.

B. Work under this specification may include the types of patches listed below. Generally, the patch type will be consistent with the existing pavement.

1. Full depth HMA finish patches.

2. Full depth PCC finish patches, without dowels.

3. Full depth PCC finish patches, without dowels, composite section.

4. Full depth PCC finish patches, with dowels.

5. Full depth PCC finish patches, with dowels, composite section.

6. Full depth PCC finish patches, continuously reinforced.

7. Full depth PCC finish patches, continuously reinforced, composite section.

2529.02 MATERIALS.

A. Hot Mix Asphalt Mixture.
Unless stated elsewhere in the contract documents, use HMA meeting or exceeding Section 2303 requirements for a 300,000 ESAL surface mixture with a PG 64-22 Performance Graded asphalt binder.

B. Portland Cement Concrete.
It is the intention to obtain concrete with a high early strength for early opening to traffic. Meet the requirements of the current Materials I.M. 529 with the following modifications:

1. Slump.
- **a.** Slump, measured according to Materials I.M. 317 prior to addition of calcium chloride solution, is to be between 1 inch (25 mm) and 2 1/2 inches (65 mm) as a target range, allowing a maximum of 3 inches (75 mm). If calcium chloride solution is not to be added, the slump is to be between 1 inch (25 mm) and 3 inches (75 mm) as a target range, allowing a maximum of 4 inches (100 mm).
- **b.** When a Type A Mid Range water reducing admixture is used, the slump, tested prior to the addition of calcium chloride, is to be between 1 inch (25 mm) and 4 inches (100 mm) as a target range, allowing a maximum of 5 inches (125 mm).

2. Air Entrainment.

The entrained air content of the unconsolidated concrete will be determined according to Materials I.M. 318, prior to addition of calcium chloride if it is to be added. The air entrainment shall be as follows:

a. When calcium chloride is to be added: 5.0%, with a tolerance of ± 2.0%.

b. When no calcium chloride is to be added: 6.5%, with a tolerance of ± 1.5%.

3. Temperature.

Refer to Paragraph 4 below for temperature requirements of Full Depth Portland Cement Concrete patching material, as delivered to the job site. Heat the water or aggregate, or both, if necessary to meet this requirement. The cost of heating is incidental to patching.

4. Cement.

For Class M mixes, meet the requirements of Section 4101. Table 2529.02-1 lists cement types and maximum allowable substitution rates. The maximum substitution for Type IS shall not exceed 25%.

Table 2529.02-1: Cement Types and Maximum Allowable Substitution Rates

Patch Type	Cement Type	Maximum Allowable Substitution	Minimum Mix Temperature
5 Hour	Type I, Type II Type IS	0% Fly Ash 0% Fly Ash	75ºF (24ºC) 80ºF (27ºC)*
10 Hour	Type I, Type II Type IS	10% Fly Ash 0% Fly Ash	65ºF (18ºC) 70ºF (21ºC)*
* When a Type A Mid Range Water reducing admixture is used, limit the minimum mix temperature to that required when Type I/II cement is used.			

5. Calcium Chloride.

a. When calcium chloride is required, furnish it in water soluble form and add it to the mixture at the job site. Use a commercial 32% calcium chloride solution, or equivalent, prepared according to Table 2529.02-2:

Table 2529.02-2: Proportions for 32% Calcium Chloride Solutions

Type of Solid Calcium Chloride	Pounds (Grams) of Solid per Gallon (Liter) of Water	Solution Produced per Gallon (Liter) of Water
Type 1 – Regular Flake (77% material)	6 (720)	1.3
Type 2 – Concrete Flake or Pellets (94% material)	4.5 (540)	1.2

b. The Engineer will check the solution concentration using a hydrometer according to Materials I.M. 373. Add the solution at the rate of 3.0 gallons per cubic yard (14.8 L/m^3) of concrete. The Engineer may approve alternate calcium chloride solutions of different concentrations provided appropriate adjustments in the total concrete composition are made.

c. Agitate the mixture until the calcium chloride is completely in solution. Continue agitation, as necessary, to maintain uniformity. The calcium chloride will crystallize out of a 32% solution at 20°F (-7°C), so the solution shall be maintained at a higher temperature at all times.

d. Except when using continuous mixing equipment described in Article 2001.20, E, ensure the calcium chloride solution is present in the mix for at least 2 minutes of mixing.

6. Water Reducer.
A Type A Mid Range water reducing admixture may be used. Use one listed in Materials I.M. 403, at the manufacturer's recommended dosage.

7. Aggregate Durability.
Unless specified otherwise, use coarse aggregate of the proper class of durability as defined in Article 4115.04.

8. Transit Mix Concrete.
Use a mix from a plant from which the concrete can be delivered and placed within 60 minutes from the time of mixing. The time may be extended to 90 minutes when a retarding admixture, used according to Materials I.M. 403 including temperature dosage guidelines (and at no additional cost to the Contracting Authority), is added at the plant. Continuous mixing equipment using volumetric proportioning may be used according to Article 2001.20, E. Place the concrete within 30 minutes after introduction of calcium chloride.

9. Concrete Mixtures.
For PCC patches, use Class M mixtures with calcium chloride. The Engineer may waive the use of calcium chloride on patches cured longer than 10 hours.

10. Dowel Bars and Tie Bars.
Use epoxy coated dowel bars meeting the requirements of Article 4151.02, C. Use tie bars cut from epoxy coated reinforcing bars as specified in Article 4151.03, C.

C. Joint Sealing Material.
Use joint sealer and backer rod meeting the requirements of Article 4136.02, A, 1. When joint or crack sealing or filling is a part of the contract, use only hot pour material.

D. Tack Coat Bitumen.
As specified in Article 2303.02, E.

E. Subbase Patch Material.
Meet the requirements of Section 4123.

F. Patch Subdrain.
Meet the requirements of Article 2502.02.

G. Subgrade Stabilization Material, Polymer Grid
Meet requirements of Section 4196.

2529.03 CONSTRUCTION.

A. General.

1. The contract documents will include a tabulation of patches showing location and approximate area. This tabulation is intended primarily for estimating purposes. The actual patch location and size will be determined by the Engineer. The patch thickness and type of patch material may be included. The contract documents will identify the existing pavement type, thickness, and reinforcement, and may identify the coarse aggregate classification.

2. When the contract documents include reconstruction of gore areas, this work may be done as a separate operation. For PCC patches in gore areas, mixtures with calcium chloride will be allowed. Cure the concrete as specified for the mixture used.

3. When the contract documents include joint and crack sealing, perform joint sealing of the patches as part of that work.

B. Full Depth Patch Thickness.
If full depth patch thickness is not shown in the contract documents, establish thickness as follows:

1. HMA Patches.
Interstate and Primary pavement: the thickness of the HMA pavement, but no less than 9 inches (230 mm) or more than 15 inches (380 mm).

2. PCC Patches.
- **a.** PCC pavements on Interstate and Primary Roads: the thickness of the pavement but no less than 9 inches (230 mm) or more than 12 inches (300 mm).
- **b.** County roads: thickness no less than 6 inches (150 mm) or more than 12 inches (300 mm).

3. Composite Patches.
PCC pavements which have been resurfaced with HMA: patch materials and thickness the same as the existing pavement except the PCC portion of the patch is not to be less than 9 inches (230 mm) or more than 12 inches (300 m) unless specified otherwise in the contract documents. If the HMA resurfacing exceeds 4 1/2 inches (120 mm)

(nominal) place an HMA patch, unless specified otherwise in the contract documents.

C. Pavement Removal.

1. General.
Remove pavement for full depth patch construction according to the following requirements:

a. When repairing PCC pavement, even though it may have been resurfaced, remove the material for the full pavement depth, unless designated otherwise. Excavation will be required for the patch thickness and, if required, for the subbase patch material.

b. The contract documents will include an estimate of the number of anchor lugs to be removed. When an anchor lug is encountered within an area to be patched:

- Break the anchor lug down to approximately 6 inches (150 mm) below the bottom of the pavement,
- Remove all exposed anchor lug reinforcing, and
- Replace the concrete with subbase patch material, compacted as required, to the elevation of the bottom of the patch.

c. Remove reinforcement from the patch area, and to approximately 1 inch (25 mm) or less from the concrete that is to remain, except for continuously reinforced pavements.

d. Unless shown otherwise in the contract documents, construct all patches to be full lane width. The length of each patch, measured parallel to the center line, will not be less than 6 feet (1.8 m) on Interstate pavements and 4 feet (1.2 m) on other pavements except continuously reinforced full depth finish patches. Continuously reinforced patches will not be less than 8 feet (2.4 m) in length.

e. Perform pavement removal according to Article 2510.03, A.

2. Full Depth HMA Finish Patches.
Except where an existing longitudinal or transverse joint forms an edge of the patch, construct the patch edge by sawing full depth of the patch. Use a saw, a concrete cutter, or other equipment that will result in a reasonably vertical edge. For patches in HMA pavement, a 15 inch (380 mm) deep saw cut will be considered full depth. After sawing, a drop hammer, hydrohammer, or other heavy equipment may be used. Do not damage pavement that will remain.

3. Full Depth PCC Finish Patches, With or Without Dowels.
This applies to PCC finish patches for jointed PCC pavement, including composite sections of resurfaced PCC pavement.

a. Patches With Dowels.
Saw the edges of proposed patches to full depth with a blade saw.

b. Patches Without Dowels.

1) Saw the transverse edges of proposed patches to a depth of 1 1/2 inches (40 mm) with a blade saw. Sever the pavement by a full depth cut with a saw or concrete cutter approximately 1 1/2 inches (40 mm) inside the original 1 1/2 inch (40 mm)

transverse saw cut. Saw the edges at center lines and lane lines with a blade saw.

2) After severance is made, pavement in removal areas may be broken by use of a drop hammer, hydrohammer, or other heavy equipment. Perform this work in a manner to not damage concrete that is to remain. Do not use heavy equipment adjacent to new concrete until the specified curing is completed.

3) Complete the preparation of patch edges using equipment no heavier than a 15 pound (7 kg) air chisel. A 30 pound (14 kg) air chisel may be used if its use does not result in significant undercutting of the pavement. The finished transverse edge shall be sawed to 1 1/2 inches (40 mm) as specified above. Remove the ledge at the bottom of the 1 1/2 inch (40 mm) saw cut to the bottom of the pavement at a uniform constant taper towards the patch interior. Limit the removal to within 0 to 1 1/2 inches (0 mm to 40 mm) from vertical. Roughen the surface to promote interlock. Avoid undercutting. If spalling at the top edge or undercutting continues, the Engineer may withdraw permission to use equipment heavier than a 15 pound (7 kg) air chisel.

4. Full Depth PCC Finish Patches, Continuously Reinforced.
This method applies to PCC finish patches for continuously reinforced PCC pavement, including composite sections of resurfaced PCC pavement, where the continuous reinforcement is to be restored.

a. Construct the transverse edges of the patch with a blade saw to a nominal depth of 1 1/2 inches (40 mm). Avoiding cutting longitudinal reinforcement. Saw the edges at center lines and lane lines with a blade saw through existing tie bars.

b. Within the patch area, sever the pavement transversely by a full depth cut with a blade saw inside the 1 1/2 inch (40 mm) saw cut to a depth through the existing reinforcing. Locate this severance so as to leave a minimum of 20 inches (500 mm) of longitudinal steel protruding into the patch area.

c. Break the pavement in such a manner not to damage concrete that will remain. Do not use heavy equipment adjacent to new concrete until the specified curing is completed.

d. Use jackhammers or other hand equipment to remove pavement between the 1 1/2 inch (40 mm) saw cut and the severance. Complete the edge of the patch at the 1 1/2 (40 mm) inch saw cut using equipment no heavier than a 15 pound (7 kg) air chisel. A 30 pound (14 kg) air chisel may be used if its use does not result in significant undercutting of the pavement. Remove the shoulder at the bottom of the 1 1/2 inch (40 mm) saw cut. Ensure the edge below the saw cut is reasonably vertical, tapered to the interior of the patch, and has a rough surface to promote interlock. Work with the air chisel should continue until the taper at the bottom of the pavement is approximately within 0 to 1 1/2 inches (0 mm to 40 mm) from vertical. Avoid undercutting. If necessary, reconstruct the saw cut so the top edge at the pavement surface is not frayed or

spalled. If spalling at the top edge or undercutting continues, the Engineer may withdraw permission to use equipment heavier than a 15 pound (7 kg) air chisel.

e. Break or remove pavement in such a manner that protruding longitudinal steel is not unduly disturbed. Preserve a 20 inch (500 mm) length of longitudinal steel. Do not bend the steel more than the minimum necessary for concrete removal and subgrade or subbase compaction.

5. Full Depth Composite Patches.
When an existing PCC pavement has been resurfaced with 4 1/2 inches (120 mm) of HMA or less, construct the patch according to Section 2212, PCC Full Depth Repair Patches and HMA Surface Patches to result in a composite patch, unless specified otherwise in the contract documents. Lightly tack the PCC area and edges of the patch, and place the hot mixture in the remaining depth and compact, while hot, to provide a dense, smooth riding surface.

D. Restoring Subbase or Subgrade for Full Depth Finish Patches.

1. When subbase is required by the contract documents or by the Engineer, remove the exposed subbase or subgrade, or both, to a depth of 6 inches (150 mm), or as specified in the contract documents, below the bottom of the new patch. Place subgrade stabilization material when required, and place subbase material. When unstable material or excessive moisture is encountered in the subgrade, the Engineer may order an additional thickness of subbase, if necessary, to ensure drainage.

2. When the existing subgrade, base, or subbase is damaged during removal operations and subbase placement is not required, perform repairs at no additional cost to the Contracting Authority. Overdepth removal may be replaced with subbase patch material or the patching mixture. When the subbase patch material cannot be properly drained, replace the overdepth removal with the patching mixture.

3. Place subbase material with a field optimum moisture content established by the Engineer. Place it in lifts not exceeding a nominal compacted thickness of 6 inches (150 mm). Compact the material by a minimum of four complete coverages using a vibratory compactor, with additional coverages as necessary to ensure maximum consolidation. The compaction procedure for subbase normally will be established by the Engineer using the initial area as a trial section.

4. Compact the exposed subgrade or subbase by a minimum of four complete coverages using a plate type vibratory compactor with a manufacturer's certified force rating of 6,000 pounds (26 kN).

E. Restoring Reinforcement for Portland Cement Concrete and Continuously Reinforced Concrete Finish Patches.

Cut off existing tie bars. Replace when required by the contract documents. Place new tie bars in predrilled holes using epoxy grout, as provided in Article 2301.03, E. When there is a common line for patching, a bent bar may be placed in a keyway and later straightened.

1. PCC Finish Patches without Dowels.

Restoration of reinforcement is not required, except for tie bars as described above.

2. PCC Finish Patches with Dowels.

a. When dowels and/or tie bars are required at the transverse edges of the patch, the contract documents will show details of the placement. Place individual dowels or tie bars in predrilled holes using epoxy grout, according to Article 2301.03, E. Control the drilling alignment using a suitable jig designed for that purpose. Coat the dowels extending into the patch area with a bond breaker. Do not coat reinforcing bars.

b. When CD joints are required, the contract documents will show details of the placement of dowel assemblies. Locate these joints to meet joints or cracks in the adjacent lane. Use dowel assemblies meeting the requirements of Article 4151.02, C. Place the dowel assemblies and secure in proper position before the concrete is placed, according to Article 2301.03, E.

3. PCC Finish Patches, Continuously Reinforced.

a. After the subbase, if required, is in place and compacted, set new reinforcement. Make the protruding longitudinal reinforcement ends as true as practical. Clean them of loose concrete and concrete which would interfere with close placement of new reinforcement.

b. Restore longitudinal reinforcement using bars of the same grade, size, and spacing as in the original pavement. The contract documents will describe the reinforcement in the existing pavement.

c. Set new longitudinal reinforcement to connect the longitudinal reinforcement across the repair area, lapping the protruding reinforcement at the same elevation. Wire tie at least twice. Furnish bars (maximum length 20 feet (6 m)) in appropriate lengths to minimize the number of splices.

F. Subdrains.

1. When subbase material and longitudinal subdrains are required by the contract documents or the Engineer, place the subbase as backfill material to drain to the longitudinal subdrain.

2. If longitudinal subdrain will not be placed, or is not present, on the side of the roadway to be patched, place patch subdrain according to Article 2502.03, C and the contract documents.

G. Placing Full Depth Hot Mix Asphalt Finish Patches.

1. After removal of the old pavement, lightly tack the edges of the old pavement and the adjacent 1 foot (0.3 m) of subgrade.

2. Deposit the HMA patch mixture in layers. Deposit the upper 5 inches (125 mm) in at least two layers, with the top layer not exceeding 2 inches (50 mm) in thickness when compacted. Lifts should be at least 3 times the mixture size. Thoroughly compact each layer, while hot, by rolling or compacting with a vibratory compactor to provide a dense compacted surface. Succeeding layers may be placed as soon as the preceding layer has been properly compacted. Smooth the final layer with a steel tired finish roller meeting requirements of Article 2001.05, B or F. A roller meeting requirements of Article 2001.05, F, may be a small roller suitable for this type of operation.

3. The Engineer may require test cores for density and depth be taken, at no additional cost to the Contracting Authority, to verify that the construction method used is satisfactory.

4. Ensure the final compacted surface is level with, or not more than approximately 1/4 inch (5 mm) above the surrounding pavement surface. Cut off patch material which extends beyond the edge of the pavement.

5. Do not open the patch to traffic until the mixture has cooled to provide stability; however, on two lane highways, do not leave barricades in place overnight. If the patch becomes distorted for any reason, smooth the surface the next working day by blading, scraping, filling, or by other approved means.

6. Prior to final acceptance, the patch shall be level with, or no more than 1/8 inch (3 mm) above, the adjacent pavement, and have a smooth riding surface.

H. Placing Full Depth Portland Cement Concrete Finish Patches.

1. Use forms on all exposed edges and also along the center line for patches that extend into an adjacent lane. Wood forms may be used in lieu of steel by using 2 inch (50 mm) nominal dimension lumber the full depth of concrete. Where old pavement has a curb, extend the forms from the bottom of the patch to the top of the curb. Stake all wood forms to hold the forms in place and in proper alignment.

2. Place, consolidate, finish, and cure of the concrete as provided in Section 2301, except as follows:

a. Moisten the subbase or subgrade or cover with a single layer of plastic film meeting requirements of Section 4107.

b. Except for preplanned joints, place the patch in a continuous manner until placement is completed. When a delay of 45 minutes can not be avoided, construct an appropriate DW joint.

c. Dump or convey the concrete into the patch areas to avoid segregation of the aggregates and cement. Spread it into place and vibrate with a mechanical vibrator. Smooth the concrete and finish it to the elevation of the adjacent PCC surface. Avoid excessive vibrating.

d. Finish full lane width patches over 25 feet (10 m) long flush with the adjacent pavement. Use a finishing machine that has at least one vibrating screed. To ensure a smooth riding surface, straight edge all patches finished flush with adjacent pavement. Texture patches by finishing with a burlap, carpet drag, or rake, to approximately match the texture of the adjacent surface.

e. Check the patches with a 10 foot (3 m) straightedge before the concrete has set. Correct spots that are 1/8 inch (3 mm) high or low, as shown by the straightedge. The existing pavement crown shall be maintained.

f. Finish all edges and ends of patches with an edging tool.

g. Construct lane edges and the ends of patches to a depth of approximately 1 1/8 inches (30 mm), leaving an opening of at least 3/8 inch (10 mm) to provide a reservoir for joint sealer. The reservoir may be constructed by hand methods or may be sawed. When white pigmented curing compound is used, protect the reservoir with tape or other suitable material.

h. On patches finished flush with the pavement surface, stamp two numerals indicating the year of placement 2 feet (0.6 m) from the outside edge, facing outward to be read from the near shoulder.

3. After the concrete has been finished and surface water has disappeared, cure the concrete. Place curing materials no later than 20 minutes after completing finishing operations. Cure concrete by completely covering it with an insulating blanket-type cover consisting of a layer of closed cell polystyrene foam protected by at least one layer of plastic film, rated by the manufacturer with a minimum R-value of 0.5 (0.08805 for metric units). Cover the blanket-type cover completely with insulation board having the following properties: cellulosic fiber sheathing with a nominal 3/4 inch (19 mm) thickness. The board may be wrapped with plastic film to protect it from rain. Place the board over the patch and adjacent surface and hold it tightly in place with weights to retain all possible heat in the concrete.

4. Cure PCC patches placed on multi-lane sections for a minimum of 10 hours before opening to traffic. Cure PCC patches placed on two-lane sections a minimum of 5 hours before opening to traffic. These restrictions may be modified in the plans or by the Engineer for specific sections.

5. Replace patches that are damaged in any manner during the curing period at no additional cost to the Contracting Authority.

6. When required, saw and seal joints in accordance with Article 2301.03, P. Sawing shall be done as soon as possible without excessive raveling of the saw cut edges.

I. Smoothness.

Apply Section 2316 to smoothness of full depth finish patches (except when the contract includes an overlay or pavement surface repair by diamond grinding or milling within the patch area) with the following modifications:

1. Profilometer testing and evaluation is required for each patch with a length of 50 feet (15 m) or more. Perform the testing near the center of the traffic lane after the patch is placed. For each patch added by the Engineer that is greater than 50 foot (15 m) long, the Contractor will be paid $500 in addition to the appropriate unit prices involved. This is to compensate for additional smoothness requirements.

2. Patches 50 feet to 100 feet (15 m to 30 m) in length:

- **a.** Test the patch length, and the existing pavement in that lane, for a distance of three times the patch length on both ends of the patch. If a patch occurs near a bridge, an intersection, and so forth, where the proper distance can not be tested, make up the required total on the other end of the patch. If interference occurs on both ends, test only to the points of interference.
- **b.** Establish one Average Base Index (ABI) of the pavement for both ends of patch.
- **c.** Calculate a new index for the entire length.
- **d.** Compare the new index with the ABI.
  - **1)** If the new index does not exceed the ABI, the work is acceptable and no correction is required.
  - **2)** Corrective action is also not required if the new profilometer index is equal to or less than 12 inches per mile (190 mm/km), regardless of the ABI.
  - **3)** If the new profilometer index is greater than 12 inches per mile (190 mm/km) and less than 30 inches per mile (470 mm/km) and is also within 2 inches per mile (32 mm/km) of the ABI, corrective action is not required.
  - **4)** If the new profilometer index is greater than 30 inches per mile (470 mm/km), corrective action is required to reduce the new index at least to the ABI.
- **e.** Corrective action involves correction of bumps and dips exceeding a vertical height of 0.5 inch (13 mm) in a 25 foot (7.6 m) span in the patch, if identified from the trace, plus appropriate surface correction within the patch and existing pavement, or both, on either end of the patch within the limits tested.

3. Patches 100 feet to 250 feet (30 m to 75 m) in length: Article 2529.03, I, 2, above applies, except the length tested is the patch length, and the existing pavement in that lane for a distance of 300 feet (90 m) on both ends of the patch.

4. Patches over 250 feet (75 m) in length: Apply the requirements for Chart B pavement, Section 2316.

J. Area Restoration.

When the patch is completed, remove the forms and place backfill material in the trench. If a form is necessary on a longitudinal joint, temporarily fill the space between the patch and the adjacent traveled lane with suitable material until the adjacent patch can be constructed. Fill the excavated space along the outside pavement edge with material similar to that in the existing shoulder. Thoroughly compact, as directed by the Engineer, before the section is opened to traffic.

K. Limitation of Operations.

1. Conduct all operations with minimum inconvenience to traffic. Maintain traffic during construction operations unless the road is closed.

2. On two-lane roads, conduct patching on only one lane at a time when traffic is maintained.

3. For roads with multiple lanes each direction, the work area may include one lane each direction or as allowed by the traffic control details.

4. Place Stop Sign Rumble Strips, when included in the plans, prior to opening roadway sections to traffic.

5. When conditions permit, patch areas may extend up to 2 feet (0.6 m) into an adjacent lane. When this encroachment is not tabulated in the contract documents, it shall be approved by the Engineer prior to beginning work. A flagger will be required at these locations. Work in an adjacent lane shall be completed and opened to traffic the same day using PCC (Class A or B) or HMA to match the normal patch area material.

6. When HMA patches on two-lane roadways and PCC patches with calcium chloride are constructed, adjust the work schedule so all equipment and obstructions are removed from the travel lanes and shoulders from 30 minutes before sunset to 30 minutes after sunrise.

7. If unforeseen difficulties should result in excavated areas being left overnight, assign a sufficient number of flaggers to warn and direct traffic until the areas are complete. No extra payment will be made for the necessary flaggers.

8. Limit full depth sawing to patch areas scheduled to be constructed the following work day. The Engineer may limit advance sawing.

9. Do not reconstruct pressure relief joints within patch areas. When these joints extend into adjacent lanes, construct a full depth patch in the adjacent lane as directed by the Engineer.

10. Joints and edges of PCC patches to be sealed may be cleaned and sealed as soon as the vertical surfaces appear dry by visual examination. Complete sealing within 5 working days after the patch is

placed. For PCC patches to be covered by HMA, cover them with HMA during the working day the curing is completed.

11. When other work is included in the contract, sequence the operations in an area in the following order:
- **a.** Undersealing,
- **b.** Longitudinal subdrains,
- **c.** Patching,
- **d.** Milling,
- **e.** Installation of retrofit load transfer, and then
- **f.** Crack and joint sealing.

12. If a DW joint becomes necessary, fill the area following the joint with a suitable temporary hot or cold paving mixture or stable granular material, as directed by the Engineer.

2529.04 METHOD OF MEASUREMENT.

Measurement for the various items involved in satisfactory construction of full depth pavement patches will be as follows:

A. Full Depth Finish Patches.

1. By count. Patches in each traffic lane will be individually counted.

2. By area. The areas of full depth finish patches will be computed in square yards (square meters) to the nearest 0.1 square yards (m^2) from measurements of the areas of pavement removed and replaced, except that each patch which is less than 2.0 square yards (2.0 m^2) in area will be counted as 2.0 square yards (2.0 m^2). The length will be measured parallel to the center line. Includes areas associated with anchor lug removal.

3. Tie bars and dowel bars at the patch edges, when required, will not be measured for payment.

B. CD Joint Assembly, EF Joint Assembly, and CT Joint.

By count for joints properly installed of each type respectively, when CD Joint Assemblies, EF Joint Assemblies, or CT Joints are required within the patch area. Each joint is for one lane width. Partial lane width joints will be counted as one lane width for payment purposes.

C. Hot Mix Asphalt (Composite Section).

Tons (megagrams), computed or estimated, of HMA placed on PCC surfaces for patches. Asphalt binder will not be measured for pay.

D. Subbase (Patches).

1. Where subbase aggregate is placed in patch areas, as required by the contract documents or the Engineer, the Engineer will compute in square yards (square meters) the areas of subbase placed as provided in Paragraph A, above. Excludes areas associated with anchor lug

removal. The Engineer will not measure subbase aggregate used for special shaping at longitudinal drains or subbase used at the Contractor's option.

2. The Engineer will separately compute areas in square yards (square meters), where subbase was directed to be placed to a depth greater than that originally specified.

3. When required, subgrade stabilization material will not be measured separately for payment.

E. Patch Subdrain.
By count.

F. Removal of Anchor Lugs.
By count for anchor lugs removed in each traffic lane.

G. Rumble Strip Panel (In Full Depth Patch)
By count for Rumble Strip Panels properly installed at locations designated on the contract documents.

2529.05 BASIS OF PAYMENT.
When a PCC finish patch is required to be finished low and covered with HMA, but a patch of composite section is not so identified in the contract documents, the additional associated cost will be paid for as extra work.

When reconstruction of gore areas is required as a part of the contract documents, this reconstruction will be measured and paid for as specified in the contract documents.

A. Full Depth Finish Patches.
When joint and crack sealing is included in the contract, joint sealing of the patches will be paid for as part of that work.

1. Full Depth Finish Patches, by Count.

a. Each. The type or types of patches to be counted will be identified by the following types and tabulated in the contract documents.

1) Full Depth HMA Finish Patches.
2) Full Depth PCC Finish Patches, Without Dowels.
3) Full Depth PCC Finish Patches, Without Dowels, Composite Section.
4) Full Depth PCC Finish Patches, With Dowels.
5) Full Depth PCC Finish Patches, Composite Section.
6) Full Depth PCC Finish Patches, Continuously Reinforced.
7) Full Depth PCC Finish Patches, Continuously Reinforced, Composite Section.

b. Payment is full compensation for all sawing or cutting necessary and for furnishing and installation of dowel bars at patch edges.

2. Full Depth Finish Patches, by Area.

a. Per square yard (square meter) to the nearest 0.1 square yards (m^2).

b. Payment is full compensation for:

- Removal of the old pavement,
- Restoring the subgrade or subbase,
- Furnishing and installation of tie bars,
- Restoring longitudinal reinforcement for continuously reinforced patches, and
- Furnishing and placing the patching material, including the asphalt binder, tack coat, curing, joint sealing, and placing backfill material in the disturbed area.

c. When the average thickness of a patch at any one location varies from the patch thickness shown in the plans, the square yard (square meter) patching quantity will be adjusted per Table 2529.05-1. Quantities will be increased when patch thickness is greater than shown in the plans and decreased when less than shown in the plans. Adjustments will not be made for increased thickness due to damaged subgrade, base, or subbase as described in Article 2529.03, D, 2.

Table 2529.05-1: Patching Quantity Adjustment

% Change of Thickness	% Change of Quantity
0 to 10	0
> 10 to 20	10
> 20 to 30	15
> 30	20

B. CD Joint Assembly, EF Joint Assembly, and CT Joint.

Each, for the type of joint.

C. Hot Mix Asphalt (Composite Sections).

1. Per ton (megagram).

2. Payment includes full compensation for placement and compaction, the asphalt binder in the HMA mix, and tack.

D. Subbase (Patches).

1. For the number of square yards (square meters) of subbase furnished and placed, the Contractor will be paid the contract unit price per square yard (square meter).

2. Payment is full compensation for:

- Furnishing and installing subbase,
- Additional excavation necessary for this placement and the removal of excavated material,
- Placing backfill material in the disturbed shoulder area.

- Furnishing and installing subgrade stabilization material when required.

3. When subbase has been placed to a greater depth than specified in the contract documents, at the Engineer's direction, payment per square yard (square meter) for those areas will be increased by 20% for each inch (30 mm) of increased depth. This increased payment is full compensation for additional excavation and subbase material, associated compaction, and if so ordered, additional depth for the transverse subdrain.

E. Patch Subdrain.

1. Each.

2. Payment is full compensation for the following:
- Excavation of the trench and removal of excess trench material from the project, and
- Furnishing and placing 4 inch (100 mm) perforated corrugated polyethylene pipe, porous backfill, impervious fill, shoulder material, and rodent guard.

F. Removal of Anchor Lugs.

1. Each.

2. Payment is full compensation for removal and for furnishing and placing subbase material, as specified. If removal of anchor lugs is not a bid item in the contract documents, payment will be paid $600 per lane in which an anchor lug, or portion of anchor lug, is removed.

G. Rumble Strip Panel (In Full Depth Patch)
Each. Payment is full compensation for construction of the panels as detailed on the contract documents.

Section 2530. Partial Depth Finish Patches

2530.01 DESCRIPTION.

A. Remove pavement in areas designated in the contract documents or by the Engineer to be patches. This includes furnishing and placing patching material to provide a new traffic surface, and restoring the adjacent shoulder as shown in the contract documents. This work is in areas where the size, shape, and depth of patch depends on the extent of pavement deterioration and shall be determined during the removal operation.

B. Partial depth finish patches may be identified and constructed as one of the following types:

1. **Partial Depth PCC Finish Patches.**
These patches are square or rectangular in shape. Saw the edges. Removal may be by milling or other equipment. This type of patch will be identified by tabulation in the contract documents. The size and location for each lane will be shown.

2. **Partial Depth Regular HMA Finish Patches.**
These patches are in the shape of a square or rectangle. They have square corners and straight edges to allow almost all of the removal by a milling machine. An air hammer or saw may be necessary to complete removal along edges and at corners. This type of patch will be identified by tabulation in the contract documents. The size and location in each lane will be shown.

3. **Partial Depth Irregular HMA Finish Patches.**
These patches are not square or rectangular in shape. They have at least one side that is not straight or one corner that is not square which will prohibit complete removal by a milling machine. Other equipment such as an air hammer or saw may be necessary to accomplish the removal. This type of patch will be identified by tabulation in the contract documents. This tabulation will be an estimate of the number of patches per lane mile, and the estimated total area of patch.

2530.02 MATERIALS.

Meet the requirements for the type of material specified.

A. Hot Mix Asphalt Patching Material.
Unless stated elsewhere in the contract documents, use HMA meeting or exceeding Section 2303 requirements for a 300,000 ESAL 3/8 or 1/2 inch (9.5 mm or 12.5 mm) surface mixture with PG 64-22 Performance Graded asphalt binder.

B. Portland Cement Concrete Patching Material.
Meet one of the requirements below. When patching encroaches on an adjacent lane which is open to traffic or when there is patching on two lane pavements or other locations where overnight closures are not permitted, use Class A or Class B patching material. On pavements with three or more lanes and where overnight closure is permitted, use Class C patching material.

1. **Class A Patching Material.**
   - **a.** Use a modified Portland cement type manufactured to provide rapid set and high early strength. Meet the requirements of Materials I.M. 491.20.
   - **b.** When a mortar is furnished, add the manufacturer's recommended quantity of coarse aggregate.

2. **Class B Patching Material.**
   - **a.** Use high early strength rapid set (5 hour) PCC meeting the requirements of Materials I.M. 529 and the following requirements:

Use Class M mixture patching material with calcium chloride. Class M mixtures with calcium chloride are not to contain fly ash. When calcium chloride is used in a mixture, place the concrete within 30 minutes after the introduction of the calcium chloride. For coarse aggregate, meet the requirements of Section 4115 and Gradation No. 5, Aggregate Gradation Table, Appendix.

b. When Class B patching material is furnished for partial depth patches, it may also be furnished for full depth patches.

3. Class C Patching Material.

a. Use a PCC mixture with an early set that will allow time of opening to traffic in 24 hours to 36 hours as directed by the Engineer. For coarse aggregate, meet the requirements for Class B patching material. Use Class M mixture meeting the requirements of the current Materials I.M. 529 without the addition of calcium chloride.

b. When Class C patching material is furnished for partial depth patches, it may also be furnished for full depth patches.

4. Modifications to Mixtures for Class B and Class C Patching Material.

Apply the following modifications to the PCC mixtures for Class B and Class C patching material:

a. Slump.

1) Slump, measured according to Materials I.M. 317 prior to addition of calcium chloride solution, is to be between 1 inch and 2 1/2 inches (25 mm and 65 mm) as a target range, allowing a maximum of 3 inches (75 mm). If calcium chloride solution is not to be added, the slump is to be between 1 inch and 3 inches (25 mm and 75 mm) as a target range, allowing a maximum of 4 inches (100 mm).

2) When a Type A Mid Range water reducing admixture is used, the slump, tested prior to the addition of calcium chloride, is to be between 1 inch (25 mm) and 4 inches (100 mm) as a target range, allowing a maximum of 5 inches (125 mm).

b. Air Entrainment.

The entrained air content of the unconsolidated concrete will be determined according to Materials I.M. 318, prior to addition of calcium chloride if it is to be added. When calcium chloride is to be added, air entrainment is to be 5.0%, with a tolerance of ± 2.0%. When no calcium chloride is to be added, air entrainment is to be 6.5%, with a tolerance of ± 1.5%.

c. Temperature.

The temperature of Class B patching material, as delivered to the job site, is to be as required in Article 2530.02, B, 4, d below. Ensure the temperature of Class C patching material, as delivered to the job site, is greater than 65°F (18°C). Heating the water, aggregate, or both, may be necessary to meet this requirement. The cost of heating is incidental to patching.

d. Cement.

1) For Class M concrete mixtures, meet the requirements of Section 4101.

2) Refer to Table 2530.02-1 for cement types and maximum allowable substitution rates. The maximum substitution for Type IS is not to exceed 25%.

Table 2530.02-1: Cement Types and Maximum Allowable Substitution Rates

Patch Class	Cement Type	Maximum Allowable Substitution	Minimum Mix Temperature
B	Type I, Type II Type IS	0% Fly Ash 0% Fly Ash	75ºF (24ºC) 80ºF (27ºC)*
C	Type I, Type II Type IS	10% Fly Ash 0% Fly Ash	65ºF (18ºC) 70ºF (21ºC)*
* When a Type A Mid Range water reducing admixture is used, limit the minimum mix temperature to that required when Type I/II cement is used.			

e. Calcium Chloride.

1) Where calcium chloride is required, furnish it in water solution form and add it to the mix at the job site. Use a commercial 32% calcium chloride solution, or equivalent, prepared according to Table 2530.02-2:

Table 2530.02-2: Proportions for 32% Calcium Chloride Solutions

Type of Solid Calcium Chloride	Pounds (Grams) of Solid per Gallon (liter) of Water	Solution Produced per Gallon (liter) of Water
Type 1 – Regular Flake (77% material)	6 (720)	1.3
Type 2 – Concrete Flake or Pellets (94% material)	4.5 (540)	1.2

2) The Engineer will check the solution concentration using a hydrometer according to Materials I.M. 373. Add the solution at the rate of 3.0 gallons per cubic yard (14.8 L/m^3) of concrete. Calcium chloride solutions of different concentrations may be approved by the Engineer, provided appropriate adjustments in the total concrete composition are made.

3) Agitate the mixture until the calcium chloride is completely in solution, and continue agitation, as necessary, to maintain uniformity.

4) Except when using continuous mixing equipment described in Article 2001.20, E, ensure the calcium chloride solution is present in the mix for at least 2 minutes of mixing.

f. Water Reducer.
A Type A Mid Range water reducing admixture may be used. Use one listed in Materials I.M. 403, at the manufacturer's recommended dosage.

g. Aggregate Durability.
Unless specified otherwise, use coarse aggregate of the proper class of durability, as defined in Article 4115.04.

h. Transit Mix Concrete.
Use a mix from a plant from which the concrete can be delivered and placed within 60 minutes from the start of mixing. The time may be extended to 90 minutes when a retarding admixture, used according to Materials I.M. 403 including temperature dosage guidelines (and at no additional cost to the Contracting Authority), is added at the plant. Continuous mixing equipment using volumetric proportioning may be used according to Article 2001.20, E.

i. Prepackaged Mixture.
A prepackaged mixture, proportioned as specified above for Class B or Class C matching material, may be furnished as a Class B or Class C patching material with the Engineer's approval. The coarse aggregate for prepackaged mixtures is limited to that meeting the requirements of Article 4115.05. Mix prepackaged mixtures in an on-site paddle type mixer or proportion and mix with continuous mixing equipment using volumetric proportioning according to Article 2001.20, E.

C. Joint Boards.
Comply with the following:

1. Joint boards for recreating joints and cracks: use a resilient filler, cellulosic fiber, paraffin coated cardboard, or other compressible material of the proper shape to recreate the joint during placement of the patch material.

2. Boards for recreating transverse joints: one piece, so as to have no horizontal joints.

3. Boards for recreating longitudinal joints: one piece. One piece boards will not be required in lengths exceeding 4 feet (1.2 m).

4. Joints and open transverse cracks: use a board with a nominal width of 1/4 inch (5 mm). Metal strips may be used for narrow cracks.

5. Extend boards and metal strips into the pavement to the bottom of the patch.

6. Use of a bond breaker on board surfaces is encouraged.

D. Joint Sealer.
Use joint sealer and backer rod meeting the requirements of Section 4136. Unless specified otherwise, use only hot poured joint sealer.

E. Tack Coat Bitumen.
For HMA patches, use tack coat bitumen as specified in Article 2303.02, E.

2530.03 CONSTRUCTION.

A. Equipment.

1. Remove existing surface material using a milling machine, jack hammers, or similar equipment. Hand equipment may be necessary to achieve a vertical edge and the designated shape.

2. Sawing equipment is required at edges from a milling operation.

3. The following additional equipment is required for PCC patches:
- **a.** Sandblasting equipment for cleaning of the prepared patch area on PCC pavements.
- **b.** 15 pound (7 kg) (or less) air chisel to complete patch area preparation. A 30 pound (14 kg) air chisel may be used if its use does not result in significant damage to the patch area and edges.
- **c.** Air compressor that emits oil and moisture free air for cleaning the prepared area.
- **d.** On-site paddle type concrete mixer for mixing Class A patching material or other prepackaged mixtures.

B. Partial Depth Finish Patch Construction.

1. General.
- **a.** The tabulations for partial depth finish patches shown in the contract documents are for estimating purposes only. The Engineer will designate the location and limits of these patches.
- **b.** The shape and depth may be irregular so that hand operated equipment may be necessary for all or some of the removal.
- **c.** Remove the existing pavement material within the designated area to sound concrete as determined by the Engineer. All material removed not designated for salvage becomes the property of the Contractor and shall be removed according to Article 1104.08.

2. Hot Mix Asphalt Patches.
Construct partial depth HMA finish patches as follows:

a. Preparation of Patch Area.

1) Remove material to a minimum depth of 3 inches (80 mm). Where this depth is adequate, make the prepared surface relatively even. The maximum depth is 75% of the pavement thickness, but no more than 9 inches (230 mm).

2) Remove material so that the edges of all patch areas are vertical to a depth of 1 1/2 inches (40 mm). Minor rounding of

the bottom edge is permissible. Cut and remove exposed reinforcing steel. Clean the patch area.

3) Where removal to the depth described above leaves unsound concrete within the limits of the patch area, the Engineer may designate a part of the patch area as a full depth patch. Remove the concrete for the full depth, but removal to a depth greater than 12 inches (300 mm) will not be required. Consolidate the subgrade or subbase material with a mechanical tamper or other compaction equipment as directed by the Engineer.

b. Placing HMA Patch Material.

1) After removal of the old pavement, lightly tack the edges and bottom of the patch area. Deposit and compact the HMA patch mixture in layers as follows:

a) Deposit the upper 5 inches (130 mm) in at least two layers, with the top layer not exceeding 2 inches (50 mm) in thickness, when compacted. Lifts should be at least 3 times the mixture size.

b) Thoroughly compact each layer, while hot, using appropriate compaction equipment. Succeeding layers may be placed as soon as the preceding layer has been properly compacted.

c) Smooth the final layer with a steel tired finish roller meeting requirements of Article 2001.05, B or F. A roller meeting requirement of Article 2001.05, F, may be a small roller suitable for this type of operation.

d) Ensure the final compacted surface is level with, or not more than approximately 1/4 inch (6 mm) above, the surrounding pavement.

2) Open the patch to traffic after the mixture has cooled to provide stability; however, on two lane roadways, do not leave barricades in place overnight. If the patch becomes distorted beyond the smoothness requirements for any reason, smooth the surface within 1 working day by blading, scraping, filling, or by other approved means.

3) Prior to final acceptance, a finish patch shall be level with, or not more than 1/8 inch (3 mm) above, the adjacent pavement, and have a smooth riding surface.

c. Sealing Joints and Cracks.

1) Seal all edges of HMA patches to a width of 3 inches (80 mm) centered on the edge. Use CRS-2 bitumen applied with a "V" shaped squeegee tool. Blot excess bitumen material with sand.

2) When joint and crack sealing work is part of the contract, saw joints and cracks that cross areas of HMA finish patches to a width of 1/8 inch to 1/4 inch (3 mm to 6 mm). Saw to the depth of the patch with a maximum depth of 3 inches (80 mm). Perform this work within 3 working days after placement.

3. Portland Cement Concrete Patches.

Construct partial depth PCC finish patches as follows:

a. Preparation of Patch Area.

1) If a joint or crack is within a patch area, construct the edge of that patch to be at least 6 inches (150 mm) beyond the joint or crack.

2) Each patch will have a generally rectangular area. Remove the PCC concrete in that area to a minimum depth of 3 inches (80 mm). Many areas will require removal of unsound PCC concrete to a greater depth to reach sound concrete. The maximum depth is 75% of the pavement thickness but not more than 9 inches (230 mm).

3) Milling will be allowed, but the depth within the designated patch area is to be at least 3 inches (80 mm). Remove concrete from feathered runouts to a depth of 3 inches (80 mm) if within the designated patch area, or to a depth of 2 inches (50 mm) if outside the designated patch area. Saw these edges vertically. Ensure the prepared area has reasonably straight and vertical edges, not to exceed 1 inch (25 mm) in saw cut depth. Sawing will be required around the remainder of the patch perimeter, unless the Contractor demonstrates that an edge can be produced that is true and vertical, without sawing.

4) When removal to the maximum depth leaves unsound concrete within the patch area, the Engineer may designate a part of the patch area as a full depth patch. Remove the concrete for the full depth of the existing pavement, but no more than 12 inches (300 mm). Consolidate the subgrade or subbase material using a mechanical tamper or other compaction equipment as directed by the Engineer.

5) When it is necessary to go below reinforcing steel to reach sound concrete, cut the reinforcing steel flush with the perimeter edges of the patch and remove.

6) Clean the patch area by sandblasting, followed by cleaning with compressed air. The completed surfaces are to appear surface dry to visual examination.

7) Recreate a joint or crack in the patch area with a joint board of the proper size and shape. Extend the board to the bottom of the area to be patched, so as to separate completely all patching material on both sides. Use a board of a width approximately equal to the joint or crack. For wide openings, several thicknesses may be used.

b. Placing PCC Patch Material.

1) Scrub a cement-sand-water grout of creamy consistency onto the patch surfaces, including the edges. Place the patch material before the grout dries.

2) Mix Class A patching material with water and coarse aggregate, if required. Place the properly mixed material in the patch area, consolidated and worked into place in a manner that will provide good bonding. Level it with the adjacent pavement to provide a smooth riding surface. Texture patches longer than 1 foot (0.3 m) in the manner of the adjacent pavement surface.

3) Perform this work according to the patching manufacturer's recommendations and limitations, subject to approval of the Engineer. Furnish these recommendations to the Engineer. After 1 hour, remove the joint board in a manner that does not damage the patch. The area may then be returned to public traffic.

4) Mix Class B and Class C patching material and place in the patch area. Consolidate it by vibration in a manner that will provide good bonding. Level the patch to provide a smooth riding surface. Texture patches longer than 1 foot (0.3 m) in the manner of the adjacent pavement surface.

c. Protecting and Curing.

1) Class A patching material.
Cure according to the manufacturer's recommendations. Use a minimum curing time according to Materials I.M. 491.20, Appendix A.

2) Class B patching material.

a) Cure as specified in Article 2529.03, H.

b) Cure these patches for the minimum time specified in Article 2529.02 for the mixture used.

3) Class C patching material.

a) Cure according to Article 2529.03, H. Patches may be covered immediately with white pigmented curing compound. In this case, the specified cure may be delayed as much as 2 hours.

b) Cure patches with Class M concrete a minimum of 36 hours or as directed by the Engineer.

c) After the required curing period, the insulation blanket and the joint forming board may be removed in a manner that does not damage the patch, or removal may be delayed until the sealing is to be done provided no damage results from the delay.

d. Surface Finish.
Prior to final acceptance, level finish partial depth patches with the adjacent pavement. Ensure they have a smooth riding surface.

e. Joint and Crack Sealing.
Where joints and cracks cross areas of partial depth PCC patches, saw, seal, and clean the patch according to Article 2301.03, P. Complete sealing within 5 working days after the patch is placed. When joint and crack sealing is included in the contract, perform sealing as part of that work.

C. Limitations of Operations.

1. Unless the road is closed, maintain traffic during construction operations. Conduct all operations with minimum inconvenience to traffic. On two-lane roads, limit operations to one traffic lane at a time, except for minor encroachment in the adjacent lane for sawing and installing forms when traffic is maintained. For multiple lane roadways, the work area may include one lane in each direction.

2. An adjacent lane shall be opened to traffic prior to the old pavement being removed from a patch area.

3. When approved by the Engineer, patch areas may extend up to 2 feet (0.6 m) into an adjacent lane as allowed by the contract documents.

4. Adjust the work schedule so all work for each patch, including removal of barricades and equipment (except the cure period for PCC Class C concrete), will be completed on the same day it is started between the hours of 30 minutes after sunrise to 30 minutes before sunset. If unforeseen conditions result in excavated areas being left overnight, assign a sufficient number of flaggers to warn and direct traffic until the patches are placed. Extra payment will not be made for the necessary flaggers.

5. Place PCC patching material only when the ambient air and pavement temperatures are 45°F (7°C) or above.

6. The Engineer may limit advance sawing.

7. If an emergency makes a DW joint necessary, temporarily fill the excavated area following the joint with a suitable hot or cold paving mixture or stable granular material, as directed by the Engineer. The Engineer may direct that the lane remain closed to traffic overnight. Provide traffic control.

8. When PCC patches without calcium chloride are constructed, place two drums meeting the requirements of Article 2528.03, C, in front of each patch location where there is a possibility of turning into or returning to the closed lane. Additional drums need not be placed for patches spaced closer than 150 feet (45 m).

9. Apply Articles 1107.08, 1107.09, and 1108.03.

D. Area Restoration.
When the patch is completed, remove forms if they have been used. Fill all excavated space along the outside pavement edge with material similar to that in the existing shoulder, satisfactory to the Engineer. Thoroughly compact the material before the section is opened to traffic.

2530.04 METHOD OF MEASUREMENT.

The Engineer will determine the quantities involved in satisfactory construction of partial depth finish patches for the areas specified as follows:

A. Partial Depth PCC Finish Patches.

1. The Engineer will calculate the area of each patch in square feet (square meters) from surface measurements. The area of each patch less than 1 square foot (0.1 m^2) will be counted as 1 square foot (0.1 m^2) for payment purposes. If the patch area is increased by the

Contractor to accommodate milling equipment, only the area designated by the Engineer will be measured for payment.

2. The Engineer will also calculate the area of patches in square feet (square meters) which have been directed to be constructed full depth.

B. Partial Depth HMA Finish Patches.

1. The Engineer will measure the area for each patch and the weight (mass) of HMA placed in partial depth patches according to Article 2303.04. Regular patches and irregular patches will be calculated and totaled separately. If the patch area is increased to accommodate milling equipment, only the quantities for the area designated by the Engineer will be measured for payment.

2. Asphalt binder and tack coat will not be measured separately for payment.

3. The Engineer will also calculate the area and weight (mass) of patch material placed in HMA patches which have been directed to be constructed full depth. The Engineer will deduct quantities not used.

2530.05 BASIS OF PAYMENT.

Payment for construction of the various types of partial depth finish patches, satisfactorily constructed, at the areas specified, will be the contract unit price as follows:

A. Partial Depth PCC Finish Patches.

1. Per square foot (square meter).

2. Payment is full compensation for removal of all pavement, preparing the patch area, furnishing and placing all material, construction of joints, sawing, finishing, curing, and restoration of the area.

3. When parts of PCC partial depth finish patches are constructed to full depth at the direction of the Engineer, payment will be for the areas of those parts at 2.0 times the contract price per square foot (square meter) for partial depth PCC patches.

B. Partial Depth HMA Finish Patches.

1. Payment will be for both the patch area and the quantity of HMA placed in the patch.

a. Regular Partial Depth HMA Finish Patches, by Area.
Per square yard (square meter).

b. Irregular Partial Depth HMA Finish Patches, by Area.
Per square yard (square meter).

c. Hot Mix Asphalt Mixture.
Per ton (megagram). Includes mixture designated for full depth patches.

2. When parts of regular or irregular partial depth HMA finish patches are constructed to full depth at the direction of the Engineer, payment will be for the areas of those parts at 2.0 times the contract price per square yard (square meter) for regular or irregular partial depth HMA finish patches.

3. Payments are full compensation for:
- Removal of the old pavement,
- Preparing the patch area,
- Furnishing and placing the HMA patching material, including asphalt binder in the mixture and necessary tack coat bitumen,
- Sawing and sealing,
- Sealing the patch edges, and
- Restoration of the area.

4. When joint and crack sealing is included in the contract, it will be paid for as a part of that work.

Section 2531. Pavement Surface Repair (Milling)

2531.01 DESCRIPTION.

A. Mill the surface of HMA or PCC pavement to improve:
- The surface profile and cross section for use as a traffic surface, and
- The surface texture.

B. For the purpose of this work, milling is a general term meaning removal of a pavement surface by milling with cold planing equipment.

C. The type of coarse aggregate existing in the concrete will be identified.

D. Unless designated in the contract documents, do not extend milling across bridges.

2531.02 MATERIALS.
None

2531.03 CONSTRUCTION.

A. Equipment.

1. Meet the following requirements for milling equipment:
- **a.** Capable of removing the pavement surface to the necessary depth. Use cold planing equipment.
- **b.** Capable of milling the surface of one traffic lane in no more than two passes.
- **c.** Milling drum with a minimum of 60 cutting teeth per foot (195 cutting teeth per meter) of width with a transverse spacing of approximately 1/4 inch (5 mm).

d. Cutting teeth with a cutting head face which is pointed to an angle of not more than 75 degrees.
e. Milling drum that produces a uniformly cut surface free of ridges or valleys.

2. Use milling equipment that is automatically controlled on one side, and has cross slope control or is automatically controlled on both sides.

3. Replace broken teeth immediately.

4. Use a rotary broom as described in Article 2001.14 to clean the milled surface.

5. Use water as necessary to avoid a traffic hazard and a dust nuisance.

B. Pavement Surface Repair.

1. Mill the entire surface of the pavement in a longitudinal direction. Mill substantially the entire surface area of the pavement until:
- The pavement surface on both sides of the transverse joints and all cracks are in the same plane and have the same surface texture, and
- The pavement meets the smoothness requirement.

2. In each lane, ensure at least 95% of the area in each 100 foot (30 m) section has a newly textured surface. Except at or near joints and cracks, limit milling to no more than 1/2 inch (15 mm) in depth. At joints and cracks, limit milling to no more than 3/4 inch (20 mm) in depth.

3. Meet the following requirements for milling:
a. Progress in the direction against normal traffic in the lane being milled unless specified otherwise by the Engineer.
b. Ensure all construction traffic entering or leaving the work area moves in the direction of traffic of the open lane.
c. Begin and end at lines normal to the pavement center line within any one milled area and at the project limits. This will not be required at the end of each shift.
d. Control the depth of adjacent cuts to produce a smooth, uniform cross section, free from irregularities between adjacent passes of the milling equipment.
e. Ensure there are no transverse troughs due to lowering the drum below the cutting plane (caused by continued down pressure when forward motion of the machine has stopped).
f. Limit milling in each traffic lane to no more than two passes, but additional passes in the cutting path may be necessary to secure a smooth profile.
g. Ensure each single pass does not extend to both sides of the center line or a lane line between traffic lanes. However, ensure the first pass at the center line or lane line overlaps the joint line approximately 2 inches (50 mm) to minimize spalling.

h. Ensure the joint match, if any, between two passes in a traffic lane is within 1 foot (0.3 m) of the center of the lane, to avoid joints directly in the wheel path, and is straight or parallel to the center line or lane line.

i. Ensure each pass is designed to maintain the existing crown and a taper from center line to pavement edge.

j. Ensure the transverse slope of the milled pavement is uniform to a degree that there is no depression or misalignment greater than 1/4 inch in 12 feet (6 mm in 3.6 m) when tested by stringline or straightedge placed perpendicular to the center line. Ensure the joint match between two adjacent passes matches within 1/8 inch (3 mm).

k. In order to match the outside edge of the pavement, mill adjacent paved areas (for example, shoulders, curb and gutter, turn lanes, tapers, paved crossovers, and so forth) to minimize vertical projections.

l. Ensure the finished surface has a uniform, coarse texture. Obtain the Engineer's approval.

m. Control the forward speed of the milling machine to prevent the formation of visible corrugations on the pavement surface.

C. Smoothness.

1. The Engineer will partly profile the pavement on the initial trace using the procedure described in Article 2316.02, B. The average profile index for each area may be shown in the contract documents. The bidder is also advised that all profilograph information is available for inspection at the Office of Contracts by a request to the Contracts Engineer.

2. After the contract is awarded, the profilograph information will be available from the Engineer. This information represents a summary of conditions found to exist at the time the survey was made. The availability of this information will not constitute a guarantee that a profile other than that indicated will not be encountered at the time of milling.

3. Provide a control profilograph trace as described in Article 2316.02, B prior to performing any grinding work. This control trace will be used to identify the required smoothness for the project. Each segment of the finished ground surface is to:

- Have a final profile index of 35% of the control profilograph trace or 10 inches per mile (160 mm/km), whichever is greater, and
- Not include any bumps exceeding 0.5 inches in 25 feet (13 mm in 8 m).

4. When the Engineer approves, the following areas will be excluded from profilograph testing:

- Depressed pavement areas due to subsidence or other localized causes, and
- Areas where the maximum cut at mid panel or a fault restricts further milling.

5. End profilograph testing 15 feet (5 m) prior to excluded areas and resume 15 feet (5 m) following excluded areas.

6. Test and evaluate the milled surface according to Section 2316, with the following modifications:
- **a.** Run the test and evaluate the profilograph using the same procedure as for the control trace.
- **b.** Each segment for which continuous milling is designated will be evaluated individually, and it shall meet the smoothness and bump requirements specified above, regardless of its length.
- **c.** In excluded areas, smoothness requirements will be modified or may be waived by the Engineer.
- **d.** Certify smoothness of the finished surface according to Article 2316.02, C.
- **e.** The Engineer may test for smoothness and bumps near the center line and at other spot locations where compliance is questioned. Additional milling may be required.
- **f.** Do not use the original and final profilograph trace to determine milling depth.

D. Limitations.

1. Perform lane closures necessary to accomplish this work as shown in the contract documents, or as directed the Engineer. Open the entire roadbed to traffic at the end of the working period. Uncompleted sections may be opened to traffic without completion of milling across an entire lane.

2. Overnight lane closures will not be permitted. Work will not be permitted on Sundays or holidays described in Article 1108.03. Apply Articles 1107.08 and 1107.09.

3. Continuously remove all slurry or residue resulting from the milling operations. Do not deposit on the slab or paved shoulder. Pavement and paved shoulders shall be left in a clean condition. Residue from milling operations should not be permitted to flow across lanes occupied by public traffic or to flow into gutters or other drainage facilities. This residue may be placed on the shoulder or foreslope, or removed according to Article 1104.08.

4. When the following work is included in the contract, sequence the operations in the following order:
- **a.** Undersealing,
- **b.** Longitudinal subdrains,
- **c.** Patching,
- **d.** Milling,
- **e.** Installation of load transfer, and
- **f.** Crack and joint sealing.

E. Pavement Markings.
Place pavement markings according to Section 2527; however, pavement marking of edge lines on Interstate pavement may be delayed up to 24 hours after the lane is opened to traffic. Pavement marking will not be allowed on Sundays or holidays, unless the Engineer approves otherwise.

2531.04 METHOD OF MEASUREMENT.

A. The Engineer will calculate the area in square yards (square meters) of pavement milled, for each type of coarse aggregate from the length of each area and the nominal pavement width.

B. Adjacent paved areas milled to minimize vertical projections will not be measured for payment.

2531.05 BASIS OF PAYMENT.

A. Payment for Pavement Surface Repair (Milling Limestone) or Pavement Surface Repair (Milling Gravel) will be the contract unit price per square yard (square meter).

B. Payment is full compensation for furnishing all equipment, materials, and labor to mill the pavement and test for smoothness according to the contract documents, including removal of slurry and residue from the project.

Section 2532. Pavement Surface Repair (Diamond Grinding)

2532.01 DESCRIPTION.

A. Use a diamond grinder to grind an existing PCC pavement surface, used as traffic surface, for profile improvement. Perform grinding and texturing at the locations shown in the contract documents. Refer to Article 2532.03, B, 3 for grinding bridge decks.

B. The existing surface and the coarse aggregate will be described in the contract documents.

C. This work may involve using a diamond grinder to grind a newly constructed deck surface for temporary surface texture. Perform grinding prior to opening the deck segment to traffic.

2532.02 MATERIALS.
None.

2532.03 CONSTRUCTION.

A. Equipment.

1. Perform grinding and texturing using diamond blades mounted on a self propelled machine that has been designed for grinding and texturing

concrete surfaces. Ensure the equipment will not cause strain or damage to the underlying pavement.

2. Do not use grinding and texturing equipment that causes excessive ravels, aggregate fractures, spalls, or disturbance of the transverse and/or longitudinal joints.

3. Use grinding equipment with a minimum effective head width of 36 inches (300 mm).

4. Select the blade type and number of blades per foot (meter) to provide proper surface texture based on the concrete being ground, in particular, the coarse aggregate type.

B. Pavement Surface Repair.

1. General.

a. Grind and texture the concrete surface in a longitudinal direction.

b. Ensure the surface, after grinding, is of uniform texture.

c. When using more than one grinding machine in the same travel lane, use similar blade segment thicknesses, blade spacings, and blade diameters on all machines so the texture of the ground surface is reasonably uniform across the lane.

d. To be in compliance, the land area and the texture depth shall be within the specified ranges. It may be necessary to adjust the blade spacing during a project to stay within specified ranges.

e. For multiple passes, carefully control the equipment to minimize the overlap. Ensure overlaps do not exceed 1 inch (25 mm).

f. Ensure that, after grinding, the transverse slope of the concrete surface is uniform to a degree that there are no depressions or misalignment of slope greater than 1/4 inch in 12 feet (6 mm in 3.6 m) when tested by stringline or straightedge placed perpendicular to the center line.

g. In order to match the outside edge of the pavement, grind adjacent paved areas (for example shoulders, curb and gutter, turn lanes, tapers, paved crossovers, and so forth) to minimize vertical projections.

h. The Contractor is responsible for quality control of the texture. The Engineer will conduct random Quality Assurance inspections.

2. PCC Pavement.

a. Grind and texture entire surface area of the pavement until:

- The pavement surface on both sides of the transverse joints and all cracks are substantially in the same plane with no greater than 1/16 inch (1.59 mm) difference between adjacent sides of joints or cracks, and
- The pavement surface meets the smoothness required.

b. In each lane, ensure at least 95% of the area in each 100 foot (30 m) section has a newly textured surface. Depressed pavement areas and areas of excess faulting as identified in 2532.03, C, 1, b, 4 will be exempt from this requirement.

c. Meet the following requirements for grinding:

1) Ensure all construction traffic entering or leaving the work area moves in the direction of traffic of the open lane.
2) Begin and end at lines normal to the pavement center line within any one ground area and at the project limits. This will not be required at the end of each shift.
3) Maintain good transverse drainage at all times.
4) Assemble the grinding head to produce the tolerances in Table 2532.03-1 on pavements with the indicated coarse aggregates.

Table 2532.03-1: Grinding Head Tolerances

	Limestone	**Gravel/Quartzite**
Land area between grooves[(a)]	0.090 to 0.110 inches (2.29 to 2.79 mm)	0.080 to 0.095 inches (2.03 to 2.41 mm)
Texture depth[(b)]	Target of 1/8 inch (3.18 mm) with average between 1/16 inch to 3/16 inches (1.59 mm to 4.77 mm)	

(a) Based on an average of a minimum of ten measurements across the ground width for one pass.

(b) Based on an average of a minimum of six measurements across the ground width for one pass.

5) A test area 500 feet (150 m) long and the width of the grinding head will be allowed for each new or restacked head, provided a surface texture in reasonable conformance with the specification is being produced.

3. Bridge Deck.
a. Grind and longitudinally groove the entire surface of the bridge deck according to Article 2412.03, D, 4, a.
b. Assemble the grinding head to produce the tolerances in Table 2532.03-1on bridge decks.

C. Smoothness.

1. PCC Pavement.
a. The Engineer may partly profile the pavement using an inertial profiler. The latest inventory average international roughness index (IRI) for each area may be shown in the contract documents. The bidder is also advised that any available profile information is available electronically from the Office of Contracts by contacting the Contracts Engineer. This information represents a summary of conditions found to exist at the time the survey was made. The availability of this information will not constitute a guarantee that a profile other than that indicated will not be encountered at the time of milling.
b. Prior to performing grinding work, provide a profile using an inertial profiler meeting the requirements of Materials I.M. 341. This control profile will be used to identify the required smoothness for the project if a percent improvement is the controlling factor. Obtain a

final average IRI for each 0.1 lane-mile (161 lane-meter) segment as follows:

1) For speeds greater than 45 mph: 65.0 in/mile (1.027 m/km) or less and no bumps exceeding 0.5 inches in 25 feet (12.7 mm in 7.6 m).

2) For speeds 45 mph or less: 115.00 in/mile (1.816 m/km) and or less and no bumps exceeding 0.5 inches in 25 feet (12.7 mm in 7.6 m).

3) For extremely rough conditions: the greater of 35% of the pre-grind profile or the aforementioned requirement shall be the required smoothness or less and no bumps exceeding 0.5 inches in 25 feet (12.7 mm in 7.6 m).

4) Identify depressed pavement areas and localized areas with excess faulting greater than 1 inch (25 mm). Review these areas with the Engineer to determine the limits for exclusion from the profile index calculation.

c. Obtain the profile in both wheel paths of each mainline lane using a certified operator. A pavement segment is defined in Article 2317.03. Compute an average IRI for each segment of each lane by averaging the two wheel path IRI values. The wheel paths are at 3 feet (0.9 m) and 9 feet (2.7 m) from center line or lane line.

d. Verification testing requirements will be according to Article 2317.04, F

2. Bridge Deck.

Ensure the smoothness requirements of Section 2428 are met prior to performing the texturing. After texturing, test the bridge deck again according to Article 2428.02, C. Ensure the resulting profile index does not exceed the corrected profile index prior to the texturing.

D. Limitations.

1. General.

a. When nighttime work is required, include lighting at each work area. Ensure lighting does not glare into oncoming motorists.

b. Continuously remove all slurry or residue resulting from the grinding operations. Do not deposit on the slab or shoulder. Leave pavement and paved shoulders in a clean condition. Ensure residue from grinding operations does not flow across lanes occupied by public traffic or into gutters or other drainage facilities. This residue may be spread on the foreslope or removed according to Article 1104.08.

2. PCC Pavements.

a. Uncompleted sections may be opened to traffic without completion of grinding across an entire lane.

b. During nighttime grinding operations, progress in the direction with normal traffic flow.

c. When the following work is included in the contract, sequence the operations in the following order:

1) Undersealing,

2) Longitudinal subdrains,
3) Patching,
4) Installation of retrofit load transfer,
5) Diamond grinding, and then
6) Crack and joint sealing.

3. Bridge Decks.
Prior to opening to traffic, complete the work under this specification and meet the smoothness requirements.

2532.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. PCC Pavement.

1. Square yards (square meters) of Pavement Surface Repair, of the type specified, shown in the contract documents.

2. Adjacent paved areas ground to minimize vertical projections will be measured for payment. Payment will be in square yards (square meters) of Pavement Surface Repair based upon a width of 2 feet (0.61 m) times the length of the required feather pass.

B. Bridge Deck.
Square yards (square meters) of Pavement Surface Repair, of the type specified, shown in the contract documents.

2532.05 BASIS OF PAYMENT.
Payment will be as follows:

A. Contract unit price per square yard (square meter) for Pavement Surface Repair (Grinding Limestone) or Pavement Surface Repair (Grinding Gravel).

B. Payment is full compensation for furnishing all equipment, materials, and labor to:
- Grind the concrete surface,
- Test for smoothness according to the contract documents, and
- Remove slurry and residue from this operation.

C. In addition to the payments above, the Contractor may receive an incentive payment based upon the number of qualifying segments. The incentive payment will be based upon the following schedule:

Table 2532.05-1: Incentives for Pavement Surface Repair (Diamond Grinding)

International Roughness Index for greater than 45 mph	International Roughness Index for 45 mph or less	Dollars per 0.1 mile (161 m) segment per lane
Inches per mile (m/km)	Inches per mile (m/km)	
0.00 – 30.00 (0.000-0.473)	-	400
30.01 - 50.00 (0.474-0.789)	- -	1000-(20 X IRI) [1000-(1267 X IRI)]
50.01 - 65.00 (0.790-1.026)	0.00 - 115.00 (0.000-1.815)	Contract Unit Price
>65.01 (1.027)*	>115.01 (1.816)*	Grind

* For extremely rough conditions, this limit may be higher as noted above.

Section 2533. Mobilization

2533.01 DESCRIPTION.

A. Preparatory work and operations for all items under the contract, including, but not limited to those necessary for:
- The movement of personnel, equipment, supplies, and incidentals to the project site,
- The establishment of all offices, buildings, and other facilities necessary for work on the projects, and
- All other work or operations which shall be performed or costs incurred prior to beginning work on the various items on the project site.

B. Mobilization may include bonding, permit, and demobilization costs.

C. Nothing herein is to be construed to limit or preclude partial payments otherwise provided for by the contract.

D. A contract item for Mobilization will not be included for maintenance aggregate, materials, granular surfacing, or for any other minor projects.

E. When the proposal includes a lump sum item for Mobilization, the bidder shall indicate the bid price in dollars, and this is the contract price for this item. When the proposal does not include a lump sum item for Mobilization, all costs incurred by the Contractor for Mobilization are incidental to other work.

2533.02 MATERIALS.
None

2533.03 CONSTRUCTION.
None.

2533.04 METHOD OF MEASUREMENT.
None.

2533.05 BASIS OF PAYMENT.
Payment for Mobilization will be as follows:

A. Partial Payments.
Partial payments may be made as follows:

1. Partial payment of mobilization will be made for each project within 30 calendar days after receipt of a signed contract. This partial payment will be either 10% of the contract price for this item or 1% of the original project sum, whichever is less. If the partial payment for a project is less than $1000, the Engineer will delay this partial payment until 5% of the awarded project total is earned.

2. When 5% of the original project sum is earned, either 25% of the contract price for this item or 2.5% of the original project sum, whichever is less, will be paid.

3. When 10% of the original project sum is earned, either 50% of the contract price for this item or 5% of the original project sum, whichever is less, will be paid.

4. When 25% of the original project sum is earned, either 100% of the contract price for this item or 10% of the original project sum, whichever is less, will be paid.

B. Full Payment.
Upon completion of all work on the project required by the contract, full payment will be made for this contract item, including any amount not paid as a partial payment.

Section 2534. Delivery of Samples

2534.01 DESCRIPTION.
This item covers the delivery of project samples for testing purposes. It applies to Interstate and Primary projects for which certified plant inspection is required or authorized. These provisions do not apply to Non-Primary projects for which certified plant inspection is required or authorized, unless indicated in the contract documents.

2534.02 MATERIALS.
None.

2534.03 SAMPLE DELIVERY AND RECIEVING.

A. Sample Delivery.

1. Deliver to the Engineer samples for the purposes of acceptance, monitoring, and verification testing. Include aggregates and asphalt mixtures. Samples of other materials may be required.

2. Properly identify the samples. Deliver to the District Materials Laboratory for the District having jurisdiction over the contract, unless the Engineer directs otherwise. Deliver the samples promptly, as determined by the Engineer.

B. Sample Receiving.

1. Samples received by the District Materials Engineer will be promptly tested. Materials for projects with accelerated work schedules will be given special consideration.

2. Not all samples are to be tested. The selection of samples to be tested will be made by the District Materials Engineer, based on Construction Office and Materials Office instructions. Samples initially identified for testing will normally be tested at least by the end of the working day following delivery. These test results will be available to the Contractor as soon as testing is completed.

2534.04 METHOD OF MEASUREMENT.
None.

2534.05 BASIS OF PAYMENT.
Preparing, identifying, and delivering samples will be considered incidental to the cost for samples of the appropriate item.

Section 2535. Bin Type Crib Walls

2535.01 DESCRIPTION.

A. Bin type crib walls will be used to retain earth embankments when lateral clearance will not allow normal earth slopes. These walls may be constructed of precast concrete units in the form of alternate courses of stretchers and headers or may be constructed of formed galvanized sheets so that when assembled, they will form a succession of vertical, rectangular cells which will be filled with suitable backfill material.

B. Both precast concrete units and formed galvanized sheets are required to conform to the contract documents.

2535.02 MATERIALS.
For materials used in construction of the cell walls, meet the following requirements for the respective types:

A. Concrete Crib Units.
Precast concrete complying with the applicable requirements of Section 2407.

B. Formed Galvanized Sheets.

1. Sheets.
Comply with requirements of Section 4141 for the type of base metal and galvanizing. Ensure the sheets are of the gage specified in the contract documents. Sheets may be galvanized before punching and forming.

2. Nuts and Bolts.
Use bolts and nuts galvanized according to ASTM A 153, Class C. Use unfinished regular bolts meeting requirements of ASTM A 307, Grade A, full diameter body.
- Threads: ANSI B1.1, Unified Coarse Thread Series.
- Bolt heads and nuts: either standard square, hexagonal, or heavy hexagonal style; meet the requirements of ASTM A 307 or ASTM A 563.

2535.03 CONSTRUCTION.

A. Excavation.

1. Excavate the site to provide a firm foundation at the desired elevation. If the wall face is to be battered, excavate the foundation to be sloped to the heel to provide the required batter of the wall face. Otherwise, excavate the foundation to be level. Compact the soil beneath the entire bin area by rolling or tamping to provide a firm foundation.

2. Unless designated otherwise, when construction of bin type crib wall is included in the contract for grading a section of road, all excavation in connection with this construction is classified according to Article 2102.03, B, the same as other excavation in the contract. When not included in contracts for grading, all excavation in connection with this construction is Class 23 Excavation according to Article 2402.03, J.

B. Construction of Crib Walls.

1. When the total height of wall does not exceed 6 feet (1.8 m), the foundation may be level and wall face vertical. When the height of wall exceeds 6 feet (1.8 m), batter the wall face as indicated in the contract documents, but no less than 2 inches in 12 inches (50 mm in 300 mm). Adjust the foundation to provide the required batter in the wall face. Ensure courses of stretchers or plates in the wall face are level.

2. When specified in the contract documents, cover the subgrade for the wall with special backfill material meeting requirements of Section 4132. When drainage is provided beneath the wall foundation, cover the drain and foundation with porous backfill material meeting requirements of Section 4131.

3. Concrete Units.
a. Furnish concrete crib wall units in two patterns: one to be used as stretchers, and the other to be used as headers in building the wall. Ensure these units:
- Meet the requirements for dimensions and reinforcement shown in the contract documents,
- Are free from cracks, spalls, or surface depressions on any face,
- Have rectangular cross section, and

- Are beveled as shown in the contract documents.

b. Place a double row of stretchers along the line of the toe of the wall. Place one or more rows of stretchers along the heel of the wall, as indicated in the contract documents, according to the height of the wall. Ensure the end stretchers are of a length that full bearing is provided for the end headers. Place headers at right angles to the wall face at 6 foot (1.8 m) intervals. Leave a space of 1/4 inch (6 mm) between the stretcher and the projecting lug of the header to allow for slight movement of the wall.

c. Use the stretchers for the wall face that are indicated in the contract documents. Open type stretchers will provide approximately a 5 inch (125 mm) vertical opening between courses of stretchers. Closed type stretchers will provide approximately 1 inch (25 mm) vertical space between courses of stretchers.

d. Ensure stretcher courses in the wall face are level. If shimming is necessary, do so using layers of heavy asphalt roofing paper at bearings. Where the wall is stepped up or down, hold end headers in place using extra headers placed parallel to and between the rows of stretchers.

4. Formed Galvanized Sheets.

a. Ensure sheets are fabricated so they may be assembled and bolted to form cells of the shape and dimensions shown in the contract documents. Assemble the sheets as shown in the contract documents. Sheets may be placed individually and bolted in place, or the transverse walls and posts may be assembled as a unit and sheets of the front and rear walls placed individually.

b. After the plates of each course are in place, draw tight all bolts in that course.

c. Tighten all bolts in each course at least twice to assure that all bolts are properly tightened.

C. Placing Backfill.

1. After each 3 foot (1 m) lift of crib wall cell is completed, promptly place backfill material consisting of suitable earth or granular material, as specified. Ensure the backfill material completely fills the cell, as well as the space between the cell and any face of natural earth behind the wall. Place backfill material in layers no greater than 6 inches (150 mm), thoroughly compacted by tamping. Granular material may be compacted by vibration.

2. Use a method of compaction that neither distorts the wall nor displaces the units.

2535.04 METHOD OF MEASUREMENT.

Measurement for the items associated with Bin Type Crib Walls will be as follows:

A. Excavation.

1. Part of a contract for grading a section of road: as provided in Section 2102.

2. Not a part of a contract for grading a section of road: Class 23 excavation will be computed as provided in Section 2402. In addition, the quantity of excavation will include only material actually removed above the elevation of the subgrade designated in the contract documents and bounded by:

- Vertical planes 1 foot (0.3 m) beyond the horizontal projection of the headers at the ends, and
- The stretchers at the rear and by the natural ground surface at the top and front.

B. Backfill Material.

1. Granular backfill material furnished: cubic yards (cubic meters) or in tons (megagrams) as indicated in the contract documents and as provided in Article 2402.04, E.

2. Earth backfill material: not measured.

C. Bin Type Crib Wall.
The Engineer will compute in square yards (square meters) the face area of each design of bin type crib wall from measurements of the length of wall and the height from the extreme top and bottom of stretcher units or sheets.

2535.05 BASIS OF PAYMENT.

A. Payment for the various items associated with Bin Type Crib Walls will be the contract unit price as follows:

1. Excavation.
Per cubic yard (cubic meter) for the type of excavation.

2. Backfill Material.
Per cubic yard (cubic meter) or per ton (megagram).

3. Bin Type Crib Wall.
Per square yard (square meter) for each design constructed.

B. Payments are full compensation for:

- Furnishing all materials, tools, and labor necessary to construct the crib walls complete for the respective type,
- For placing and compacting of earth or granular backfill material, and
- For all other operations necessary to the work and not covered by other items.

Section 2536. Asbestos Removal

2536.01 DESCRIPTION.

Removal, transport, and disposal of asbestos from buildings and structures scheduled for demolition or renovation. Perform the work according to 40 CFR Part 61, Subpart M. The work will be detailed in the contract documents.

2536.02 LICENSING, IDENTIFICATION OF WORK, AND RIGHTS OF POSSESSION OR OCCUPANCY.

A. Bidding.

Bids will be received for this project from bidders who hold a valid permit for this type of work issued by the Iowa Workforce Development, Labor Services Division, and from bidders who can provide documentation the work will be subcontracted to a contractor holding a valid permit.

B. Identification of Work.

1. The Contracting Authority will have inspected the buildings and structures for the presence of asbestos. Suspect materials will have been sampled and tested. The results will be included in the contract documents.

2. Access to the buildings and structures by prospective bidders will be allowed. Arrangements for access will be made by the Office of Contracts, on request.

3. The Contracting Authority assumes no responsibility for the condition of the existing buildings and structures.

4. Inspect the sites identified in the contract documents from which asbestos is to be removed prior to submittal of a bid.

5. Furnish, install, and maintain protective barricades and fences for public safety during the contract period.

C. Rights of Possession or Occupancy.

The Contracting Authority has complete authority as to the possession of properties by any occupant. The Contractor, the Contractor's authorized subcontractors, their agents, or other individuals do not have any right of authority to grant occupancy or to charge or collect any rents on any properties in this contract within the limits of this project.

2536.03 ASBESTOS REMOVAL AND DISPOSAL.

A. Reporting.

1. Give a minimum of 14 calendar days advance notification of the work to the Iowa DNR and the Iowa Labor Services Division according to 40 CFR Part 61, Subpart M and other applicable regulations concerning asbestos removal work. In addition, obtain all necessary authorizations

for the work. Provide copies of all notification and authorization information to the Engineer prior to starting work.

2. Specific reporting, authorization, and notification requirements may be specified in the contract documents.

B. Removal.

1. Remove, transport, and dispose of all asbestos specified in the contract documents. Perform this work in compliance with current applicable local laws, rules, regulations, and ordinances and requirements of the U.S. EPA, the Iowa DNR, and the Iowa Workforce Development. The Contractor is expected to be fully knowledgeable of these requirements.

2. Provide workers licensed and trained in asbestos abatement according to IA 875, Chapter 155. Ensure these workers are on-site during the asbestos removal work. Ensure evidence that the required training has been accomplished by these persons is available for inspection during normal business hours.

3. Limit this work to asbestos removal. Salvage will not be permitted. Removal of pipes, ducts, or other items as units will be permitted only if future demolition is intended and the removal of these items is necessary for asbestos removal.

4. Some of the asbestos may not be friable. It may be possible to remove and dispose of this material in a manner to maintain its non-friable condition.

5. Monitor and test for air borne asbestos particles during working hours according to the current EPA and Iowa Labor Services Division regulations. Conduct the operations to keep air borne particles within the established regulation limits. Provide the Engineer with copies of correspondence, test results, recommendations, and other information the Engineer needs to document compliance with these requirements.

6. When asbestos removal is completed, all work will be inspected for the presence of asbestos debris. Continue removal and cleaning until air monitoring clearance testing indicates a level of air borne fibers is equal to or less than the requirements in the current EPA and Iowa Labor Services Division regulations. Notify the Engineer when this sampling is started. Provide documentation to the Engineer that the level of air borne fibers, after the work is completed, is equal to or less than the requirements in the current EPA and Iowa Labor Services Division regulations.

7. Provide the Engineer with test results for all air monitoring tests within 24 hours after the sampling has been completed.

8. Comply with current EPA, State, and Federal regulations. At all times, take necessary precautions and provide necessary equipment to all persons employed on the project.

C. Disposal.

1. Dispose of removed asbestos promptly. Transport and dispose of waste containing asbestos according to current U.S. EPA and Iowa DNR regulations.

2. Identify or mark hauling vehicles used to transport asbestos waste, during loading and unloading, as required by the applicable regulations for transporting asbestos waste.

3. Provide a Waste Shipment Record (WSR) to the waste site owner or operator at the time the waste is delivered to the waste disposal site. Provide a copy of the WSR to the Engineer as well.

D. Safety Rules.
The Contractor is solely responsible for enforcement of the safety rules for employees and any person the Contractor authorizes for entry into the work area. The Engineer will have a right of entry to the work area, and they will comply with the Contractor's safety rules.

2536.04 METHOD OF MEASUREMENT.

Lump sum.

2536.05 BASIS OF PAYMENT.

A. Payment for Removal of Asbestos identified in the contract documents will be the lump sum contract price.

B. Payment is full compensation for:
- Removal of asbestos, transporting asbestos, and disposal of asbestos at an approved disposal site, and
- The cost of all labor, monitoring, materials, equipment, permits, disposal fees, and preparation of and filing reports, notifications, and records.

C. Adjustment of contract price for Removal of Asbestos which is identified in the contract documents will not be allowed should any buildings from which asbestos is to be removed be altered or damaged by others during the period of time between inspection by bidders and asbestos removal.

D. Partial payments may be paid as the work progresses, as authorized by the Engineer.

E. Should asbestos be discovered, in addition to that identified in the contract documents, removal of the additional asbestos will be paid for as extra work according to Article 1109.03, B.

Section 2537. Underground Tank System Removal and Petroleum Contaminated Soil Remediation

2537.01 SCOPE OF WORK.

Perform all work according to 567 IAC, Chapters 120 and 135, applicable OSHA regulations, and this specification.

A. Removal of Underground Tanks.
Complete the following:

1. Remove, collect, and dispose of contents of the tank system.

2. Vent, remove, transport, and destroy all components of the tank system.

3. Obtain and test soil and groundwater samples necessary to complete Iowa DNR's Tank Closure Report.

4. Furnish, install, maintain, and subsequently remove safety fence enclosure around excavated areas.

5. Remove non-contaminated soil and rubble.

6. Furnish, place, and compact suitable backfill soil to finish the excavation to grade.

7. Prepare and provide Tank Closure Reports to the Engineer.

B. Remediation of Petroleum Contaminated Soil.

1. Complete the following:
- **a.** Remove contamination by excavating a specified volume of soil.
- **b.** Transport, spread, and turn contaminated soil at remediation areas designated or approved by the Engineer, or transport and dispose of contaminated soil at an approved solid waste landfill.
- **c.** Obtain and test soil and groundwater samples necessary to complete Iowa DNR's requirements for removal of contaminated soil by excavation.
- **d.** Furnish, place, and compact suitable backfill soil to finish the excavation to grade.
- **e.** Prepare and provide an Over-Excavation of Contaminated Soil report to the Engineer.

2. In situations where suitable remediation sites are not available within the ROW, the contract documents will require delivery of petroleum contaminated soil to a solid waste landfill facility approved by the Engineer.

2537.02 DEFINITIONS.

For the purpose of this specification the following definitions will apply:

A. Contamination.
Contamination or contaminated means the presence of petroleum hydrocarbon constituents at concentration levels at or above those listed in Iowa DNR's Tier 1 Look-Up Table in 567 IAC, Chapter 135. Soils with constituent concentrations below these levels will be classified "non-contaminated."

B. Destroy.
Destroy means rendering a tank system unusable for any purpose other than scrap metal, or landfill material in the case of plastics or fiberglass. Cut up or crush, or both, all components of a system prior to being recycled as scrap or disposed of in a landfill.

C. Land Application.
Land application means the act or process of placing, leveling to a uniform thickness and application rate, incorporation, and remediation of petroleum contaminated soil to a level of constituent concentration less than those listed in the Tier 1 Look-Up Table in 567 IAC, Chapter 135. Land application and land farming are terms which are often used interchangeably.

D. Incorporation.
Incorporation means the process of mixing the contaminated soil after placement to provide a loose and divided soil texture, and leveling at the remediation site. Mixing operations such as disking or harrowing to approximately 2 inches (50 mm) greater than the depth of material placed are considered acceptable.

E. Remediation of Contaminated Soil.
Remediation of contaminated soil means the process of removing contaminated soil by excavation, surface applying the contaminated soil in a relatively thin layer, and allowing natural processes to reduce contamination levels below regulated action levels. Once contaminated soil has been land applied, it shall remain in place until the levels of contamination are below those listed in the Tier 1 Look-Up Table in 567 IAC, Chapter 135.

F. Tank System.
Tank System means underground storage tanks and all associated piping, auxiliary equipment, containment systems and leak detection equipment. A tank system includes, but is not limited to:

- Fill and vent piping,
- Product delivery piping,
- Product pumps,
- Product dispensers,
- Leak detection piping, and
- Leak detection wells.

2537.03 TANK REMOVAL AND SOIL REMEDIATION.

A. Notification.

Based on the Contractor's work schedule, the Engineer will complete necessary Iowa DNR regulatory notifications for tank removals and additional excavation for petroleum contaminated soil.

1. Removal of Underground Tanks.

Provide written notification to the Engineer 45 calendar days prior to removing underground tanks. The Engineer will provide the 30 calendar day Iowa DNR written pre-tank-removal notification.

2. Remediation of Petroleum Contaminated Soil.

a. Provide and submit the Iowa DNR's "Land Application Notification" form to the Iowa DNR with a copy sent to the Engineer at least 30 calendar days prior to beginning excavation activities.

b. The Engineer will waive this notification if:

1) Petroleum contaminated soil will be taken to an approved solid waste landfill.

2) The remediation notification was separately identified and included with the 45 calendar day notification for removal of underground tanks.

3) The excavated material will be stockpiled, pending further remediation activities. In this case, submission of the Iowa DNR notification will be required at least 30 calendar days prior to removing the soil from the stockpile for land application.

B. Location.

1. Removal of Underground Tanks.

The location of all known underground tanks will be identified in the contract documents. Should an underground tank system that is not identified in the contract documents be encountered:

a. Stop all activities in close proximity of the discovery,

b. Promptly notify the Engineer of the discovery, and

c. Do not resume work in the immediate area until authorized by the Engineer.

2. Remediation of Petroleum Contaminated Soil.

a. The location o fexcavation and Engineer-designated remediation area, or approved solid waste landfill will be designated in the contract documents. The Contractor may propose an alternate remediation area, subject to the requirements of 567 IAC, Chapter 120 and the Engineer's approval.

b. If a remediation area is located within a designated borrow or staged construction area, coordinate with the other project contractors and be prepared to stage land application operations so the remediation area remains available for construction project requirements.

c. The contract documents may contain other specific containment requirements.

C. Underground Tank Removal.

1. Removal of Tank Contents.
Prior to tank removal:

a. Remove all liquid, sludge, and/or sand from the tank system. Collect, and dispose of according to Federal, State, and local regulations.

b. Vent tanks and purge to reduce vapors below explosive levels.

2. Removal of Underground Tanks.
Remove and destroy the tank, all associated piping, and auxiliary equipment.

D. Excavation, Placing Backfill Material, and Safety Fence.

1. Removal of Underground Tanks.

a. Excavation required for underground tank removal includes:

- The excavation necessary to remove the tank including all original backfill material that was placed when the tank was installed, and
- The excavation necessary to remove piping associated with the underground tank system.

b. Immediately notify the Engineer if excavated material contains suspected contamination pursuant to 567 IAC 135.6. Remediate, in the manner described in this specification, excavated material that has petroleum contamination. All other sand fill, rubble, and materials associated with tank removal become the property of the Contractor. Remove these materials from the project according to Article 1104.08.

2. Remediation of Petroleum Contaminated Soil.

a. Approximate limits of excavation (horizontal and vertical) will be identified in the contract documents. Actual excavation limits will be determined in the field and based on the extent of contaminant migration. Continue excavation until:

- Organic Vapor Monitoring (OVM) readings and laboratory tests indicate remaining soil is at, or below, Iowa DNR's Tier 1 Look-Up Table levels published in 567 IAC, Chapter 135, or
- Directed by the Engineer to stop.

b. In situations where petroleum contaminated soil is below a layer of non-contaminated soil, remove and stockpile the non-contaminated soil before or during excavation of the contaminated area. Non-contaminated soil may be used for backfill material provided Type A compaction, according to Section 2107, can be achieved. If non-contaminated excavated soil does not meet the requirements of Article 2102.03, F or cannot achieve adequate compaction, it becomes the property of the Contractor. Remove it from the project according to Article 1104.08.

3. Placing Backfill in Excavations.

a. Furnish backfill material consisting of earth fill. Use material meeting the requirements of Article 2102.03, F.

b. Obtain the Engineer's authorization prior to placing backfill. Complete the backfill placement and compaction operation:

- According to the requirements of Section 2107 for Type A compaction, and
- Within ten working days after authorization is given.

c. Grade the site, shape to drain, and leave in a condition complying with Article 1104.08.

4. Safety Fence.

Furnish, place, and maintain safety fence meeting the requirements of Article 4188.03 around the site of work. Remove after completing backfill placement operations. Fencing material remains the property of the Contractor.

E. Sampling and Testing for Petroleum Contamination.

Ensure all sampling and environmental site work is supervised by a Groundwater Professional certified by the Iowa DNR in accordance with 567 IAC, 134. The Groundwater Professional shall obtain, prepare, and submit samples for laboratory analysis. Ensure this work is performed in a manner consistent with standard practices for sampling and testing of petroleum contamination and 567 IAC, 135. Ensure analysis of samples is performed by a laboratory certified by Iowa DNR pursuant to 567 IAC, 83.

1. Removal of Underground Tanks, Sampling and Testing.

a. After a tank has been removed, have the Groundwater Professional obtain soil and groundwater samples and submit them for laboratory analysis as required by 567 IAC, 135.

b. Submit all laboratory analysis reports and a copy of the Chain-of-Custody form to the Engineer as soon as available from the testing laboratory.

c. Dispose of all soil and water generated during the sampling, testing, and installation of ground water monitoring wells. Dispose of this material according to applicable Federal, State, and local regulations.

d. Sample and test as follows:

1) Soil Samples.

a) The locations for sampling in the areas where the tanks and the associated piping have been removed are as defined in the Iowa DNR guidance document for "Underground Storage Tank Closure Procedures for Tank and Piping Removal".

b) The presence of standing water in an excavation may cause bottom soil samples to be invalid. In this situation, take required bottom soil samples from the excavated sidewall immediately above the surface water and in the assumed down gradient direction when possible. Ensure the Tank Closure Report contains an explanation and justification for all alternate sampling locations.

2) Ground Water Sample.

a) Sampling locations are as outlined in 567 IAC, 135. Ensure groundwater sampling wells are:

(1) Installed and closed by a Certified Water Well contractor registered in the State of Iowa pursuant to 567 IAC, 82.

(2) Cased wells constructed according to 567 IAC 110.11.

b) Ensure water samples are obtained from cased, fully developed, purged, and stabilized wells. After use, close all sampling locations according to applicable Iowa DNR regulations. Provide a completed Iowa DNR "Abandoned Water Well Plugging Record," DNR Form 542-1226, to Iowa DNR for each well closed. Submit a copy of these forms to the Engineer at the conclusion of the project.

c) Obtain the Engineer's approval prior to closing a well.

2. Remediation of Petroleum Contaminated Soil, Sampling and Testing.

a. During excavation of contaminated soil, have the Groundwater Professional test a representative sample of soil from each truck load for VOCs, using appropriate confined head-space air sampling procedures and portable Organic Vapor Monitoring (OVM) equipment. Ensure OVM equipment is calibrated using a benzene standard and readings are approximately correlated to known Total Petroleum Hydrocarbon (TPH) concentrations in a soil matrix. Continue excavation until:

- In the judgment of the Groundwater Professional, remaining soil contamination is below Iowa DNR's Tier 1 Look-Up Table levels, or
- Excavation is stopped by the Engineer.

b. Upon completion of excavation, ensure the Groundwater Professional obtains soil samples for laboratory analysis from the excavated side walls and bottom according to 567 IAC, 135 unless directed otherwise by the Engineer. Have the Groundwater Professional develop a final site sampling plan and submit it to the Engineer for approval prior to final sampling. Ensure this plan, at a minimum, identifies the total number of samples to be collected and the distribution of sampling locations.

F. Documentation and Reports.

1. Removal of Underground Tanks.

a. Submit a completed Tank Closure Report to the Engineer within 30 calendar days of completing tank removal. Ensure this report complies with the requirements of 567 IAC, 135. In the report include the location of all tanks, piping, sampling locations, and excavation limits referenced to station and offset distance from mainline or side road survey center line on the tank closure site map. The use of a Professional Land Surveyor licensed in the State

of Iowa is not required for the development of a tank closure site map.

b. Complete and return to the Engineer a written "Certificate of Destruction" for all tanks which have been removed. These forms are available from the Engineer.

2. Remediation of Petroleum Contaminated Soil.
Document all field activities. Make all field documentation available to the Engineer upon request. Prepare and submit an Over-Excavation Soil Report at the end of the project. In this report include, at a minimum:

a. Daily Diary.
A narrative record of daily site events relative to excavation, sampling, transporting, and spreading of soil as outlined in this specification.

b. Field OVM Testing.
A field log tabulating all OVM field testing, dates and approximate times for individual tests, the results of each OVM test, and site map designating approximate site location of removed soil being tested.

c. Laboratory Results and Site Map.
A copy of all laboratory analytical results, a scaled site map locating sampling locations, and a copy of all chain-of-custody forms. Ensure site maps are referenced to station and offset distance from mainline or side road survey center line. The use of a Professional Land Surveyor licensed in the State of Iowa is not required for the development of a sampling and soil excavation site map.

d. Abandoned Water Well Plugging Record.
Include in the report a copy of DNR Form 542-1226 for each ground water sampling well constructed and closed.

2537.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Removal of Underground Tanks.
By count for the number of underground tanks removed.

1. Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Removal of Underground Tanks).
By count for the number of soil and water samples taken and tested by a laboratory as described in this specification.

2. Water Sampling Well.
By count for the number of water sampling wells constructed and closed. Payment for water sampling wells constructed, but which are required by the Engineer to remain available for later sampling, will be according to Article 1109.03, B.

B. Remediation of Petroleum Contaminated Soil.
Cubic yards (cubic meters) of excavated petroleum contaminated soil determined by cross-sectioning the excavated area before and after

excavation. Quantities will be computed from cross section measurements by the average end area method.

1. **Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Remediation of Petroleum Contaminated Soil).**
   By count for the number of samples taken and tested by a laboratory as described in this specification.

2. **Embankment-in-place.**
   Cubic yards (cubic meters) determined according to the provisions of Article 2102.04. Non-contaminated soil stockpiled during the excavation, and which is used for backfill material, will not be measured for payment.

2537.05 BASIS OF PAYMENT.

Payment for the items below will be at the contract unit price as follows:

A. Underground Tanks

1. **Removal of Underground Tanks.**
   a. Each. Payment is full compensation for:
   - Removal of the tank and associated piping,
   - All labor, equipment, material, health and safety requirements, excavation, and backfill material and placement necessary for required removal,
   - Transporting and destruction of the tank system,
   - Removal, containment, transportation, and disposal of the tank system's contents,
   - Removal of non-contaminated excavated materials from the project,
   - Furnishing, placing, and removing safety fence,
   - Furnishing, placing, and compacting backfill material,
   - Final grading and seeding of the excavated area,
   - Providing the services of a Groundwater Professional, and
   - Preparing and submitting Certificate of Destruction forms.

   b. If remediation of contaminated soil is required by the contract documents, the cost of remediation is included in the cost of Remediation of Petroleum Contaminated Soil.

2. **Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Removal of Underground Tanks).**
   a. Each for soil or water samples taken and tested by a laboratory as described in this specification.
   b. Payment is full compensation for:
   - All labor, equipment, sample preparation, transportation, and testing to comply with applicable Iowa DNR regulations,
   - Disposal of all contaminated soil from sampling events, and
   - Preparation and submittal to the Engineer of Iowa DNR's Tank Closure Reports.

3. Water Sampling Well.

a. Each for water sampling wells constructed and closed.

b. Payment is full compensation for:

- All labor, equipment, and materials to install each cased well,
- Purging prior to taking samples,
- Closing the well
- Disposal of all contaminated soil and water generated as a result of well installation,
- Purging and sampling events, and
- The preparation and submittal to the Engineer of Iowa DNR's Abandoned Water Well Plugging Records.

4. Remediation of Petroleum Contaminated Excavation.

Payment for remediation of contaminated excavation soil not identified in the contract documents, but associated with Removal of Underground Tanks, will be according to Article 1109.03, B.

B. Petroleum Contaminated Soil.

1. Remediation of Petroleum Contaminated Soil.

a. Per cubic yard (cubic meter).

b. Payment is full compensation for:

- All labor, equipment, and materials required to excavate, transport, spread, incorporate, and turn petroleum contaminated soil in compliance with Federal, State, and local regulations,
- Contractor's employee health and safety requirements,
- Furnishing, placing, and removing safety fence,
- Final grading and seeding of the excavated area, and
- Providing the services of a Groundwater Professional.

c. Payment includes:

- Landfill costs if so designated in the contract documents. Stockpiling, covering the stockpile, and work associated with ultimate placement in a borrowed or staged construction area is incidental to this item.
- Turning the petroleum contaminated soil once a month for the first three months during landfarm season as defined in 567 IAC, 120. Payment for additional turning directed by the Engineer will be according to Article 1109.03, B. Field sampling and testing using OVM equipment is incidental to this item.

2. Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Remediation of Petroleum Contaminated Soil).

a. Each for soil or water samples taken and tested by a laboratory as described in this specification.

b. Payment is full compensation for:

- All labor, equipment, materials, sample preparation, transportation, and testing to comply with Iowa DNR requirements for petroleum contaminated soil,

- The preparation and submittal to the Engineer of site documentation including a Site Sampling Plan, if required, and
- An Over-Excavation Report.

3. Embankment-in-place.

a. Per cubic yard (cubic meter).

b. Payment is full compensation for furnishing, transporting, placing, compacting, and final grading of the backfill material.

c. Placement and compaction of non-contaminated backfill soil stockpiled as a result of the excavation is incidental to this item.

Section 2538. Salvage, Removal, and Disposal of Obstructions

2538.01 DESCRIPTION.

Salvage, remove, and dispose of buildings and other obstructions from the project site as designated in the contract documents.

2538.02 NOTIFICATION AND RIGHTS OF POSSESSION OR OCCUPANCY.

A. Notification.

1. Notify the Engineer, in writing, of the intended starting and completion dates for demolition no less than 25 calendar days prior to the start of demolition.

2. If unable to begin work on the intended start date, notify the Engineer, by telephone with a written follow-up, of the new intended start date. To meet the requirements of 40 CFR 61.145(b), provide notification of the inability to commence work on the intended start date as soon as possible before, but no later than 1 working day prior to, the original intended start date. Failure to commence work on the specified start date, and failure to notify of a change in start date 1 working day prior to the original start date, will result in the need for a new 25 calendar day notification to the Engineer.

3. The Contracting Authority will provide notification of the work to the Iowa DNR.

B. Rights of Possession or Occupancy.

1. The Contracting Authority retains the exclusive right to grant occupancy and collect rent on any property included in this contract.

2. Do not view the interior of occupied houses.

2538.03 SALVAGE, REMOVAL, AND DISPOSAL.

A. General.

1. Unless designated otherwise in the contract documents, the Contractor may elect to:
- Demolish the buildings on site and remove the building materials, or
- Move the building structure intact from the site.

2. Demolition by burning and the burning of demolition debris and material is prohibited.

3. Perform Clearing and Grubbing according to Section 2101.

B. Regulated Materials.

1. The Contracting Authority will have inspected the building for the presence of asbestos, mercury, and PCB-containing materials. These materials will be removed by others.

2. Mercury-containing materials include:
- Fluorescent, high pressure sodium, mercury vapor, metal halide light bulbs, and
- Thermostats containing a liquid filled capsule.

3. PCB-containing materials include capacitors, ballasts, and transformers where the component is contained within a metal jacket and does not have a specific, legible, label stating no PCB's are present.

4. Should the Contractor encounter unforeseen regulated materials, immediately suspend all activities that may disturb the suspect regulated material and notify the Engineer.

C. Underground Tanks.

1. If the presence of underground tanks is known, they will be indicated in the contract documents. Unless specified otherwise in the contract documents, perform all work involved in removing and disposing of underground tanks, the associated plumbing, and the contents, as well as placing backfill in the excavation, according to Section 2537.

2. Should the Contractor encounter an underground tank not indicated in the contract documents, avoid disturbing the tank, its associated plumbing, and its contents. Promptly notify the Engineer.

D. Removal Requirements.

1. Rodent Extermination.
When required by local government ordinances, exterminate rodents before commencing demolition.

2. Utilities.

a. Water and Sewer Disconnections.

1) Tap off all water service lines at the main according to the requirements of the local jurisdiction.

2) Seal storm and sanitary sewers leading to the buildings to be removed. Unless otherwise required by the City or County, use a burlap plug capped with concrete. If desirable to use drains during the removal work, take preventive measures to prevent dirt, plaster, and other material from entering and clogging sewers.

3) Water and sewer disconnections may be performed prior to the intended start date referenced in Article 2538.02, A, with no working days charged.

b. Other Disconnections.

1) Disconnection of other utilities will typically be arranged by the Contracting Authority prior to salvage and removal work. Verify the disconnection of all utilities and notify Iowa One-Call at 800.292.8989 prior to the commencement of work.

2) If a utility has not been disconnected at the time the work is to commence, make arrangements for the disconnections. This work will be paid for according to Article 1109.03, B.

3. Permits.

Some local jurisdictions require a permit for the performance of demolition work or the moving of intact structures, or both, according to Article 1107.03.

4. Dust Control.

Minimize the spread of fugitive dust during demolition of masonry by thoroughly wetting the material.

5. Safety Fence.

Furnish and place a safety fence meeting the requirements of Article 4188.03 around the site of work. Leave the safety fence in place until the demolished materials are removed from the site and backfill is placed in all holes or excavated areas. The fencing material remains the property of the Contractor.

6. Removal of Buildings and Materials.

a. Unless directed otherwise in the contract documents, remove all structures, trash, rubbish, basement walls, floors, foundations, sidewalks, steps and driveways from the specified parcel. All materials remain the property of the Contractor, unless designated otherwise in the contract documents.

b. Remove and dispose of all materials according to Federal, State, and local regulations. Cover all demolition materials being removed from the site, or transport in a manner that prevents visible emissions. Transport all demolition materials that are not being recycled or salvaged directly to a landfill approved by the Iowa DNR (or the equivalent environmental department in a surrounding State) to accept construction and demolition wastes.

c. Complete the removal of intact structures from the right-of-way within the contract period.

d. Remove and dispose of appliances and other items that may contain refrigerants according to 40 CFR, Part 82. Appliances and other items that may contain refrigerants include, but are not limited to, refrigerators, freezers, dehumidifiers, and portable or central air conditioners. Venting refrigerants into the atmosphere when removing or disposing of these appliances is prohibited. Ensure a technician certified through a U.S. EPA approved course evacuates refrigerants from these appliances. Ensure equipment used to evacuate refrigerants is certified by the ARI or UL.

e. Remove building cornerstones and other historical markers without damaging. Deliver to the Engineer.

f. Obtain the Engineer's approval prior to commencing backfill placement.

7. Septic Tanks and Cisterns.

Remove septic tanks and cisterns, when included in the contract documents, as described below:

a. Septic Tanks.

1) Remove liquids and sludge from all septic tanks prior to their removal. Ensure pumping, transporting, and disposing of septic tank sewage is performed by a Commercial Septic Tank Cleaner licensed for such work by the State of Iowa. Ensure sewage is disposed of according to IA 567, 68.

2) Remove septic tanks and place backfill in the excavation according to Article 2538.03, D, 9. Removed septic tanks become property of the Contractor. Transport off the project.

3) Plug all lateral lines (inflow and outflow) at the side of the excavation or tank.

b. Cisterns.

Remove all cisterns and place backfill in the excavation according to Article 2538.03, D, 9. Cisterns will be considered demolition debris. Remove from the site.

8. Wells.

a. Seal the well with methods and materials according to IAC 567, 39, Requirements for Properly Plugging Abandoned Wells. Ensure wells are sealed by a certified well subcontractor.

b. Remove all obstructions before beginning to fill and seal the abandoned well. Use one or more of the following materials to fill the well:

- Sand,
- Pea gravel,
- Class A, B, or C granular surfacing material,
- Agriculture lime.

c. Ensure all fill materials are free of foreign matter and any toxic residue. Introduce the material at the bottom of the well, or at the starting location. Fill and place progressively upward to the bottom of the seal material location.

d. Use one or more of the following materials to seal the well:

- Neat cement (14 lbs. (1.7 kg) cement per gallon (liter) of water),
- Graded bentonite, bentonite pellets, or bentonite grout,
- Sand cement grout (1 sack of cement/equal volume masonry sand/not more than 6 gallons (23 L) water),
- PCC.

e. Place sealing materials using a grout pipe, tremie pipe, cement bucket, or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Bentonite pellets or graded bentonite may be added as sealing materials by pouring in place and agitating to avoid bridging.

f. For a deep well, place neat cement from 10 feet (3 m) below the bottom of the casing to 10 feet (3 m) above the bottom of the casing or to the static water level, whichever is higher.

g. For wells complete in multiple aquifers, re-use this same procedure throughout subsequent aquifers.

h. Cut off the upper portion of the well casing at least 4 feet (1.2 m) below ground or construction level. Plug the upper 6 feet (2 m) of the remaining casing with neat cement.

9. Placing Backfill Material.

a. For placing backfill material, furnish earth fill material meeting the requirements of Article 2102.03, F. Place backfill material and compact according to the requirements of Section 2107 for Type A compaction. Complete within 10 working days after completion of the removal of structures.

b. Grade and shape the site to drain and ensure the condition of the completed site complies with Article 1104.08.

10. Erosion Control.

Seed and fertilize, as specified in the contract documents, all areas disturbed by the Contractor's operations. The Engineer may require additional erosion control measures. Additional erosion control measures will be paid for according to Article 1109.03, B.

2538.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Salvage, Removal, and Disposal of Obstructions identified in the contract documents: lump sum item; no measurement.

B. Sealing Wells: by count for each well filled and sealed.

2538.05 BASIS OF PAYMENT.

Payment will be as follows:

A. Salvage, Removal, and Disposal of Obstructions on Parcel No. _; and Salvage, Removal, and Disposal of Obstructions:

1. Lump sum.

2. Payment is full compensation for:
- Removal and disposal of buildings, building materials, contents of buildings, appliances, trash, rubbish, basement walls, foundations, sidewalks, steps and driveways,
- Water and sewer disconnection,
- Obtaining permits,
- Removal and handling of refrigerants,
- Furnishing and compacting backfill material,
- Finish grading of disturbed areas,
- Furnishing and placing seed and fertilizer,
- Placing and removing safety fencing, and
- Removal of septic tanks and cisterns.

3. Other items of work will be paid for in accordance with Article 1109.03, B.

B. Sealing Wells:

1. Contract unit price per unit.

2. Payment is full compensation for materials, equipment, excavation, filling, and sealing according to the contract documents.

Section 2539. Concrete Pavement Undersealing by Pressure Grouting

2539.01 DESCRIPTION.

A. Underseal and support the concrete pavement to specified grade tolerances by drilling and injecting cement/fly ash grout as shown in the contract documents.

B. The contract may also include patches, longitudinal subdrains, pavement surface repair, and crack and joint sealing.

2539.02 MATERIALS.

A. Mix Design.

The mix design for the pressure grout for undersealing is as follows:

1. One part by volume of Type I Portland cement, and three parts by volume of Class C fly ash. Use fly ash from a source approved for this use according to Materials I.M. 491.17.

2. Add water to achieve required fluidity, according to Paragraph B of this article.

3. Obtain the Engineer's approval for additives.

4. The mix design approval will include a suggested set time, intended for ideal temperature conditions.

B. Fluidity.
Measure fluidity of the grout slurry using the method described by Materials I.M. 375. Time of efflux shall range from 10 seconds to 16 seconds. A more fluid mix having a flow cone time of efflux of 9 seconds to 15 seconds may be used during the initial injection at each hole. These measurements will be made by the Engineer, normally at least once every 4 working hours.

C. Material Proposal.
Submit to the Engineer the proposal for materials and additives to be used for the mix design.

2539.03 CONSTRUCTION.

A. Contractor Qualification.

1. Competency in concrete pavement undersealing is required.

2. Before the work is started, submit to the Engineer evidence of competence and previous experience with this type of work. Include in the evidence:
- An equipment list,
- Personnel and their experience, and
- A detailed undersealing procedure which will be followed.

3. Submit this evidence to the Contracts Engineer prior to the letting. Specific approval will be required before this work is started.

B. Equipment.
Furnish all equipment necessary for the adequate performance of the work of this contract. As a minimum, these are as follows:

1. Grout Plant.
a. Mixing may be with a colloidal mixer or other type of mixer as approved by the Engineer. Ensure the mixer has the capability of thoroughly mixing the various components of the grout.
b. Ensure the following:
- The plant includes a positive action or rotor injection pump, capable of forcing grout through a hole drilled in the pavement so that grout will fill voids and cavities beneath the pavement slab.
- The pump is capable of supplying a pressure up to 200 psi (1380 kPa) at the end of the discharge pipe so as to be able to lift the slab without damaging the pavement.
- The pressure is monitored by an accurate pressure gage in the grout line.
- The supply tank is equipped with paddles or other means of agitation to maintain a homogeneous mixture.

c. Measure the dry materials by weight (mass), if in bulk, or use materials packaged in uniform volume sacks. Batch the water through a meter or scale.

2. Water Tanker.
Supply water from a water truck with adequate capacity and pressure for delivery to the grout plant.

3. Drilling Equipment.
a. Furnish compressed air or hydraulically operated rock drills, or other devices, which have the capability of drilling grout injection holes through the pavement and subbase material, if any.
b. Ensure the equipment is in good condition and is operated in a manner that the holes are vertical and not "out-of-round."

4. Transport.
Furnish the material transport as well as the handling equipment.

5. Miscellaneous Equipment.
Furnish the following:
- All necessary hoses, valves, and valve manifolds to control pressure and volume,
- Pressure gage protectors,
- Expanding packers for the grout injection,
- Wood plugs,
- Hole washing tools,
- Drill steel and bits, and
- All miscellaneous tools, equipment, and supplies that may be required to complete the work.

C. Undersealing by Pressure Grouting.
Underseal the pavement by pressure grouting as shown in the contract documents. The Engineer will designate specific locations for pavement undersealing.

1. Drilling Holes.
a. Drill 1 1/4 inch to 1 1/2 inch (30 mm to 40 mm) diameter holes through the concrete pavement at the locations designated by the Engineer and in a pattern designated in the contract documents or approved by the Engineer. If a pattern is not designated, a three hole pattern will normally be used at each joint or crack in each lane:
- One hole is to be placed in the approach panel, 1.5 feet (0.5 m) from the joint or crack, and 4 feet to 8 feet (1.2 m to 2.4 m) from the center line.
- Two holes are to be placed in the leave panel, 3 feet (1 m) from the joint or crack, and 3 feet (1 m) from the panel edges.

b. For holes nearest the edges of the slab, the joints, or a major crack, a maximum tolerance of 3 inches (75 mm) from the precisely marked location is considered to be reasonable. For other holes, a

maximum tolerance of 6 inches (150 mm) is considered to be reasonable. Comply with the following:

1) Do not drill holes directly over joints or cracks.

2) Rotate the drills to avoid cracking the pavement and to provide satisfactory holes of the proper diameter for effective operations in pressure grouting.

3) When drilling holes, hold the drills perpendicular as possible to the pavement surface.

4) Plug irregular or unsatisfactory holes which cannot be satisfactorily used in pressure grouting by filling with the hole patching mixture. Drill new holes.

5) Ensure the downward weight (mass) does not exceed 200 pounds (100 kg) during drilling.

c. Ensure concrete spalling resulting from drilling does not exceed 20% of the pavement thickness. When such spalling occurs, the Engineer may require a lower down feed pressure to be used.

d. Ensure the holes do not extend more than 4 inches (100 mm) below the base of the pavement or stabilized subbase, if any.

2. Washing Holes.

Holes may be washed to create a small cavity, allowing initial spread of grout.

3. Undersealing.

a. When undersealing, pump grout under the pavement panel until movement in the slab is detectable. For the purpose of detection, use:

- A beam having a base length of at least 4 feet (1.2 m), and
- At least two accurate gages (capable of detecting movement of 0.010 inch (0.25 mm)) placed so that relative movement can be checked between both adjacent panels and the shoulder.

b. Comply with the following:

1) Limit panel movement to 0.10 inch (2.5 mm) or less.

2) Limit the initial pressure to 20 psi (150 kPa) or less.

3) After pumping has been started, limit the pumping pressure to 7 psi (50 kPa) or less.

c. If the Engineer determines that continued grout injection at a specific location is no longer feasible due to major voids, the Engineer may direct the Contractor to cease grout injection at that particular location.

4. Water Displacement.

Allow water that is displaced from the void structure by the grout to flow out freely. Excessive loss of the grout through cracks, joints, or in the shoulder area will not be tolerated.

5. Inspection Holes.

a. The Engineer may require inspection holes to be drilled in the shoulder area at the pavement edge. The purpose shall assure that the grout is not infiltrating existing underdrains during the pumping operation.

b. Drilling of inspection holes will be limited to areas where there are existing subdrains.

6. Radial Cracks.
Cracks extending radially from the grout injection holes will be presumed to have been caused by improper injection techniques by the Contractor.

7. Hole Patching.
- **a.** Upon completion of the undersealing, plug all drill holes by tamping the hole full of very dry concrete (1 part cement, 2 parts sand).
- **b.** Finish the plug flush with the pavement surface.
- **c.** Fill inspection holes with material similar to that in the shoulder area.

D. Limitations of Operations.

1. Do not perform pavement undersealing when the temperature at the bottom of the pavement slab is below 40°F (4°C).

2. Do not allow grout to be held in the mixer or injection pump sump for more than 45 minutes after mixing. Do not use grout held for a longer time than this. Grout held in the mixer for more than 45 minutes will be deducted from the pay quantity.

3. Traffic will be permitted on the undersealed pavement slab when the grout has obtained a set satisfactory to the Engineer. Use the minimum set time included in the mix design approval intended for ideal temperature conditions. It is anticipated that the set time will be extended to approximately 6 hours at 40°F (4°C) and 4 hours at 50°F (10°C). The minimum set time will vary with individual material combinations.

4. Conduct the work on only 50% of the pavement width at a time.

5. Allow traffic to use the pavement during construction operations. Conduct all operations to provide a minimum of inconvenience to traffic.

6. Adjust the work schedule so that all traffic lanes can be opened to public traffic during nonworking hours.

7. Limit drilled holes to the amount that can be grouted during the following working day, unless the Engineer approves otherwise.

8. If unforeseen conditions should result in uncompleted sections being left overnight and requiring protection, provide a sufficient number of traffic control devices and flaggers to warn and direct traffic from the time construction operations have stopped until they have resumed again. No extra payment will be made for the necessary traffic control devices and flaggers.

9. Apply Articles 1107.08, 1107.09, and 1108.03. When there is a contract item for Traffic Control, furnish, erect, and maintain all signs, barricades, and other traffic control devices required by the contract documents.

10. Remove debris resulting from the operations from the traffic lanes and shoulders as the work progresses and before the traffic lane is opened to public traffic.

11. Shoulder adjustments will be made by the Contracting Authority, as the Engineer deems appropriate. Except when additional shoulder work is required by the contract, the Engineer will provide and maintain signing for vertical drop-offs at the pavement edges that remain after the Contractor has completed the pressure grouting operation. Provide signing, barricades, and other traffic control required by the contract documents for the shoulder while work at the specific location remains uncompleted.

12. When other work is included in the project, sequence the operations so that undersealing, longitudinal subdrains, patching, diamond grinding, and crack and joint sealing are done in an area in that order. All of these operations required by the contract documents should be completed in an area in the same construction season, or not started until the following construction season.

E. Acceptance.
Before final acceptance, clean up all unused material. Ensure the surrounding areas are left in a neat and orderly condition as provided in Article 1104.08.

2539.04 METHOD OF MEASUREMENT.

A. Measurement for Pavement Undersealing by Pressure Grouting will be as follows:

1. Holes (for Pressure Grouting).
By count for Holes drilled through the pavement at locations designated by the Engineer. Irregular or unsatisfactory holes which cannot be satisfactorily used in pressure grouting will not be counted.

2. Portland Cement (for Pressure Grouting).
Calculated from the bulk weight (mass) in tons (megagrams) or number of sacks of cement furnished and used in the work. This will include the quantity used in pressure grouting and in filling drilled holes. Cement that is not used will be deducted.

B. When grouting is discontinued at any specific location, as directed by the Engineer, the holes drilled and the Portland cement used will be included in the measured quantities.

C. Inspection holes will be counted separately.

D. Water and fly ash will not be measured for payment.

2539.05 BASIS OF PAYMENT.

A. Payment for Pavement Undersealing by Pressure Grouting will be the contract unit price as follows:

1. **Holes (for Pressure Grouting).**
   Each.

2. **Portland Cement (for Pressure Grouting).**
   Per ton (megagram) for cement used in the work.

B. When the contract documents include an item for Traffic Control, payment will be the lump sum contract price according to Section 2528.

C. When the undersealing operation results in radial cracking, payment will be reduced by $0.50 ($1.60) for each linear foot (meter) of crack measured by the Engineer, to the nearest foot (0.1 m).

D. Payment for the number of inspection holes drilled will be 50% of the contract unit price for a hole for pressure grouting.

E. Payments are full compensation for:
- Furnishing all materials, including fly ash and water and hole sealing mixture,
- Proportioning and mixing,
- Drilling holes,
- Pumping and repumping,
- Filling the holes, and
- Furnishing all equipment, tools, labor, and incidentals necessary to complete the work in accordance with the contract documents.

Section 2540. Longitudinal Joint Repair

2540.01 DESCRIPTION.

A. For longitudinal joint repair:
- Mill the existing unstable asphalt material down to the PCC base over longitudinal widening joints and the center line joint, as shown in the contract documents or as directed by the Engineer. The width to be milled will be designated in the contract documents.
- Clean and seal or fill the existing longitudinal opening in the concrete base.
- Fill the milled trench with the specified mixture.

B. The Engineer may also designate other joints and cracks for this repair.

2540.02 MATERIALS.

A. Use the following materials for filling the longitudinal joint in the PCC base:

1. For a 0 to 3/4 inch (0 mm to 20 mm) opening, fill the existing joint with either PG 58-xx or CRS-2 emulsion.

2. For an opening greater than 3/4 inch (20 mm), fill the existing joint with a 3/8 inch to 1/2 inch (9.5 mm to 12.5 mm) commercial HMA mixture with PG 58-xx or other suitable hot or cold bituminous mixture approved by the Engineer.

B. For completing the joint repair (filling the milled trench above the PCC base), use a 300,000 ESAL HMA or similar mixture approved by the Engineer.

2540.03 CONSTRUCTION.

A. Equipment.

1. Use milling equipment capable of removing deteriorated material 6 inches (150 mm) in width and up to 7 inches (175 mm) in depth in a single pass operation. Use equipment capable of delivering high pressure compressed air to the joint from a nozzle on a flexible hose to:

- Remove other deteriorated material, and
- Clean the existing joint in the PCC base.

2. The intent is to use maintenance type equipment for filling joints with bituminous material and for producing and placing asphalt mixtures for joint and trench filling. The Engineer may waive those requirements that make it impractical to use this type of equipment.

3. To compact the lower lifts, use any one of the following:

- Mechanical tampers meeting the requirements of Article 2001.04,
- Trench rollers,
- Vibratory compactors, or
- Weighted vehicles operated in the trench.

B. Joint Repair.

1. Use milling equipment to remove the deteriorated material above the longitudinal joint. Remove all deteriorated material to the PCC base surface, including any mesh. Spread this material on the adjacent shoulder, or remove according to Article 1104.08.

2. Remove all loose and adjacent deteriorated material from the existing joint in the PCC base to a depth of at least 4 inches (100 m) using high pressure compressed air. Air blast the joint twice. Should the air blast remove deteriorated material in a manner that undermines any of the asphalt surfacing, use hand tools to produce a nearly vertical face of sound material.

3. It is anticipated that the blasting operation will, on occasion, remove or indicate the need for removal of material outside of the trenched area. When these additional areas are in excess of 2 square feet in 10 linear feet (0.2 m^2 in 3 m), they will be considered as part of the surface patching operation. The material used to repair these areas will be measured and paid for as surface patching.

4. Fill joints in the PCC Base with the material specified in Article 2540.02. Spade and rod into place the material used to fill joints over 3/4 inches (20 mm) in width. Compact the material with suitable hand tools to the satisfaction of the Engineer. Take care not to overfill the joint.

5. Lightly tack the vertical faces and the base of trench prior to filling the trench with HMA. Ensure these surfaces are clean and dry enough to make this tacking operation effective.

6. Place the material for filling the trench in uniform lifts of no more than 3 inches (80 mm) in depth. Compact the material with a minimum of three passes with compaction equipment. Cores may be required to ensure that compaction is adequate. Ensure the finish elevation of the trench material is level with, or no more than 1/4 inch (6 mm) above, the surrounding pavement surface.

C. Limitations.
Apply Article 2212.03, C.

2540.04 METHOD OF MEASUREMENT.
Measurement for Longitudinal Joint Repair will be to the nearest 0.1 foot (0.1 m) on the basis of 6 inch (150 mm) width of repair.

2540.05 BASIS OF PAYMENT.

A. Payment will be paid the contract unit price per linear foot (meter) of Longitudinal Joint Repair completed.

B. Payment is full compensation for:
- All labor, materials, equipment necessary for milling to the existing PCC base,
- Removal of all deteriorated material from the joint and trench,
- Cleaning and filling the joint with the specified material, and
- Filling the trench with HMA.

Section 2541. Crack and Joint Cleaning and Sealing (HMA Surfaces)

2541.01 DESCRIPTION.

A. Rout and clean (prepare) cracks in HMA surface and seal the prepared cracks with a joint sealer.

B. Crack and joint cleaning and sealing is intended to address transverse (thermal) cracking, longitudinal cracking, joint reflective cracking, low severity fatigue cracking, and low severity block cracking. Crack and joint cleaning and sealing is not intended to clean or seal moderate or high severity block cracking, moderate or high severity fatigue cracking, edge cracking, alligator cracking, or mat slippage cracking. Definitions for these pavement distress types can be found in the „Distress Identification Manual for the Long-Term Pavement Performance Program' (Publication No. FHWA-RD-03-031, dated June 2003, web address: (http://www.tfhrc.gov/pavement/ltpp/reports/03031/03031.pdf).

2541.02 MATERIALS.

A. Use a poured joint sealer material meeting the requirements of Article 4136.02. A hot pour sealer will be required.

B. In conjunction with this sealer, use backer rod meeting the requirements of Article 4136.02. Use backer rod of a size that compression is required for installation in the crack so it maintains its position during the filling operation. More than one size may be necessary to complete the work.

2541.03 CONSTRUCTION.

A. Equipment.

1. Routing or Sawing Equipment.
Use power driven routing or sawing equipment capable of cutting the cracks to the required dimensions. Do not use equipment designed to "plow" the cracks to dimension.

2. Air Compressors.
Use air compressors that provide moisture and oil free air and are of sufficient size to blow sand and other foreign material from the crack and the pavement surface.

3. Equipment Used for Heating and Placing the Material.
Use oil jacketed, double boiler type equipment capable of heating the material to 400°F (205°C) and pumping the material into the prepared cracks.

B. Crack and Joint Cleaning and Sealing.

1. Cleaning Cracks and Joints.

a. Cracks and Joints with Average Opening of 3/8 Inch (10 Mm) or Less.
Rout or saw to provide a minimum sealant reservoir of 3/8 inch (10 mm) in width by a nominal 1/2 inch (13 mm) in depth.

b. Cracks and Joints with Existing Width Greater Than 3/8 Inch (10mm).
Use backer rod or clean dry sand. Clean cracks and joints of all foreign material to a depth necessary to accommodate the sealer

material and the backer rod, or sand, to be used. Ensure backer rod is dry when placed.

2. Sealer Material.
Heat, handle, and apply according to the manufacturer's recommendations.

3. Filling Cracks.
- **a.** Ensure cracks are clean and dry prior to sealing.
- **b.** Slightly overfill the entire crack reservoir with sealant.
- **c.** Tightly squeegee with a narrow V-shaped squeegee immediately after placement of the sealant while still hot.
- **d.** Operate the squeegee within approximately 1 foot (0.3 m) of the wand tip used to place the sealant.
- **e.** Sealant on the roadway surface in excess of 1/2 inch (13 mm) on each side of the crack edge will not be acceptable.

4. Prior to Opening to Traffic.
Remove asphalt cement concrete and foreign material resulting from crack preparation from the roadway by brooming, compressed air, or other methods satisfactory to the Engineer.

C. Limitations.

1. Do not perform crack sealing after September 30.

2. Perform crack cleaning and sealing only when the ambient air and pavement surface temperatures are above 40°F (4°C). When near this minimum, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the crack surfaces.

3. Conduct the work on only one lane of the pavement width at a time. When work encroaches on an adjacent lane, a flagger will be required at that location.

4. Apply Articles 1107.08, 1107.09, and 1108.03.

5. Lanes may be opened to traffic only after the sealer has set sufficiently so it will not pick up under traffic. Blotting material may be applied to the sealer, but only after the sealer surface has set so as to avoid penetration of the blotting material into the sealer.

6. Before the pavement is opened to traffic, ensure debris and saw slurry or dust from dry sawing or routing operations is removed from the pavement surface.

7. Clean all dry sawed or routed joints or cracks using a stream of air sufficient to remove all dirt, dust, and deleterious material that can adhere to the joint face before the pavement is opened to traffic. Complete this work within 3 hours after the joint or crack has been dry sawed or routed.

8. Clean all wet sawed joints with high pressure water immediately after sawing to remove residue produced by the sawing operation.

9. Seal cracks within 3 working days after preparation.

2541.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Crack and Joint Cleaning and Sealing (HMA Surfaces).

1. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 kilometer), of main line pavement and shoulders on which cracks and joints were cleaned and sealed. Calculations will be based on the center line distance of main line, two-lane pavement, corrected for main line pavement of more than two lanes, including climbing lanes.

2. Shoulders 4 feet (1.2 meters) wide or less will not be measured separately.

3. At intersections, rest areas, and interchanges designated for cleaning and sealing, the additional areas of widened pavement, ramps, storage lanes, turning lanes, paved medians, and parking in rest areas will not be separately measured for payment.

4. Between limits for which cleaning and sealing is intended for either pavement or shoulders, no deductions will be made for bridges, intersections, or other interruptions where cracks or joints are not to be cleaned and sealed.

B. Sealer Material (HMA Surfaces).

Pounds (kilograms) of sealer material used in cracks and joints.

2541.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Crack and Joint Cleaning and Sealing (HMA Surfaces).

1. Per mile (kilometer) for pavement or shoulders on which the cracks and joints were cleaned and sealed.

2. Shoulders 4 feet (1.2 meters) or less in width are incidental to the price bid for Crack and Joint Cleaning and Sealing (HMA Surfaces).

3. Payment is full compensation for all labor, equipment, and materials (except for sealer, but including backer rod or sand) for cleaning and sealing cracks and joints.

B. Sealer Material (HMA Surfaces).

1. Per pound (kilogram). Price is predetermined.

2. Payment is full compensation for furnishing the sealer material only.

Section 2542. Crack and Joint Cleaning and Sealing (Portland Cement Concrete Pavement)

2542.01 DESCRIPTION.

A. Rout or saw and clean random cracks and existing transverse and longitudinal joints in PCC pavement. Seal the prepared cracks and joints with an approved sealing material.

B. Crack and joint cleaning and sealing is intended to address longitudinal cracking, transverse cracking, and corner breaks. Crack and joint cleaning and sealing is not intended to clean or seal durability ("D") cracking or map cracking. Definitions for these pavement distress types can be found in the „Distress Identification Manual for the Long-Term Pavement Performance Program' (Publication No. FHWA-RD-03-031, dated June 2003, web address: (http://www.fhwa.dot.gov/publications/research/infrastructure/pavements/tpp/reports/03031).

2542.02 MATERIALS.

A. Use hot poured joint sealer and backer rod that meet the requirements of Article 4136.02.

B. Installation of preformed elastomeric joint seals meeting the requirements of Article 4136.02 may be required in the contract documents. Substitution of elastomeric joint seal material for poured joint sealer material will not be allowed unless specified otherwise in the contract documents.

2542.03 CONSTRUCTION.

A. Equipment.

1. Routing or Sawing Equipment.

a. Use power driven routing or sawing equipment, where required, capable of cutting the cracks to the required dimensions without excessive spalling of the adjacent surface.

b. Use power driven sawing equipment (wet or dry), where required, capable of sawing the sealant reservoir to the dimensions shown in the contract documents.

2. Water and Abrasive Blasting Cleaning Equipment.

a. To remove existing joint sealer, debris, and loose material from the crack or joint, use water cleaning equipment capable of delivering water with a pressure of 2,000 psi (13.8 MPa) from a nozzle.

b. Use abrasive blast equipment capable of removing the existing sealant, saw slurry, silt, or other foreign material from the vertical face of the crack or joint to the specified depth. Ensure the equipment leaves a clean, dry, newly exposed concrete surface.

3. Air Compressors.
Use air compressors that provide moisture and oil free air and are of sufficient size to blow sand and other foreign material from the crack or joint prior to placing the sealant material.

4. Equipment for Heating and Placing Sealant Material.
Use an oil jacketed, double boiler type, heating kettle or other thermostatically controlled equipment of a type approved by the Engineer, capable of heating the material to 400°F (205°C) and pumping the material into the prepared crack or joint.

5. Auxiliary Equipment.
Provide auxiliary equipment, such as brooms, scrapers, etc., as necessary to perform the work.

B. Construction.

1. A partial depth finish patch may be required when joints or cracks have edge spalls or other distress greater than 3 inches (75 mm) in width. If not otherwise included as part of the contract work, these areas will be designated by the Engineer as extra work. Construct partial depth finish patches according to Section 2530. Seal joints or cracks less than or equal to 3 inches (75 mm) in width without patching.

2. Clean cracks and joints of existing joint sealer, vegetation, dirt, and all other foreign material to the depth of the bottom of the backer rod. Sand blast the edges throughout the proposed depth of the joint sealer, leaving a clean, dry, newly exposed concrete surface on the vertical edges. This will require two passes of the sand blasting operation for each joint and crack: one pass for each joint or crack edge. Set the angle of approach of the sand blast nozzle to each vertical face of the reservoir to be approximately 30 degrees. The sand blast nozzle shall have a guide which inserts in the joint and assures positive location and directional control of the nozzle.

3. Perform sand blasting just prior to the application of the joint sealer. When cleaned joints or cracks are contaminated before being sealed, reclean them by sand blast before sealing. Rain will be considered contamination.

4. Place a backer rod at the bottom of the joint or crack as a bond breaker. Install it dry. If the width of opening exceeds the maximum size available, approved alternates of bond breakers at the bottom of the crack or joint may be used.

5. Widen cracks and joints in partial depth HMA finish patches to 1/2 inch (13 mm), if widening is necessary. Extend the cleaning and sealing operation across the joint or crack.

6. Prior to placing backer rod and joint sealer:
- Ensure cracks and joints are dry.

- Use compressed air to blow cracks and joints clean.

7. Fill joints and cracks to the level shown in the contract documents.

8. Heat, handle, and apply the sealer material according to the manufacturer's recommendations.

9. Rout or saw cracks and joints with an average opening of 3/8 inch (10 mm) or less to provide a minimum sealant reservoir of 3/8 inch (10 mm) in width by a nominal 1/2 inch (13 mm) in depth. For cracks and joints with an existing width greater than 3/8 inch (10mm), place backer rod to a depth that will provide at least 5/8 inch (16 mm) clearance above the backer rod for the sealer. Clean cracks and joints of all foreign material to a depth necessary to accommodate the sealer material and the backer rod to be used. Ensure backer rod is dry when placed.

C. Traffic Control.

1. When there is a separate item for traffic control, furnish all signs and traffic control devices, such as flaggers, barricades, traffic cones, warning lights, and pilot car signs (when required) according to Section 2528. Erect, maintain, and remove all traffic control devices.

2. Conduct the work on only one lane of the pavement width at a time. When work encroaches on an adjacent lane, a flagger will be required at that location.

3. Apply Articles 1107.08, 1107.09, and 1108.03.

D. Limitations.

1. When other work is included in the contract, sequence operations in the following order:
a. Undersealing,
b. Longitudinal subdrains,
c. Patching,
d. Installation of retrofit load transfer,
e. Grinding or milling, and then
f. Crack and joint sealing.

2. Perform joint and crack sealing only when the ambient air and pavement surface temperatures are above 40°F (4°C). When near this minimum temperature, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the joint surfaces.

3. Lanes may be opened to traffic only after the sealer has set sufficiently so it will not pick up under traffic. Blotting material may be applied to the sealer, but only after the sealer surface has set so as to avoid penetration of the blotting material into the sealer.

4. Remove old sealant, other debris, and saw slurry from the pavement surface before the pavement is opened to traffic.

5. Before the pavement is opened to traffic, clean the dry sawed or routed joints or cracks with a stream of air sufficient to remove all dirt, dust, and deleterious material that can adhere to the joint face. Complete this work within 3 hours after the joint or crack has been dry sawed or routed.

6. Clean wet sawed joints using high pressure water immediately after sawing to remove residue produced by the sawing operation.

7. Seal joints and cracks within 5 working days after completion of any sawing or routing or removing old joint sealant material or debris from the crack or joint.

8. Do not perform crack and joint sealing after September 30. When joint sealer cannot be placed in an otherwise completed joint or crack prior to this date due to temperature or other conditions, temporarily seal these joints or cracks with a joint sealer over the winter shutdown period. Remove this seal and reclean and reseal the joint or crack according to this specification during the next construction season (at no additional cost to the Contracting Authority).

9. Do not overfill with sealant. Immediately remove sealant placed on the pavement surface.

2542.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Crack and Joint Cleaning and Sealing (PCC Pavement).

1. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 km), of main line pavement and shoulders on which cracks and joints were cleaned and sealed. Calculations will be based on the center line distance of main line, two-lane pavement, corrected for main line pavement of more than two lanes, including climbing lanes.

2. Shoulders 4 feet (1.2 meters) or less in width will not be measured separately for payment.

3. At intersections, rest areas, and interchanges designated for cleaning and sealing, the additional areas of widened pavement, ramps, storage lanes, turning lanes, paved medians, and parking in rest areas will not be separately measured for payment.

4. Between limits for which cleaning and sealing is intended for either pavement or shoulders, no deductions will be made for bridges, intersections, or other interruptions where cracks or joints are not to be cleaned and sealed.

B. Sealer Material (PCC Pavement).
Pounds (kilograms) of sealer material used in cracks and joints.

2542.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Crack and Joint Cleaning and Sealing (PCC Pavement).

1. Per mile (kilometer) for pavement or shoulders on which the cracks and joints were cleaned and sealed.

2. Shoulders 4 feet (1.2 meters) or less in width are incidental to the price bid for Crack and Joint Cleaning and Sealing (PCC Pavement).

3. Payment is full compensation for all labor, equipment, and materials (except for sealer, but including backer rod) for cleaning and sealing cracks and joints.

B. Sealer Material (PCC Pavement).

1. Per pound (kilogram). Price is predetermined.

2. Payment is full compensation for furnishing the sealer material only.

C. Partial Depth Finish Patches.
If not included otherwise as part of the contract work, payment for partial depth finish patches designated by the Engineer will be as extra work according to Article 1109.03, B.

Section 2543. Transverse Joint Repair for HMA Pavements

2543.01 DESCRIPTION.
Mill unstable material from transverse joints of existing HMA pavements as directed by the Engineer, clean the milled trench, fill the milled trench with the specified mixture, and seal the edges of the repair when required.

2543.02 MATERIALS.

A. Unless stated elsewhere in the contract documents, use HMA meting or exceeding Section 2303 requirements for a 300,000 ESAL surface mixture.

B. The mixture size may be 3/4 inch, 1/2 inch, or 3/8 inch (19 mm, 12.5 mm, or 9.5 mm).

C. Use tack coat bitumen meeting the provisions of Article 2303.02, E.

2543.03 CONSTRUCTION.

A. Equipment.

1. Furnish milling equipment capable of removing deteriorated material a minimum of 12 inches (0.3 m) in width in one pass and to the depth specified in the contract documents.

2. Furnish tools or hand tools approved by the Engineer to remove other deteriorated material and clean the joint in the existing pavement.

3. Furnish one of the following to compact the lower lifts:

- Mechanical tampers meeting the requirements of Article 2001.04,
- Trench rollers,
- Vibratory compactors, or
- Weighted vehicle wheels operated in the trench.

B. Transverse Joint Repair.

1. Mill a transverse area not less than 12 inches (0.3 m) wide or more than 24 inches (0.6 m) wide for the entire pavement width at joint repair areas. Additional width may be specified by the contract documents or by the Engineer. The maximum depth of the milled area will also be specified in the contract documents.

2. Remove all loose material and clean the joint using methods approved by the Engineer. The use of hand tools may be required to provide a nearly vertical face of sound material. All removed material becomes the property of the Contractor, unless specified otherwise in the contract documents.

3. Prior to filling the milled area with HMA, lightly tack the vertical faces and the base of the area. Ensure these surfaces are clean and dry to make the tacking operation effective.

4. Place HMA in uniform lifts not to exceed 3 inches (75 mm) in depth.

5. Compact each lift with a minimum of three passes using the compaction equipment specified.

6. Ensure the finish elevation of the compacted material in the milled area is level with, or not more than 1/4 inch (5 mm) above, the surrounding pavement surface.

7. If the transverse joint repair is to be used for the roadway wearing surface, seal the edges of transverse joint repair with a coat of CRS-2 Bitumen. Apply the bitumen material with a V-shaped squeegee tool at a width of 3 inches (75 mm) centered on the joint edge. Blot excess bitumen material with sand.

C. Limitations of Operations.

1. Conduct the work on one lane at a time unless the road is closed to traffic. Conduct all operations to provide a minimum of inconvenience to traffic.

2. Complete all the milling, cleaning, filling and compacting, and sealing of each transverse joint repair in 1 day if the road is not closed to traffic.

3. If unforeseen conditions should result in milled trench sections being left overnight, assign a sufficient number of flaggers to warn and direct traffic from the time construction operations have stopped until they have resumed again. No extra payment will be made for the necessary flaggers.

4. Apply Articles 1107.08, 1107.09, and 1108.03.

2543.04 METHOD OF MEASUREMENT.

A. Measurement for Transverse Joint Repair will be the number of tons (megagrams) placed.

B. Unused quantities will be deducted based on actual scaled weight (mass) or estimates.

2543.05 BASIS OF PAYMENT.

A. Payment for Transverse Joint Repair will be the contract unit price per ton (megagram) for the specified material used.

B. Payment is full compensation for:

- Removal of all deteriorated material from the joint,
- Cleaning,
- Tack coat,
- Asphalt binder,
- HMA production, placement, and compaction in the trench, and
- Sealing the transverse joint repair edges, when required.

Section 2544. Cleaning and Filling Cracks for HMA Surfaces

2544.01 DESCRIPTION.

A. Clean and fill cracks in an existing pavement or paved shoulder. Fill large cracks and spalled areas with HMA. Fill smaller cracks with filler material.

B. This type of work is intended primarily for existing pavements that are not to be resurfaced. If additional work is to be required, it will be defined elsewhere in the contract documents.

2544.02 MATERIALS.

A. General.

1. Use an HMA mixture meeting the requirements of Section 2303 for a 3/4 inch, 1/2 inch or 3/8 inch (19 mm, 12.5 mm or 9.5 mm) mixture size, or a similar mixture from a commercial source subject to approval of the Engineer. A high performance bituminous cold premix mixture may be used with the Engineer's approval. The Engineer's approval of the use of a premix will be based on the availability of the specified hot mixture when this work is being done and the length of haul.

2. For tack-coat material, use SS-1, SS-1H, CSS-1, CSS-1H, and MC-70 meeting requirements of Section 4138 or 4140. Do not mix CSS and SS grades. Prior to October 1, use emulsion as the tack-coat bitumen. For Fall work after that date, a cutback asphalt may be used.

3. For filler material, use emulsified asphalt meeting the following requirements for CRS-2P or CRS-2 and of the quality to also be used for seal coat construction.

4. For blotting material, use a sand meeting requirements of Section 4124 or 4125, or a similar sand approved by the Engineer.

B. Polymer-Modified Cationic Rapid Set Asphalt Emulsion, CRS-2P.

Use a rapid set emulsion that has elastic properties.

C. Cationic Rapid Set Asphalt Emulsion, CRS-2.

Use a material having the properties of rapid set emulsion.

D. Requirements.

Use CRS-2P and CRS-2 emulsions complying with Section 4140.

2544.03 CONSTRUCTION.

A. Equipment.

Includes the following:

1. Water cleaning equipment capable of delivering water with a pressure of 2,000 psi (13.8 MPa) from a nozzle to the crack being cleaned.

2. Compressed air capable of providing moisture free and oil free air to blow sand and other foreign material from a crack.

3. Air chisel or hand tools to remove loose and spalled material adjacent to cracks.

4. Heating kettle or pressure distributor for applying filler material through a hand-operated wand or nozzle.

B. Cleaning and Filling.

1. General.

a. Clean with either a high-pressure air or with water equipment, except do not use water blasting equipment when the temperature is below 32°F (0°C). In all cases, ensure vegetation is removed from the cracks. Cleaning methods other than those specified in this specification may be necessary to remove vegetation. Obtain the Engineer's approval for other cleaning methods.

b. When specifically required by the plans, place a soil sterilant, such as Spike or an approved equal, in the crack prior to placing the filler material.

c. For filling cracks, use a hand-operated wand or pouring pot, either of which is capable of placing the filler material into the crack and filling to the adjacent surface. Use a nozzle or spout small enough to place the filler material into the crack without soiling the adjacent surface.

d. Immediately after placement of the filler, use a narrow, 2 inch (50 mm) or less, V-shaped, rubber-edged squeegee to tightly squeegee all cracks filled with emulsion. Take proper measures (for example a sand dam or an application of blotter material, in conjunction with the squeegee operation) to hold the filler in place, preventing run-out at pavement or shoulder edges and low areas.

2. Cracks Wider than 1 Inch (25 mm).

a. Clean the cracks of loose and spalled material, old crack filler when deemed necessary by the Engineer, sand, and other foreign debris using high-pressure water. Continue cleaning until essentially all debris and loose materials have been removed to a depth of 3 inches (75 mm) within the crack opening.

b. Blow the cleaned cracks free of water.

c. Lightly tack the crack surfaces with tack-coat material as a hand operation.

d. Fill the cracks with the hot mix specified. Rod and tamp into place and level with the adjacent surface. Ensure the mixture is warm and pliable when placed. Place this mixture prior to filling cracks with emulsion. Place a thin application of emulsion over the hot mix and tightly squeegee.

3. Cracks 1/4 Inch to 1 Inch (5 mm to 25 mm) in Width.

a. Clean with air pressure or high-pressure water sufficient to remove old crack filler, sand, and other foreign debris when the Engineer requires. Clean to a depth of at least 1 inch (25 mm). Clean down to sound material, but a depth greater than 3 inches (75 mm) will not be required.

b. Fill cracks with emulsion filler material. Use a hand-operated wand capable of placing the filler material into the crack and filling it to the adjacent surface. Use a nozzle attached to the wand small enough to place filler material into the crack without soiling the adjacent surface.

4. Cracks Less than 1/4 Inch (5 mm) in Width.
Clean sufficiently to remove sand and other foreign debris, and, when deemed necessary by the Engineer, old crack filler. Fill cracks with emulsion filler material.

5. Map-cracked Areas.
Cover with emulsion filler material using a suitable hand-operated squeegee. Apply as a thin, smooth application. Promptly blot the filler material with a light application of blotter material.

C. Limitations.

1. On projects where a fog seal or other surface treatment is to be done in conjunction with this work, complete the crack filling first. Except when this work is in preparation for a seal coat or slurry seal, do not perform crack filling on pavements from May 15 to September 30. Crack filling on paved shoulders will be allowed during this time.

2. When filling cracks with emulsion, allow sufficient time for the emulsion to flow to the bottom of the crack and to fill it completely full. In filling, a second pass may be necessary before leaving the work zone.

3. One additional filling, or refilling, will be necessary where the filler has settled into the crack opening. The Engineer will identify these areas.

4. The cleaned cracks need not be filled the same day they are cleaned. However, at the time of filling, ensure cracks are free of standing water as determined by visual examination. Recleaning may be necessary if the openings become contaminated before being filled. The work may be done as a single, coordinated operation.

5. Conduct the work on only one lane of the pavement at a time, and according to the traffic control plan. Use of a pilot car may be required.

6. Allow traffic to use the pavement during this construction. Conduct all operations so as to provide a minimum of inconvenience to traffic.

7. Apply Articles 1107.08, 1107.09, and 1108.03.

2544.04 METHOD OF MEASUREMENT.

Measurement for maintenance cleaning and filling cracks, satisfactorily completed, will be as follows:

A. Cleaning and Filling Cracks.

1. Cleaning and Filling Cracks (Pavement Maintenance).

a. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 km), of main line pavement on which cracks were cleaned and filled. Calculations will be based on the center line distance of main line, two-lane pavement, corrected for main line pavement of more than two lanes, including climbing lanes.

b. At intersections, rest areas, and interchanges designated for cleaning and filling, the additional areas of widened pavement, ramps, storage lanes, turning lanes, paved medians, and parking in rest areas will not be separately measured for pavement.

c. Between limits for which cleaning and filling is intended for either pavement or shoulders, no deductions will be made for bridges, intersections, or other interruptions where cracks are not to be cleaned and filled.

2. Cleaning and Filling Cracks (Shoulder Maintenance).

a. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 km), of paved shoulders on which cracks were cleaned and filled. Calculations will be based on the center line distance of the adjacent main line pavement, a single measurement for shoulders on both sides of the pavement.

b. At intersections, rest areas, and interchanges designated to be cleaned and filled, the additional areas of paved shoulders on ramps, gores, and turning lanes will not be measured separately for payment.

B. Hot Mix Asphalt for Crack Filling.

Weight (mass) of hot mixture used for filling cracks larger than 1 inch (25 mm). Mixture not used in the work will be deducted, based on actual scaled weights (mass) or estimates.

C. Filler Material (Maintenance).

1. Computed according to Article 2307.04, B. The total quantity will include the material placed in cracks and used to cover map-cracked areas.

2. Blotting material and tack-coat material will not be measured separately for payment.

2544.05 BASIS OF PAYMENT.

A. Payment for cleaning and filling cracks will be the contract unit price as follows:

1. Cleaning and Filling Cracks (Pavement Maintenance) or Cleaning and Filling Cracks (Shoulder Maintenance).
Per mile (kilometer) for pavement or shoulders on which the cracks were cleaned and filled.

2. Hot Mix Asphalt for Crack Filling.
Per ton (megagram) for HMA used in filling cracks over 1 inch (25 mm).

3. Filler Material (Maintenance).
Per gallon (liter).

B. Payments are full compensation for:

- Cleaning the cracks,

- Furnishing and placing the HMA,
- Filler material,
- All blotting material and tack-coat material that is necessary, and
- Furnishing all equipment and labor.

Section 2545. Overlay of Type B Guide Signs

2545.01 DESCRIPTION.

A. Overlaying of existing Type B signs. The signs to be overlaid will be identified in the contract documents.

B. This work is intended to be done by applying retroreflective sheeting, as specified in Article 4186.03, to sheets of thin aluminum and applying to existing sign panels with pop-rivets.

2545.02 MATERIALS.

A. Use retroreflective sheeting meeting the requirements of Article 4186.03.

B. Ensure the thin aluminum sheets have a thickness of 0.063 inches ± 0.004 inches (1.6 mm ± 0.1 mm) and meet the requirements of ASTM B 209/B 209M, Alloy 6061-T6 with no specified limit for yield strength of bend test.

C. Apply the retroreflective sheeting, as specified in Article 4186.03, to the thin aluminum sheets according to the sheeting manufacturer's recommendations.

2545.03 PREPARING PANELS, APPLYING ALUMINUM OVERLAY STRIPS, AND APPLYING LEGENDS.

A. Preparation of Panels.

1. Leave the sign panel to be overlaid in place on sign supports while the work is in progress. If proposing an alternate method requiring removal of the panel, submit the procedure to the Engineer for approval prior to beginning work.

2. Remove all existing legends, symbols, shields, and borders from the sign panel without damage to the aluminum extrusions. Removed items become the property of the Contractor. Remove rivets protruding from the surface of the sign panel. Additional preparation work may be shown in the contract documents.

B. Application of Aluminum Overlay Strips.

1. Apply the thin overlay aluminum strips with retroreflective sheeting in uniform width vertical strips no less than 1.5 feet (0.5 m) wide, except the last strip may be of lesser width. Form vertical joints by butting aluminum strips together as close as possible without overlapping.

2. Edge molding on the panel is to remain in place. Indent the overlay strips 3/4 inch (20 mm) from the left and right edge of the sign face to allow the edge molding to grip the extrusions.

3. With the sign 4 feet (1.2 m) or less in height, place the overlay strip horizontal in one piece.

4. Attach the overlay sheets with rivets. Use aluminum pull through, hollow blind rivets with a diameter of 1/8 inch (3 mm) and a brazier head with an appropriate grip range. The maximum spacing between rivets is to be 12 inches (0.3 m) both vertical and horizontal. The maximum spacing that the rivets may be indented is 3 inches (75 mm) from edge of the overlay strips.

5. Control color matching of pieces of overlay by maximum use of overlay from a single lot number on each sign. When overlay from different lots is to be used on a sign, match the colors. In matching, place the overlay pieces side by side and inspect visually in existing light from a 10 foot (3 m) distance perpendicular to the faces of the pieces. If a difference in color is perceptible at that distance, the pieces are not to be used on the same sign.

C. Application of Legend.
For legends to be placed on refurbished sign panels, use retroreflective sheeting applied to an aluminum base according to Type B sign layouts on the plans. Use detachable type legends. Use new material meeting the requirements of Article 4186.05. Attach legends to the sign panel as specified in Article 4186.06, D.

D. Limitations.
The sequence of overlay work and the time requirements for each sign are subject to the limitations shown on the plans.

2545.04 METHOD OF MEASUREMENT.

Measurement for Overlay Type B Guide Signs will be in square feet from measurements to the nearest 0.1 feet (square meters from measurements to the nearest 0.1 m) computed for the area of the vertical, front face of the signs, as specified in the contract documents, according to Article 2524.04.

2545.05 BASIS OF PAYMENT.

A. Payment for Overlay Type B Guide Signs will be the contract unit price per square foot (square meter) of sign area overlaid.

B. Payment is full compensation for:
- Sign panel preparation,
- Furnishing and applying overlay sheeting material to existing sign panels, and
- Furnishing and applying all legend, border, and symbols according to the contract documents.

Section 2546. Gabions and Revet Mattresses

2546.01 DESCRIPTION.

Gabions are intended for high strength installations in both horizontal and vertical structures. Revet mattresses are intended for lower strength, horizontal or nearly horizontal structures.

2546.02 MATERIALS AND FABRICATION.

Ensure gabions and mattresses are constructed using materials meeting the following requirements. Ensure they are fabricated as required for gabions, unless mattresses are specifically designated in the contract documents. At the Contractor's option, for lid fastening of twisted mesh baskets at edges and diaphragms, either lacing wire or steel ring fastener system may be used. For welded wire mesh baskets, use “Lacing Wire” for lid fastening at edges and diaphragms. Baskets shall be fabricated by twisting or welding a mesh from steel wire.

A. Baskets.

1. Double Twisted Wire Baskets.

- **a.** Twisted wire mesh for gabion baskets and revet mattresses shall be formed in a uniform hexagonal pattern with double twists so bound as to prevent unraveling.
- **b.** Twisted wire mesh baskets shall meet the requirements of ASTM A 975 and fabricated from soft temper galvanized wire with a Class III Coating in accordance with ASTM A 641 (Style 1) and, if specified, subsequently coated with PVC (Style 3).
- **c.** For gabions, the mesh opening shall not exceed 4.5 inches (115 mm), and area shall not exceed 10 square inches (6450 mm^2).
- **d.** For mattresses, the maximum linear dimension of mesh opening shall not exceed 3.25 inches (80 mm).
- **e.** Wire for twisted wire mesh gabion baskets, revet mattresses, edges and selvage shall have a tensile strength of 60,000 to 70,000 psi (413.7 to 485 MPa).
- **f.** Wire for lacings and connections of twisted wire mesh gabions and mattresses shall have a tensile strength of 60,000 to 75,000 psi (413.7 to 515 MPa).

2. Welded Wire Baskets.

- **a.** Welded wire baskets shall meet the requirements of ASTM A 974, Style 2, manufactured from uncoated hard drawn steel wire conforming to ASTM A 853 and the fabric subsequently coated with zinc using the hot dip process; if specified, the galvanized fabric may have an additional coating of PVC (Style 5).
- **b.** Weight of the zinc coating on the fabric shall conform to the requirements of ASTM A 641 Class 3.
- **c.** Welded wire mesh for gabion baskets shall have each connection welded to obtain a minimum average shear strength of 584 pounds (2600 N), with a minimum shear strength of 450 pounds (2000 N).
- **d.** For revet mattresses, the minimum average shear strength of welded connections shall be 292 pounds (1300 N), with a minimum shear strength of 225 pounds (1000 N).

e. Wire shall have a minimum tensile strength of 80,000 psi (550.0 MPa) for welded wire baskets and mattresses.

f. For gabions, the mesh opening shall not exceed 3 inches (76.2 mm), and area shall not exceed 9 square inches (5806 mm^2).

g. For mattresses, the mesh opening shall not exceed 3 by 1.5 inches (76 by 38 mm).

3. Wire.

Ensure wire complies with the following:

a. Mesh, edge, and selvage wire are the same material.

b. Minimum sizes shown in Table 2546.02-1:

Table 2546.02-1: Minimum Wire Sizes

	Gabions	Mattresses
Mesh	11 gage (3.06 mm)	13 1/2 gage (2.18 mm)
Edges and selvage	9 gage (3.76 mm)	11 gage (3.06 mm)
Lacing and connecting	13 1/2 gage (2.18 mm)	13 1/2 gage (2.18 mm)

4. Steel Ring Fastener System.

Steel Ring Fastener System may be used only with twisted mesh wire baskets. Ensure one of the following is used:

- Galvanized 11 gage (3.05 mm) wire with a tensile strength meeting the requirements of ASTM A 764, Class I Tensile, and with a Class 3, Type B or C coating of a minimum of 0.80 ounce (244 g) of zinc per square foot (square meter).
- Stainless steel 11 gage (3.05 mm) wire (use only with PVC coated gabion baskets and mattresses) with a tensile strength meeting the requirements of ASTM A 313, Type 302, Class I.

5. Basket Fabrication.

a. Ensure baskets are fabricated as shown in the contract documents. Standard sizes are shown in Table 2546.02-2:

Table 2546.02-2: Gabion Basket Fabrication

GABIONS				
Dimensions, ft. (m)[a]			Number of Cells or Compartments	Capacity yd^3 (m^3)
Length	Width	Height		
6 (1.8)	3 (0.9)	3 (0.9)	2	2.0 (1.5)
9 (2.7)	3 (0.9)	3 (0.9)	3	3.0 (2.3)
12 (3.6)	3 (0.9)	3 (0.9)	4	4.0 (3.1)
6 (1.8)	3 (0.9)	1.5 (0.5)	2	1.0 (0.8)
9 (2.7)	3 (0.9)	1.5 (0.5)	3	1.5 (1.1)
12 (3.6)	3 (0.9)	1.5 (0.5)	4	2.0 (1.5)
6 (1.8)	3 (0.9)	1 (0.3)	2	0.66 (0.5)
9 (2.7)	3 (0.9)	1 (0.3)	3	1.0 (0.8)
12 (3.6)	3 (0.9)	1 (0.3)	4	1.33 (1.0)

MATTRESSES				
Dimensions, ft. (m)[(a)]			Number of Cells or Compartments	Capacity yd^3 (m^3)
Length	Width	Height		
9 (2.7)	6 (1.8)	0.50 (0.17)	3	6 (5.2)
12 (3.6)	6 (1.8)	0.50 (0.17)	4	8 (6.69)
9 (2.7)	6 (1.8)	0.75 (0.23)	3	6 (5.2)
12 (3.6)	6 (1.8)	0.75 (0.23)	4	8 (6.69)
9 (2.7)	6 (1.8)	1.0 (0.3)	3	6 (5.2)
12 (3.6)	6 (1.8)	1.0 (0.3)	4	8 (6.69)
[(a)] Dimensions are subject to a tolerance of ±5%.				

b. Ensure baskets are fabricated into panels in such a manner that the base, sides, and ends can be assembled into a single, rectangular unit of the specified size. Ensure all perimeter edges of the baskets are selvaged with the specified wire so that the selvaged connections have the same strengths as the body of the mesh.

c. Baskets will normally be furnished in bundles of flat panels of appropriate sizes. On site assembly is intended.

d. Ensure the gabion units are furnished with the necessary diaphragms secured in proper position on the base in a manner so that no additional tying at this juncture will be necessary.

e. Ensure the mattress units are subdivided into compartments by the insertion of diaphragms made of the same mesh as the rest of the mattress. Ensure the diaphragms are factory secured in proper position at the base with a continuous spiral wire, in such a manner that no additional tying at this junction will be necessary.

6. Elongation.

Ensure the wire mesh permits elongation equivalent to a minimum of 10% of the length of the section under test without reducing the gage or tensile strength of the individual wire.

7. Elasticity.

a. Ensure the mesh withstands, without rupture of any wire or opening of any mesh fastening, the following load test:

1) The ends of an uncut section of mesh 6 feet (1.8 m) long, not less than 3 feet (1 m) wide and including all selvage binding, are securely clamped for 3 feet (1 m) along the width of the sample. When the width of the sample under test exceeds 3 feet (1 m), the clamps will be placed in the middle portion of the width, and the excess width will be allowed to fall free on each side of the clamped section.

2) The sample is then subjected to sufficient tension to cause 10% elongation of the sample section between the clamps.

3) After elongation and while clamped as described above (and otherwise unsupported), the section is subjected to a load applied to an area of 1 square foot (0.1 m^2), located approximately in the center of the sample section between the

clamps, and in a direction perpendicular to the direction of the tension force. For gabions, use a load equaling or exceeding 6000 pounds (26.7 kN). For mattresses, use a load equaling or exceeding 4000 pounds (17.8 kN).

b. Ensure the ram head used in the test is circular with its edges beveled or rounded to prevent cutting of the wires.

8. Certification.

a. As a condition of source approval, the manufacturer may be required to furnish test results which show compliance with elongation and elasticity requirements.

b. Ensure each shipment of wire structures to a job site is accompanied by a certification which states that the material meets the requirements of this specification. A shipment consists of all materials arriving at the job site at substantially the same time.

c. Ensure all certifications are signed by an authorized representative of the company.

B. Anchor Stakes.
Use anchor stakes made from 2 inch (50 mm) nominal diameter, galvanized standard weight pipe meeting the requirements of ASTM A 53. The length will be shown in the contract documents.

C. Engineering Fabric.
Use engineering fabric meeting the requirements of Article 4196.01, B, 3.

D. Gabion Stone.
Meet the requirements of Article 4130.06.

E. Grout.
Apply Article 2507.02, B.

2546.03 CONSTRUCTION.

A. Perform the work as required by the contract documents. Excavate or smooth the area, or both, as necessary for proper placement of the gabions or mattresses, as shown in the contract documents. The contract documents may also require compaction of the prepared surface, or placement of selected or special backfill material in preparing the surface.

B. When specified, furnish and transport concrete grout and place within the voids to the full width of the gabion basket.

C. When designated in the contract documents, place engineering fabric under and behind the baskets. Place the fabric in vertical strips, or transverse to the flow line, lapped at least 3 inches (75 mm) with the downstream strip to the outside of the structure.

D. At the construction site, assemble the baskets into rectangular baskets of the specified sizes. Assemble them to be single unit construction. Weave the base, lid, and sides into a single unit. Connect the ends to the base section

in a manner so that strength and flexibility at the point of connection is at least equal to that of the mesh.

E. Carefully place the baskets into their proper positions for slope and alignment as shown in the contract documents. When the slope is not shown, slope the faces of gabions at 1 (horizontal) to 6 (vertical).

F. When anchor stakes are designated for mattresses, drive them into position as shown in the contract documents. The top of the anchor stake should be at the elevation of the tops of adjacent baskets. Securely tie the anchor stakes to adjacent baskets at the top and the base of the baskets.

G. Connect adjacent baskets in a manner so that the connection is strong enough that a failure will occur in the mesh, rather than the lacing. Adjoining gabions and mattresses are to be connected at vertical corner edges and diaphragms. Stacked gabions are to be also connected at the horizontal edges, front and back. Lace all connections with loops at approximate 4 inch (100 mm) intervals, and as recommended by the manufacturer. To achieve proper alignment during filling, use a come-along or other means to tension gabions 3 feet (0.9 m) high placed in a line.

H. Carefully fill each basket with the revetment stone specified. Machine placement will be permitted. However, considerable handwork is necessary and will be required to assure orientation for maximum density without bulges, a compact and dense exposed face, and maximum aggregate contact with the lid and other baskets placed or to be placed in the structure.

I. For gabions 3 feet (0.9 m) high, fill in three lifts, 1 foot (300 mm) at a time, orienting the stones with each lift as necessary.

J. When a 3 foot (0.9 m) high cell is to be exposed in the finished structure, securely install two connecting wires between each lift, connecting each cell face to be exposed with the opposite face or diaphragm. Locate the wires with equal horizontal spacing. Install the wires by looping each end around two mesh openings, then wrapping the wire tightly around itself with at least four full wraps. Lock the end of the wire in place by lacing it under the previous lap. (For each 3 foot (0.9 m) high cell with one face to be exposed, four connecting wires are required. For the same cell as an end unit, there are two exposed faces and eight connecting wires are required.)

K. Connecting wires are not required for mattresses.

L. Fasten the lids in place at edges and diaphragms as specified above.

M. If steel ring fasteners are used, limit spacing to nominal 5 inches (±1.0 inch) (125 mm (± 25 mm)).

N. Special features or details may also be required. Construct these as shown in the contract documents.

O. When specified, do not place grout until the Engineer has inspected and approved the gabion. Sufficient jarring of rocks may be done to aid penetration of the grout to ensure all voids are filled and the grout fully penetrates the basket. Place grout according to Article 2507.03, E.

P. When the structure is completed, finish the earthwork as shown in the contract documents.

2546.04 METHOD OF MEASUREMENT.

A. Gabions or Mattresses.

1. Gabions or Mattresses: Calculated volume satisfactorily placed. When placement is according to the contract documents, plan quantities will be used.

2. Anchor Stakes (if required for mattresses): by count.

3. Associated earthwork: Article 2402.04 or 2102.04 applies.

B. Concrete Grout for Gabions.

Article 2507.04 applies.

2546.05 BASIS OF PAYMENT.

Payment will be for the contract unit price as follows:

A. Gabions or Mattresses.

1. Gabions or Mattresses:
- **a.** Per cubic yard (cubic meter).
- **b.** Payment is full compensation for:
  - Furnishing and placing engineering fabric as shown in the contract documents,
  - Furnishing, assembling, and placing the baskets, and
  - Furnishing and placing the revetment stone in the baskets.

2. Anchor Stakes: each.

3. Associated earthwork: Article 2402.05 or 2102.05 applies. For small quantities, the contract documents may designate this work as incidental. If so, it will not be paid for separately.

4. Special features or details: as shown in the contract documents. They may be made incidental, with no separate payment.

B. Concrete Grout for Gabions.

Article 2507.05 applies.

Section 2547. Temporary Stream Access

2547.01 DESCRIPTION.

This work consists of the construction, use, maintenance and removal of temporary structures used to provide construction access across along or into waters of the United States. Temporary structures are any features not a part of the completed project that are constructed or installed to provide access to the project site including stream crossings, causeways, pads and temporary bridges or barges.

2547.02 MATERIALS.

Furnish fill materials. Do not obtain from the stream unless specifically allowed elsewhere in the contract documents.

2547.03 CONSTRUCTION.

A. The type of structure used, if any, is at the Contractor's discretion provided it complies with Article 1105.14. Unless indicated otherwise in the contract documents, the Contracting Authority will obtain approval for temporary stream crossings, constructed according to Standard Road Plan RL-16 or as shown in the contract documents, in the Section 404 permit. Obtain a Section 404 permit for temporary stream crossings not to be constructed according to RL-16 or the contract documents.

B. Ensure temporary structures do not restrict expected high flows or disrupt the movement of aquatic life native to the stream or water body. Expected high flows are those flows which the Contractor expects to experience during the period of time that the crossing is in place. Temporary structures are not to extend over 100 feet (30 m) into any swamp, bog, marsh, or similar area that is adjacent to the stream or water body.

C. Ensure pre-construction downstream flow conditions are maintained.

D. Maintain temporary structures to prevent unnecessary erosion and other non-point sources of pollution.

E. Completely remove temporary structures within 30 calendar days of no longer being needed. Revetment that has been removed may be incorporated elsewhere in the project, provided it meets the specification for the intended final use. Remove all other fill material to an upland area. Reshape and stabilize all disturbed areas.

2547.04 METHOD OF MEASUREMENT.

None.

2547.05 BASIS OF PAYMENT.

Temporary Stream Accesses is incidental to Mobilization.

Section 2548. Milled Rumble Strips - HMA or PCC Surface

2548.01 DESCRIPTION.

Provide equipment, furnish all necessary labor and materials, and perform all operations necessary for milling rumble strips in HMA or PCC surfaces. Mill rumble strips to the dimensions and spacing shown in the contract documents. Apply diluted asphalt emulsion to the milled shoulder rumble strips on HMA surfaces by means of a bituminous distributor.

2548.02 MATERIALS.

A. Milling.
Equip milling equipment with a cutting head having cutting tips arranged in a pattern as to provide a smooth cut, approximately 1/16 inches (2 mm) between peaks and valleys.

B. Asphalt Emulsion Fog Seal.

1. Use asphalt emulsion Grade CSS-1h, meeting requirements of Section 4140.

2. Dilute the asphalt emulsion with water prior to application to the milled shoulder rumble strip. The dilution rate is one part of asphalt emulsion to one part of water.

2548.03 CONSTRUCTION.

Notify the Engineer if degraded areas are encountered that will not accommodate milled rumble strips. Skip those sections.

A. Test Strip.
Demonstrate to the Engineer on an initial 500 foot (150 m) test section that the equipment and method will provide the desired milled rumble strip and surface inside each depression without damaging the adjacent pavement. If the desired results are not being provided, as determined by the Engineer, provide different equipment or methods, or make necessary adjustments to provide the desired results. If the initial 500 foot (150 m) section results are unsatisfactory, repair or replace the section as determined by the Engineer, at no additional cost to the Contracting Authority.

B. Milling.

1. Mill shoulder rumble strips in a straight line, offset from the painted edge line as shown in the contract documents. Do not deviate from that offset more than ± 2 inches (50 mm). Ensure the depth of the rumble strips is as shown in the contract documents. The Engineer will randomly check the alignment and depth.

2. Mill centerline rumble strips in a straight line, on the centerline joint as shown in the contract documents. Do not deviate from that location more than ± 1 inch (25 mm). Ensure the depth of the rumble strips is as

shown in the contract documents. The Engineer will randomly check the alignment and depth.

3. Remove waste material (millings) resulting from the operation on a daily basis. The waste material may be used as fillet material adjacent to the paved shoulder or it may become property of the Contractor and disposed of off the project. Disposal of material may be at an approved landfill or approved stockpile, or by other methods that will allow the material to be recycled. Remove waste material prior to opening adjacent lane to traffic.

C. Asphalt Emulsion Fog Seal.

1. Ensure the equipment meets the requirements of Section 2001.

2. Ensure the application width covers the entire milled shoulder rumble strip.

3. Place the diluted asphalt emulsion fog seal according to Article 2308.03, D, at a rate of 0.13 gallon per square yard (0.6 L/m^2).

4. Do not place asphalt emulsion on a damp or wet surface.

5. Apply asphalt emulsion during weather conditions under which satisfactory application can be obtained. Do not apply asphalt emulsion when the air temperature is below 50°F (10°C). Do not place asphalt emulsion after October 15 without the Engineer's permission.

D. Limitations.
Do not disturb desirable grass areas and desirable trees outside the construction limits. Do not park or service vehicles and equipment or use these areas for storage of materials. Obtain the Engineer's approval for storage, parking, and service areas.

2548.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Milled Shoulder Rumble Strips.
Stations (meters) shown in the contract documents, measured along each edge of mainline pavement. Unless stated otherwise in the contract documents, no deduction will be made for gapped areas. The quantity will be adjusted for the length of degraded shoulders skipped, as defined in Article 2548.03 of this specification. The quantity will be adjusted for test sections that were deemed unsatisfactory.

B. Milled Centerline Rumble Strips.
Stations (meters) shown in the contract documents, measured along the centerline of mainline pavement. Unless stated otherwise in the contract documents, no deduction will be made for gapped areas. The quantity will be adjusted for the length of degraded pavement skipped, as defined in Article

2548.03 of this specification. The quantity will be adjusted for test sections that were deemed unsatisfactory.

C. Asphalt Emulsion for Fog Seal (Shoulder Rumble Strips).
Gallons (liters) computed from field measurements of distributors or from tank cars or transport trucks as provided in Article 4100.03. When quantities computed from field measurements check within 1.0% of the billed gallons (liters), payment will be based on billed gallons (liters). When quantities computed from field measurements differ from billed gallons (liters) by more than 1.0%, payment will be based on the quantity from field measurements. From these quantities, any amount used by the Contractor as fuel, left in cars, or otherwise not delivered to the road surface will be deducted. The Engineer will advise the Contractor promptly, in writing, of quantities deducted.

2548.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Milled Shoulder Rumble Strips.
Per station (meter) for the type specified.

B. Milled Centerline Rumble Strips.
Per station (meter) for the type specified.

C. Asphalt Emulsion for Fog Seal (Shoulder Rumble Strips).

1. Per gallon (liter) for undiluted Asphalt Emulsion for Fog Seal (Shoulder Rumble Strips) that is mixed and used on the project. Diluted asphalt emulsion that is delivered to the project site, but not applied to the roadway surface will not be considered for payment.

2. Payment is full compensation for cleaning the shoulder surface, furnishing and applying diluted asphalt emulsion, mixing water, and protecting the adjacent pavement and edge lines.

Section 2549. Pipe and Manhole Rehabilitation

2549.01 DESCRIPTION.
This section was developed in conjunction with Sections 4050 and 6020 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Pipe Lining:

1. Resin impregnated, cured-in-place.

2. Deformed/reformed polyethylene.

3. Folded/formed polyvinyl chloride.

4. Sliplining.

B. Pipe spot repairs.

C. Rehabilitate existing manholes to waterproof and to prevent inflow and infiltration, to prevent corrosion, or to reestablish the structural integrity of the manhole. Includes construction of structural liners, protective liners, and chimney seals.

2549.02 MATERIALS.

A. Pipe Rehabilitation.

1. Apply Article 4147.01.

2. The Engineer may allow substitutions. Provide as a minimum the following information for evaluation:

a. Product Information.

1) Product name.
2) Year product first available in the United States.
3) Total footage or number of line segments installed in the United States.
4) Results of all available product testing, including but not limited to leakage, physical properties, pipe stiffness, chemical resistance, strain-corrosion, external loading, flow characteristics, infiltration/inflow reductions, structural capacity, and external hydrostatic loading capacity.
5) Samples of before and after product.
6) Design method.
7) Typical lining thickness for pipe sizes included in the project.

b. Manufacturer Information.

1) Manufacturer name.
2) Years of experience manufacturing the product.
3) Country of manufacture of all product components.
4) Quality control procedures for product manufacture, including inspection requirements, testing procedures, and allowable tolerance levels.
5) Related ASTM standards, or other nationally recognized standards for product manufacturing.

c. Installer Information.

1) Installer name.
2) Completed project list for last five years including for each project and year completed, client name/address/contact person/phone number, footages installed by pipe diameter, and number of lateral reinstatements.
3) Detailed installation procedures, including estimated times for each task, lateral reinstatement methods, number of required excavations, and other items unique to each product.
4) Video of installation process, if available.
5) Evidence of properly trained personnel.

6) Related ASTM standards or any nationally recognized standards for product installation.
7) Available equipment list.
8) Detailed procedures for repairing the product in the event of future damage or failure and for tapping future service connections, including required specialized equipment or training.
9) Videos of two rehabilitated sewer sections showing before and after conditions.
10) Additional information may be required. The submittal of prequalification information in no way implies that the product, manufacturer, or installer will be deemed to be qualified. The Contracting Authority, in its sole discretion, will determine whether a product, manufacturer, or installer does or does not qualify as an approved equal.

B. Manhole Rehabilitation.
Apply Article 4147.02

2549.03 CONSTRUCTION.

A. Pipe Rehabilitation.

1. Public Relations Program.
Establish a Public Information and Notification Program for contacting each home or business connected to the affected sanitary sewer, informing them of the work to be done and when the sewer will be off line. The following specific steps are part of the Public Information and Notification Program:
a. Provide written notice to be delivered to each affected home or business describing work, schedule, how the work affects them, and a local telephone number of the Contractor they can call to discuss the project or their problems.
b. Personally contact each home or business on the day lateral verifications using closed circuit video inspection are to be performed. The homeowner or business will be asked to run water down their drain to verify each lateral. If the homeowner is unavailable, attempt other arrangements (cleanouts) to drain water through the lateral to verify each connection.
c. Provide written notice and personally contact the home or business the day prior to beginning inversion of the section of sewer to which they are connected.
d. Personally contact all homes or businesses that can not be reconnected within the time stated in the written notice.
e. Furnish and service portable toilets for use by the home or business occupants if so required by any affected served business or homeowner.

2. Special Requirements.
a. Prior to start of work, notify all affected parties 24 hours in advance as to the length of time their service will be blocked.

b. Notify the Engineer's Water Works Department to use meter and pay for water, if required.
c. Unless specified otherwise, the Contracting Authority will provide water for installation of cured-in-place pipe from a nearby hydrant through a separate valve mounted on the hydrant.

3. Examination.
a. Cleaning.
1) Clean and remove soil, grit, debris, and obstructions prior to video inspection or insertion of lining pipe, or both.
2) Do not flush debris to downstream sections.
3) Deposit removed material at an approved site.
b. Video Inspection.
1) Furnish the Engineer with a recording of sewers: 1) before the lining process and while the flow is being bypassed; and 2) after lining process and service reconnections have been completed.
2) Provide an on screen numerical display of camera location, indexed from the starting manhole, in feet (meters).
c. Service and Obstruction Location.
1) Coordinate and cooperate with the Engineer for service and obstruction location.
2) Locate the active sewer services by one of following:
a) Use video inspection to observe service locations, breaks, obstructions, and structural failures.
b) Insert a sounding device through the service, noting its location on the ground surface.
c) Dye testing.

4. Bypassing Sewage.
a. Submit a bypassing plan to the Engineer for review.
b. Plug the line at a point upstream of pipe to be rehabilitated if bypassing is required.
c. Pump flow to a downstream point or adjacent system as directed by the Engineer.
1) Provide pump and bypass lines of adequate capacity to handle all flows.
2) Provide adequate reserve pumps on site for emergency use and for storm flows.

5. Obstructions.
a. Remove all obstructions.
b. If an obstruction is encountered that cannot be removed by equipment operating within the pipe, excavate and remove the obstruction upon approval of the Engineer.
c. Place backfill material, compact, and restore the surface according to the contract documents.

6. Temporary Sewer Service.
If full normal sewer service is not re-established within the times stated, provide temporary facilities or hotel accommodations for affected residents and businesses.

7. Sliplining.

a. Excavation.

1) For sliplining insertions, excavate at or near one structure and work from the existing manhole at the other end of the section to be pulled.

2) Insertion Pit.

a) For sliplining with segmented pipe (one pipe section at a time), construct the insertion pit as required to accommodate the length of individual pipe sections.

b) For sliplining with pipe that is to be welded together above ground and pulled into sewer, dig a pit length 12 times the inside pipe diameter and slope the pit end back to the ground surface at 2.5 (horizontal) to 1.0 (vertical).

b. Test Head.

1) Pull the pulling head with one short section of slipling pipe through the sewer before inserting the liner to test for taps or obstructions protruding too far into the sewer.

2) Attach cables to both ends of the test head to allow for removal if an obstruction is encountered.

c. Installation.

Push segmented pipe into the host pipe according to the manufacturer's recommendations, or pull in a continuously welded pipe according to ASTM F 585.

d. Service Reconnection.

1) Allow the sliplining pipe to recover according to the manufacturer's recommendations.

2) Do not leave the sanitary service unconnected for more than 24 hours.

3) Complete reconnections involving excavation of service lines according to the local plumbing codes.

4) Reconnect excavated service connections according to the local plumbing code, except that the annular space between the host pipe and the sliplining pipe is to be filled with grout.

e. Grouting.

1) Before trimming the ends of the pipe and sealing, allow for the pipe to recover its original length according to the manufacturer's recommendations. Recovery time is at least equal to the time required to pull the pipe into place.

2) Fill the space between the sliplining pipe and the host pipe with CLSM complying with Article 2552.02, E, 3, or other material approved by the Engineer. Pump filler in from the lower end of the sliplining pipe.

8. Resin Impregnated Cured-In-Place Pipe Lining.

a. Install according to the manufacturer's recommendations for this lining process and ASTM F 1216 unless noted otherwise.

b. Use a resin impregnated tube, hydraulically inverted in place with an approved lubricant, and cured in place according to ASTM F 1216, Section 7.

c. Make the tube continuous between manholes. The tube may span several manhole reaches as allowed by the equipment, properties of the CIPP, and the size and condition of the sewer.

d. Ensure the tube is free of uncured spots, lifts (spots cured away from the sewer), and delaminations. Remove and replace deficient sections.

e. Service Reconnections.

1) Do not leave sanitary service unconnected for more than 24 hours.

2) Complete reconnections involving excavation of service lines according to the local plumbing code.

9. Deformed/Reformed High Density Polyethylene Pipe or Folded/Formed Polyvinyl Chloride Pipe Lining Installation.

Install according to the manufacturer's recommendations for particular lining material and process, unless specified otherwise.

a. Lining Installation.

1) Designate location where insertion is to begin, subject to the Engineer's approval.

2) Transport lining to the site in one continuous length on spools compatible with manufacturer's designated process.

3) Heat lining material at the job site as necessary for insertion. Pull lining into the sewer with appropriate pulling heads, cables, and heat distribution equipment.

4) Ensure lining is continuous between manholes as allowed by the tensile properties of lining and the size and condition of the sewer.

5) Connect fully inserted lining to the heat source distribution equipment.

6) Round and expand by uniformly distributed heat, steam, and pressure and by mechanical devices.

7) After lining has been expanded to a tight fit, cool gradually under pressure until the process is complete.

8) Provide a continuous pipe lining, without joints, over the entire length of pipe.

9) Ensure the lining is free of all material defects, pits, pinholes, cracks, crazing, folds, or unrounded sections.

10) Repair all defects at no additional cost to the Contracting Authority.

b. Service Reconnections.

1) Do not leave sanitary service unconnected for more than 24 hours.

2) Complete reconnections involving excavation of service lines according to the local plumbing code.

10. Spot Repairs by Pipe Replacement.

a. Excavate trench according to Section 2552.

b. Remove existing pipe to the extent required and disconnect affected sewer services.
c. Install replacement pipe of the same nominal size as the existing pipe.
1) Use the same materials as specified in the contract documents that comply with Section 2504.
2) Place bedding material according to Section 2552.
d. Install pipe repair coupling.
1) Cut pipes to length require allowing no more than a 1/2 inch (13 mm) gap between butted pipe ends at coupling location. Cut pipes perpendicular to centerline.
2) Clean the outside surface of the existing and replacement pipes as required to provide a positive seal with the pipe repair coupling.
3) Wrap coupling around pipes, centered on butt joint, and tighten bolts according to manufacturer's recommendations.
e. Reconnect sewer services.
f. Place backfill material in trench according to Section 2552.

11. Cleanup and Closeout.
a. Verify that the services are reconnected and fully operable, with at least 90% of original capacity.
b. Submit initial and final video tapes, CDs, or DVDs to the Engineer.
c. Remove all equipment and debris.

B. Manhole Rehabilitation.

1. Submittals.
a. Concrete mix design, if required by the Engineer.
b. Catalog cuts of all mortar mixes, sealants, and liners.

2. Rubber Chimney Seal.
Apply Article 2435.03, A.

3. Urethane Chimney Seal.
a. Prepare the surface according to the manufacturer's recommendations, including sandblasting, pressure washing, sealing leaks or gaps, and drying the surface.
b. Apply primer, prepare product, and brush-apply the seal to a minimum thickness of 175 mils (4.5 mm), covering 2 inches (50 mm) above the bottom of the frame and the entire adjustment ring area to 3 inches (75 mm) below the bottom adjustment ring.

4. In-Situ Manhole Replacement, Cast-in-place Concrete.
a. Preparation.
Prepare according to the forming system manufacturer's recommendations, including the following:
1) Clean the existing surface to remove loose material and debris.
2) Remove existing steps that might interfere with the erection of the forms.
3) Control infiltration that may affect placement of concrete.

b. Installation.

Install and test according to the forming system manufacturer's recommendations, including the following:

1) Place pipe extensions through the structure to maintain flow during installation.

2) Erect forms inside the manhole. Secure the assembled internal forms to prevent shifting and to provide sufficient stiffness and strength to prevent collapse.

3) Install a plastic liner when specified.

4) Seal the forms at the bottom of the manhole to ensure the concrete does not enter the sewer.

5) Carefully place concrete between the forms and the existing manhole walls. Place concrete from the bottom up to prevent segregation of concrete.

6) Consolidate concrete as required to fill all pockets, seams, and cracks within the existing manhole wall.

7) Remove the forms when the concrete has cured sufficiently.

8) Weld and test joints if a plastic liner is installed.

9) Apply a sealing strip around the circumference of the invert top where it meets the vertical wall and around all pipe penetrations to form a waterstop.

10) Overlay the invert top with concrete or high-strength mortar. Vary thickness from 3 inches (75 mm) at the wall to 1/2 inch (13 mm) at the edge of the channel.

11) Apply an epoxy lining to the invert top. Apply clean sand to the epoxy to create a non-slip surface.

12) Seal the plastic liner to the manhole casting and existing pipe stubs as recommended by the manufacturer.

13) Install a new casting.

5. Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal.

a. Surface Preparation.

Prepare according to the manufacturer’s recommendations, including the following:

1) Wash the interior with a high pressure washer.

2) Plug active leaks with the appropriate sealing material.

b. Mortar Application.

Apply according to the manufacturer's recommendations, including the following:

1) Apply with a rotating centrifugal casting applicator, beginning at the bottom of the manhole.

2) Retrieve the applicator head at the manufacturer's recommended speed to achieve the desired thickness.

3) Apply to the full required thickness utilizing multiple passes as necessary. Minimize the time between passes so subsequent passes are cast against fresh mortar.

4) Verify thickness with a wet gage at several locations to ensure proper depth.

5) Hand-apply high-strength mortar to the invert surface. Vary thickness from 3 inches (75 mm) at the wall to 1/2 inch (13 mm) at the edge of the channel.

c. Epoxy Seal Application.
Seal according to the manufacturer's recommendations, including the following:

1) Apply with a rotating centrifugal casting applicator or airless sprayer onto the fresh mortar liner.

2) If the epoxy seal is applied more than 24 hours after application of the mortar liner, or if the mortar liner is contaminated, clean the liner and then apply the epoxy.

d. Finishing.
Install a new casting.

2549.04 METHOD OF MEASUREMENT.

A. Pipe Lining.
Measurement for each type and size of pipe lining will be in linear feet (meters) along the centerline of the pipe lining from center of manhole to center of manhole.

B. Building Sanitary Sewer Service Reconnection.
Each active existing building sanitary sewer service reconnected to the pipe lining, including the services reconnected by excavating and reconnecting services or by trenchless reconnection methods, will be counted.

C. Spot Repairs by Pipe Replacement.
Both of the following methods will be specified for measurement of spot repairs by pipe replacement:

1. Spot Repairs by Count.
Each spot repair location will be counted.

2. Spot Repairs by Linear Foot (Meter).
Measurement will be in linear feet (meters) along the centerline of the replacement pipe.

D. Rubber Chimney Seal.
Each rubber chimney seal installed on an existing manhole will be counted.

E. Urethane Chimney Seal.
Each urethane chimney seal installed on an existing manhole will be counted.

F. In-Situ Manhole Replacement, Cast-in-place Concrete.
Measurement of the vertical dimension of in-situ manhole replacement will be in feet (meters) from the lowest flowline to the top of the rim.

G. In-Situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner.
Measurement of the vertical dimension of in-situ manhole replacement with plastic liner will be in feet (meters) from the lowest flowline to the top of the rim.

H. Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal.
Measurement for depth of the vertical dimension of manhole lining will be in feet (meters) from the bottom of the lining to the top of the lining for each liner thickness specified.

2549.05 BASIS OF PAYMENT.

A. Pipe Lining.

1. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe lining.

2. Payment is full compensation for pipe lining removal of internal obstructions, pipe cleaning, inspection, and all costs associated with the public information and notification program.

B. Building Sanitary Sewer Service Reconnection.

1. Payment will be made at the contract unit price for each reconnection.

2. Payment is full compensation for building sanitary sewer service reconnection.

C. Spot Repairs by Pipe Replacement.
Both of the following methods will be specified for payment of spot repairs by pipe replacement:

1. Spot Repairs by Count.
- **a.** Payment will be made at the contract unit price for each spot repair.
- **b.** Payment is full compensation for uncovering and removing existing pipe, placing backfill material for replacement pipe, and restoring the surface.

2. Spot Repairs by Linear Foot (Meter).
- **a.** Payment will be made at the contract unit price per linear foot (meter) of spot repair.
- **b.** Payment is full compensation for furnishing and installing replacement pipe and connections.

D. Rubber Chimney Seal.

1. Payment will be made at the contract unit price for each chimney seal.

2. Payment is full compensation for all necessary compression or expansion bands and extension sleeves as necessary to complete chimney seal.

E. Urethane Chimney Seal.
Payment will be at the contract unit price for each urethane chimney seal.

F. In-Situ Manhole Replacement, Cast-in-place Concrete.

1. Payment will be at the contract unit price per vertical foot (meter).

2. Payment is full compensation for handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, and testing the manhole upon completion.

G. In-Situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner.

1. Payment will be at the contract unit price per vertical foot (meter).

2. Payment is full compensation for handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, sealing at the frame and cover, sealing pipe penetrations as recommended by the manufacturer, and testing the manhole upon completion.

H. Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal.

1. Payment will be at the contract unit price per vertical foot (meter) for each liner thickness properly installed.

2. Payment is full compensation for the handling of sewer flows during lining operations as required to properly complete the installation, and replacement of the existing casting with a new casting.

Section 2550. Night Work Lighting

2550.01 DESCRIPTION.

Furnish, install, operate, maintain, move, and remove night time lighting to illuminate construction work areas for night work when construction activities (vehicles, equipment, or workers) are within 15 feet (4.6 m) of an open lane of traffic. Night work is defined as work performed between 30 minutes before sunset and 30 minutes after sunrise.

2550.02 LIGHTING PLAN.

A. Submit a lighting plan to the Engineer for review no later than the Preconstruction Conference. On the lighting plan show:
- The areas to be illuminated,
- Type and layout of the lighting systems, and
- Calculations of the averaged maintained lighting intensity.

B. Provide night work lighting in areas where construction equipment or workers are active within 15 feet (4.6 m)of an open lane of traffic. Illuminate

the work area and extend the lighting a minimum of 25 feet (7.6 m) in advance and beyond the work area. Meet the following requirements for lighting:

- Minimum intensity of 5 foot candles (54 lux) over the entire area described above.
- Sources positioned to not interfere with or impede traffic in any direction and not cause glare for motorists or spillover onto adjacent properties.

C. Illumination may be accomplished by using a combination of portable lights, floodlights, equipment lights, roadway lights (temporary or existing), or other lighting methods that will provide the required minimum lighting intensity.

D. The Engineer may require modifications to the lighting setup in order to fit field conditions.

2550.03 LIGHT METER.

Provide the Engineer one light meter (to be returned to the Contractor at the completion of night work) capable of measuring light intensity in foot candles (lux). Provide the Engineer instructions for operating the light meter

2550.04 TRAFFIC CONTROL.

A. Ensure all vehicles and equipment (except for hand operated equipment) operating or parked within 15 feet (4.6 m) of an open lane of traffic and all vehicles and equipment entering or exiting the work area display amber high intensity rotating, flashing, or oscillating lights.

B. Place and remove all traffic control devices during daytime hours, when possible, unless specified otherwise in the contract documents.

C. Continually review all traffic control devices, including monitoring of lights, to ensure proper installation and working order.

2550.05 METHOD OF MEASUREMENT AND BASIS OF PAYMENT.

All costs associated with furnishing, installing, operating, maintaining, moving, and removing night work lighting and other traffic control requirements required by this specification, are incidental to the lump sum bid price for Mobilization.

Section 2551. Crash Cushions

2551.01 GENERAL.

A. Furnish and install crash cushions accepted as crashworthy devices by the FHWA and meeting the requirements of NCHRP Report 350, Test Level 3 criteria. Approved products are listed in Materials I.M. 455, Appendix A. All products listed in Materials I.M. 455, Appendix A, are acceptable for use as temporary crash cushions.

B. When a permanent, redirective, or severe-use crash cushion is required by the contract documents, install one of the crash cushions specifically designated for such use in Materials I.M. 455, Appendix A.

C. In case of a discrepancy between these specifications and the manufacturer's recommendations, these specifications govern.

2551.02 MATERIALS.

A. Meet the manufacturer's requirements.

B. Ensure crash cushions are in good repair when installed.

C. For permanent crash cushions and spare parts kits, use equipment and materials of new stock, unless the contract documents provide for the relocation or the use of fixtures furnished by others.

D. Refer to Materials I.M. 455, Appendix A, for parts to be included in spare parts kits. Spare parts kits are to be supplied by the crash cushion manufacturer and contain materials designated for repairing the specific brand and model of crash cushion furnished.

2551.03 CONSTRUCTION.

A. General.

1. Install crash cushions according to the manufacturer's recommendations. Prior to installation, provide the Engineer with:

- Three copies of the manufacturer's most current product manuals covering installation and maintenance of the unit.
- Required certification statements.
- Additional hardware, tools, or documentation supplied by the manufacturer.

2. The manufacturer may require the use of additional connection hardware, construction of a backup structure, or construction of a paved footing for a specific installation. When required, construct and attach these items to the obstacle, the crash cushion, or both, in a manner specified by the manufacturer.

3. Complete grading work, if required, prior to installation of crash cushions.

4. When a roadway is closed to public traffic for construction, install all crash cushions prior to opening the road to traffic.

5. Do not allow attachments to new concrete or to anchor bolts set in epoxy resin to be stressed until the new concrete or epoxy resin has attained an age of 3 calendar days. This time requirement may be lengthened by the Engineer during cool weather.

B. Temporary Crash Cushions.

1. Unless shown otherwise in the contract documents, apply a retroreflective panel as described for permanent crash cushions.

2. When damaged, repair or replace the crash cushion. Initiate service to a damaged crash cushion within one hour of notification. Do not allow the object being shielded to be exposed to traffic for more than 12 hours.

3. When a temporary crash cushion is no longer required, remove it. The crash cushion becomes the property of the Contractor. Remove anchor bolts, if used, and fill the bolt holes with one of the non-shrink grouts listed in Materials I.M. 491.13, Appendix A.

4. When a crash cushion is required after the final stage of a project, leave it in place. The crash cushion becomes the property of the Contracting Authority.

C. Permanent Crash Cushions.

1. Mark the approach end of the crash cushion with a rectangular panel consisting of materials approved by the manufacturer and install according to the manufacturer's recommendations. Cover the panel with alternating black and retroreflective yellow stripes that meet the following:

- Minimum of 3 inches (75 mm) in width,
- Slope down at an angle of 45 degrees toward the side on which traffic is to pass the crash cushion.
- Form chevrons that point upwards if traffic can pass to either side of the crash cushion.
- Retroreflectivity requirements for Type III or Type IV reflective sheeting (yellow stripes only).

2. Crash cushions with a flat face, the panel is to cover the entire face of the crash cushion.

3. Crash cushions with a rounded face, the panel is to cover the entire height and width of that portion of the face between the sides of the crash cushion. However, the panel need not cover that portion of the face within 12 inches (300 mm) of the ground or higher than 42 inches (1050 mm).

4. Permanent crash cushions become the property of the Contracting Authority.

2551.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Temporary Crash Cushions.

By count.

B. Permanent Crash Cushions.
By count.

C. Crash Cushion Spare Parts Kits.
By count for crash cushion spare parts kits delivered to the local maintenance office.

D. Backup structures, paved footings, and additional connection hardware.
Not measured separately for payment.

2551.05 BASIS OF PAYMENT.
Payment will be contract unit price as follows:

A. Temporary Crash Cushions.

1. Installed: each.

2. Repaired or replaced due to damage by public traffic: extra work according to Article 1109.03, B.

B. Permanent Crash Cushions.
Each.

C. Crash Cushion Spare Parts Kit.
Each.

D. Backup structures, paved footings, and additional connection hardware.
Incidental to crash cushions.

Section 2552. Trench Excavation and Backfill

2552.01 DESCRIPTION.
This section was developed in conjunction with Section 3010 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Excavate trench for pipe installation.

B. Stabilize trench and install pipe bedding materials.

C. Place backfill material in trench.

2552.02 MATERIALS.

A. Materials Excavated from a Trench.

1. Standard Trench Excavation.
All materials encountered during trench excavation, except rock and over-excavation.

a. Suitable Backfill Material.
Class II, Class III, Class IVA, or Class IVB as defined in Article 2552.02, B.

b. Unsuitable Backfill Material.
Includes, but is not limited to:

1) Soils not classified as suitable backfill material, as defined in Article 2552.02, B.
2) Individual stones or concrete chunks larger than 6 inches (150 mm) and averaging more than one per cubic foot (0.03 cubic meters) of soil.
3) Frozen materials.
4) Stumps, logs, branches, and brush.
5) Trash, metal, or construction waste.
6) Soil in clumps or clods larger than 6 inches (150 mm) and without sufficient fine materials to fill voids during placement.
7) Environmentally contaminated soils.
8) Materials removed as rock excavation or over-excavation.

c. Topsoil.
Class V material. Apply Article 2552.02, C.

2. Rock Excavation.
Boulders or sedimentary deposits that cannot be removed from the trench without continuous use of pneumatic tools or blasting.

3. Over-Excavation.
Excavation of unsuitable or unstable material in trenches below the pipe zone.

B. Bedding Material.

1. Class I Material.

a. Crushed stone complying with the following gradation:

Sieve	Percent Passing
1 1/2 inch (37.5 mm)	100
1 inch (25 mm)	95 to 100
1/2 inch (12.5 mm)	25 to 60
No. 4 (4.75 mm)	0 to 10
No. 8 (2.36 mm)	0 to 5

b. The Engineer may allow the use of gravel or authorize a change in gradation subject to materials available locally at the time of construction.

c. The Engineer may authorize the use of crushed PCC for pipe sizes up to 12 inches (300 mm).

d. Use aggregates having a percentage of wear, Grading A or B, not exceeding 50%, determined according to AASHTO T 96.

C. Backfill Material.

1. Class II Material.
Manufactured and non-manufactured open graded (clean) or dense graded (clean) processed aggregate, clean sand, or coarse grained natural soils (clean) with little or no fines. Class II materials are further described in Table 2552.02-1 in the Appendix.

2. Class III Material.
- **a.** Natural coarse-grained soils with fines. Class III materials are further described in Table 2552.02-2 in the Appendix.
- **b.** Do not use where water conditions in trench may cause instability.

3. Class IVA Material.
- **a.** Natural fine grained inorganic soils. Class IVA materials are further described in Table 2552.02-3 in the Appendix.
- **b.** The Engineer will determine if material is not suitable for use as backfill material under deep fills, surface applied wheel loads, heavy vibratory compactors, tampers, or other conditions.
- **c.** Do not use where water conditions in trench may cause instability.
- **d.** Material is suitable for use in dry trench conditions only.

4. Class IVB Material.
- **a.** Natural fine grained inorganic (high elastic silts and plastic clays - fat clay) with a liquid limit greater than 50%. Class IVB materials are further described in Table 2552.02-4, in the Appendix.
- **b.** When approved by the Engineer, material may be used as final trench backfill in a dry trench.
- **c.** Do not use in the pipe embedment zone.

D. Topsoil (Class V Material).

1. Organic soils. Class V materials are further described in Table 2552.02-5, in the Appendix.

2. Use only as topsoil outside of the pavement, unless specified otherwise or allowed by the Engineer.

3. Do not use in the pipe embedment zone.

E. Stabilization (Foundation) Materials.

1. Clean 2 1/2 inch (63.5 mm) crushed stone with the following gradation:

Sieve	Percent Passing
2 1/2 inch (63 mm)	100
2 inch (50 mm)	90 to 100
1 1/2 inch (37.5 mm)	35 to 70
1 inch (25 mm)	0 to 20
1/2 inch (12.5 mm)	0 to 5

2. The Engineer may authorize a change in gradation subject to materials available locally at time of construction.

3. Crushed concrete may be used, if approved by the Engineer, if it is within ± 5% of the gradation for each size of material.

F. Special Pipe Embedment and Encasement Material.

1. Concrete Cradle, Arch, or Encasement.
Minimum 3000 psi (21 MPa) compressive strength.

2. Flowable Mortar.
Apply Section 2506.

3. Controlled Low Strength Material (CLSM).

a. Approximate quantities per cubic yard (cubic meter):

1)	Cement	50 pounds (30 kg)
2)	Fly ash	250 pounds (150 kg)
3)	Fine aggregate	2910 pounds (1729 kg)
4)	Water	60 gallons (296 L)

b. A compressive strength of at least 50 psi (345 kPa) at 28 calendar days can be expected.

2552.03 CONSTRUCTION.

A. Trench Excavation.

1. Notify the Engineer prior to the start of excavation activities.

2. Remove topsoil to a minimum depth of 12 inches (300 mm) and stockpile.

3. Excavate trench to required elevations and dimensions.
- **a.** Protect existing facilities, trees, and shrubs during trench excavation.
- **b.** Place excavated material away from trench.
- **c.** Grade spoil piles to drain. Do not allow spoil piles to obstruct drainage.

4. Unsuitable backfill material:
- **a.** If unsuitable backfill material is encountered, notify the Engineer.
- **b.** Remove rock, rubbish, boulders, debris, and other unsuitable backfill materials at least 6 inches (150 mm) below and on each side of the pipe.
- **c.** Keep unsuitable backfill material separated from suitable backfill material and topsoil.
- **d.** Restore trench to design dimensions using bedding or stabilization material.

B. Rock or Unstable Soils in Trench Bottom.

1. Notify the Engineer prior to over-excavation.

2. The Engineer will determine the need for over-excavation and trench foundation stabilization prior to installation of pipes and structures.

3. Refer to the contract documents for details of over-excavation of rock and wet or soft foundations.

C. Trench Protection.

1. Install adequate trench protection (sheeting, shoring, and bracing) to prevent ground movement or damage to adjacent structures, pipelines, and utilities.

2. Move trench boxes carefully to avoid disturbing pipe, bedding, or trench wall.

D. Dewatering.
Submit a dewatering plan to the Engineer for approval.

1. Maintain water levels below the bottom of trench excavation.

2. Perform the dewatering operation according to the dewatering plan approved by the Engineer. Dewatering plan may be modified to meet actual field conditions, with approval of the Engineer.

3. Ensure operation of the dewatering system does not damage adjoining structures and facilities. Cease dewatering operations and notify the Engineer if damage is observed.

4. Discharged water:
- **a.** Do not discharge water into sanitary sewers.
- **b.** Discharging water into storm sewers requires the Engineer's approval.
- **c.** Obtain permission of adjacent property owner prior to discharging water onto their property.
- **d.** Maintain and control water discharge as necessary to prevent a safety hazard for vehicular and pedestrian traffic.
- **e.** Direct water discharge away from electrical facilities or equipment.
- **f.** Use dewatering equipment that will minimize disturbance from noise and fumes.
- **g.** Protect discharge points from erosion. Provide sediment control for sediment contaminated water discharged directly from trench.

E. Pipe Bedding and Backfill Material.

1. General.
- **a.** Bedding and backfill material used for pipe installation will depend on:

1) Type of installation (water main, sanitary sewer gravity main, sanitary sewer force main, or storm sewer).
2) Pipe material.
3) Depth of bury.
4) Pipe diameter.

b. After pipe installation, place remaining bedding material and immediately place backfill material in trench.

c. Adjust the moisture content of excessively wet, but otherwise suitable, backfill material by spreading, turning, aerating, and otherwise working material as necessary to achieve required moisture range.

d. Adjust the moisture content of excessively dry, but otherwise suitable, backfill material by adding water, then turning, mixing, and otherwise blending the water uniformly throughout the material until the required moisture range is achieved.

e. Hydraulic compaction (flooding with water) is not allowed unless authorized by the Engineer.

2. Pipe Bedding.

a. Granular Material.

1) Class I granular material is required for all gravity mains. Use when specified for pressure pipes.
2) Place bedding material in the bottom of the trench in lifts no greater than 6 inches (150 mm) thick. Consolidate and moderately compact bedding material.
3) Shape bedding material to evenly support pipe at the proper line and grade, with full contact under the bottom of the pipe. Excavate for pipe bells.
4) Install pipe and system components.
5) Place, consolidate, and moderately compact additional bedding material adjacent to the pipe to a depth equal to 1/6 the outside diameter of the pipe.

b. Suitable Backfill Material.

1) Only use with pressure pipe.
2) Use suitable backfill material to shape trench bottom to evenly support pipe at the proper line and grade, with full contact under the bottom of the pipe. Excavate for pipe bells.

c. Special Pipe Embedment and Encasement Materials.

1) If required in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other bedding materials.
2) Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

3. Haunch Support.

Place from the top of the pipe bedding to the springline of the pipe.

a. Granular Material.

1) Place Class I material in lifts no greater than 6 inches (150 mm) thick.
2) Consolidate and moderately compact by slicing with a shovel or using other approved techniques.

b. Suitable Backfill Material.
- **1)** Place in lifts no greater than 6 inches (150 mm) thick.
- **2)** For Class II backfill material, consolidate and moderately compact by slicing with a shovel or using other approved techniques.
- **3)** For Class III and Class IVA backfill materials, compact to at least 90% of Standard Proctor Density. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

c. Special Pipe Embedment and Encasement Materials.
- **1)** If required in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other haunch materials.
- **2)** Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

4. Primary and Secondary Backfill.

a. General.
- **1)** For primary backfill, place from the springline of the pipe to the top of the pipe.
- **2)** For secondary backfill, place from the top of the pipe to 1 foot (300 mm) above the top of the pipe.

b. Granular Material.
- **1)** Place in lifts no greater than 6 inches (150 mm) thick.
- **2)** Compact to at least 65% relative density.

c. Suitable Backfill Material.
- **1)** Place in lifts no greater than 6 inches (150 mm) thick.
- **2)** For Class II backfill material, compact to at least 65% relative density.
- **3)** For Class III and Class IVA backfill materials, compact to at least 95% of Standard Proctor Density. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

d. Special Pipe Embedment and Encasement Materials.
- **1)** If specified in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other primary or secondary backfill materials.
- **2)** Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

5. Final Trench Backfill.

a. Place suitable backfill material from 1 foot (300 mm) above the top of the pipe to the top of the trench.
- **1)** Use no more than 8 inch (200 mm) thick lifts for backfill areas more than 3 feet (1 m) below the bottom of pavement.
- **2)** Use no more than 6 inch (150 mm) thick lifts for backfill areas less than or equal to 3 feet (1 m) below the bottom of pavement.

b. Place backfill material after recording locations of connections and appurtenances or at the Engineer's direction.

c. Class I and Class II backfill material:
- **1)** Compact to at least 65% relative density within right-of-way.

2) Compact to at least 50% relative density outside right-of-way.

d. Class III and Class IVA backfill material:

1) Compact to at least 95% of Standard Proctor Density within right-of-way.

2) Compact to at least 90% of Standard Proctor Density outside right-of-way.

3) Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

e. In areas to remain unpaved, terminate backfill material 8 inches (200 mm) below finish grade. Use topsoil for the final 8 inches (200 mm) above trench backfill material.

f. Terminate backfill material at subgrade elevation in areas to be paved.

F. Trench Compaction Testing.

1. General.

When trench compaction testing is specified in the contract documents as the Contractor's responsibility, provide testing of trench backfill material using the services of an independent testing laboratory approved by the Engineer.

2. Soil Testing.

a. Cohesive soils.

1) Determine moisture-density relationships by ASTM D 698 (Standard Proctor). Perform at least one test for each type of cohesive soil used.

2) Determine in-place density and moisture content. Use ASTM D 1556 (sand-cone method) and D 2216 (laboratory moisture content), or use ASTM D 6938 (nuclear methods for density and moisture content).

b. Cohesionless soils.

1) Determine maximum and minimum index density and calculate relative density using ASTM D 4253 and D 4254.

2) For Class I granular bedding material, determine gradation according to ASTM C 136.

3. Field Testing.

a. Testing Frequency and Locations.

Perform testing of the final trench backfill, beginning at a depth of 2 feet (600 mm) above the top of the pipe, as follows:

1) Coordinate the timing of testing with the Engineer.

2) The Engineer will determine the location of testing.

3) For each 2 vertical feet (600 mm) of consolidated fill, provide tests at a maximum horizontal spacing of 200 feet (60 m) and at all street crossings.

4) Additional testing may be required by the Engineer in the event of non-compliance or if conditions change.

5) If necessary, excavate to the depth and size as required by the Engineer to allow compaction tests. Place backfill material and recompact.

b. Test Failure and Retesting.
Rework, recompact, and retest as necessary until specified compaction and moisture content is achieved in all areas of the trench. In the event of failed tests, the Engineer may require retesting as deemed necessary.

2552.04 METHOD OF MEASURMENT.

A. Rock Excavation.
Measurement will be by cubic yards (cubic meters) of rock removed.

B. Trench Foundation.
Measurement will be in tons (megagrams) for the quantity of stabilization material required to replace material removed by over-excavation. Measurement will be based on the scale tickets for the material delivered and incorporated into the project. Trench foundation required to correct unauthorized over-excavation will not be measured.

C. Replacement of Unsuitable Backfill Material.
Measurement will be in cubic yards (cubic meters) for the quantity of backfill material required to replace unsuitable backfill material remove during standard trench excavation. Measurement will be based on compacted material in place.

D. Special Pipe Embedment or Encasement.
Measurement will be by the linear foot (meter) along the centerline of pipe for each type of special embedment or encasement.

E. Trench Compaction Testing.

1. The Contractor is not responsible for trench compaction testing or payment unless specified otherwise in the contract documents.

2. If the contract documents specify that the Contractor is responsible for trench compaction testing performed by an independent testing laboratory hired by the Contractor, measurement will be a lump sum.

2552.05 BASIS OF PAYMENT.

A. General.
The following items are incidental to the underground utility being installed and will not be paid for separately:

1. Standard trench excavation.

2. Removal and disposal of unsuitable backfill material encountered during standard trench excavation.

3. Removal of abandoned private utilities encountered during trench excavation.

4. Furnishing and placing granular bedding material.

5. Placing and compacting backfill material.

6. Dewatering.

7. Sheeting, shoring, and bracing.

8. Adjusting the moisture content of excavated backfill material to the range specified for placement and compaction.

9. Temporary support for existing water, sewer, gas, telephone, electrical, and other utilities or services that cross the trench.

B. Rock Excavation.
Payment will be at the contract unit price per cubic yard (cubic meter) for the quantity of rock removed.

C. Trench Foundation.

1. Payment will be at the contract unit price per ton (megagram) for the quantity of stabilization material furnished and placed.

2. Payment is full compensation for:
- Removal and disposal of over-excavated material required to stabilize trench foundation, and
- Furnishing, hauling, and placing stabilization material.

D. Replacement of Unsuitable Backfill Material.

1. Payment will be at the contract unit price per cubic yard (cubic meter) for the quantity of backfill material furnished.

2. Payment is full compensation for furnishing, hauling, and placing backfill material.

E. Special Pipe Embedment or Encasement.

1. Payment will be at the contract unit price per linear foot (meter) for each type of special pipe embedment or encasement.

2. Payment is full compensation for furnishing and placing all required special pipe embedment or encasement materials.

F. Trench Compaction Testing.

1. If the contract documents specify that the Contractor is responsible for trench compaction testing performed by an independent testing laboratory hired by the Contractor, payment will be at the contract unit price for the lump sum.

2. The Contractor will be responsible for payments associated with all retesting resulting from failure of initial tests.

Section 2553. Trenchless Construction

2553.01 DESCRIPTION.

This section was developed in conjunction with Section 3020 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Excavate launching and receiving pits.

B. Install casing or carrier pipe by trenchless methods.

C. Install carrier pipe inside casing pipe (if required).

D. Place backfill material in excavations.

2553.02 MATERIALS.

A. Carrier Pipe.

1. Carrier Pipe Installed within Casing Pipe.
- **a. Sanitary Sewer Gravity Main.**
  Apply Article 4149.02, A.
- **b. Sanitary Sewer Force Main.**
  - **1) Restrained Joint Ductile Iron Pipe:** Apply Article 4149.02, B.
  - **2) Restrained Joint PVC Pipe:** Apply Article 4149.02, B.
- **c. Storm Sewer.**
  Apply Article 4149.03.
- **d. Water Main.**
  - **1) Restrained Joint Ductile Iron Pipe:** Apply Article 4150.02, A.
  - **2) Restrained Joint PVC Pipe:** Apply Article 4150.02, A.

2. Carrier Pipe Installed without a Casing Pipe.
- **a. Sanitary Sewer Gravity Main.**
  - **1) Reinforced Concrete Pipe:** Apply Article 4149.02, A.
  - **2) Vitrified Clay Pipe:** Apply Article 4149.02, A.
  - **3) Restrained Joint Ductile Iron Pipe:** Apply Article 4149.02, B.
  - **4) Restrained Joint PVC Pipe:** Apply Article 4149.02, B.
- **b. Sanitary Sewer Force Main.**
  - **1) Restrained Joint Ductile Iron Pipe:** Apply Article 4149.02, B.
  - **2) Restrained Joint PVC Pipe:** Apply Article 4149.02, B.
- **c. Storm Sewer.**
  - **1) Reinforced Concrete Pipe:** Apply Article 4149.03.
  - **2) Reinforced Concrete Arch Pipe:** Apply Article 4149.03.
  - **3) Reinforced Concrete Elliptical Pipe:** Apply Article 4149.03.
  - **4) Reinforced Concrete Low Head Pressure Pipe:** Apply Article 4149.03.
- **d. Water Main.**
  - **1) Restrained Joint Ductile Iron Pipe:** Apply Article 4150.02, A.

2) **Restrained Joint PVC Pipe:** Apply Article 4150.02, A.

e. **Roadway Pipe Culvert.**
Reinforced Concrete Pipe: Apply Section 4145.

B. Casing Pipe.

1. **Pipe.**
Use only new steel pipe meeting the requirements of ASTM A 139/A 139M, Grade B; ASTM A 252, Grade 2; or ASTM A 53/A 53M, Grade B. Pipe may be welded or seamless. Wall thickness will be as specified in the contract documents.

2. **Joints.**
   a. Comply with American Welding Society Code D1.1M/D1.1. Weld all joints with full penetrating weld. Welders shall be qualified according to Materials I.M. 560. Welds shall comply with Materials I.M. 558.
   b. Upon approval of the Engineer, an interlocking casing pipe connection system may be used in lieu of field welding the sections of casing pipe.

3. **Pipe Diameter.**
Minimum inside diameter as specified in the contract documents. If diameter is not specified, use a minimum inside casing diameter of at least 4 inches greater than the largest outside diameter of the carrier pipe, including pipe bells.

C. Casing Spacers.

1. Use manufactured casing spacers to position carrier pipe in casing. Do not use wood skids.

2. Meet the following material requirements:
   a. **HDPE Band/Panel and Riser:** ASTM D 638.
   b. **Stainless Steel or Carbon Steel Band/Panel and Riser:** Type 304 stainless steel according to ASTM A 240/A 240M or carbon steel according to ASTM A 36/A 36M.
      1) **Liner:** Elastomeric PVC per ASTM D 149.
      2) **Spacer Skid/Runner:** Abrasion resistant polymer with a low coefficient of friction.
      3) **Fasteners:** Type 304 (18-8) stainless steel per ASTM A 193/A 193M.

D. Backfill Material for Abandoned Tunnels.

1. **Option 1:** Use Class C concrete, approximately 4 inch (100 mm) slump.

2. **Option 2:** Flowable mortar according to Article 2506.02.

3. **Option 3:** CLSM according to Article 2552.02, E, 3.

E. Backfill Material.

1. Excavated Materials.
Apply Section 2435 for classification of excavated materials. Use only suitable material for backfill material.

2. Special Fill Materials.
For use where specified in the contract documents.
- **a. PCC:** Use Class C concrete, approximately 4 inch (100 mm) slump.
- **b. Flowable Mortar:** Apply Section 2506.02.
- **c. Controlled Low Strength Material (CLSM):** Apply Article 2552.02, E, 3.

F. Casing End Seal.

1. Manufactured: Minimum 1/8 inch (3.0 mm) thick manufactured synthetic rubber casing end seal with stainless steel bands and fasteners.

2. PCC: Apply Section 2403. Do not use PCC casing end seals with flexible carrier pipes.

2553.03 CONSTRUCTION.

A. Excavation.

1. Notify the Engineer prior to the start of excavation activities.

2. Remove topsoil to minimum depth of 12 inches (300 mm) and stockpile.

3. Excavate the minimum size pits necessary to safely and properly perform the work.
- **a.** Protect existing facilities, trees, and shrubs during excavation.
- **b.** Place excavated material away from trench.
- **c.** Grade and shape spoil piles to drain and protect adjacent areas from runoff. Do not allow spoil piles to obstruct drainage. Stabilize stockpiles with seeding and provide sediment control around stockpiles.

4. Remove rock, rubbish, debris, and other materials not suitable for use as backfill material.

B. Sheeting Shoring, and Bracing.
Apply Article 2552.03, C.

C. Dewatering.
Apply Article 2552.03, D.

D. Trenchless Installation.

1. General.

Select a method of installation that is appropriate for the soil conditions anticipated and will: 1) allow the pipe to be installed to the desired line and grade within the specified tolerances; 2) prevent heaving or settlement of the ground surface or damage to nearby facilities; and 3) prevent damage to the carrier pipe and lining materials within the carrier pipe.

a. Installation Methods.

1) Auger Boring: A method that utilizes a rotating cutting head to form the bore hole and a series of rotating augers inside a casing pipe to remove the spoil.

2) Directional Drilling: A method for installing pipe from a surface launched drilling rig. A pilot bore is formed and then enlarged by back reaming and removing the spoil material. The pipe is then pulled in place.

3) Open-ended Pipe Ramming: A method that involves driving a steel casing pipe with a percussive hammer. The front end of the casing pipe is open ended. Spoils are removed from the pipe.

4) Pipe Jacking: A method in which pipe is pushed into the ground with hydraulic jacks while soil is simultaneously excavated. Excavation is normally completed with a tunnel boring machine.

5) Microtunneling: A method of pipe jacking using a remote controlled tunnel boring machine.

6) Utility Tunneling: A method of forming large diameter tunnels. As excavation takes place at the front of the tunnel, a liner is constructed to temporarily support the tunnel. Upon completion of the tunnel the pipe is pushed in place.

7) Other: Other methods may be allowed with the Engineer's approval.

b. Line and Grade.

1) Install pipe at line and grade that will allow the carrier pipe to be installed at its true starting elevation and grade within a maximum alignment deviation of the pipe centerline.

2) When no deviation tolerances are specified in the contract documents, apply the following maximum deviations to the carrier pipe:

a) Gravity pipe:

(1) Horizontally: ± 1.0 foot per 100 feet (0.3 m per 30 m).

(2) Vertically: ± 0.2 feet up to 100 feet (0.06 m per 30 m). An additional ± 0.1 foot per 100 feet (0.03 m per 30 m) thereafter. Backfall in pipe will not be allowed.

b) Pressurized pipe:

(1) Horizontally: ± 2.0 feet (0.6 m).

(2) Vertically: ± 1.0 foot (0.3 m). Maintain the minimum depth specified in the contract documents.

c) Greater deviation or interference with other identified facilities may be cause for rejection.

c. Deviation from Line and Grade.

1) Provided adequate clearance remains for proper installation of the carrier pipe, the Contractor will be allowed to correct deviations in grade of a casing pipe in order to achieve design grade of the carrier pipe by:

- Pouring an invert in the casing pipe, or
- Shimming the carrier pipe with casing spacers to a uniform grade.

2) Installations deviating from the specified tolerances that cannot be adjusted to conform to the specified tolerances may be rejected by the Engineer. If a non-conforming installation is not rejected, provide all additional fittings, utility accesses, or appurtenances needed to accommodate horizontal or vertical misalignment, at no additional cost to the Contracting Authority.

3) Abandon rejected installations and place special fill materials, at no additional cost to the Contracting Authority. Replace abandoned installations, including all additional fittings, manholes, or appurtenances required to replace rejected installations.

2. Casing Pipe or Un-cased Carrier Pipe Installation.

a. Install pipe by approved methods.

b. Use a jacking collar, timbers, and other means as necessary to protect the driven end of the pipe from damage.

c. Do not exceed the compressive strength or tensile capacity of the pipe during pushing or pulling operations.

d. Fully support bore hole at all times to prevent collapse. Insert pipe as soil is removed, or support bore with drilling fluid.

e. Fully weld all casing pipe joints. Use an interlocking connection system when approved by the Engineer.

f. Fill space between the inside of the bore hole and the outside of the pipe with special fill material if the space is greater than 1 inch (25 mm).

3. Carrier Pipe Installation through Casing.

a. Clean dirt and debris from the interior of the casing pipe after installation.

b. Install casing spacers on carrier pipe sections as necessary to support the pipe barrel according to the pipe manufacturer's recommendations subject to the following minimum requirements:

1) Install a spacer within 1 foot (0.3 m) of each side of the carrier pipe joint and at a maximum spacing of 6 feet (1.8 m).

2) Do not support pipe by joint bells.

3) Lubricate casing spacers with drilling mud or flax soap. Do not use petroleum-based lubricants or oils.

c. Ensure that thrust loads will not damage carrier pipe joints. Provide thrust collars between joint shoulders of concrete pipe.

d. Provide timbers for sufficient cushioning between the end of the pipe pushed and the jacking equipment to prevent damage to the

pipe. Do not allow the steel jack face to thrust against the unprotected pipe end.

e. Position jacks so that resultant force is applied evenly to the entire end of the pipe.

f. Assemble pipe joints in the jacking pit before pushing the carrier pipe into the casing.

g. Close the end of the casing pipe around the carrier pipe with a casing end seal.

h. When specified in the contract documents, fill the annular space between the carrier and casing pipe with flowable mortar or CLSM.

E. Pit Restoration.

1. Remove installation equipment and unused materials from the launching and receiving pits.

2. When the carrier pipe extends beyond the limits of trenchless installation and into the bore pit, place bedding and backfill material according to Section 2435.

3. Place suitable backfill material in the pit. Apply the testing requirements of Section 2435.

4. Restore the site to original condition or better.

2553.04 METHOD OF MEASUREMENT.

Trenchless Construction will not be measured for payment. Excavation for boulders less than or equal to one-third the diameter of the pipe being installed, or parts of existing structures identified in the contract documents will not be measured for payment, but are to be considered incidental to the price bid for trenchless construction. Excavation and removal of boulders larger than one third the diameter of the pipe being installed, or parts of existing structures not identified in the contract documents, will be paid for in accordance with Article 1109.03, B.

2553.05 BASIS OF PAYMENT.

Trenchless Construction is incidental to the underground utility pipe being installed and will not be paid for separately.

Section 2554. Water Mains, Valves, Fire Hydrants, and Appurtenances

2554.01 DESCRIPTION.

This section was developed in conjunction with Division 5 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct water mains and building service pipes.

B. Install valves, fire hydrants, and appurtenances for water mains.

C. Test and disinfect water mains, valves, fire hydrants, and appurtenances.

2554.02 MATERIALS.

A. Pipe, Fittings, Valves, Fire Hydrants, and Appurtenances.
Apply Section 4150.

B. Testing and Disinfection.

1. Liquid Chlorine: according to AWWA B300 and AWWA B301.

2. Sodium Hypochlorite: according to AWWA B300.

3. Calcium Hypochlorite: according to AWWA B300.

4. All disinfecting agents to be NSF 60 certified. Supply and store in original container.

2554.03 CONSTRUCTION.

A. Pipe and Fittings.

1. Pipe Installation.

a. General.

1) Do not use deformed, defective, gouged, or otherwise damaged pipes or fittings.

2) Keep trench free of water. Clean pipe interior prior to placement in the trench.

3) Install pipe with fittings and valves to the lines and grades specified in the contract documents.

4) Clean joint surfaces thoroughly and apply lubricant approved for use with potable water and recommended by the manufacturer.

5) Push the pipe joint to the indication line on the spigot end of the pipe before making any joint deflections.

6) Limit joint deflections to one degree less than pipe manufacturer's recommended maximum limit.

7) Tighten bolts in a joint evenly around the pipe.

8) Install concrete thrust blocks on fittings 16 inches (400 mm) in diameter or smaller. For fittings larger than 16 inches (400 mm), install restrained joints, and when specified in the contract documents, also install concrete thrust blocks.

9) Keep exposed pipe ends closed with rodent-proof end gates at all times when pipe installation is not occurring.

10) Close ends of installed pipe with watertight plugs during nights and non-working days.

11) Do not allow water from the new pipeline to enter existing distribution system piping until testing and disinfection are successfully completed.

b. Trenched.

1) Excavate trench and place pipe bedding and backfill material as specified in Section 2552.

2) Provide uniform bearing along the full length of the pipe barrel. Provide bell holes.

c. Trenchless.
Apply Section 2553.

2. Additional Requirements for DIP Installation.

a. Utilize full length gaged pipe for field cuts. Alternatively, field gage pipe selected for cutting to verify the outside diameter is within allowable tolerances.

b. Cut the pipe perpendicular to the pipe barrel. Do not damage the cement lining. Bevel cut the ends for push-on joints according to the manufacturer's recommendations.

c. Encase all pipe, valves, and fittings with polyethylene wrap according to Article 2554.03, A, 5.

3. Additional Requirements for PVC Pipe Installation.

a. Cut the pipe perpendicular to the pipe barrel. Deburr and bevel cut the spigot end of the pipe barrel to match the factory bevel. Remark the insertion line.

b. When connecting to shallow depth bells, such as on some cast iron fittings or valves, cut the spigot end square to remove the factory bevel. Deburr the end and form a partial bevel on the end.

4. Additional Requirements for Prestressed Concrete Cylinder Pipe Installation.

a. Install according to AWWA M9.

b. Relieve gasket tension by inserting a small rod between the gasket and the gasket groove and running the tool around the pipe twice.

c. Check gasket position using a metal feeler gage after the joint has been assembled.

d. Complete joint exterior grouting after pipe has been properly positioned using non-shrink grout.

5. Polyethylene Encasement Installation.

a. Apply polyethylene encasement to buried ductile iron pipe and to buried fittings, fire hydrants, and appurtenances. The polyethylene encasement is to prevent contact between the pipe and the bedding material, but it need not be airtight or watertight.

b. Install polyethylene encasement according to AWWA C105, using tubes for flat sheets, and the pipe manufacturer's recommendations.

c. Do not expose the polyethylene encasement to sunlight for long periods before installation.

d. Remove lumps of clay, mud cinders, and so forth on the pipe surface before encasing the pipe. Prevent soil or bedding material from becoming trapped between the pipe and polyethylene.

e. Lift polyethylene encased pipe with a fabric type sling or padded cable.

f. Secure and repair encasement material using polyethylene tape, or replace as necessary.

6. Tracer System Installation.

a. Install with all buried water main piping. Refer to the contract documents for details of tracer wire installation.

b. Begin and terminate the system at all connections to existing mains.

c. Install wire continuously along the lower quadrant of the pipe. Do not install wire along the bottom of the pipe. Attach wire to the pipe at the midpoint of each pipe length. Use 2 inch (50 mm) wide by 10 mil (250 µm) thick polyethylene pressure sensitive tape.

d. Install splices only as authorized by the Engineer. Allow the Engineer to inspect all below grade splices of tracer wire prior to placing the backfill material.

e. Install ground rods adjacent to connections to existing piping and at locations specified in the contract documents.

f. Bring two wires to the surface at each fire hydrant location and terminate with a tracer wire station.

g. Final inspection of the tracer system will be conducted at the completion of the project and prior to acceptance by the Engineer. Verify the electrical continuity of the system. Repair discontinuities.

7. Conflicts

a. Horizontal Separation of Gravity Sewers from Water Mains.

1) Separate gravity sewer mains from water mains by a horizontal distance of at least 10 feet (3 m) unless:

- The top of a sewer main is at least 18 inches (450 mm) below the bottom of the water main, and
- The sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth at a minimum horizontal separation of 3 feet (1 m) from the water main.

2) When it is impossible to obtain horizontal clearance of 3 feet (1 m) and a vertical clearance of 18 inches (450 mm) between sewers and water mains, the sewers shall be constructed of water main materials meeting the requirements of Article 4150.02, A. However, provide a linear separation of at least 2 feet (600 mm).

b. Separation of Sewer Force Mains from Water Mains.
Separate sewer force mains and water mains by a horizontal distance of at least 4 linear feet (1.2 m).

c. Separation of Sewer and Water Main Crossovers.

1) Vertical separation of sanitary sewers crossing under any water main should be at least 18 inches (450 mm) when measured from the top of the sewer to the bottom of the water main. If physical conditions prohibit the separation, the sewer may be placed not closer than 6 inches (150 mm) below a water main or 18 inches (450 mm) above a water main. Maintain the maximum feasible separation distance in all cases.

2) Where the sewer crosses over or less than 18 inches (450 mm) below a water main, locate one full length of sewer pipe of water main material so both joints are as far as possible from the water main. The sewer and water pipes shall be

adequately supported and have watertight joints. Use a low permeability soil for backfill material within 10 feet (3 m) of the point of crossing.

8. Transitions in Piping Systems.
Where the specified material of a piping system entering or exiting a structure changes, make the change at the outside of the structure wall, beyond any wall pipe or wall fitting required, unless specified otherwise.

9. Structure Penetrations.

a. Wall Pipes.

1) Install where pipes penetrate and terminate at a wall or floor surface of a concrete structure, or where the pipe protrudes through the concrete wall or floor and the protrusion is otherwise unsupported.

2) Provide a waterstop flange near the center of the embedment length. The waterstop shall be cast integrally with the wall pipe, or fully welded to it around the pipe circumference.

b. Wall Sleeves.

1) Install where a pipe passes through a structure wall.

2) Sleeves in concrete walls are to be supplied with a waterstop collar, fully welded, and cast-in-place in the concrete.

10. Water Service Stub.

a. Install water service pipe, corporations, stops, and stop boxes according to the contract document.

b. Install 1 inch (25 mm) and smaller corporation valves tapped at 45 degrees above horizontal at a minimum distance of 18 inches (0.5 m) from pipe bell, or other corporation. Install 1 1/2 inch (38 mm) and 2 inch (50 mm) corporation valves tapped horizontal a minimum distance of 24 inches (600 mm) from pipe bell or other corporation.

c. Construct trench and place backfill material according to Section 2552.

B. Valves, Fire Hydrants, and Appurtenances.
Remove valves, fire hydrants, and appurtenances contaminated with mud and surface water from the site. Do not use in construction unless thoroughly cleaned, inspected, and approved by the Engineer.

1. General.

a. Install according to the contract documents.

b. Apply polyethylene wrap to all iron pipe, valves, fire hydrants, and fittings.

c. Set tops of valve boxes to finish grade.

d. Check the working order of all valves by opening and closing through entire range. Before opening the valves, check with the Engineer on operating requirements.

e. Test and disinfect all valves, fire hydrants, and appurtenances as components of the completed water main according to Article 2554.03, C.

2. Flushing Device (Blowoff).
Install and construct as specified in the contract documents.

3. Fire Hydrant.
- **a.** Install according to the contract documents.
- **b.** If the fire hydrant valve is positioned adjacent to the water main, attach it to an anchor tee.
- **c.** If the fire hydrant valve is positioned away from water main, restrain all joints between the valve and water main.
- **d. Fire Hydrant Depth Setting.**
  - **1)** Use adjacent finished grade to determine setting depth.
  - **2)** Set bottom of breakaway flange between 2 and 5 inches (25 and 125 mm) above finished grade.
  - **3)** If finished grade is not to be completed during the current project, consult with the Engineer for proper setting depth.
- **e.** Coordinate installation with tracer wire installation.
- **f.** Orient fire hydrant nozzles as directed by the Engineer.

4. Adjustment of Existing Valve Box or Fire Hydrant.
- **a. Minor Valve Box Adjustment.**
  For existing adjustable boxes that have sufficient adjustment range to bring to finished grade, raise or lower valve box to finished grade.
- **b. Valve Box Extension.**
  For existing valve boxes that cannot be adjusted to finished grade, install valve box extensions as required.
- **c. Valve Box Replacement.**
  For existing valve boxes that cannot be adjusted to finished grade, remove and replace the valve box.
- **d. Fire Hydrant Adjustment.**
  - **1)** Add extension barrel sections and stems as necessary to set existing fire hydrant at finished grade.
  - **2)** Paint exterior of new barrel section to match existing fire hydrant unless otherwise specified.

C. Testing and Disinfection.
Notify the Engineer at least 2 working days in advance of testing or disinfection operations to coordinate the operations. The Engineer will be in attendance during testing or disinfection.

1. Sequence of Testing and Disinfection
Perform operations according to AWWA C651 in the sequence below. Successfully complete each operation before continuing to the next operation. The Engineer will provide reasonable quantities of water for flushing and testing.
- **a. Continuous Feed or Slug Method (After Water Main Installation).**
  The sequence of testing and disinfection may be modified with approval of the Engineer.
  - **1)** Perform initial flush.
  - **2)** Perform disinfection.

3) Flush after disinfection.
4) Perform pressure and leak testing.

b. Tablet Method (Concurrent with Water Main Installation).
Use this method only if approved by the Engineer. Modify the procedure for flushing, disinfection, and pressure and leak testing as needed if tablet method is used.
1) Perform disinfection.
2) Flush after disinfection.
3) Perform pressure and leak testing.

2. Initial Flushing.

a. Flushing.
1) Coordinate flushing with the Engineer.
2) Flush pipe prior to disinfection using potable water.
3) Measure flushing velocity.
4) Obtain a minimum flushing velocity of 2.5 feet (0.76 m) per second in the pipe to be disinfected.

b. Minimum Flushing Rate.
According to AWWA C651, Table 3, based on 40 psi (276 kPa) residual pressure (see Table 2554.03-1 below).

Table 2554.03-1: Minimum Flushing Rate

Pipe Diameter, inches (mm)	Flow Rate for Flushing, gallons/minute (L/s)	Number of Taps[b]			Number of 2 1/2 inch (63.5 mm) Fire Hydrant Outlets[a]
		1 inch (25 mm)	1 1/2 inch (38 mm)	2 inch (50 mm)	
4 (100)	100 (6.3)	1	-	-	1
6 (150)	200 (12.6)	-	1	-	1
8 (200)	400 (25.2)	-	2	1	1
10 (250)	600 (37.9)	-	3	2	1
12 (300)	900 (56.8)	-	-	2	2
16 (400)	1600 (100.9)	-	-	4	2

[a] With a 40 psi (276 kPa) pressure in the main with the hydrant flowing to atmosphere, a 2 1/2 inch (63.5 mm) fire hydrant outlet will discharge approximately 1000 gallons (3780 L) per minute; and a 4 1/2 inch (115 mm) fire hydrant will discharge approximately 2500 gallons (9460 L) per minute
[b] Number of taps on pipe based on discharge through 5 feet (1.5 m) of galvanized iron pipe with one 90 degree elbow.

c. Property Protection.
Protect public and private property from damage during flushing operations.

3. Disinfection.

a. General.
1) Disinfect according to AWWA C651. The tablet method contained in AWWA C651 shall not be used unless approved by the Engineer.

2) Keep piping to be chlorinated isolated from lines in service and from points of use.
3) Coordinate disinfection and testing with the Engineer.
4) Obtain and test water samples, unless otherwise provided by the Engineer.

b. Procedure.
1) Induce a flow of potable water through the pipe.
2) Introduce highly chlorinated water to the pipe at a point within 5 pipe diameters of the pipe's connection to an existing potable system, or within 5 pipe diameters of a closed end, if there is no connection to an existing system.
3) Introduce water containing a minimum of 25 mg/L free chlorine until the entire new pipe contains a minimum of 25 mg/L free chlorine.
4) Retain chlorinated water in the pipe for at least 24 hours and no more than 48 hours.

4. Final Flushing.
a. Flush pipe using potable water until chlorine residual equals that of the existing potable water system.
b. Dispose of chlorinated water to prevent damage to the environment. Dechlorinate highly chlorinated water from testing before releasing into the ground or sewers. Obtain Engineer approval prior to flushing activities.
1) Check with the local sewer department for the conditions of disposal to the sanitary sewer.
2) Chlorine residual of water being disposed will be neutralized by treating with one of the chemicals listed in Table 2554.03-2:

Table 2554.03-2: Amounts of Chemicals Required to Neutralize Various Residual Chlorine Concentrations in 100,000 Gallons (378,500 L) of Water

Residual Chlorine Concentration mg/L	Sulfur Dioxide (SO_2) pounds (kg)	Sodium Bisulfite ($NaHSO_3$) pounds (kg)	Sodium Sulfite (Na_2SO_3) pounds (kg)	Sodium Thiosulfate ($Na_2S_2O_3 + 5H_2O$) pounds (kg)	Ascorbic Acid ($C_6O_8H_6$) pounds (kg)
1	0.8 (0.36)	1.2 (0.54)	1.4 (0.64)	1.2 (0.54)	2.1 (0.95)
2	1.7 (0.77)	2.5 (1.13)	2.9 (1.32)	2.4 (1.09)	4.2 (1.91)
10	8.3 (3.76)	12.5 (5.67)	14.6 (6.62)	12.0 (5.44)	20.9 (9.48)
50	41.7 (18.91)	62.6 (28.39)	73.0 (33.11)	60.0 (27.22)	104 (47.17)

5. Pressure and Leak Testing.

a. Remove debris from within pipe. Clean and swab out pipe if required.

b. Secure unrestrained pipe ends against uncontrolled movement.

c. Isolate new piping from the existing water system.

d. Fill and flush all new piping with potable water. Ensure all trapped air is removed.

e. Pressurize the new pipe to the test pressure at the highest point in the isolated system. Do not pressurize to more than 5 psi (34 kPa) over the test pressure at the highest point in the isolated system.

f. Test and monitor the completed piping system at 1.5 times the system working pressure or 150 psi (1035 kPa), whichever is greater, for 2 continuous hours.

g. If at any time during the test the pressure drops to 5 psi (34 kPa) below the test pressure, repressurize the pipe by pumping in potable water in sufficient quantity to bring the pressure back to the original test pressure.

h. Accurately measure the amount of water required to repressurize the system to the test pressure.

i. Maximum allowable leakage rate according to AWWA C600:

English Units

$$L = \frac{(S)(D)(P)^{0.5}}{148{,}000}$$

Where:
L = allowable leakage, in gallons per hour.
S = length of pipe tested, in feet.
D = pipe diameter, in inches.
P = average test pressure, in pounds per square inch.

Metric Units

$$L = \frac{(S)(D)(P)^{0.5}}{794{,}797}$$

Where:
L = allowable leakage, in liters per hour.
S = length of pipe tested, in feet.
D = pipe diameter, in millimeters.
P = average test pressure, in kilopascals.

Table 2554.03-3 assumes an average test pressure (P) of 150 psi (1035 kPa) and 1000 feet (300 m) of test section:

Table 2554.03-3: Maximum Allowable Leakage Rate

Pipe Diameter		Maximum Allowable Leakage Rate	
inches	**mm**	**gallons/hour/1000 feet of pipe**	**liters/hour/300 meters of pipe**
4	100	0.33	1.21
6	150	0.50	1.82
8	200	0.66	2.43
10	250	0.83	3.04
12	300	0.99	3.64
14	350	1.16	4.25
16	400	1.32	4.86
18	450	1.49	5.46

20	500	1.66	6.07
24	600	1.99	7.29
30	750	2.48	9.11
36	900	2.98	10.93

j. If the average measured leakage per hour exceeds the maximum allowable leakage rate, repair and retest the water main.
k. If the measured pressure loss does not exceed 5 psi (34 kPa) the test will be considered acceptable.
l. Repair all visible leaks regardless of the amount of leakage.

6. Bacteria Sampling.
Test water mains according to AWWA C651. If the initial disinfection procedure fails to produce satisfactory bacteriological results or if other water quality is affected, repeat the disinfection procedure.

7. Putting Water Main in Service
Put the completed water system in service only after obtaining permission of the Engineer.

2554.04 METHOD OF MEASUREMENT.

A. Pipe and Fittings.

1. Water Main.
a. Trenched.
Measurement for each type and size of pipe installed in an open trench will be in linear feet (meters) along the centerline of the pipe, including the length through the fittings.
b. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along the centerline of the casing pipe.

2. Water Main with Casing Pipe.
a. Trenched
Measurement for each type and size of pipe with a casing pipe installed in an open trench will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.
b. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe.

3. Fittings.
One of the following methods will be specified for measurement of water main fittings:

a. Fittings by Count.
Measurement for each type and size of fitting installed as specified in the contract documents or as required for proper installation of the water main will be counted.

b. Fittings by Weight (Mass).
Measurement for each type and size of fitting installed as specified in the contract documents or as required for proper installation of the water main will be counted. Determine the total weight (mass) of fittings counted in pounds (kilograms) based on the standard fitting weights (masses) published in AWWA C153 for ductile iron compact fittings.

4. Water Service Stubs.
Each type and size of water service and stub from the water main to the stop box will be counted.

B. Valves, Fire Hydrants, and Appurtenances.

1. Valve (Butterfly or Gate).
Each type and size of valve will be counted.

2. Tapping Valve Assembly.
Each size of tapping valve assembly will be counted.

3. Fire Hydrant Assembly.
Each fire hydrant assembly will be counted.

4. Flushing Device (Blowoff).
Each size of flushing device will be counted.

5. Valve Box Adjustment, Minor.
Minor adjustment of an existing valve box by raising or lowering the adjustable valve box will not be measured.

6. Valve Box Extension.
Each existing valve box adjusted to finished grade by adding a valve box extension will be counted.

7. Valve Box Replacement.
Each existing valve box replaced with a new valve box will be counted.

8. Fire Hydrant Adjustment.
Each existing fire hydrant adjusted to finished grade by addition of an extension barrel section and stem will be counted.

9. Other Fixture Adjustment.
Adjustment of other fixtures by raising or lowering them will not be measured.

C. Testing and Disinfection.
None.

2554.05 BASIS OF PAYMENT.

A. Pipe and Fittings.

1. Water Main.

a. Trenched.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of pipe.

2) Payment is full compensation for trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, tracer system, testing, disinfection, and polyethylene wrap for ductile iron pipe and ductile and gray iron fittings.

b. Trenchless.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of pipe.

2) Payment is full compensation for:

- Furnishing and installing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Tracer system,
- Testing, and
- Disinfection.

2. Water Main with Casing Pipe.

a. Trenched.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of water main.

2) Payment is full compensation for furnishing and installing both water main and casing pipe, trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, casing spacers, furnishing and installing annular space fill material, tracer system, testing, and disinfection.

b. Trenchless.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of water main.

2) Payment is full compensation for:

- Furnishing and installing both water main and casing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Casing spacers,
- Furnishing and installing annular space fill material,
- Tracer system,
- Testing, and
- Disinfection.

3. Fittings.

One of the following methods will be specified for payment of water main fittings:

a. Count.
Payment will be the contract unit price for each type and size of fitting. Payment is full compensation for restrained joints and thrust blocks.

b. Weight (Mass).
Payment will be made at the contract unit price per pound (kilogram). Payment is full compensation for restrained joints and thrust blocks.

4. Water Service Stubs.

a. Payment will be made at the contract unit price for each type and size of water service stub.

b. Payment is full compensation for corporation, service pipe, stop, and stop box.

B. Valves, Fire Hydrants, and Appurtenances.

1. Valve (Butterfly or Gate).

a. Payment will be the contract unit price for each type and size of valve.

b. Payment is full compensation for all components attached to the valve or required for its complete installation, including underground or above ground operator, square valve operating nut, valve box and cover, valve box extension, and valve stem extension.

2. Tapping Valve Assembly.

a. Payment will be the contract unit price for each tapping valve assembly.

b. Payment is full compensation for tapping sleeve, tapping valve, the tap, valve box and cover, valve box extension, and valve stem extension.

3. Fire Hydrant Assembly.

a. Payment will be the contract unit price for each fire hydrant assembly.

b. Payment is full compensation for the fire hydrant, barrel extensions sufficient to achieve proper bury depth of anchoring pipe and height of fire hydrant above finished grade, and components to connect the fire hydrant to the water main, including anchoring pipe, fittings, thrust blocks, pea gravel or porous backfill material, and fire hydrant gate valve, except tapping valve assembly if used.

4. Flushing Device (Blowoff).
Payment will be at the contract unit price for each flushing device.

5. Valve Box Adjustment, Minor.
When shown in the contract documents, minor adjustment of an existing valve box by raising or lowering the adjustable valve box is incidental. When not shown or tabulated, adjustment will be paid for according to Article 1109.03, B.

6. Valve Box Extension.
Payment will be at the contract unit price for each valve box extension.

7. Valve Box Replacement.
a. Payment will be at the contract unit price for each valve box replacement.
b. Payment is full compensation for:
- Removal of existing valve box,
- Excavation,
- Furnishing and installing new valve box,
- Furnishing and placing backfill material,
- Compaction, and
- All other necessary appurtenances.

8. Fire Hydrant Adjustment.
a. Payment will be at the contract unit price for each adjustment of an existing fire hydrant.
b. Payment is full compensation for:
- Removal and reinstallation of the existing fire hydrant,
- Furnishing and installing the extension barrel section and stem, and
- All other necessary appurtenances.

9. Other Fixture Adjustment.
When shown in the contract documents, adjustment of other fixtures by raising or lowering them is incidental. When not shown or tabulated, adjustment will be paid for according to Article 1109.03, B.

C. Testing and Disinfection.
Testing and disinfection of water systems is incidental to the construction of pipe and fittings.

Section 2555. Deliver and Stockpile Salvaged Materials

2555.01 DESCRIPTION.
Deliver and stockpile salvaged materials as tabulated in the contract documents.

2555.02 MATERIALS.
None.

2555.03 CONSTRUCTION.

A. The contract documents will identify the quantity of each item to be salvaged, delivery location, and stockpiling requirements.

B. Salvage without damaging, disassemble, clean, and match mark (if required) items to be stockpiled. Bundle in lots normal to the product being salvaged. Replace items damaged from Contractor's operations with new materials (at no additional cost to the Contracting Authority).

C. Deliver salvaged materials, to the location indentified on the contract documents, during normal business hours. Contact the Engineer to schedule delivery and stockpiling of materials at stockpile site.

D. Stockpile salvaged materials in an orderly fashion without intermingling. Provide blocking as necessary to ensure items are not in contact with soil.

2555.04 METHOD OF MEASUREMENT.
None. Lump sum item.

2555.05 BASIS OF PAYMENT.
The lump sum price for Deliver and Stockpile Salvaged Materials will be full payment for salvaging, disassembling, cleaning, match marking, bundling, delivering, blocking, and stockpiling.

DIVISION 26. ROADSIDE DEVELOPMENT

This work consists of developing and improving the right-of-way by shaping and establishing turf, primarily for control of surface drainage and soil and wind erosion, and by installing plant materials. Comply with the requirements of the contract documents and the following sections:

2601. Erosion Control.
2602. Water Pollution Control (Soil Erosion).
2610. Furnish and Install Shrubs, Trees, and Vines.
2611. Furnish and Install Shrubs and Trees with Warranty.
2612. Mowing.

Section 2601. Erosion Control

2601.01 DESCRIPTION.
Perform the following erosion control measures on areas within and adjacent to the right-of-way according to the contract documents and this specification:

- Seeding and fertilizing,
- Overseeding and fertilizing
- Stabilizing crop seeding and fertilizing,
- Sodding,
- Special ditch control with wood excelsior mat or other specified material,
- Special ditch control over sod,
- Slope protection with the specified material,
- Fertilizing,
- Fertilizing for stabilizing crop seeding,
- Mulching for control of surface drainage, and
- Removal of temporary water pollution control measures according to Section 2602.

2601.02 MATERIALS.

A. Furnish materials meeting the requirements of Section 4169.

B. Apply materials at no less than the minimum rate specified in the contract documents. Apply seed for native grass, wildflower and wetland grass seeding on a PLS basis, as computed by the Engineer.

C. Additional compensation will not be allowed for materials in excess of that specified, unless directed by the Engineer.

D. If, after application of fertilizer, it is determined by test that the fertilizer fails to comply with minimum requirements, furnish and apply additional fertilizer to comply with minimum requirements as defined in Article 4169.03.

E. Perform work in a manner that will provide the Engineer the opportunity to verify the quantity of material furnished and the rate of application. Divide the project area into small natural areas that are to be constructed as identifiable

units. Furnish a tally of the quantities of each material as it is used on each area. This may include the quantities below.

- Weights (mass) from approved scales of truck loads of bulk materials,
- Other scaled weights (mass),
- Counts of containers, bags, or bales, or estimates of partially used packages of materials, as approved by the Engineer.

F. Provide the Engineer with the opportunity to verify the quality and quantities in a manner that will allow continuous operation with minimum delays.

G. When handling inoculants, and sticking agents, follow safety precautions as specified on the product label.

2601.03 PLACEMENT OF EROSION CONTROL.

A. Equipment.
Use equipment meeting the requirements of Section 2001 and the following, except that other equipment which produces similar results will be considered for approval. Use methods and procedures consistent with equipment manufacturers' recommendations; however, do not operate ground driven equipment at speeds greater than 10 mph (15 km/h).

1. Disk.
When preparing a seedbed on ground having heavy vegetation, use a disk having cutaway blades. Provide for the addition of weight (mass) to obtain proper cutting depth.

2. Slope Harrow.
Use a rolling weight (mass) attached by heavy chain to a tractor. Use a chain of suitable length, with picks attached and a means of rotating the picks as the rolling weight (mass) is pulled in a direction parallel to the movement of the tractor.

3. Field Tiller.
Use equipment designed for preparation of the seedbed to the degree specified.

4. Rotary Tiller.
Use equipment with rotary type blades designed for the preparation of seedbed to the degree specified.

5. Spike Tooth Harrow.
Use equipment designed to:

- Provide adjustment of the spike teeth to level the ground, or
- Be used as specified by the Engineer.

6. Compaction Equipment.

a. Cultipacker.

1) Use a pull type cultipacker with individual rollers or wheels. Cultipackers having sprocket type spacers between the wheels

may be used. Ensure the cultipacker produces a corrugated surface on the area being compacted.

2) Use a cultipacker that operates separate from all other operations. Attachment of the cultipacker to the seeder or disk will not be permitted, except when the combined cultipacker seeder is manufactured to operate as a unit. Provide for the addition of weight (mass).

b. Compaction Rollers.
Apply Article 2001.05, A.

c. Hand Tamping Equipment.
Use base plate type hand tamping equipment adapted to the performance of the work. Obtain the Engineer's approval.

d. Expanded Mesh Roller.
Use open grid type equipment or the cultipacker type equipment modified by covering with expanded metal mesh.

7. Hydraulic Seeder and Mulcher.

a. Use hydraulic seeding equipment with a pump rated at no less than 100 gallons (350 L) per minute. Inoculant, seed, and fertilizer may be applied in a single operation, unless stated otherwise in the contract documents. Apply hydraulic mulch as a separate operation. Ensure the equipment has suitable working pressure and a nozzle adapted to the type of work.

b. Ensure the supply tanks have a means of mechanical agitation. Calibrate the tanks and provide a calibration stick or other approved device to indicate the volume used or remaining in the tank.

8. Gravity Seeders.

a. Ensure gravity seeders:

- Provide agitation of the seed,
- Have an adjustable gate opening, and
- Uniformly distribute seed on the prepared seedbed.

b. Use a seed hopper equipped with baffle plates spaced no more than 2 feet (0.6 m) apart. Ensure baffle plates extend from the agitator shaft to within approximately 2 inches (50 mm) of the top of the seed hopper.

c. Wind guards will be required to facilitate seeding when moderate wind conditions exist and when required by the Engineer. Place wind guards in front or in back (or both) of the seed outlet and extend to near the ground line.

d. This seeder may be used for the application of fertilizer.

9. Endgate Cyclone Seeders.

Ensure endgate cyclone seeders are:

- Suitably mounted,
- Provide movement by mechanical means, and
- Drop through an adjustable flow regulator onto a rotating, power driven, horizontal disk or fan.

10. Hand Cyclone Seeders.
Use a seeder that drops the seed through an adjustable flow regulator onto a rotating, hand driven, horizontal disk or fan.

11. Native Grass Seed Drill.
Use a drill designed to provide uniform distribution of native grass and wildflower seeds. Provide separate seed boxes to apply both small seeds as well as fluffy bearded seeds. If a no till attachment is specified, use an attachment manufactured by the same manufacturer as the drill.

12. Pneumatic Seeder.
Use a pneumatic (air blower) system with enough power and hose to reach 300 feet (100 m).

13. Aerial Equipment.
When aerial application of seed and fertilizer is specified, use aerial equipment capable of providing a uniform distribution of seed and fertilizer on the specified area.

14. Straw Mulching Machine.
Use a type that will uniformly apply mulch material over the desired area without excessive pulverization. The Engineer may consider excessive pulverization as the general absence of straw longer than 6 inches (150 mm) after distribution.

15. Mulch Stabilizer.

a. Use a mulch stabilizer designed to anchor straw or hay mulch into soil by means of dull blades or disks. Use blades or disks that:
- Are flat,
- Have a nominal minimum diameter of 20 inches (500 mm), and
- Are spaced at approximately 8 inch (200 mm) intervals.

b. The blades may have cutaway edges. Pull the mulch stabilizer using mechanical means. Use a mulch stabilizer that weighs approximately 1,000 pounds (has a mass of approximately 450 kg). When directed by the Engineer, increase the weight (mass) by the addition of ballast.

16. Mechanical Trencher.
Use a machine designed for the specific purpose of constructing a trench for placement of check slots to the depth specified.

17. Mowers.
Use rotary, flail, disk, or sickle type mowers that do not bunch or windrow mowed material.

18. Silt Fence Machine.
Use a machine that will slice-in and place silt fence at a minimum depth of 12 inches (300 mm).

B. Seeding.

1. On various portions of the right-of-way, except the traveled portion of the roadbed:
- Prepare the seedbed,
- Furnish, sow, and cover the seed, and
- Compact the seedbed.

2. Seed other areas as may be indicated in the contract documents or directed by the Engineer. The limits of areas to be seeded will be clearly marked before the seedbed is prepared.

3. Do not disturb areas having a satisfactory growth of desirable grasses or legumes.

4. Sow seed only at times of the year when temperature, moisture, and climatic conditions will promote germination and plant growth. Normal permanent seed application dates are between March 1 and May 31, and between August 10 and September 30. If an area is disturbed, but not seeded by September 30th, scarify the area to a 3 inch (75mm) depth and mulch. Perform seeding according to the following procedures:

a. Seedbed Preparation.

1) Ensure the area to be seeded is relatively smooth. Fill washes and gullies to conform to the desired cross section. When such fills exceed 6 inches (150 mm), compact the material with a tractor wheel or other suitable field equipment. Coordinate preparation of all ditches designated for special ditch control with the seedbed preparation.

2) Thoroughly work areas accessible to field machinery to a depth of no less than 3 inches (75 mm). Use mechanical rotary tillage equipment to prepare the seedbed on earth shoulders, urban or raised medians, rest areas, and islands. Hand prepare areas inaccessible to field machinery to a depth of not less than 2 inches (50 mm). Ensure the entire width of the shoulder and areas around headwalls, wingwalls, flumes, and other structures are prepared in the manner specified.

3) Where weed growth has developed extensively, weeds may be disked into the ground. If weed growth develops sufficiently to interfere with proper seedbed preparation, mow the weeds and remove them from the project (at no additional cost to the Contracting Authority).

4) Use crawler type or dual wheeled tractors to prepare seedbeds. Operate equipment in a manner to minimize displacement of soil and disturbance of the design cross section.

5) Prior to rolling with the cultipacker, harrow ridging in excess of 4 inches (100 mm) caused by operation of tillage equipment. Prior to permanent seeding, roll the area with no less than one pass of the cultipacker.

6) Remove ruts that develop during the sequence of operations before subsequent operations are performed.

7) After seedbed preparation has been completed, pick up and remove all debris according to Article 1104.08, including 3 inch (75 mm) diameter or larger stones, logs, stumps, cable, or other objectionable material that will interfere with the seeding operation.

b. Application of Fertilizer.

1) Spread fertilizer over the areas at the rate designated. Unless otherwise specified in the contract documents, use a rate of 750 pounds per acre (840 kg/ha) of 13-13-13 (or equivalent) commercial fertilizer.

2) Spread fertilizer with a mechanical spreader which will secure a uniform rate of application. Do not use truck mounted spreading equipment for bulk fertilizer. On areas accessible to field machinery, spread fertilizer after the preliminary preparation of seedbed, but prior to the sowing of any seed. Disk in the fertilizer and roll the area prior to the application of permanent seed. If the roller cannot be operated satisfactorily, the Engineer may permit substituting a harrow for the roller. On areas inaccessible to field machinery, spread fertilizer after preparation of the seedbed and thoroughly rake into the soil.

3) If using a hydraulic seeder, apply fertilizer in combination with seeding as specified in Article 2601.03, B, 4, h. When the contract documents require two applications of fertilizer, perform the second application during the next permanent seeding period following initial seeding and fertilizer application.

c. Application of Seed.

1) Use the seed mixture in Table 2601.03-1 for permanent seeding of rural areas, unless otherwise specified in the contract documents:

Table 2601.03-1: Permanent Seed Mixture, Rural Areas

Fescue, Fawn	55 lbs. per acre (62 kg/ha)
Ryegrass, Perennial	45 lbs. per acre (51 kg/ha)
Birdsfoot Trefoil	5 lbs. per acre (6 kg/ha)

2) Use the seed mixture in Table 2601.03-2 for permanent seeding of urban areas, including any areas previously maintained as a lawn. Use an application rate of 4 pounds per 1,000 square feet (2 kg per 100 m^2.)

Table 2601.03-2: Permanent Seed Mixture, Urban Areas

Bluegrass, Kentucky Ryegrass, Perennial (Fineleaf variety) Fescue, Creeping Red	70% 10% 20%
A commercial mixture may be used if it contains high percentage of similar bluegrasses; it may or may not contain Creeping Red Fescue.	

d. Application of Special Seed.

1) When not shown in the contract documents but directed by the Engineer, a special seed or seed mixture may be required in addition to the regular seed mixture. Apply this seed at the rate ordered as a separate operation either immediately before or immediately after sowing the regular grass mixture.

2) No additional work other than sowing of the seed will be required.

3) On limited areas, this seed may be applied by hand cyclone seeders.

e. Preparation of Seed.

1) Except when a hydraulic seeder is used, thoroughly mix all seed specified for the contract prior to placing the seed in the seed hopper. Ensure the Engineer witnesses all seed mixing for Native Grass, Wildflower and Wetland Grass seeding mixtures. Provide 48 hour notice to the Engineer prior to mixing the seed.

2) Inoculate legumes with a standard culture at the rate as specified by the manufacturer of the inoculant, according to Article 4169.04. Use a type of inoculant specified for each legume seed and approved by the Engineer.

3) Do not allow inoculated seed to be exposed to direct sunlight for more than 30 minutes. Prior to use, reinoculate seed that is not sown within 8 hours after inoculation. Preinoculated seed with manufacturer's recommended protective coating may be used in lieu of seed with Contractor applied inoculant.

4) When the gravity or cyclone seeder is used for application of seed, inoculate legume seed according to the manufacturer's recommended procedures before mixing with other grass seeds for sowing. If the hydraulic seeder is used, inoculant, in quantities specified above, may be applied directly into the supply tank with seed, water, and other material. Furnish and apply inoculant.

5) Treat seed with a commercial sticking agent. Apply prior to application of inoculant, or as a mixture when the sticking agent is compatible with other materials, except with hydraulic equipment. A sticking agent is not required if a liquid formulation of inoculant is used.

6) Use mechanical mixing equipment to apply the sticking agent and inoculant on seed quantities over 50 pounds (25 kg) per batch.

f. Sowing Grasses and Legumes.

1) On areas accessible to field machinery, grass and legume seed may be sown with:

- A gravity, cyclone, or hydraulic seeder,
- A native grass seed drill,
- Aerial equipment, or
- As specified in the contract documents.

2) On areas inaccessible to field machinery, use of hand cyclone seeders will be permitted.

3) Sowing of grass and legume seed must be performed as a split rate application (no less than two passes).

4) Hairy vetch may be seeded until September 30. Other legume and native grass seed shall not be seeded after August 31. Defer the work until spring. The spring seeding of legume and native grass seed may be performed in one operation, with a cyclone seeder, hydraulic seeder, or aerial equipment when the ground is friable from frost action.

5) Covering, compaction, rolling, dragging, or raking of the seedbed will not be required provided the friable condition exists. For spring seeding (following fall seedbed preparation) after April 1, the Contractor will be required to roll or harrow when, in the opinion of the Engineer, a friable condition does not exist.

6) Apply crownvetch seed only in the spring or as designated in the contract documents. The crownvetch seeding required is considered the final operation of seeding, fertilizing, and mulching for erosion control projects under construction during the spring seeding period.

g. Covering and Compaction of Grasses and Legumes.

1) Follow sowing of the grasses and legumes with at least one complete rolling with the cultipacker. Roll shoulders immediately to prevent loss of seed due to air currents caused by passing traffic.

2) Where compaction equipment will not operate satisfactorily, lightly drag or rake in the seeded area by hand. Roll the seedbed with a cultipacker both before and after seeding.

h. Seeding and Fertilizing with Hydraulic Seeder.

1) The Contractor may use a hydraulic seeder when the seedbed has been prepared according to Article 2601.03, B, 4, a. When a hydraulic seeder is used, apply seed or fertilizer, or both, at the rates specified in approximately 400 gallons (4000 L) of water slurry per acre (hectare).

2) Apply the mixture within 1 hour after fertilizer and seed are placed in the hydraulic seeder. Continuous agitation will be required. Seed remaining in the fertilizer solution for more than 1 hour will be unacceptable. Additional seed at the specified rate will be required.

i. Fall Seeding.

1) The normal fall seeding period is August 10 through September 30.

2) Apply crownvetch seed only in the spring seeding period or as designated in the contract documents.

3) Seeding after August 31 consists of stabilizing crop seed, hairy vetch (legume seed), and grass seed except native grass. Sow other legume seed and native grass seed the following spring as soon as possible after March 1, and before April 1, when the ground is friable from frost action, as directed by the Engineer and according to Article 2601.03, B, 4, f.

j. Urban Seeding.

1) Apply fertilizer prior to preparing the seedbed.

2) A rotary tiller will be required for the preparation of seedbed according to Article 2601.03, B, 4, a. Prior to the application of seed, ensure the seedbed is firm, smooth, and free of any material 1 1/2 inches (40 mm) in diameter or greater including clods, rocks, and other debris. Roll the seedbed both before and after the application of seed. For rolling, use either open grid type equipment or cultipacker type equipment modified by covering with expanded metal mesh.

3) Prepare, roll, seed, and fertilize areas inaccessible to field equipment by hand or using hand operated equipment, including lawn type, hand cyclone, or gravity equipment. Obtain the Engineer's approval for such equipment.

k. Pneumatic Seeding.

Includes furnishing and applying compost to a depth of 1 inch (25 mm) on all designated disturbed areas. Apply compost using a pneumatic (air blower) system with sufficient hose to reach 300 feet (100 m). Driving on the soil to apply the compost will not be allowed. Apply seed with the top 1/4 inch (6 mm) of compost material. Incorporate fertilizer into the full depth of compost material. Prepare the seedbed according to Article 2601.03, B, 4, j.

l. Spring Overseeding.

1) Seedbed preparation will not be required, provided the overseeding is applied when the ground is friable from frost action after February 1 and before April 1 or as directed by the Engineer.

2) For overseeding, when in the opinion of the Engineer a friable soil condition does not exist, the Contractor shall roll with a cultipacker or harrow.

3) Sow grass legume seed mixture as a split rate application (no less than two passes).

m. Native Grass Seeding and Wetland Grass Seeding.

1) Between April 1 and June 30 and between August 1 and August 31, use the seed mixtures of Tables 2601.03-3 and 2601.03-4 for areas designated for native grass seeding or wetland grass seeding, unless specified otherwise in the contract documents.

Table 2601.03-3: Seed Mixture, Native Grasses

Common Name	Scientific Name	PLS (per ac)	PLS (per ha)
Native Grasses and Wildflowers: Furnish seed certified as Source Identified Class (Yellow Tag) Source G0-Iowa. Grain Rye is excluded from this requirement.			
Grain rye	Secale cereale	22.5 lbs.	25 kg
Canada wild rye	Elymus canadensis	12 lbs.	13 kg
Switchgrass	Panicum virgatum	2 lbs.	2.2 kg
Big bluestem	Andropogon gerardi	8 lbs.	9 kg
Indiangrass	Sorghastrum nutans	8 lbs.	9 kg
Little bluestem	Schizachyrium scoparium	4 lbs.	4.5 kg
Sideoats grama	Bouteloua curtipendula	3 lbs.	3.4 kg
Blue grama	Bouteloua gracilis	3 lbs.	3.4 kg
Purple prairie clover	Dalea purpurea	4 oz.	280 g
Blackeyed susan	Rudbeckia hirta	4 oz.	280 g
Prairie blazing star	Liatris pycnostachya	4 oz.	280 g
Butterfly weed	Asclepias tuberosa	4 oz.	280 g
Wild bergamot	Monarda fistulosa	4 oz	280 g
Gray-headed coneflower	Ratibida pinnata	4 oz.	280 g
New England aster	Symphyotrichum novae-angliae	2 oz.	140 g

Table 2601.03-4: Seed Mixture, Wetland Grasses

Common Name	Scientific Name	PLS (per ac)	PLS (per ha)
Blue vervain	Verbena Hastata	1 oz.	70 g
Boneset	Eupatorium perfoliatum	1 oz.	70 g
Nodding bur marigold	Bidens cernua	8 oz.	560 g
Swamp milkweed	Asclepias incarnata	1 lb.	1.1 kg
Sneezeweed	Helenium autumnale	2 oz.	140 g
Water plantain	Alisma plantago-aquatica	4 oz.	280 g
Arrowhead	Sagittaria latifolia	4 oz.	280 g
New England aster	Symphyotrichum novae-angliae	2 oz.	140 g
Big Bluestem	Andropogon gerardii	1 lb.	1.1 kg
Switchgrass	Panicum virgatum	8 oz.	560 g
Prairie cordgrass	Spartina pectinata	1 lb.	1.1 kg

Virginia wild-rye	Elymus virginicus	5 lbs.	5.6 kg
Bluejoint grass	Calamagrostis	1 oz.	70 g
Rice cutgrass	Leersia oryzoides	4 oz.	280 g
Dark Green bulrush	Scirpus atrovirens	1 oz.	70 g
Fox sedge	Carex vulpinoidea	4 oz.	280 g
Softstem bulrush	Schoenoplectus tabernaemontani	8 oz.	560 g
Spike rush	Eleocharis palustris	4 oz.	280 g
Porcupine sedge	Carex hystericina	8 oz.	560 g
Broom sedge	Carex scoparia	2 oz.	140 g
Tussock sedge	Carex stricta	2 oz.	140 g

2) Uniformly apply seed to areas with the seedbed prepared as in Article 2601.03, B, 4, a. Seed areas accessible to field equipment with a native grass seed drill, gravity, or broadcast equipment. Cultipack as specified in Article 2601.03, B, 4, g. Broadcast seed other areas and follow with a light dragging or hand raking.

3) In areas with existing stabilized crop residue, apply seed with a native grass seed drill with a no till attachment. Seedbed preparation and cultipacking will not be required.

4) Perform seeding as a split rate application (no less than two passes).

n. Wildflower Seeding.

1) Apply the wildflower seed mix designated in the plans between April 15 and June 30, and between August 1 and August 31. Uniformly apply seed to areas with the seedbed prepared as in Article 2601.03, B, 4, a.

2) Seed areas accessible to field equipment using a native grass seed drill at an approximate depth of 1/8 inch (3 mm), or using gravity or broadcast equipment. Cultipack as specified in Article 2601.03, B, 4, a. Broadcast seed other areas and follow with a light dragging or hand raking.

3) In areas with existing stabilized crop seeding residue, apply seed with a native grass seed drill with a no till attachment. Seedbed preparation and cultipacking will not be required.

4) Perform wildflower seeding as a split application (no less than two passes).

o. Mowing.

1) Mowing may be required prior to permanent seeding and any time during the growing season following permanent seeding. The Engineer will notify the Contractor in writing prior to each mowing. Notification may be issued as early as 15 calendar days following the execution of the contract. The Contractor will be given 5 mowing days, plus 1 additional day for each 50 acre (20 ha) increment, that has been requested to be mowed. A mowing day is a calendar day, exclusive of Saturdays,

Sundays, or recognized legal holiday, on which weather or other conditions (not under the control of the Contractor) will permit mowing operations to proceed for no less than 3/4 of a normal work day in the performance of a controlling item of work. When multiple projects are combined into a single contract, mowing days will be administered independently for each project. Mowing days will be charged starting on the day following the Contractor's notification. A price adjustment will be assessed at a rate of $200.00 per mowing day after the work was to be completed.

2) Use suitable equipment for mowing. Bunching or windrowing mowed vegetation will not be permitted. When wet soil conditions result in rutting, suspend mowing. Repair rutting damage at the direction of the Engineer at no additional expense to the Contracting Authority. Hand equipment will be required for areas inaccessible to other equipment. Set the cutting height at approximately 6 inches (150 mm). More than one pass may be required for each mowing.

C. Stabilizing Crop Seeding and Fertilizing.

Prepare the seedbed according to Article 2601.03, B, 4, a.

1. Stabilizing Crop Seed Mixture.

a. Unless otherwise specified in the contract documents, use the stabilizing crop seed mixture rates and schedule shown in Table 2601.03-5.

Table 2601.03-5: Seeding Rates and Schedule

Spring -- March 1 to May 20	
Oat Grain rye Red clover Timothy	2 bu. per acre (72 kg/ha) 25 lbs. per acre (28 kg/ha 5 lbs. per acre (6 kg/ha) 5 lbs. per acre (6 kg/ha)
Summer -- May 21 to July 20	
Oat Grain rye Red clover Timothy	3 bu. per acre (108 kg/ha) 35 lbs. per acre (39 kg/ha) 5 lbs. per acre (6 kg/ha) 5 lbs. per acre (6 kg/ha)
Fall – July 21 to September 30	
Oat Grain rye Red clover Timothy	2 bu. per acre (72 kg/ha) 35 lbs. per acre (39 kg/ha) 5 lbs. per acre (6 kg/ha) 5 lbs. per acre (6 kg/ha)

b. Apply stabilizing crop seeding using full seedbed preparation and incorporation.

c. Overseeding of stabilizing crop seeding will only be allowed on areas which are not accessible to field equipment.
d. Treat all legume specified for stabilizing crop seed with inoculant prior to mixing with the remainder of the seed mixture.
e. If an area is disturbed, but not seeded with stabilizing crop by September 30th, scarify to a 3 inch (75 mm) depth and mulch.

2. Fertilizing for Stabilizing Crop Seeding.
a. Apply commercial fertilizer to all seeded areas at the rate of 450 pounds per acre (500 kg/ha) of 13-13-13 (or equivalent) unless specified otherwise in the contract documents.
b. Apply the provisions of Article 2601.03, B, 4, b.

3. Covering and Compaction of Stabilizing Crop Seeding.
a. Cover stabilized crop seed and fertilizer with a light disking or with other tillage equipment such as a rigid harrow, spring tooth harrow, or field cultivator.
b. Follow the tillage by rolling the area with a cultipacker. If the cultipacker cannot be operated satisfactorily, the Engineer may permit the harrow to be substituted for the cultipacker.

4. Stockpile Stabilization Seeding.
Seedbed preparation will not be required for areas not accessible to field equipment.

D. Composting.
Compost may be used as a top dress application or as an incorporated soil amendment.

1. Top dress applications may be used for urban seeding or on soils that are highly erosive or sloped soils to prevent surface or rill erosion and to provide organic material and nutrients needed for vegetative establishment. Ensure areas top dressed with compost have little or no drainage onto them.

2. In highly erosive soils or sloped embankments with drainage onto the area, incorporate compost by mixing it into the top soil a minimum of 2 inches (50 mm) to prevent the compost from washing off the slope.

E. Mulching.
Mulch seeding areas unless otherwise designated in the contract documents.

1. Time of Mulching.
Apply mulch to areas requiring mulch as soon as seed is sown and final rolling completed. If an area is disturbed, but not seeded by September 30th, scarify the area to a 3 inch (75 mm) depth and mulch.

2. Application of Mulch.

a. Straw Mulch.

1) Evenly and uniformly distribute mulch and anchor it into the soil. Use an application rate for reasonably dry material of approximately 1 1/2 tons per acre (3.5 Mg/ha) of dry cereal straw, native grass straw, or other approved material, depending on the type of material furnished.

2) In all accessible mulched areas, consolidate the mulch into the soil with a mulch stabilizer. Tuck slope areas on the contour. Use crawler type or dual wheel tractors for the mulching operation. Operate equipment in a manner to minimize displacement of the soil and disturbance of the design cross section.

b. Hydraulic Mulches.

Apply hydraulic mulches at no less than the manufacturer's recommended minimum rate using standard hydraulic mulching equipment.

F. Reseeding, Refertilizing, and Remulching.

1. When ordered by the Engineer reseed, refertilize, and remulch (at the contract unit prices) an area when:

- All work related to seeding on the area has been completed, but is washed out or damaged prior to final acceptance of the project by the Engineer, and
- The area involves seeding in combination with mulching or fertilizing, or both.

2. If a fertilized or seeded area is damaged by rain prior to the required mulching, refertilize or reseed, or both, that area at a rate not to exceed the specified rate as designated by the Engineer. Perform this work at no additional cost to the Contracting Authority.

G. Sodding.

1. Refer to the contract documents for areas to be sodded. The Engineer may designate other areas for sodding.

2. Prior to shaping the sodbed, the Engineer will define upon the ground the limits of areas to be sodded, and indicate the center lines of waterways. Cover the designated areas with live sod meeting requirements of Article 4169.06.

3. Closely place and properly fit the sod against structures and adjacent sod according to the following provisions:

a. Preparation of Sodbed.

1) Shape and prepare all surfaces to be sodded. Ensure areas to be sodded are firm and even surfaces. Ensure they are free of material 1 1/2 inches (40 mm) in diameter or greater including clods, rocks, and other debris. Ensure all ditch channels,

slopes, and flumes to be sodded have a typical cross section as shown in the contract documents.

2) Construct the ditch channel to secure a relatively level, flat bottom ditch cross section with a minimum depth of 6 inches (150 mm), measured from the finished sodbed ground line at the edge of the ditch. Scarifying prior to shaping may be necessary to assure the minimum depth. A minimum sod ditch overall width of 7 1/2 feet (2.2 m) (sloping sides) will be required.

3) Use a soil compaction roller complying with Article 2601.03, A, for compaction and reshaping of ditches. Limit layers of fill materials to no more than 8 inches (200 mm) in depth.

4) After the surface of the layer has been smoothed and before material for the next layer is deposited upon it, compact the layer:

- With no less than one pass of a soil compaction roller per inch (25 mm) of loose thickness of the layer, and
- Until the roller is supported entirely on its tamping feet.

5) The roller will be considered entirely supported on its tamping feet when the tamping feet penetrate no more than 3 inches (75 mm) into an 8 inch (200 mm) layer being compacted. A single section roller may be necessary for this operation in some locations.

6) Extend the compacted area approximately 6 inches to 12 inches (150 mm to 300 mm) beyond the width of the ditch.

7) After compaction, shape the ditch.

b. Fertilizer for Sod.

1) Two applications are required (initial and prior to final acceptance). After sodbed preparation and prior to placing sod, fertilize the area to be sodded and the adjacent disturbed area at a rate of 10 pounds per 1000 square feet (5 kg per 100 m^2). Use a commercial fertilizer specified for the project.

2) Place the final application of fertilizer at a rate of 10 pounds per 1000 square feet (5 kg per 100 m^2) within 5 calendar days of the end of the 30 calendar day watering period and prior to final acceptance of the project. Place the final application when the grass is dry and with a dry form of fertilizer.

3) For both of the above applications, if the type of fertilizer is not specified, apply 13-13-13 (or equivalent) commercial fertilizer. Spread the fertilizer with a mechanical spreader which will secure a uniform rate of application. Manipulation or mixing with the soil, other than that incidental to Article 2601.03, G, 3, d, will not be required.

c. Placing Sod.

1) Do not place sod between May 31 and September 1, or on frozen ground unless otherwise directed by the Engineer.

2) Place sod in rows or strips. On slopes, place the strips transverse to the flow of water over the area. On the sides and bottoms of ditches and channels, place the strips at right angles to the center line of the channel. Place sod strips tightly against each other so that no open joints are apparent.

3) Stagger joints at the ends of sod strips at least 1 foot (0.3 m) on adjacent rows or strips of sod. Cut sod to be placed in road ditch channels, intercepting ditches, or sod flumes where the total sodded width is less than 7 1/2 feet (2.2 m) into strips having lengths equal to the width of the sodded area. At the top of slope or at the edge of a channel, lay sod so water from adjacent areas will have free flow onto the sodded area. In road ditch channels and flumes, begin sodding at the outlet or lower end and progress upward. On slopes, begin sodding at the bottom and progress upward. If necessary to protect sod already laid, furnish (without extra compensation) ladders or planks for workers to use.

4) The Engineer may order sod flumes, slopes, and ditch channels to be staked to minimize erosion loss before establishment. Stake sod as shown in the contract documents and as required by the Engineer.

d. Finishing Sod.

1) Firm the soil along the edge of the sodded area. Properly shape and smooth the adjacent disturbed area to allow surface water to flow into the sod ditch. Excessive soil placed over the edge of the sod will not be permitted.

2) Prepare and seed the seedbed for all rural disturbed areas adjacent to the sod. Rake the seed in. Seed the disturbed area with the following seed mixture at the rate of 2 pounds per 1000 square feet (1 kg per 100 m^2):

Fescue, Fawn	80%
Ryegrass, Perennial	20%

3) For urban projects adjacent to sod, use the seed mixture specified for the project. Mulch the disturbed area with grass, hay, or straw at the rate of 70 pounds per 1000 square feet (35 kg per 100 m^2).

4) After sodding and seeding, water the sod, sodbed, and disturbed areas according to Article 2601.03, G, 3, e.

5) When sod ditches are constructed after October 1, overseed grasses the following spring, between March 1 and April 1, when weather and soil conditions are favorable.

6) When initial watering of the sod does not secure adequate bond between the sod and soil, the Engineer may require rolling. If sod is allowed to be placed between May 31 and August 10, and it is not to be staked, roll the sod using equipment approved by the Engineer. Remove from the project sod rejected from sod ditches. Remove from the site any other material not otherwise incorporated into the work.

7) In urban areas, islands, and rest areas, roll the sod prior to or following the initial watering using a hand operated, lawn type roller approved by the Engineer.

e. Watering Sod.

1) Provide watering equipment and an approved water supply before beginning any sodding operation. Six waterings will be required. Allow no more than 1 hour to elapse between laying and initial watering of sod. Perform the second, third, and

fourth waterings at 4 calendar day intervals, and the fifth and sixth waterings at weekly intervals. Perform all waterings unless notified by the Engineer in writing at least 1 calendar day prior to the day the watering is to occur. A price adjustment will be assessed at a rate of $200.00 per day for each calendar day that the Contractor fails to complete the watering from the day watering is to commence.

2) Ensure all waterings are sufficient to thoroughly saturate the sod, sodbed, and adjacent disturbed areas to a depth of approximately 4 inches (100 mm).

3) Each watering may require a maximum of 100 gallons of water per square (40 L of water per square meter). Apply the water as a spray or dispersion to prevent damage to the sod. Complete each watering within a 4 hour period. More than one application for each watering may be necessary to provide adequate saturation without runoff.

f. Urban, Island, and Safety Rest Area Sodding.

1) Prepare areas to be sodded, except ditch channels, according to Article 2601.03, B, 4, j.

2) During the total watering period, mow the sod once to a 3 inch (75 mm) height approximately 3 weeks after placement.

H. Constructing and Reshaping Intercepting Ditches and Flumes.

1. Construct ditches to intercept the flow of surface water and conduct it into proper drainage channels, as provided in Article 2102.03, H when:

- The slope of adjacent land is toward the backslope of road excavations, and
- The extent of the area drained will result in sufficient water flowing over the backslope to cause serious erosion.

2. Ensure intercepting ditches and flumes comply with the typical cross section shown in the contract documents.

3. Form the ditch by excavating or blading earth from the area on the downhill side of the ditch location. Deposit this material in a windrow and compact it to form the ditch and provide the bank for the downhill side.

4. For reshaping of intercepting ditches, compact the earth excavated from the ditch to the bank on the lower side of the ditch.

I. Special Ditch Control, Turf Reinforcement Mat, and Slope Protection.

Use material meeting the requirements of Article 4169.09. The Engineer will designate the areas for each type of work.

1. Special Ditch Control Wood Excelsior Mat or Other Material Specified.

Perform the following according to the contract documents:

- Shape channels on all ditches.

- Furnish and apply seed and fertilizer, mulch, ditch control material, and water.

2. Turf Reinforcement Mat (TRM).
Perform the following according to the contract documents:
- Shape channel, ditches, or slopes.
- Furnish and apply TRM.
- Furnish and apply a minimum of 1 inch (25mm) of soil suitable for the establishment of vegetation on the TRM.
- Furnish and apply seed and fertilizer.
- Furnish and apply special ditch control wood excelsior mat on the soil fill
- Watering.

3. Special Ditch Control over Sod.
Furnish and apply specified material, including staples, over the sodded areas.

4. Slope Protection Wood Excelsior Mat or Other Material Specified.
Furnish and apply the specified material on the slopes designated by the Engineer.

J. Preparation of Area to be Treated with Special Ditch Control, Turf Reinforcement Mat, and Slope Protection.

1. Shape the ditch channel in the same manner as preparing a ditch for sod as provided in Article 2601.03, G, 3, a.

2. During ditch shaping operations, provide a seedbed with a friable soil condition on the surface. Prepare slope areas to be protected with ditch control material as preparing a seedbed for seeding as provided in Article 2601.03, B, 4, a, except with a depth no less than 3/4 inch (20 mm).

3. Remove all material 1 1/2 inches (40 mm) in diameter or greater, including clods, rocks, and other debris, which will prevent contact of the ditch control material with the seedbed.

4. Coordinate preparation and placement of the ditch control material or TRM with the seedbed preparation, seeding (including sticking agent and inoculant), fertilizing, and mulching of the adjacent area of right-of-way.

5. Prepare areas to be protected with slope protection materials in the same manner as provided in Article 2601.03, B, 4, a.

K. Seeding For Special Ditch Control and Slope Protection.
Sow seed prior to placement of ditch control material, unless directed otherwise by the Engineer. Treat seed with sticking agent and inoculant.

1. Special Ditch Control in Depressed Medians and Other Ditch Areas.
Seed ditches and depressed medians at a rate of 5 pounds per 1000 square feet (2.5 kg per 100 m^2), as directed by the Engineer, using the following seed mixture:

Ditches Outside Shoulder	
Fescue, Fawn	70%
Fescue, Creeping Red	10%
Ryegrass, Perennial	20%
Median Ditches	
Fescue, Fawn	77%
Birdsfoot Trefoil (Empire)	3%
Ryegrass, Perennial	20%

2. Slope Protection and Urban Seeding Areas.
Use the seed mixture specified for the project.

L. Fertilizer for Special Ditch Control and Slope Protection.

1. After the area is prepared and prior to laying the specified material, fertilize the ditch channel at the rate of 10 pounds per 1000 square feet (5 kg per 100 m^2). Use the commercial fertilizer specified for the project.

2. If the type of fertilizer is not specified for the project, apply 10 pounds per 1000 square feet (5 kg per 100 m^2) of 13-13-13 (or equivalent) commercial fertilizer. Spread the fertilizer with a mechanical spreader to secure a uniform rate of application. Manipulation or mixing with the soil other than that incidental to Article 2601.03, O, will not be required.

3. For slope protection, use the fertilizer specified for the project.

M. Application of Special Ditch Control and Turf Reinforcement Mat Materials on Seeded Areas.
The areas of special ditch control will be designated by the Engineer. Shape the ditch channel as provided in Article 2601.03, G, 3, a. Apply the provisions of Articles 2601.03, J; 2601.03, K; 2601.03, O; and 2601.03, Q.

1. Wood Excelsior Mat.
- **a.** Space check slots on ditch channels so one check slot occurs within each 50 foot (15 m) increment on slopes of more than 4%.
- **b.** Apply wood excelsior mat without tension and in the direction of the flow of water. Where more than one strip is required, lap the lap joint no less than 3 inches (75 mm). Bury the anchor slot on the top edge of the wood excelsior mat from 6 inches to 12 inches (150 mm to 300 mm), as designated by the Engineer.
- **c.** On junction slots, bury the upslope end of each strip of wood excelsior mat 6 inches (150 mm). Firmly tamp the soil. Overlap the ends of the wood excelsior mat at least 12 inches (300 mm) and staple, with the upgrade section on top.

d. Staple the terminal fold at the bottom end of the wood excelsior mat.

e. Use staples meeting the requirements of Article 4169.10, A. Space staples as shown in the contract documents.

2. Other Materials.
Place TRM on channel or slope after shaping. Apply according to the manufacturer's instructions and the contract documents.

N. Special Ditch Control over Sod.
When shown in the contract documents, place plastic netting or other approved material over sod and staple it in place. Space staples 3 feet (1 m) apart in the row. Space rows no more than 2 feet (0.6 m) apart. Place staples alternately to adjacent rows. No junction slots or check slots are required. Anchor slots and terminal folds will be required.

O. Finishing Adjacent to Special Ditch Control and Turf Reinforcement Areas.
For adjacent areas disturbed outside of ditch channels, uniformly shape, fertilize, seed, and rake in the seed in the same manner required for disturbed areas adjacent to sod ditches, except use the seed specified in Article 2601.03, J. Complete this work during the normal permanent seeding period or by the date specified to complete seeding.

P. Application of Slope Control Materials over Seeded Areas.
Details for applying slope control materials over seeded areas will be shown in the contract documents.

Q. Watering of Special Ditch Control, Turf Reinforcement Mat, and Slope Protection.

1. Provide watering equipment and an approved water supply before starting special ditch control, TRM, or slope protection work. Water the area no later than the day following placement of the materials. If the Contractor fails to water by the second day following placement a price adjustment will be assessed at a rate of $200.00 per calendar day until the watering has been completed.

2. Apply three additional waterings at intervals of 5 to 8 calendar days. Perform all waterings unless notified by the Engineer in writing at least 1 calendar day prior to the day the watering is to occur. If the Contractor fails to complete the watering before the 8th calendar day has elapsed a price, adjustment will be assessed at a rate of $200.00 per calendar day, beginning on the 9th day, until the watering is completed.

3. Ensure all waterings are sufficient to thoroughly saturate the seedbed to a depth of approximately 2 inches (50 mm).

4. Each watering may require a maximum of 50 gallons of water per square (20 L of water per square meter). Apply the water as a spray or

dispersion to prevent damage to the seedbed. Complete each watering within a 4 hour period.

5. More than one application for each watering may be necessary to provide adequate saturation without runoff.

R. Completion of the Work.

1. Give priority to medians, islands, interchange quadrants, urban areas, and rest areas, including the area between rest areas and the highway. Schedule the work so that all work, except sodding, in these areas is completed first, except as authorized by the Engineer.

2. Coordinate and complete all phases of this work, except sodding, so the operation for any phase of work will not extend more than 2 miles (3 km) from portions already completed, except with the Engineer's permission. Complete all phases of this work, excluding the 30 calendar day maintenance of sodded areas, within the specified construction schedule.

3. When any work included in the contract is washed out or damaged prior to final acceptance of the project, the Engineer may order replacement of the damaged portion. The Engineer will advise the Contractor of the approximate quantity of replacement required. Perform these repairs during the normal permanent seeding period. Maintain the work in a manner satisfactory to the Engineer.

4. The Contractor is responsible for replacement in addition to the quantity directed by the Engineer to complete the work in an acceptable condition should the Contractor fail to:
- Make this replacement when directed by the Engineer, or
- Perform necessary maintenance to the area.

2601.04 METHOD OF MEASUREMENT.

Measurement for the various items of work involving erosion control, satisfactory completed, will be as follows:

A. The Engineer will compute in acres to the nearest 0.1 acre (hectares to the nearest 0.1 hectare) the surface areas of
- Overseeding and Fertilizing,
- Seeding and Fertilizing,
- Mulching,
- Compost,
- Native Grass Seeding,
- Wetland Grass Seeding,
- Wildflower Seeding,
- Stabilizing Crop Seeding and Fertilizing,
- Seeding Special Areas, and
- Crownvetch Seeding.

B. Surface areas of Sodding: squares of 100 square feet (square meters) calculated from measurements to the nearest foot (0.1 m).

C. Debris picked up and removed according to Article 2601.03, B, 4, a: cubic yards (cubic meters) by cross sectional measurement or in the hauling units, at the option of the Engineer.

D. Special Ditch Control, Turf Reinforcement Mat, and Slope Protection: squares of 100 square feet (square meters) calculated from measurements to the nearest foot (0.1 m). Measurement of actual area covered will be used, but will not exceed an area based on the actual measured length and design width. Materials used for anchor slots, junction slots, check slots, terminal folds, lap joints, mulch, and seed and fertilizer for Special Ditch Control are incidental.

E. Watering: by counting loads from a transporting tank of known volume or by metering.

F. Mobilization for watering: by count. Mobilization for the initial watering required at installation of the plant material will not be measured for count.

G. Mowing described in Article 2601.03, B, 4, n: acres to the nearest 0.1 acre (hectares to the nearest 0.1 hectare) of surface area.

2601.05 BASIS OF PAYMENT.

A. Payment for the various items of work involved in erosion control will be made as described below. When suitable soil for filling holes, gullies, or washes is not available adjacent to the area to be filled or when soil must be removed, payment for necessary loading and hauling directed by the Engineer will be as extra work according to Article 1109.03, B.

1. Contract unit price per acre to the nearest 0.1 acres (hectare to the nearest 0.1 hectares) for the following. Payment is full compensation for preparing the area and furnishing and applying each material.

- Overseeding and Fertilizing,
- Seeding and Fertilizing,
- Compost,
- Native Grass Seeding,
- Wetland Grass Seeding,
- Wildflower Seeding,
- Stabilizing Crop Seeding and Fertilizing, and
- Crownvetch Seeding.

2. Seeding Special Areas:

a. Contract unit price per acre to the nearest 0.1 acres (hectare to the nearest 0.1 hectares).

b. Payment is full compensation for preparing the area and furnishing and applying the seed and fertilizer as specified.

3. For sowing special seed ordered by the Engineer, but not provided for in the contract documents: delivered cost of the seed plus 10% of the contract unit price for Seeding and Fertilizing.

4. Sodding:
- **a.** Contract unit price per square (square meter).
- **b.** Payment is full compensation for:
  - Preparing the sodbed,
  - Furnishing, placing, and finishing the sod,
  - Fertilizing, and
  - Repair of adjacent areas disturbed by the sodding operation.

5. Squares (square meters) of staking of sod flumes, slopes, and ditch channels: 25% of the contract unit price for Sodding in addition to payment for Sodding.

6. Mulch furnished and placed: predetermined contract unit price per acre (hectare).

7. Debris picked up according to Article 2102.03, C, for grading work:
- **a.** Payment for debris pickup of additional boulders resulting from Stabilized Crop Seeding and Fertilizing will be as described in Article 2102.05 for Class 12 boulders. If there is no Class 12 item, payment will be at 10 times the contract unit price for Class 10 excavation.
- **b.** Payment for the number of cubic yards (cubic meters) of debris picked up and removed in conjunction with other work will be paid at 25% of the contract unit price for Stabilizing Crop Seeding or Seeding and Fertilizing, as applicable.

8. Squares (square meters) of Special Ditch Control over Sod, Wood Excelsior Mat or other material, as specified:
- **a.** Contract unit price per square (square meter).
- **b.** Payment is full compensation for the special ditch control preparation and materials. This includes seedbed preparation, seed and fertilizer, special ditch control (wood excelsior mat), stapling and installation of materials.

9. Squares (square meters) of Turf Reinforcement Mat:
- **a.** Contract unit price per square (square meter).
- **b.** Payment is full compensation for the Turf Reinforcement Mat, preparation and materials including shaping channels, ditches and slopes, soil fill, seed and fertilizing, wood excelsior mat and watering.

10. Squares (square meters) of Slope Protection with Wood Excelsior Mat or other material, as specified:
- **a.** Contract unit price per square (square meter).
- **b.** Payment is full compensation for the slope protection materials in addition to the amount paid for seed and fertilizer.

11. When a large area is to be watered, the contract documents will include an item for watering. For the quantity of water applied to sod, Article 2601.03, G, 3, e, and to special ditch control and slope protection, Article 2601.03, Q, payment will be the predetermined contract unit price per 1000 gallons (kiloliter). When an item for watering is not included, the cost of watering is included in the amount paid for the item to be watered.

12. Mobilization for watering: pre-determined price of $350.00 for each required watering.

13. Mowing as described in Article 2601.03, B: contract unit price per acre to the nearest 0.1 acres (hectare to the nearest 0.1 hectares).

B. Payment for these items is full compensation for furnishing all materials, equipment, tools, and labor necessary to complete the work according to the contract documents. It includes:

- Removal of rock and other debris from the area,
- Filling gullies and washes,
- Preparing the seedbed or sodbed,
- Furnishing and placing sod and staking sod,
- Furnishing and placing seed including any treatment required,
- Furnishing and placing fertilizer and mulch,
- Tucking the mulched areas,
- Furnishing and placing wood excelsior mat,
- Furnishing water, and
- Other care during the care period.

C. Payment will not be allowed for any area seeded until all seeding of the area permitted by the season is completed, including crownvetch seeding in the spring, and until the Special Ditch Control, Slope Protection, fertilizer, and mulch are placed.

D. Payment will not be allowed for the Special Ditch Control and Sod until the watering, as specified, has been completed. Replace or repair, at the discretion of the Engineer, Special Ditch Control and Sod areas which are damaged by weather or other causes before the specified initial watering has been completed, at no additional cost to the Contracting Authority.

E. Payment for areas of completed work which are damaged by weather or other causes during the care period and which are repaired at the direction of the Engineer will be at the contract unit prices for the respective types of work involved. Should the repair work not be done with reasonable promptness, payment for repair will be limited to the work described at the time of notification.

F. Payment for furnishing extra length stakes or staples when directed by the Engineer will be as extra work according to Article 1109.03, B.

Section 2602. Water Pollution Control (Soil Erosion)

2602.01 DESCRIPTION.

A. Temporary control measures for projects to control water pollution caused by soil erosion. Additional measures are described in Section 2601.

B. Projects that are regulated by the requirements of Iowa DNR National Pollutant Discharge Elimination System (NPDES), General Permit No. 2, for Storm Water Discharge Associated with Industrial Activity for Construction Activities, will be identified in the contract documents. The Prime Contractor for these projects will be required to complete, sign, and return, along with the signed contract, a certification statement for storm water discharge associated with industrial activity for construction activities. Affected Subcontractors for the project will be required to sign and return an affidavit identifying them as co-permittees with the Contracting Authority prior to starting work.

C. Coordinate temporary water pollution control work with permanent erosion control work to ensure economical, effective, and continuous erosion control throughout the construction and post construction period.

2602.02 MATERIALS.

Use materials complying with Division 41.

2602.03 CONSTRUCTION.

A. Prior to the preconstruction conference furnish the Engineer initial Erosion Control Implementation Plan (ECIP) for accomplishment of temporary and permanent erosion control. In addition, furnish the proposed method of erosion control on haul roads and borrow pits as well as the plan for the removal of excess materials from the project.

B. Obtain the Engineer's acceptance for the ECIP and methods before commencing work. Schedule and perform all operations so erosion control features are placed according to accepted ECIP. Update ECIP as needed to address changes in schedule of operations or staging, weather changes, or other changes required in order to comply with applicable permit requirements.

C. Provide immediate, permanent or temporary, water pollution control measures to prevent contamination of adjacent watercourses and property. This work may involve:

- Constructing or installing silt fence, silt fence for ditch checks, silt ditches, silt dikes, silt basins, and slope drains,
- Constructing or installing perimeter and slope sediment control devices (straw wattles, wood excelsior logs, or filter socks filled with compost filter material), and
- Using temporary mulches, mats, seeding, or other control devices or methods, as necessary to control erosion and sediment pollution.

D. Unless otherwise specified, use compost as a filter medium in filter socks, filter berms, or filter blankets for sediment control.

E. Stabilize disturbed areas, in which construction activity will not occur for a period of 21 calendar days, no later than the 14th calendar day after no construction activity has occurred. Stabilization measures include temporary seeding, permanent seeding, mulching, sod, or other methods the Engineer approves.

F. Incorporate all erosion control features into the project at the earliest practical time, as outlined in the accepted schedule. Construct water pollution control measures:

- At locations shown in the contract documents and as determined by the Contractor,
- At locations where conditions develop during construction that were unforeseen during design, or
- Where needed to control water pollution that develops during normal construction practices.

G. Maintain water pollution control features in appropriate functional condition from initial construction through completion of the project. Restore siltation control features to their original condition where siltation has reduced their capacity by 50% or more.

H. Maintenance of Silt Fence and Silt Fence for Ditch Check includes excavation and disposal of silt material trapped by the silt fence or silt fence for ditch checks. Shaping of the ditch bottom to the original ditch template is incidental to this item. Dispose of the silt material off the project unless Engineer approves a suitable site within the project limits.
Maintenance also includes repair of silt fence due to undermining, leaning, or fabric becoming unattached from posts. Repair requiring new fabric will be paid for under type of silt fence properly installed and will not be considered maintenance.

I. Limit clearing and grubbing, excavation, borrow, and embankment operations in progress to an area commensurate with their capability. Progress in keeping the finish grading, mulching, seeding, and other pollution control measures current according to the accepted work schedule. The Engineer may suspend operations if the Contractor fails to provide adequate erosion control measures in a timely manner.

J. In the event of conflict between these requirements and water pollution control laws, rules, or regulations of other Federal, State, or local agencies, the more restrictive laws, rules, or regulations will apply.

K. The Contractor is responsible for water pollution control for work outside the right-of-way or easement obtained by the Contracting Authority.

2602.04 METHOD OF MEASUREMENT.

Measurement for water pollution control items will be as follows:

A. Silt Ditches.
Linear feet (meters) to the nearest 0.1 foot (0.1 m).

B. Silt Fence.
Linear feet (meters) to the nearest 0.1 foot (0.1 m).

C. Silt Fence for Ditch Checks.
Linear feet (meters) to the nearest 0.1 foot (0.1 m).

D. Silt Dikes.
Linear feet (meters) to the nearest 0.1 foot (0.1 m).

E. Silt Basins.
By count for each silt basin.

F. Removal of Silt Fence or Silt Fence for Ditch Check.
Linear feet (meters) to the nearest foot (0.1 m).

G. Removal of Silt Basins.
Cubic yards (cubic meters) as Class 10 Excavation according to Article 2102.04 for material used to fill silt basins.

H. Maintenance of Silt Fence or Silt Fence for Ditch Check.
Linear feet (meters) to the nearest foot (meter).

I. Perimeter and Slope Sediment Control Device.
Linear feet (meters) to the nearest foot (meter) of each size.

2602.05 BASIS OF PAYMENT.

A. Payment for water pollution control items will be the contract unit price as described below. Payment for construction of water pollution control items is full compensation for labor, equipment and materials necessary to construct the items according to the contract documents.

1. Silt Ditches.
Per linear foot (meter) for the length of silt ditches properly constructed.

2. Silt Fence.
Per linear foot (meter) for the length of silt fence properly installed.

3. Silt Fence for Ditch Checks.
Per linear foot (meter) for the length of silt fence for ditch checks properly installed.

4. Silt Dikes.
Per linear foot (meter) for the length of silt dikes properly constructed.

5. Silt Basins.
Each for properly constructed silt basins.

6. Removal of Silt Fence or Silt Fence for Ditch Check.
Per linear foot (meter) for the length of silt fence or silt fence for ditch check properly removed.

7. Removal of Silt Basins.
Per cubic yard (cubic meter) for Class 10 Excavation, according to Article 2102.05, for each silt basin properly filled.

8. Maintenance of Silt Fence or Silt Fence for Ditch Check.
Per linear foot (meter) for silt fence or silt fence for ditch check properly cleaned out or repaired.

9. Perimeter and Slope Sediment Control Device.

Per linear foot (meter) for length of device of each size properly installed.

B. When it is necessary for the Contractor to clean out, repair, or reconstruct a silt ditch, dike, or basin, the additional payment will be 100% of the contract unit price for construction of that item. When applicable bid items are not in the contract documents, payment for clean out, repair, or reconstruction will be according to Article 1109.03, B.

C. If water control measures are required due to the Contractor's negligence, carelessness, or failure to install the controls as a part of the work as scheduled, and are ordered by the Engineer, perform this work at no additional cost to the Contracting Authority.

D. All water pollution control features are to be in functional condition before final acceptance of the contract.

Section 2610. Furnish and Install Shrubs, Trees, and Vines

2610.01 DESCRIPTION.
Furnish and install plants and planting material of the type, class, species, grade, and size specified in the contract documents.

2610.02 MATERIALS.
Furnish plants and planting materials for installation and incidental materials required for proper placement meeting the requirements of Section 4170. Substitutions will be permitted according to Article 4170.02, B, 6.

2610.03 INSTALLATION.

A. Handling and Temporary Storage.

1. Maintain plants in good condition during handling at point of delivery and in transportation from temporary storage. Protect all roots with moist straw, moss, or other suitable material.

2. When being transported in an open vehicle, further protect all plants with a tarpaulin.

B. Location of Plantings.

1. The Engineer will stake the location of planting of each type of material specified. Locations of trees will be staked individually before excavation for planting.

2. The outline and number of plants for shrub beds will be indicated without staking the location of individual plants.

3. Do not set plants in rows or straight lines, unless required.

C. Pruning.

1. General.
- **a.** Complete pruning prior to wrapping.
- **b.** Perform all pruning to retain the natural shape of the plant. Unless removing dead or damaged material, do not top plants. Prune back broken and damaged branches to the closest outward growing bud on healthy sound wood. Remove rubbing branches and suckers. Remove all stubs. Remove all debris resulting from pruning from the right-of-way according to Article 1104.08.

2. Deciduous Trees.
- **a.** Remove all broken, damaged, or otherwise defective branches, as well as all branches which may not develop properly. In addition, eliminate narrow crotches or competing leaders.
- **b.** Prune trees to develop an upright leader which will best promote the symmetry of the tree. Prune flowering or specimen trees to develop their natural form.

3. Evergreen Trees and Shrubs.
Remove dead and broken branches.

4. Deciduous Shrubs.
Remove dead or irregular branches.

5. Vines and Ground Cover.
Remove broken, damaged, or dead portions from vines and ground cover plants.

D. Wrapping.

1. Complete wrapping in the Fall prior to the final watering in the year the plant is planted.

2. Wrap deciduous trees (except Hawthorn, Russian Olive, and other multi-stemmed varieties) from the ground line up to and including the

crotch formed by the first major branch. Self tie or secure wrapping with paper tape.

3. Remove identification ties and tags on plant material at the end of the contract period.

E. Planting.

Spring planting dates for evergreens are between March 1 and April 30, and for deciduous plants are between March 1 and May 15. Fall planting dates for evergreens are between September 1 and September 30, and for deciduous plants are between October 1 and November 30. Complete any plantings not completed by the completion date specified in the contract documents during the next planting period, unless otherwise directed by the Engineer. Plant the plant materials according to the following:

1. Area Preparation and Excavation of Planting Wells.

a. Prior to excavation, till entire area to be mulched with a rotary tiller or other method the Engineer approves. Ensure existing vegetation and its root system is obliterated to a minimum depth of 4 inches (100 mm). Several passes may be required based on equipment and soil conditions. Obtain Engineer's approval for tilling prior to excavating planting wells.

b. Unless shown otherwise in the contract documents, perform the excavation according to Table 2610.03-1:

Table 2610.03-1: Planting Well Excavation

ENGLISH UNITS		
Type of plant material	**Diameter**	**Excavation depth**
Bare root trees:		
Less than 1/2 "	Root spread +12 "	1 1/2 '
1/2 " to 1 3/4 "	3 '	2 '
1 3/4 " to 3 "	4 '	2 '
3 " to 4 "	5 '	3 '
4 " to 6 "	6 '	3 '
6 " and over	As specified	As specified
B & B trees & shrubs	Ball diameter + 16 "	Ball height + 8 "
Shrubs	24 "	18 "
Dwarf shrubs, vines, & ground cover	Root spread +12 "	18 "
Container grown	Cont. diameter + 16 "	Cont. height + 8 "
Seedlings[(a)]	Root spread +12 "	12 "
METRIC UNITS		
Type of plant material	**Diameter**	**Excavation depth**
Bare root trees:		
Less than 15 mm	Root spread +0.3 m	0.5 m
15 mm to 45 mm	1.0 m	0.6 m
45 mm to 80 mm	1.3 m	0.6 m

80 mm to 100 mm	1.5 m	1.0 m
100 mm to 150 mm	2.0 m	1.0 m
150 mm and over	As specified	As specified
B & B trees & shrubs	Ball diameter + 0.4 m	Ball height + 0.2 m
Shrubs	0.6 m	0.45 m
Dwarf shrubs, vines, & ground cover	Root spread +0.3 m	0.45 m
Container grown	Cont. diameter + 0.4 m	Cont. height + 0.2 m
Seedlings[(a)]	Root spread + 0.3 m	0.3 m
[(a)] Does not apply if a seedling planter is used.		

c. On slopes, measure the depth at the low point on outer edge of the planting well.
d. During excavation, further loosen the soil in the bottom of the planting well to a depth of 6 inches (150 mm). If an auger is used to excavate the planting well, use a spade or other approved method to remove the compacted, smooth surface on the sides of the well.
e. If the excavation is in an impervious soil, the planting may be relocated with the Engineer's approval.
f. For seedlings, a seedling planter may be used.

2. Backfill Material and Fertilizer.
a. Acquire backfill material for plantings from soil salvaged from the excavation of the planting well. Ensure backfill material has a uniform appearance and is loose, friable, and free of hard clods and rock 2 inches (50 mm) in diameter or larger.
b. For initial plantings and first year replacements, fertilize using 0-46-0 fertilizer thoroughly mixed with the backfill material at the following rates:
- 1 1/2 pounds (0.7 kg) of fertilizer per tree.
- 1/4 pound (0.1 kg) of fertilizer per shrub, seedling or vine.

c. Prior to the final watering, spread 20-10-10 chemically combined commercial fertilizer uniformly over the mulched area of each plant at the following rates:
- 1 pound (0.5 kg) per tree.
- 1/4 pound (0.1 kg) per shrub, seedling or vine.

3. Placing Backfill Material for Bare Root Plant Material.
a. Prior to planting, prune all broken or cut roots back to sound wood with a clean cut. Prune approximately 1/2 inch (15 mm) off all roots 1/2 inch (15 mm) diameter and larger.
b. Place the plant at the same grade line as it grew in the nursery. Backfill material may be firmed by tamping, but vigorous tamping will not be permitted.
c. Exercise care during backfill material placement to avoid damage to the roots.
d. At this point, water the plant as specified in Paragraph 6 of this article.

4. Placing Backfill Material for Balled and Burlapped Plant Material.

a. Before placing the plant, place and tightly firm the backfill material until the planting well is deep enough to set the top of the ball at the existing grade line. Place the plant and firmly pack the backfill material around the base of the ball to hold the plant in an upright position.

b. Ensure soil in the plant ball is moist at the time of planting. Remove any wire, twine, burlap, and so forth tied or wrapped around the stem of the plant.

c. Complete all of these processes with minimum disturbance of the soil ball:

1) After placement, remove the upper half of any wire mesh.

2) Cut and fold the remaining mesh into the bottom of the well.

3) Push the burlap from the top and sides of the ball to the bottom of the planting well.

4) Continue placing backfill material to the finished grade line.

5) After placement, remove the sides of all wooden baskets.

d. At this point, water the plant as specified in Article 2610.03, E, 6.

5. Placing Backfill Material for Container Grown Plant Material.

a. Thoroughly water container plants the day prior to planting.

b. Before placing the plant, firm the backfill material until the planting well is deep enough to allow the top of the soil in the container to match the existing grade line.

c. Carefully remove the plant from the container and place the plant in the planting well with minimum disturbance to the soil ball.

d. Firmly pack the backfill material around the base of the roots to hold the plant in an upright position. Continue placing backfill material to the finished grade line.

e. Carefully remove plants from all containers (plantable and non-plantable) in a manner that does not disturb the potted soil or the roots.

6. Watering and Final Shaping.

a. Water plants initially within 4 hours of planting unless otherwise directed by the Engineer.

b. Perform the initial watering by inserting a pipe to the bottom of the planting well and filling the well with water. At all times, perform watering at an extremely low pressure to prevent washing.

c. Reposition the plant as necessary to allow proper planting depth. Take necessary precautions to minimize root damage.

d. At this time, additional backfill material may be required to compensate for any settlement. Shape the final backfill material of the planting to form a 2 inch (50 mm) deep basin at the base of the plant.

e. After allowing the water to drain into the soil, the above procedure is repeated until the required amount of water necessary to thoroughly soak the backfill material with no further settlement has been applied.

f. Perform subsequent waterings as follows:

1) Fill each plant basin completely and allow the water to drain into the soil.

2) Refill the plant basin with water. Repeat this process until the required amount of water has been applied.

3) Penetration of the backfill material with a pipe or other means will not be allowed. Adjust water pressure to ensure no damage to the plant or displacement of soil or mulch.

g. Watering schedule is as follows:

Table 2610.03-2: Watering Schedule

Initial Watering	within 4 hours of planting
Second Watering	7 calendar days after the initial watering
Third Watering	14 calendar days after the second watering
Fourth and subsequent Waterings	21 calendar days apart until November 1
Second Growing Season (As applicable)	Water plants monthly from May through November

h. Ensure replacements receive the first three waterings as listed above, and then are watered monthly with the rest of the project.

i. Notify the Engineer prior to watering. If the Contractor requests, and the Engineer concurs, deviation from the watering schedule may be allowed. Weather and soil conditions that result in adequate water being available to the plant at the time of a scheduled watering may delay, delete, or reduce that watering as directed by the Engineer. The Engineer may request additional watering when dry soil conditions exist.

F. Staking and Guying.

1. Complete staking by the end of each day for all plant material planted during the day, unless otherwise approved by the Engineer. Use two stakes placed on opposite sides of the tree to stake all deciduous trees 1 inch to 2 1/2 inches (25 mm to 60 mm) in diameter, except multi-stemmed varieties of Hawthorn, Amur Maple, Serviceberry, and Russian Olive and all upright evergreens from 4 feet to 8 feet (1.2 m to 2.5 m) in height. Place one of the stakes on the southwest side of the tree or as directed by the Engineer. Extend the stakes to approximately 50% of the height of the tree or a maximum of 7 feet (2 m) from the ground after being driven until firm. Drive the stakes parallel to the trunk of the tree and in unexcavated soil.

2. Using ties approved by the Engineer, firmly tie between the two stakes all upright evergreens from 4 feet to 8 feet (1.2 m to 2.5 m) and all deciduous trees 1 inch to 2 1/2 inches (25 mm to 60 mm) in diameter, except multi-stemmed varieties of Hawthorn, Amur Maple, Serviceberry, and Russian Olive. Fasten ties to the stakes 6 inches (150 mm) from the top.

3. Guy deciduous trees over 2 1/2 inches (60 mm) in diameter and all evergreens over 8 feet (2.5 m) in height using three guys equally spaced about the perimeter of the tree. Use a collar encased with material specified in Article 4170.09, D, to attach guys to the tree.

Attach at a point approximately one-half to two-thirds of the distance from the ground to the top. Firmly attach the guys to anchors embedded in the ground.

4. Use anchors of the sizes in Table 2610.03-3:

Table 2610.03-3: Anchor Sizes

Tree Diameter	Anchor Shank		Anchor Minimum Disk Diameter
	Min. Dia.	Min. Length	
2 1/2 to 4 " (60 to 100 mm) over 4 " (over 100 mm)	1/2 " (13 mm) 3/4 " (20 mm)	24 " (0.6 m) 36 " (1.0 m)	4 " (100 mm) 5 " (125 mm)

5. Place anchors at a distance from the trunk of the tree which is approximately 50% the distance from the ground to the point where the collar is attached. Use the anchors specified in the contract documents or approved equal.

6. Approximately 1 foot (0.3 m) from the trunk of each tree not specified to be tied or guyed, drive one 5 foot (1.5 m) witness stake until firm. At shrub groups, drive a 5 foot (1.5 m) stake, until firm, 2 feet (0.6 m) outside the outermost shrubs at a frequency that defines the shape of the area. On living snow fence and seedlings, place one stake 2 feet (0.6 m) outside every tenth shrub or seedling along sides exposed to areas being mowed.

7. Use staking and guying material specified in Article 4170.09, D.

G. Mulching.

1. Furnish and place material as specified around trees, shrubs, vines, and seedlings according to the contract documents. Install mulch around the plant material within 4 calendar days after planting. Clear the following areas of all foreign material and vegetation and mulch:

- An area 6 feet by 6 feet (1.8 mm by 1.8 mm) around all trees,
- The entire area of shrub groups including 2 feet (0.6 m) outside the outermost shrubs, and
- A 9 inch (225 mm) radius around seedlings.

2. Use a temporary 6 foot x 6 foot x 4 inch (1800 mm x 1800 mm x 100 mm) form to facilitate placement of the mulch around the trees.

3. Repair mulch displaced or disturbed at no additional cost to the Contracting Authority.

H. Cleanup.

1. Remove excess soil and rocks from excavations, according to Article 1104.08, as directed by the Engineer.

2. Remove packing materials, burlap, brush, limbs and other trimmings, according to Article 1104.08.

3. Prepare disturbed areas and seed as specified in Article 2601.03, B.

4. Cleanup work will be considered incidental to construction work, and no extra compensation will be allowed.

I. Plant Establishment Period and Replacement.

1. The establishment period of one or two growing seasons as specified in the contract documents begins at the time the last plant is planted and incidental work related to the plantings is complete. If an establishment period is not specified in the contract documents, the establishment period is 1 year.

2. During the period of the contract, properly care for all plants. Water and weed them, spray with insecticides, cultivate, adjust stakes, wraps, and ties, and perform other work which is necessary to keep the plants in a live, healthy, and growing condition. Water plants as specified or as required by the Engineer.

3. Ensure the entire mulched area is free of vegetation. Vegetation in the mulch may be removed by pulling or cutting at ground level. In the 2 foot (0.6 m) area adjacent to the mulch, maintain vegetation to a height between 6 inches to 9 inches (150 mm to 225 mm). Replace plants damaged due to Contractor's carelessness at no additional cost to the Contracting Authority.

4. Obtain the Engineer’s approval for pesticide use for competing vegetation, insect, or disease control prior to application. Apply pesticides according to product label directions and current state laws and regulations.

5. Replace plants (except seedlings) that are not in a live, healthy, growing condition at the end of each growing season. Install replacement plants during the planting periods mentioned in Article 2610.03, E. If the contract is for one growing season, plant replacement plants in the fall of that year.

6. If the contract is for two growing seasons, plant replacement plants for the first growing season the following spring. Plant replacement plants for the second growing season in the fall of that year.

7. Evergreens will be checked at approximately August 15 and deciduous plants will be checked at approximately September 1. The Engineer will furnish a replacement list.

8. Supply replacement plants of the variety and size originally specified. Install as specified in Article 2610.03, E, including fertilizing and watering. The original mulch may be reused for replacement plants. An additional care period will not be required for second year replacement plants.

2610.04 METHOD OF MEASUREMENT.

Measurement for materials, satisfactorily installed will be measured as follows:

A. Plants.
By count for shrubs, trees, or vines in place.

B. Mulch.
Computed in cubic yards (cubic meters) in place by adding the volumes of each mulch area. The volume of each mulch area will be determined from the length and width measured to the nearest 0.1 foot (0.1 m) and depth to the nearest 0.05 feet (10 mm).

C. Fertilizer.
By count and weight (mass) of packages in pounds (kilograms) or by measurement at the time it is applied.

D. Water.
By units of 1000 gallons (kiloliter) at the time it is applied.

E. Tillage
Lump sum.

2610.05 BASIS OF PAYMENT.

A. Payment will be contract unit price as follows:

1. Plants.
Each for the number of shrubs, trees, or vines in place.

2. Mulch.
Per cubic yard (cubic meter).

3. Fertilizer.
Per pound (kilogram).

4. Watering.
Per 1000 gallon unit (kiloliter unit).

5. Tillage.
Lump sum.

B. Payments are full compensation for furnishing all materials, equipment and labor, and for performing all work necessary according to the contract documents including:

- Excavation and placing backfill,
- Wrapping, staking, tying, guying and pruning of trees,
- Maintenance during the establishment period, and
- Replacements.

C. When excavation is made in impervious soils or the excavation of a new planting well is directed by the Engineer, payment for the work will be as extra work according to Article 1109.03, B.

D. When substitution of a plant or planting material becomes necessary, payment will be made at the contract unit price for the substitute.

Section 2611. Furnish and Install Shrubs and Trees with Warranty

2611.01 DESCRIPTION.

A. Furnish and install tree and shrub materials of the type, class, species, grade, and size specified in the contract documents. The requirements in Section 2610 do not apply to this work unless stated otherwise in this specification.

B. The contract period for this work is two growing seasons for all plants.

2611.02 MATERIALS.

Meet the requirements of Section 4170.

2611.03 CONSTRUCTION.

A. Location of Plantings.

1. Notify the Engineer when utility locates are complete. After utility locates have been completed, the Contracting Authority will stake plant locations with coded flags. Location adjustments may be necessary.

2. Preserve coded flags adjacent to proposed plants until after final fall inspection. Remove material used for flagging, including tags and flagging tape, from the right of way according to Article 1104.08 immediately after final fall inspection is completed.

B. Planting.

1. Plant trees and shrubs and first year replacements between March 1 and May 15. Plant second year replacements between September 1 and September 30 for evergreens and between October 1 and November 30 for deciduous plants.

2. Contractor may use Articles 2610.03, A; 2610.03, D; or 2610.03, E as guidance for planting techniques to enhance survivability of plant materials, at no additional cost to the Contracting Authority.

3. Dig planting wells for single plants 3 feet (1 meter) toward the mainline highway from the flag location unless otherwise directed by the Engineer.

4. Excavate to a minimum diameter of 24 inches (600 mm) for trees and 18 inches (450 mm) for shrubs. Remove plants from containers (plantable and nonplantable) in a manner that does not disturb the roots. Remove twine, wire, and burlap around the stem of the plant. Remove containers, twine, wire and burlap from the project.

5. Install plants in a straight, upright manner. Ensure plants remain plumb throughout the contract period.

6. Install plants such that the root collar is at soil grade upon completion of installation of backfill, and the root collar remains at soil grade.

C. Staking and Guying.

1. The Contractor may use Article 2610.03, F as guidance for staking and guying to enhance survivability of plant materials. However, deciduous trees 6 feet (1.8 meters) or taller in height require staking and guying according to Article 2610.03, F.

2. Repair stakes and guys broken or damaged during the contract period. Remove stakes and guys according to Article 1104.08 in the fall of the second year.

3. Installation, repair, and removal of stakes and guys are incidental to planting and will not be paid for separately.

D. Mulching.

1. Furnish and apply mulch to all of the proposed trees and shrubs. Place mulch as shown in the contract documents to a depth of 3 inches (75 mm). Maintain an air space at the base of tree trunks and shrub canes.

2. Furnish and apply 2 inches (50 mm) of mulch in the fall of the second year to replenish the mulched areas of proposed plants after final plant replacement is complete. Ensure mulch bed is weed free prior to application of additional mulch.

3. Furnishing and applying mulch, as well as replacing mulch displaced or disturbed by the Contractor during the contract period, are incidental to planting and will not be paid for separately.

E. Filter Fabric.

1. Install filter fabric as follows:
- **a.** In areas to be mulched for proposed plants:
  - **1)** Rototill and hand rake the area to a loose condition that:
    - Is friable and free of debris, clods and rock, and
    - Has a smooth surface with a uniform appearance.
  - **2)** Place filter fabric flush with the ground.
- **b.** Secure fabric using staples complying with Article 4169.10, A.

2. Furnishing and installing filter fabric is incidental to planting and will not be paid for separately.

F. Plant Establishment Period and Replacement.

1. The plant establishment period will be the first two growing seasons. The establishment period will begin when the last plant of the initial installation is planted and incidental work related to the plantings is complete.

2. Use chemical methods to control competing vegetation in the entire mulched area throughout the contract period. Chemical methods to remove vegetation shall be applied by a Certified Pesticide Applicator - Category 6 (Right of Way).

3. Obtain the Engineer's approval prior to applying pesticides and herbicides used for competing vegetation, insect, or disease control. Use pesticides and herbicides according to product label directions.

4. Replace all plants that are not in a live, healthy, growing condition at the end of each of the first two growing seasons. Plant the replacement plants for the first growing season the following spring. Plant the replacement plants for the second growing season in the fall of that year. Ensure replacement plants are of the variety and size originally specified in the contract documents.

5. The Contractor may salvage and reuse the original mulch for replacement plants. If the original mulch is not available, suitable, or salvageable for reuse, place new mulch around the replacement plants. The Contractor is responsible for replacement costs.

G. Inspection of Plant Materials.

1. Verify correct species have been planted. Also verify compliance with ANSI Z60.1, American Standard for Nursery Stock.

2. The Engineer will inspect the plant materials, staking and guying, and mulch after the initial installation or on May 16, whichever comes first. This includes the inspection for:
- Size, number, location, alignment, and viability of plant materials,
- Correct depth and area of mulch, and

- Installation of stakes and guys as specified in the contract documents.

3. In August of each year of the establishment period, identify all dead plants using tie-on plastic flagging, all of one color, in a location that is easily seen.

4. By August 30 of each year, submit to the Engineer marked copies of the plant location plan sheets showing the number and species of replacement plants required for each location for that year. Submit tabulations of the total number of replacement plants of each species on each plan sheet. Indicate the total number of replacement plants for the project.

5. The Contracting Authority will inspect the plant materials in the fall of each growing season. The Contracting Authority will verify, during this inspection, the number of living plants and determine if the correct species of plants were used.

6. The Contracting Authority will also inspect and verify any replacement plant materials after installation.

2611.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Shrubs with the specified mulch: by count of live shrubs installed.

B. Trees with the specified mulch: by count of live trees installed.

2611.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price for each Tree, Furnished and Installed according to the contract documents.

B. Payment will be the contract unit price for each Shrub, Furnished and Installed according to the contract documents.

C. For each time each species is requested for substitution, a $250.00 price reduction will be charged. When substitutions are made, the Engineer will price adjust downward. No participation in price increases will be incurred.

D. Payments will be made in increments according to the following schedule:

1. After Initial Installation is Complete.
Sixty-five percent of the placed quantity will be paid for all live plants of each size and variety installed with the specified mulch, and meeting the staking and guying requirements. This payment will be made after the initial inspection by the Engineer.

2. End of the First Growing Season.

a. Payment will be based on the total project's first year survival rate. Plants not in compliance with the contract documents will be considered dead.

b. A percent of the placed quantity will be paid for each tree and shrub correctly installed according to the schedule in Table 2611.05-1:

Table 2611.05-1: Payment, End of First Growing Season

Total Project Survival Rate	% of Placed Quantity
85 - 100%	10%
60 - 84%	5%
Below 60%	0%

3. After First Year Replacement Installation.

After replacement plants have been installed, 5% of the placed quantity will be paid for all plants considered alive at the end of the previous growing season including all plants replaced.

4. End of the Second Growing Season.

a. Payment will be based on the total project's second year survival rate. Plants not in compliance with the contract documents will be considered dead.

b. A percent of the placed quantity will be paid for each tree and shrub correctly installed according to the following schedule. Payment for plants requiring replacement will be after replacement is complete. Payment will be according to the schedule in Table 2611.05-2:

Table 2611.05-2: Payment, End of Second Growing Season

Total Project Survival Rate	% of Placed Quantity
85 - 100%	20%
60 - 84%	10%
Below 60%	0%

E. Payments are full compensation for:

- Furnishing all materials, equipment, and labor,
- Performing all work necessary according to the contract documents including excavating, placing backfill, mulching, pruning of trees and shrubs, replacements, and
- Methods used to ensure the survivability of the planted trees and shrubs.

F. When excavation is made in impervious soils or the excavation of a new planting well is directed by the Engineer, the Contractor will be paid for this extra work according to Article 1109.03, B.

Section 2612. Mowing

2612.01 DESCRIPTION.

Mow a strip of vegetation along the edges of shoulders, in the medians, and within designated interchange areas. Perform incidental hand mowing around obstacles.

2612.02 MATERIALS.

None.

2612.03 MOWING.

A. Equipment.

1. Use tractors with sickle type mowers, underbody rotary mowers, gang type rotary mowers, or other types the Engineer approves. Equip rotary mowers with a suction type blade and safety chains or other approved protective devices. Ensure sickle bar mowers have protective shields on all sections. Replace broken sections to ensure a clean, smooth cut. Make available on the project an extra set of operable blades to fit available equipment.

2. Equip each tractor with an amber revolving light:

- Visible from the front and rear,
- Mounted at least 10 feet (3 m) high as measured to the lamp axis, and
- Flashes between 60 and 120 times per minute.

3. In lieu of an amber revolving light, an amber strobe light may be used.

4. Equip each tractor with a standard triangular slow moving vehicle emblem mounted 4 feet (1.2 m) above the ground with a dimension of 13 1/2 inches (345 mm) per side, a red or fluorescent orange flag, and a rear view mirror. Locate as shown in the contract documents. Use a flag that is 16 inches by 16 inches (400 mm by 400 mm) minimum.

5. Set mower cutting height so that, after completion of the mowing operation, the height of remaining stubble averages 6 inches ± 1 inch (150 mm ± 25 mm).

B. Types.

1. General.

a. The contract documents will specify the type of mowing required. The Engineer will issue a Notice to Proceed to the Contractor for each mowing, based on the projected date when 50% of the vegetation will reach 14 inches (350 mm).

b. Mow a strip of vegetation 15 feet (4.5 m) wide immediately adjacent to the edges of the shoulders and throughout the length of the project. This also includes outside and inside ramp shoulders.

2. Metro Mowing.

a. Metro mowing consists of three to four mowings as stated in the contract documents. Approximate start dates are usually prior to Memorial Day, late June to early July, early to mid August (in a four mowing contract), and after Labor Day.

b. Mow the entire median. In addition to mowing along the shoulder and in the median, mow all other accessible areas including foreslopes, backslopes, ditch bottoms, interchange areas, islands, and along fences.

3. Spring and Fall Mowing.

a. Spring and fall mowing consists of two to four mowings, as stated in the contract documents. Approximate start dates are usually prior to Memorial Day, late June to early July, early to mid August (in a four mowing contract), and after Labor Day.

b. Mow the entire median.

4. Fall Mowing.

a. Fall mowing consists of one mowing, usually after Labor Day.

b. Mow the entire median.

C. Requirements.

1. Prior to mowing, examine the area to be mowed for objects that may cause damage. Immediately remove objects thrown onto the roadway.

2. Advance roadway warning signs will not be required.

3. When not mowing, limit mowing equipment travel to the right hand shoulder of the main line pavement. Do not travel in the traffic lanes except to cross the pavement for purposes of mowing adjacent to the left shoulder.

4. Do not use existing median crossovers. These are for emergency operations only. Confine turnarounds to interchanges.

5. Unless specified otherwise in the contract documents, perform all work during the hours of 30 minutes after sunrise to 30 minutes before sunset.

6. When mowing along the main line and right ramp shoulders, progress in the same direction as traffic. Mowing along the left ramp shoulder in the direction opposite the flow of traffic will be permitted if it can be accomplished without equipment using the left shoulder. Conduct mowing operations so that the equipment does not encroach on the traveled way. When mowing behind guardrail, the direction of travel may be opposite that of adjacent traffic.

7. To avoid leaving a ragged appearance, set the speed of the mowing equipment not to exceed the ability of the mower to cut cleanly. Monitor the operation and maintain the cutting edges in a sharp condition or

replace as necessary to prevent unmown strips (rooster tails) or damage to vegetation.

8. Perform mowing in a single pass. If any unmown strip or damage to vegetation is encountered, immediately suspend the operation and take corrective measures, at no additional cost to the Contracting Authority. The Engineer may inspect cutting edges at any time. Additional mowing widths are permissible to take advantage of wider mowing equipment which may be difficult to modify to the required width. The Contractor will not be paid for this additional mowing width.

9. The contract documents will specify the limits of mowing at interchanges and rest areas, if applicable. When more than one pass of the mowing equipment is required, lap successive passes to avoid leaving uncut vegetation. More than one pass of the mowing unit may be necessary to accomplish the mowing. Bunching or windrowing of the mowed vegetation will not be permitted.

10. Hand equipment will be required for areas inaccessible to other equipment, and for trimming around and under delineator posts, sign posts, guardrail, bridges, culverts, or other obstructions. Complete the hand trimming within 3 working days after the adjacent area is mowed with the tractor. This may include hand pulling of weeds. At the direction of the Engineer, replace all roadside trees, shrubs, or appurtenances such as delineator posts, signs, tile systems, tile outlets, etc. damaged due to the mowing operations, at no additional cost to the Contracting Authority.

11. When wet soil conditions result in rutting, suspend mowing. At the direction of the Engineer, repair rutting damage caused by the mowing operation.

12. Parking of Contractor vehicles and equipment will be permitted within the Interstate right-of-way only at locations designated by the Engineer. In no case will they be allowed closer than 50 feet (15 m) from the shoulder. Parking of private vehicles within the Interstate right-of-way is prohibited.

2612.04 METHOD OF MEASUREMENT.

The area for Roadside Mowing, in acres (hectares), will be shown in the contract documents. The quantity will be based on main line, center line, and ramp base line stationing, with the area calculated in. The length of shoulders at bridges will be deducted when calculating the quantity. The quantity at intersections of main line and ramp shoulders will be calculated so there will not be a deduction or a duplication of quantities. Additional mowing required around guardrails, obstacles, and median crossovers will not be measured separately.

2612.05 BASIS OF PAYMENT.

A. Payment for Roadside Mowing will be the contract unit price per acre (hectare) indicated in the contract documents.

B. Payment is full compensation for mowing according to the contract documents, including:

- Mowing around guardrails, signs, delineators, drainage structures, bridges, and in islands, and
- Trimming with hand equipment.

C. When the Engineer determines mowing is not necessary due to factors such as the lack of vegetation growth during drought conditions, but hand trimming is still required, payment will be 25% of the contract unit price per acre (hectare).

DIVISION 41. CONSTRUCTION MATERIALS

Section 4100. General Provisions

4100.01 DESCRIPTION.

A. Apply Section 1106 to all materials. Apply Article 1101.02 when a standard specification or test method is included by reference using abbreviations. These references are to be construed as the latest standard specification or test method published prior to the date of the contract.

B. When the Specifications do not describe material quality, use only high quality materials capable of withstanding normal installation stresses.

4100.02 INSPECTION ARRANGEMENTS.

A. Notify the Contracting Authority at its central office of the source of the various materials required for each project. Provide notification sufficiently in advance of any shipment of materials so that inspection may be arranged at the producing plant if the Engineer so elects.

B. If the quantity of materials rejected for failure to meet specification requirements is 20% or more of the material presented for inspection, the inspection operation may be suspended until the producer has either:

- Regraded the material, or
- Revised the production methods to produce material meeting requirements of this specification.

C. A producer or jobber may request inspection of material for warehouse stock or for use in plants where stocks of materials (inspected and reserved for

use in construction or maintenance in which the Contracting Authority has an interest) cannot be kept segregated from materials which will be used on other work. The cost of inspection of the materials which have been inspected and reserved, but are later diverted to other uses not connected with this construction or maintenance, may be charged to the producer or jobber.

D. At the option of the Engineer, acceptance may be based on:
- Tests of official samples,
- Tests of producer's samples,
- Producer's certifications,
- Visual inspection, or
- Any combination of the above.

E. Any material furnished on a certification, approved brand, or producer's sample basis may be subject to additional testing or inspection, and approval on this basis may be withdrawn at any time.

F. Laboratory facilities may be required as provided in Section 2520 for the inspection of any material.

4100.03 MEASUREMENT OF LIQUID BITUMINOUS MATERIALS.
Liquid bituminous materials will be measured in U.S. standard gallons (liters) at a base temperature of 60°F (15°C). Volumes measured at other temperatures will be corrected to a base 60°F (15°C), using the appropriate Volume Correction Factor in Table 2 (Table 1 for metric units) of ASTM D 4311.

A. Field Measurement.

1. Before each shipment of bitumen to be paid for directly by the Contracting Authority is unloaded, allow the Engineer the opportunity to make the measurements that are necessary to determine the net quantity of materials delivered.

2. Payment will be based on billed volume except when the Engineer has made field measurements to determine the quantity of material delivered. When quantities computed from field measurements agree within 1.0% of the billed volume, payment will be based on the billed volume.

B. Shipments.
Unless otherwise provided in the contract, Materials I.M. 437 applies.

4100.04 METHODS OF SAMPLING AND TESTING.
Unless designated otherwise in the contract documents or the Office of Materials Test Method No. Iowa or Materials I.M.s, perform materials testing using apparatus and methods that comply with requirements of the current AASHTO "Standard Specifications for Highway Materials and Methods of Sampling and Testing," including published interim standards.

4100.05 UNITS OF AGGREGATE FOR SAMPLING.

A. Aggregates to be used may be required to be separated into distinct units. Keep these separate for a sufficient time to provide for proper testing and inspection. Ensure each unit meets the requirements for the kind of material represented.

B. When the Engineer approves, aggregates from more than one approved source may be combined by accurately proportioning each material. Ensure each source meets the specification requirements for the intended use.

C. When aggregates from more than one approved source are combined to meet PCC requirements, ensure the combination of coarse aggregate meets requirements of Articles 4115.03 and 4115.04. Ensure the combination does not contain more than 0.8 of the maximum percentage of any objectionable materials specified in Article 4115.02. Aggregates for use in such combinations will be accepted only with the Engineer's approval and according to provisions stated in that approval. The provisions include the following:

- The maximum percentage of each of the objectionable materials that the aggregate from each source may contain, and
- The percentage of aggregate from each source that the combination is required to contain.

4100.06 TESTING ZINC COATING.

A. The weight (mass) of coating on zinc-coated articles will be determined using Iowa DOT Office of Materials Laboratory Test Methods. Normally, Test Method No. Iowa 802 will be used. Test Method No. Iowa 803 may be used when allowed by the coating specification or when the Engineer approves nondestructive testing. Method 804 may be used when a coating is specified by uniformity.

B. Test specimens will be selected after delivery to the project site, unless arrangements have been made for sampling them at the point of production or some intermediate point.

4100.07 GALVANIZING.

When galvanizing is called for and the requirements are not specified in the contract documents, apply the requirements listed below. Determine the weight (mass) of both zinc and cadmium coatings according to Article 4100.06.

A. Malleable Iron or Steel Castings.
Apply ASTM A 153, Class A.

B. Rolled, Pressed, and Forged Hardware Articles.
Except for those that are included under Classes C and D, apply ASTM A 153, Class B.

C. Drive Screws and Bolts (over 3/8 inch (8.5 mm) in diameter), Washers 3/16 inch (4.8 mm) and 1/4 inch (6.4 mm) Thick, and Similar Articles.
Apply ASTM F 2329.

D. Screws, Stove Bolts, and Bolts (3/8 inch (9.5 mm) and under in diameter), Washers Under 3/16 inch (4.8 mm) Thick, Rivets, Nails, and Similar Articles.
Apply ASTM F 2329.

E. Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip, 1/8 inch (3 mm) Thick and Heavier.
Apply ASTM A 123.

F. Welded and Seamless Steel Pipe and Tubing.
Apply ASTM A 53.

4100.08 CONCRETE COMPRESSION TEST SPECIMENS.

A. Concrete compression test specimens may be cast:
- According to Materials I.M. 315, or
- Horizontally in molds with a diameter of 4 1/2 inches (114.3 mm) and length of 9 inches (228.6 mm) or a diameter of 6 inches (152.4 mm) and length of 12 inches (304.8 mm).

B. When compressive strength is a specification requirement, use of horizontal molds is subject to agreement of the Contractor.

Section 4101. Portland Cement

4101.01 GENERAL REQUIREMENTS.

A. ASTM C 150 Cements.

1. Unless specified otherwise, meet the requirements of ASTM C 150.

2. Limit the alkali content expressed as total equivalent sodium oxide to no more than 0.60% for all cements.

B. ASTM C 595 Cements.
Unless specified otherwise, meet the requirements of ASTM C 595 and the following requirements:

1. Pozzolan constituent of Type IP cement no more than 25 weight (mass) percent of the Portland-pozzolan cement.

2. Slag constituent of Type IS cement no more than 35 weight (mass) percent of the Portland blast-furnace slag cement.

3. No Class C fly ash in Type IP cement.

4. To produce blended cement, use Portland cement meeting the requirements of Article 4101.01, A, but with the alkali content expressed as a total equivalent being no more than 0.75%.

C. Cement Type Usage.
Comply with the following unless specified otherwise:

1. Type I or Type II cement may be used for pavements, structures, and other applications. Type III cement may be used in precast and prestressed concrete only.

2. Type IP or Type IS cement may be furnished at the Contractor's option when Type I or Type II cement is specified. Apply the limitations of the following articles:
- 2301.02, B.
- 2403.02, B.
- 2407.02.
- 2412.02.
- 2413.02.
- 2424.02.
- 2426.02.
- 2507.02.
- 2513.02.
- 2529.02.
- 2530.02.
- 2539.02.

3. Use the same unit volume of Type IP or Type IS cement in the concrete that is specified for Type I or Type II cement.

D. Lumps in Cement.
Cement which contains 5.0% or more of lumps retained on a No. 20 (850 µm) sieve will be rejected. Cement which contains less than 1.0% of lumps may be used without adjustment in the batch. Cement which contains from 1.0% to 5.0% of lumps, will have the batch weights (mass) of cement used increased by 2.0% of the original value for each 1.0% or fraction of 1.0%.

E. Air Entrainment.
Accomplish by the addition, at the time of mixing, of an approved air entraining admixture specified in Section 4103. Do not use air entraining cement.

4101.02 ACCEPTANCE AND INSPECTION.
Use Portland cement manufactured, inspected, tested, and accepted according to Materials I.M. 401. Use Portland cement according to Materials I.M. 401.

4101.03 LIMITATIONS.
Cement will be tested for lumps before being used if it has been stored:
At the work site or in local warehouses for more than 60 calendar days, or
In the producer's silo for more than one year.

Section 4102. Water for Concrete and Mortar

4102.01 GENERAL REQUIREMENTS.

A. Use water for concrete or mortar that is free from detrimental amounts of oil, salts, acids, alkali, organic matter, or other objectionable substances. Do not use recycled wash water in concrete.

B. Where the source of water is relatively shallow, maintain it at a suitable depth and screen the intake to exclude objectionable amounts of silt, mud, grass, or other foreign material. Filter, or otherwise clarify, water containing suspended matter in excess of 2000 ppm.

C. Use water meeting the following quality requirements:

1. Hardness, determined as calcium carbonate, not more than 750 ppm.

2. Methyl Orange, Alkalinity, determined as calcium carbonate, not more than 1000 ppm.

3. Phenolphthalein Alkalinity, determined as calcium carbonate, not more than one-half the methyl orange alkalinity.

4. Total Acidity, determined as calcium carbonate, no more than 100 ppm.

D. Potable water obtained from a municipal supply, suitable for drinking, may be accepted without testing.

Section 4103. Liquid Admixtures for Portland Cement Concrete

4103.01 GENERAL REQUIREMENTS.

A. Comply with AASHTO M 154 for air entraining admixtures and AASHTO M 194 for other liquid admixtures.

B. Unless the Engineer approves, do not use admixtures containing more than 1.0% chloride ions.

C. Inspection and acceptance of liquid admixtures for PCC will be according to Materials I.M. 403.

D. Air Entraining Admixtures.
Stir, agitate, or circulate air entraining admixtures prior to use to ensure a uniform and homogeneous mixture.

E. Retarding and Water Reducing Admixtures.

1. Use retarding and water reducing admixtures compatible with the air entraining agent used.

2. As approved by the Engineer, use admixtures either:
- In amounts recommended by the manufacturer for conditions which prevail on the project, or
- According to Materials I.M. 403.

3. When used, introduce admixtures into the mixer after all other ingredients are in the mixer. The Engineer may approve other procedures.

4. Agitate retarding and water reducing admixtures prior to and during their use according to Materials I.M. 403.

5. When supplementary cementitious materials are used in the concrete, apply the liquid admixture dosage rate to both the cement and supplementary cementitious materials weight (mass) combined.

F. Other Admixtures.
Other admixtures may be used with the Engineer's approval and according to the manufacturer's recommendations.

Section 4104. Burlap for Curing Concrete

4104.01 GENERAL REQUIREMENTS.

A. Meet the requirements of AASHTO M 182 (10 ounces (310 g)) except as modified below. Use jute or kenaf fabric that has not been in contact with wool, sugar, molasses, or other substance that might have an objectionable effect on fresh concrete.

B. In lieu of the minimum weight (mass) specified, a sample dried in an oven at a temperature of 215°F to 225°F (102°C to 107°C) for 10 minutes weighing no less than 8.0 ounces per square yard (270 g/m^2) will be considered acceptable.

C. Sew burlap into covers of width sufficient to cover the full width of concrete surface to be covered, plus one foot (0.3 m). In sewing the covers, place all welt seams on the same side of the sheet.

Section 4105. Liquid Curing Compounds

4105.01 GENERAL REQUIREMENTS.
Comply with AASHTO M 148 and the following requirements.

4105.02 SPRAYABILITY.
Use compounds of a consistency that they can be readily applied by spraying to a uniform coating at a material temperature above 40°F (4°C).

4105.03 MOISTURE RETENTION.
White pigmented liquid curing compounds, when tested in accordance with ASTM C 156 using an application rate of 200 square feet per gallon (5 m^2/L) shall restrict the loss of water to not more than 0.20 kg/m^2 in 24 hours or 0.40 kg/m^2 in 72 hours.

4105.04 DRYING TIME.
Use liquid curing compounds that:
- Dry to the touch in no more than 4 hours, and
- Do not track off the concrete when walked upon after 12 hours.

4105.05 WHITE PIGMENTED COMPOUNDS.

A. Use compounds consisting of finely ground white pigment and vehicle, ready mixed for use without alteration.

B. Ensure the pigment does not:
- Settle excessively or cake in the container, and
- Thicken in storage to cause a change in consistency which may result in a nonuniform spray.

C. Use a compound that after being sprayed on a test slab and drying has an apparent daylight reflectance no less than 60% relative to magnesium oxide.

D. Agitate the compound just prior to it being removed from the container. Agitate it continuously during application.

4105.06 DARK COLORED COMPOUNDS.
Use asphalt emulsion or asphalt cut back with a volatile solvent. Use a mixture containing no less than 50.0% asphalt. Use an application rate of no less than 0.08 gallon per square yard (0.36 L/m^2) (12.5 square yards per gallon (2.8 m^2/L)).

4105.07 CLEAR COMPOUNDS.
Apply the following in lieu of other requirements of this section:

A. Use clear liquid membrane curing compounds complying with the requirements of AASHTO M 148, Type 1-D, Class A. Use only one type of compound on a structure. Do not use different compounds on the same structure.

B. Inspection and acceptance of clear compounds for curing will be according to Materials I.M. 405.07.

4105.08 CARRYOVER STOCK.

A. Approvals of individual lots of curing compound are valid for the year in which the compound is manufactured.

B. Lots of 5 barrels (1000 L) or more of white pigmented compound which have been carried over the winter will be retested if stored in a heated warehouse.

C. Do not use carryover lots of white pigmented compound less than 5 barrels (1000 L).

D. Do not use carryover lots of curing compounds which have been frozen.

Section 4106. Plastic Film and Insulating Covers for Curing Concrete

4106.01 PLASTIC FILM.

A. Comply with the following:

1. Tough, pliable, moisture proof, and durable

2. Material will retain its moisture proof properties while it is in place on the surface of the concrete.

3. White pigmented material that is opaque.

4. No less than 0.85 mils (21 µm) thick.

5. No less than 70% daylight reflectance relative to magnesium oxide when tested according to ASTM E 1347.

B. If the thickness of plastic film is less than 3.4 mils (85 µm), do not use it more than once for curing concrete.

4106.02 INSULATING COVERS.

Comply with the following:

A. Cellulosic fiber sheeting with a nominal 3/4 inch (20 mm) thickness.

B. Similar to sheeting specified in ASTM C 208.

Section 4107. Plastic Film for Subgrade Treatment

4107.01 GENERAL REQUIREMENTS.

A. Use polyethylene film no less than 0.85 mils (21 µm) thick, either clear or white pigmented type. Use strips wide enough to provide a lap no less than 12 inches (0.3 m) between adjacent strips.

B. Plastic film which has been used no more than once for curing concrete pavement and has been salvaged in usable condition may be used for treatment of subgrade.

Section 4108. Supplementary Cementitious Materials

4108.01 FLY ASH.

A. Comply with AASHTO M 295, either Class F or Class C, except the value of available alkalies is not to exceed 1.50% as determined by Materials I.M. 491.17. Sources with fly ash between 1.5% and 2.5% available alkalies may be approved based on satisfactory results of the mortar bar expansion test specified in Materials I.M. 491.17. For Class C fly ash, the pozzolanic activity test with lime will not be required.

B. When Class F is required, a Class C fly ash with minimum total oxides (SiO_2 + Al_2O_3 + Fe_2O_3) of 66% and minimum SiO_2 of 38% may be used.

C. Approval of the source of fly ash will be required. This is to be based on fly ash produced when the power plant is using specific materials, equipment, and processes. Any change in materials, equipment, and processes voids the source approval, and a new approval of the source will be required.

D. Inspection and acceptance of fly ash will be according to Materials I.M. 491.17.

4108.02 GROUND GRANULATED BLAST FURNACE SLAG.

Comply with ASTM C 989 Grade 100 or Grade 120. Approval of the source of GGBFS will be required. Inspection and acceptance of GGBFS will be according to Materials I.M. 491.14.

Section 4109. Aggregate Gradations

4109.01 DESCRIPTION.

A. Coarse Aggregate
Particles retained on the No. 4 (4.75 mm) or larger sieve.

B. Fine Aggregate.
Particles passing the No. 4 (4.75 mm) sieve.

4109.02 GRADATION.

Refer to the Aggregate Gradation Tables in the Appendix.

4109.03 UNACCEPTABLE MATERIALS.

A. Article 1106.04 applies. Stockpiles contaminated with organic or other foreign materials may be cause for rejection of the aggregate. The Engineer will determine acceptability by visual examination or other methods.

B. The Engineer may reject the use of material from ledges or beds that individually do not pass the quality requirements for the intended aggregate product. Specific production methods may be required to permit the use of material from marginal ledges or beds.

Section 4110. Fine Aggregate for Portland Cement Concrete

4110.01 DESCRIPTION.
Natural sands resulting from disintegration of rock through erosional processes. Acquire mineral aggregate from an approved source as described in Materials I.M. 409.

4110.02 GRADATION.
Meet the requirements for Gradation No. 1 of the Aggregate Gradation Table, Article 4109.02.

4110.03 QUALITY.

A. Meet the requirements of Table 4110.03-1:

Table 4110.03-1: Test Limits and Methods

Fine Aggregate Quality	Test Limits	Test Method
Shale and Coal	2.0% (maximum)	Materials I.M. 344
Mortar Strength	6000 psi (41.4 MPa) (minimum)	Office of Materials Test Method No. Iowa 212

B. The Engineer may require additional mortar strength testing for sources where quality changes.

Section 4111. Class L Fine Aggregate for Portland Cement Concrete

4111.01 DESCRIPTION.
Natural sands resulting from disintegration of rock through erosional processes. Acquire mineral aggregate from an approved source as described in Materials I.M. 409. Use Class L fine aggregate in Class L concrete mixtures as specified in Materials I.M. 529.

4111.02 GRADATION.
Meet the requirements for Gradation No. 1 of the Aggregate Gradation Table, Article 4109.02. No more than 45% is to pass one sieve and be retained on the sieve with the next higher number when the fine aggregate is sieved through the following sieves: No. 4, No. 8, No. 16, No. 30, No. 50, and No. 100 (4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300µm, and 150 µm).

4111.03 QUALITY.
Meet the requirements of Table 4111.03-1:

Table 4111.03-1: Test Limits and Methods

Fine Aggregate Quality	Test Limits	Test Method
Shale and Coal	2.0% (maximum)	Materials I.M. 344
Mortar Strength	5200 psi (35.9 MPa) (minimum)	Iowa DOT Materials Laboratory Test Method No. Iowa 212

Section 4112. Intermediate Aggregate for Portland Cement Concrete

4112.01 DESCRIPTION.

A. Crushed carbonate stone chips or pea gravel from approved sources as described in Materials I.M. 409. Coarse natural sand resulting from disintegration of rock through erosional processes, without addition of crushed over-sized material may be used in place of the intermediate and fine aggregate.

B. For crushed limestone or dolomite chips, meet the durability class required for the coarse aggregate. Acquire uncrushed pea gravel or coarse sand from any PCC approved durability class gravel. When the gravel durability is lower than the coarse aggregate durability requirements, the pea gravel is not to exceed 15% of total aggregate in the mix. Aggregate meeting the requirements of Section 4117 will be considered coarse sand.

4112.02 GRADATION.

A. Intermediate Aggregate.
For gradations, intermediate aggregate is considered coarse aggregate. Meet the following gradation limits:

Sieve Size	% Passing
1/2 inch (12.5 mm)	95-100
No. 8 (2.38 mm)	0-10

B. Coarse Sand.
Meet the following gradation limits:

Sieve Size	% Passing
1/2 inch (12.5 mm)	100
3/8 inch (9.5 mm)	90-100
No. 4 (4.75 mm)	75-95
No. 8 (2.36 mm)	60-90
No. 30 (600 µm)	10-60
No. 200 (75 µm)	0-1.5

4112.03 QUALITY.

A. Intermediate Crushed Stone.
Meet the requirements of Table 4112.03-1:

Table 4112.03-1: Aggregate Quality

Aggregate Quality	Maximum Percent Allowed	Test Method
Alumina[(a)]	0.5	Office of Materials Test Method No. Iowa 222
A Freeze	6	Office of Materials Test Method No. Iowa 211, Method A
Clay Lumps and Friable Particles	0.5	Materials I.M. 368
[(a)] If the Alumina value fails, determine the A Freeze value for specification compliance.		

B. Pea Gravel and Coarse Sand.

1. For the portion of coarse sand passing the No. 4 (4.75 mm) sieve, meet the quality requirements of Section 4110.

2. For pea gravel and the portion of coarse sand retained on the No. 4 (4.75 mm) sieve, meet the quality requirements of Table 4112.03-2:

Table 4112.03-2: Maximum Permissible Amounts of Objectionable Materials

Objectionable Materials.	Maximum Percent Allowed	Test Method
Coal and carbonaceous shale	0.5	AASHTO T 113
Total of all shale, similar objectionable materials, coal and iron combined	1.0	AASHTO T 113
Organic Materials, except coal	0.01	Office of Materials Test Method No. Iowa 215
Unsound chert particles retained on 3/8 inch (9.5 mm) sieve (Nonstructural concrete)	3.0	Materials I.M. 372
Unsound chert particles retained on 3/8 inch (9.5 mm) sieve (Structural concrete)	2.0	Materials I.M. 372
Note: Chert particle which break into three or more pieces when subjected to the freezing and thawing test will be considered unsound. Chert in aggregate produced from limestone sources is defined as unsound when any of the fractions of the crushed or uncrushed chert do not meet the soundness requirements.		

Section 4115. Coarse Aggregate for Portland Cement Concrete

4115.01 DESCRIPTION.

Gravel or crushed stone particles meeting one of the aggregate durability classes listed below. Acquire aggregates from an approved source meeting the requirements of Materials I.M. 409.

A. Class 2 Durability.
No deterioration of pavements of non-Interstate segments of the road system after 15 years and only minimal deterioration in pavements after 20 years of age.

B. Class 3 Durability.
No deterioration of pavements of non-Interstate segments of the road system after 20 years of age and less than 5% deterioration of the joints after 25 years.

C. Class 3i Durability.
No deterioration of pavements of the Interstate Road System after 30 years of service and less than 5% deterioration of the joints after 35 years.

4115.02 QUALITY.

Meet the requirements of Tables 4115.02-1 and 4115.02-2:

Table 4115.02-1: Aggregate Quality

Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion (Cr. Stone)	50	AASHTO T 96
Abrasion (Gravel)	35 (may be increased by 0.1% for each 1% of particles with at least one fractured face)	AASHTO T 96
Alumina[(a)]	0.5	Office of Materials Test Method No. Iowa 222
A Freeze	6	Office of Materials Test Method No. Iowa 211, Method A
Clay Lumps and Friable Particles	0.5	Materials I.M. 368

(a) If the Alumina value fails, determine the A Freeze value for specification compliance. Office of Materials Test Method No. Iowa 222 does not apply to gravel.

Table 4115.02-2: Maximum Permissible Amounts of Objectionable Materials

Objectionable Materials.	Maximum Percent Allowed	Test Method
Coal and carbonaceous shale	0.5	Materials I.M. 372
Total of all shale, similar objectionable materials, and coal combined	1.0	Materials I.M. 372
Organic Materials, except coal	0.01	Office of Materials Test Method No. Iowa 215
Unsound chert particles retained on 3/8 inch (9.5 mm) sieve (Nonstructural concrete)	3.0	Materials I.M. 372
Unsound chert particles retained on 3/8 inch (9.5 mm) sieve (Structural concrete)	2.0	Materials I.M. 372

Note: Chert particle which break into three or more pieces when subjected to the freezing and thawing test will be considered unsound.

Chert in aggregate produced from limestone sources is defined as unsound when any of the fractions of the crushed or uncrushed chert do not meet the soundness requirements.

4115.03 GRADATION.

Meet the requirements of Article 4109.02 and Table 4115.03-1:

Table 4115.03-1: Aggregate Gradations

Mix Class (Materials I.M. 529)	Mix Number (Materials I.M. 529)	Gradation Numbers (Article 4109.02)
D	57, 57-6	3 or 5
A, B, C	2 to 8, V47B	3, 4, or 5
M	4	3, 4, or 5
A, B, C, M	V	7

4115.04 AGGREGATE USE DURABILITY REQUIREMENTS.

A. Meet the requirements of Table 4115.04-1:

Table 4115.04-1: Aggregate Use Durability Requirements

Specification Section Number	Minimum Durability Class Required			Use
	3i	3	2	
2122, 2201, 2212, 2213, 2301, 2302, 2310, 2529, 2530 Interstate System Primary System Other	X*	X*	X	PCC Paved Shoulders, Base, Base Repair, Base Widening PCC Pavement, Widening, PCC Overlay, Finish Patches, and Bridge Approaches
2403			X	Structural Concrete
2406 (See 2403)			X	Concrete Structures
2407			X	Precast Units
2407, 2501		X		Prestressed Units, Concrete Piles
2412 (See 2403)			X	Concrete Bridge Decks
2413 (See 2413.02, D, 1)		X		Bridge Deck Surfacing, Repair, & Overlay
2414 (See 2403)			X	Concrete Railings
2415 (See 2403)			X	Concrete Box, Arch, & Circular Culverts
2416 (See 4145)			X	Rigid Pipe Culverts
2424			X	Shotcrete
2503 (See 2403)			X	Storm Sewers (Catch Basins, Intakes, & Utility Access)
2505 (See 2403)			X	Guardrails (Concrete End Anchorage)
2511, 2515 (See 2403)			X	PCC Sidewalks, Paved Driveways
2512 (See 2403)			X	PCC Curb & Gutter
2513 (See 2403)			X	Concrete Barrier
2516 (See 2403)			X	Concrete Walls and Steps

2517 Primary System Other		X	X	Railroad Approach Sections
2522 (See 2403)			X	Tower Lighting (Concrete Footings & Foundations)
2523 (See 2403)			X	Highway Lighting (Concrete Footings & Foundations)
2524 (See 2403)			X	Highway Signing (Concrete Footings & Foundations)
2525 (See 2403)			X	Traffic Signals (Concrete Footings & Foundations)
* For patches and PCC base repair, Class 2 durability or better aggregate will be required if the existing pavement was constructed of Class 2 or lower durability aggregate. If the existing pavement was constructed of Class 3 or Class 3i durability aggregate, use Class 3 aggregate or better and Class 3i aggregate, respectively, in the repair.				

B. Use crushed stone coarse aggregate for:

- Aesthetic concrete cast with form liners or rustication. This includes Mechanically Stabilized Earth (MSE) walls and noise walls.
- Concrete receiving color sealer or texture treatments.
- Concrete for precast box culverts that are to receive color sealer.

4115.05 COARSE AGGREGATE FOR BRIDGE DECK SURFACING, REPAIR, AND OVERLAY.

Acquire from a Class 3 durability or better source meeting the following requirements:

A. Quality.
Meet the requirements of Tables 4115.05-1 and 4115.05-2:

Table 4115.05-1: Aggregate Quality

Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	40	AASHTO T 96
Alumina[(a)]	0.5	Office of Materials Test Method No. Iowa 222
A Freeze	6	Office of Materials Test Method No. Iowa 211, Method A
Absorption	2.5	Office of Materials Test Method No. Iowa 201
(a) If the Alumina value fails, determined the A Freeze value for specification compliance. Office of Materials Test Method No. Iowa 222 does not apply to gravels.		

Table 4115.05-2: Maximum Permissible Amounts of Objectionable Material

Objectionable Materials	Maximum Percent Allowed	Test Method
Unsound chert particles retained on No. 4 (4.75 mm) sieve	0.5	Materials I.M. 372
Total of all unsound chert, shale, coal, and iron combined	1.0	Materials I.M. 372
Organic Materials, except coal	0.01	Office of Materials Test Method No. Iowa 215
Note: Unsound chert particles are defined in Article 4115.02.		

B. Gradation.
Meet the gradation requirements for Gradation No. 6 of the Aggregate Gradation Table, Article 4109.02.

Section 4117. Class V Aggregate for Portland Cement Concrete

4117.01 DESCRIPTION.
A mixture of fine and coarse particles of feldspathic rocks from an approved source as described in Materials I.M. 409.

4117.02 GRADATION.
Meet the gradation requirements for gradation No. 7 of the Aggregate Gradation Table, Article 4109.02.

4117.03 QUALITY.

A. For the portion retained on the No. 4 (4.75 mm) sieve, meet the requirements of Table 4117.03-1 for coarse aggregate for concrete.

Table 4117.03-1: Aggregate Quality

Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	40	AASHTO T 96
A Freeze	6	Office of Materials Test Method No. Iowa 211, Method A
Clay Lumps	0.5	Materials I.M. 368

B. For the portion of Class V aggregate passing the No. 4 (4.75 mm) sieve, meet the requirements of Table 4117.03-2 for fine aggregate for concrete:

Table 4117.03-2: Fine Aggregate Quality

Fine Aggregate Quality	Test Limits	Test Method
Shale and Coal	2.0 % (maximum)	Materials I.M. 344
Mortar Strength	6000 psi (41.4 MPa) (minimum)	Office of Materials Test Method No. Iowa 212

4117.04 COMBINATIONS.
Use Class V aggregate for PC concrete only in combination with limestone as specified in Materials I.M. 529. Acquire limestone from sources meeting the specified coarse aggregate durability for PC concrete.

A. Fine Limestone.
Meet the gradation requirements for gradation No. 8 of the Aggregate Gradation Table, Article 4109.02.

B. Coarse Limestone.
Meet the requirements of Section 4115.

4117.05 CEMENT REQUIREMENTS.
For Interstate and Primary projects, use the cement types and substitutions of Table 4117.05-1 when Class V aggregate is used.

Table 4117.05-1: Cement Types and Substitutions

Cement Type	Min. Required Substitution	Max. Allowable Substitution
Type I, Type II	20% Class F Fly Ash	25% Class F Fly Ash
Type I, Type II	25% GGBFS	35% GGBFS
Type IS, IP	---	20% Class C Fly Ash

Section 4120. Granular Surfacing and Granular Shoulder Aggregate

4120.01 DESCRIPTION.
Uniform mixture of fine and coarse particles of crushed stone, gravel, or a combination of these materials with sand. Crushed recycled materials are to total no more than:

- 30% of the shoulder aggregate for new construction.
- 50% of the total for existing granular shoulders.

4120.02 GRANULAR MATERIAL.

A. Granular Surfacing.
Furnish material meeting the requirements of Article 4120.04, or when specified in the contract documents, meet the requirements of Article 4120.03, 4120.05, or 4120.06.

B. Granular Shoulders.

1. Furnish material meeting the requirements of Article 4120.04 or recycled materials. When specified in the contract documents, meet the requirements of Article 4120.05 or 4120.06. For recycled materials, meet the following requirements:

- Recycle PCC, RAP, or composite pavements to meet the requirements of Materials I.M. 210.
- Crush PCC or composite pavement to meet the requirements for Gradation No. 11 of the Aggregate Gradation Table, Article 4109.02.
- Process RAP to pass the 1.5 inch (37.5 mm) sieve.

2. The contract documents may allow a Class C gravel and crushed aggregate mixture for granular shoulders meeting the following:

- 30% to 50% crushed stone meeting soundness and abrasion requirements of Article 4120.05. Meet the requirements for Gradation No. 10 of the Aggregate Gradation Table, Article 4109.02 with the exception of 8% to 16% passing the No. 200 (75 µm) sieve.
- 30% to 50% recycled crushed PCC or composite materials meeting the above requirements for Granular Shoulders. Meet the requirements for Gradation No. 10 of the Aggregate Gradation Table, Article 4109.02 with the exception of 8% to 16% passing the No. 200 (75 µm) sieve.
- 30% to 50% RAP processed to pass the 1.5 inch (37.5 mm) sieve.

4120.03 CLASS C GRAVEL.

Meet the requirements for gradation No. 10 of the Aggregate Gradation Table, Article 4109.02 and Table 4120.03-1:

Table 4120.03-1: Coarse Aggregate Quality (Class C Gravel)

Coarse Aggregate Quality	Maximum Percent Allowed	Test Method
C Freeze	15	Office of Materials Test Method No. Iowa 211, Method C
Shale (+ No. 4 (4.75mm) sieve)	10	Materials I.M. 372
Total of Clay Lumps and Friable Particles, plus % passing No. 200 (75µm) sieve	15	Materials I.M.s 368 and 306
Total of Shale, Clay lumps and friable particles, plus % passing. No. 200 (75 µm) sieve	20	Materials I.M.s 372, 368, and 306

4120.04 CLASS A CRUSHED STONE.
Meet the requirements for Gradation No. 11 of the Aggregate Gradation Table, Article 4109.02 and Table 4120.04-1:

Table 4120.04-1: Coarse Aggregate Quality (Class A Crushed Stone)

Coarse Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	45	AASHTO T 96
C Freeze	15	Office of Materials Test Method No. Iowa 211, Method C
Clay Lumps and Friable Particles	4	Materials I.M. 368
Note: For shoulders only, abrasion limits may be raised to 55 if Alumina does not exceed 0.7 or A Freeze does not exceed 10.		

4120.05 CLASS B CRUSHED STONE.
Meet the requirements for Gradation No. 11 of the Aggregate Gradation Table, Article 4109.02 and Table 4120.05-1:

Table 4120.05-1: Coarse Aggregate Quality (Class B Crushed Stone)

Coarse Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	55	AASHTO T 96
C Freeze	20	Office of Materials Test Method No. Iowa 211, Method C
Total of Abrasion & C Freeze	65	
Clay Lumps and Friable Particles	4	Materials I.M. 368

4120.06 CLASS D CRUSHED STONE.
Refer to the contract documents for gradation and quality requirements.

4120.07 AGGREGATE FOR PAVED SHOULDER FILLETS.
Crushed stone or recycled materials meeting the requirements for Gradation No. 11 of the Aggregate Gradation Table, Article 4109.02, and meeting the quality requirement of Article 4120.04. For recycled materials, meet the requirements of Article 4120.02, B.

Section 4121. Granular Subbase Material

4121.01 DESCRIPTION.
Aggregate of the following types:

- Crushed stone,
- Gravels of which 30% or more of the particles retained on the 3/8 inch (9.5 mm) sieve have at least one fractured face as defined in Materials I.M. 305,

- Crushed PCC pavement meeting the requirements of Materials I.M. 210, or
- Uniformly blended combinations of these materials.

4121.02 GRADATION.

A. Crushed material: meet the requirements for Gradation No. 12a of the Aggregate Gradation Table, Article 4109.02.

B. Gravel: meet the requirements for Gradation No. 12b of the Aggregate Gradation Table, Article 4109.02.

4121.03 QUALITY.
The requirements of Table 4121.03-1 apply to the individual virgin aggregates before combining:

Table 4121.03-1: Coarse Aggregate Quality (Virgin Material)

Coarse Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	50	AASHTO T 96
Alumina[(a)]	1.5	Office of Materials Test Method No. Iowa 222
A Freeze	25	Office of Materials Test Method No. Iowa 211, Method A
(a) If the Alumina value fails, determine the A Freeze value for specification compliance. Office of Materials Test Method No. Iowa 222 does not apply to gravel.		

Section 4122. Crushed Stone Base Material

4122.01 DESCRIPTION.
Crushed stone meeting the following requirements.

4122.02 GRADATION.

A. Produce Macadam Crushed Stone with a nominal maximum size of 3 inches (75 mm). Screen over a 3/4 inch (19mm) screen, or when specified in the contract documents, a 1 inch (25mm) screen. This is identified as Gradation No. 13 of the Aggregate Gradation Table, Article 4109.02.

B. The aggregate passing the 3/4 inch (19mm) or 1 inch (25 mm) screen may be furnished as the Choke Stone material; however, 6% to 16% of the material shall pass the No. 200 (75 µm) sieve.

4122.03 QUALITY.

A. For Macadam Stone Base and Choke Stone, meet the requirements of Table 4122.03-1 when crushed to a 3/4 inch (19 mm) or 1 inch (25 mm) nominal size for testing:

Table 4122.03-1: Macadam Quality

Macadam Quality	Maximum Percent Allowed	Test Method
Abrasion	50	AASHTO T 96
C Freeze	10	Office of Materials Test Method No. Iowa 211, Method C

B. Choke Stone that is a byproduct of the Macadam production need not be tested. For Choke Stone that is not a byproduct of Macadam production, meet the requirements of Table 4122.03-2:

Table 4122.03-2: Choke Stone Quality

Choke Stone Quality	Maximum Percent Allowed	Test Method
Abrasion	45	AASHTO T 96
C Freeze	15	Office of Materials Test Method No. Iowa 211, Method C

Section 4123. Modified Subbase Material

4123.01 DESCRIPTION.

Aggregate of the following Types:

- Crushed stone,
- Gravels for which 75% or more of the particles retained on the 3/8 inch (9.5 mm) sieve have at least one fractured face as defined in Materials I.M. 305,
- Recycled pavements meeting Materials I.M. 210, or
- Uniformly blended combinations of these materials with a maximum of 50% RAP.

4123.02 GRADATION.

A. Meet the requirements for Gradation No. 14 of the Aggregate Gradation Table, Article 4109.02.

B. Process RAP to pass the 2 inch (50 mm) sieve.

C. Uncrushed gravel and/or sand may be uniformly blended with crushed recycled pavement or crushed stone at a maximum rate of 50% to meet gradation requirements.

4123.03 QUALITY.

A. The requirements of Table 4123.03-1 apply to blended and non-blended virgin materials:

Table 4123.03-1: Aggregate Quality (Blended and Non-blended Virgin Materials)

Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion [(a)]	45	AASHTO T 96
C Freeze	15	Office of Materials Test Method No. Iowa 211, Method C
Alumina [(b)] (No. 40 (425 µm) material)	4.7	Office of Materials Test Method No. Iowa 222

(a) Virgin material with Al_2O_3 not exceeding 0.7 (+4) or A-freeze not exceeding 10 may have an abrasion maximum of 55.
(b) For gravel or gravel/non-gravel blend, have a plasticity index not exceeding 7 for each source.

B. Acquire gravel or gravel/non-gravel blend products from a gravel source with a plasticity index not exceeding 7.

Section 4124. Aggregate for Slurry Mixtures

4124.01 DESCRIPTION.
Crushed stone.

4124.02 GRADATION.
Meet the requirements for Gradation No. 22 or No. 23 (as specified in the contract documents) of the Aggregate Gradation Table, Article 4109.02.

4124.03 QUALITY.
Type 4 or better friction classification aggregate as shown in Materials I.M. T203. Meet the requirements of Table 4124.03-1 based on aggregate crushed to 3/4 inch (19 mm) nominal size.

Table 4124.03-1: Aggregate Quality (Slurry Mixtures)

Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	40	AASHTO T 96
A Freeze	10	Office of Materials Test Method No. Iowa 211, Method A
Alumina[(a)]	0.7	Office of Materials Test Method No. Iowa 222
Sand Equivalence	45 (Minimum)	AASHTO T 176
Organic Materials	0.01	Office of Materials Test Method No. Iowa 215

(a) If the Alumina value fails, determine the A Freeze value for specification compliance. Office of Materials Test Method No. Iowa 222 does not apply to gravel.

Section 4125. Aggregate for Bituminous Sealcoat

4125.01 DESCRIPTION.

Crushed stone, gravel, or sand.

- Must be washed.
- Crushed aggregate is required for primary and interstate roadways and may be specified for other projects.
- Produce crushed gravel as a separate operation by crushing the gravel particles retained on a screen at least 1/4 inch (6 mm) larger than the aggregate size specified.

4125.02 GRADATION.

Meet aggregate gradation requirements for the gradation number specified in Table 4125.02-1. Unless specified otherwise, use the 1/2 inch (12.5 mm) sieve size.

Table 4125.02-1: Aggregate Gradation Requirements (Bituminous Sealcoat)

Size	Gradation No.
1/2 inch (12.5 mm) Crushed Gravel or Stone	19
Screened Gravel	20
3/8 inch (9.5 mm) Crushed Gravel or Stone	21[(a)]
Sand Cover Aggregate	1[(b)]

(a) 1/2 inch (12.5 mm) size may be used when 3/8 inch (9.5 mm) size is specified except for Primary Road applications.

(b) For a crushed stone product allow up to 4% passing the #200 (75 µm) sieve.

4125.03 QUALITY.

- Free from objectionable clay coatings that prevent emulsions from fully coating the aggregate when determined using Materials I.M. 349.
- Type 4 or better frictional classification as shown in Materials I.M. T203.
- For cover aggregate for bituminous sealcoat, meet the requirements of Table 4125.03-1:

4125.03-1: Aggregate Quality (Bituminous Sealcoat)

Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	40	AASHTO T 96
C Freeze	10	Office of Materials Test Method No. Iowa 211, Method C
Shale (+ No. 4 (4.75 mm) sieve)	5.0	Materials I.M. 372
Shale (+ No. 16 (1.18 mm) sieve) (Sand cover aggregate)	2.0	Materials I.M. 344

Section 4127. Aggregate for Hot Mix Asphalt

4127.01 DESCRIPTION.

A. Crushed stone, gravel, slag, sand, and filler from an approved source. Crushed gravel may be used to satisfy crushed particle and friction requirements for HMA mixtures. Produce crushed gravel as a separate operation by crushing the portion of a gravel aggregate retained on a screen at least 1/4 inch (6 mm) larger than the sieve size that 100% of the gravel will pass after crushing.

B. If a gravel aggregate has less than 5% retained on the No. 4 sieve (6 mm), the Engineer may replace the requirements of Table 4127.02-1 with the requirements of Article 4127.03.

4127.02 COARSE AGGREGATE.

Meet the requirements of Table 4127.02-1:

Table 4127.02-1: Coarse Aggregate Quality (Hot Mix Asphalt)

Coarse Aggregate Quality	Type A Maximum %	Type B Maximum %		Test Method
		Primary	Other	
Abrasion	45	45	45	AASHTO T 96
Absorption	6.0	6.0	6.0	Office of Materials Test Method No. Iowa 201
Alumina[(a)]	0.7	1.5	2.5	Office of Materials Test Method No. Iowa 222

A Freeze	10	25	45	Office of Materials Test Method No. Iowa 211, Method A
C Freeze	N/A	10	10	Office of Materials Test Method No. Iowa 211, Method C
Clay Lumps/Friable Particles	0.5	N/A	N/A	Materials I.M. 368
Organic Material	0.01	0.01	0.01	Office of Materials Test Method No. Iowa 215
(a) If the Alumina value fails, determine the A Freeze value for specification compliance. Office of Materials Test Method No. Iowa 222 does not apply to gravel.				

4127.03 FINE AGGREGATE.

A. Natural sand containing no more than 0.01% organic matter when tested using Iowa Test Method 215. A gradation for wearing course mixture of no more than 50% retained between two consecutive standard sieves below the No. 4 (4.75 mm).

B. Crushed gravel or stone processed from coarse aggregate meeting the requirements of Article 4127.02.

4127.04 COMBINED AGGREGATES.

A. Use aggregate, which does not contain adherent films of clay or other matter that will prevent coating of particles with asphalt binder. Meet gradations of Materials I.M. 510.

B. Maximum shale allowed in the fine portion of the combined materials:

Table 4127.04: Maximum Shale Allowed

Aggregate Type	Maximum Percent Allowed	Test Method
Type A	2.0	Materials I.M. 344
Type B	5.0	Materials I.M. 344

4127.05 MINERAL FILLER.
For fine material added to the mixture, separate from cold feed, meet the requirements for mineral filler in AASHTO M 17, except determine the gradation according to AASHTO T 11.

Section 4130. Revetment Stone, Erosion Stone, and Gabion Stone

4130.01 REVETMENT DESCRIPTION.

A. Broken limestone, dolomite, quartzite, or granite from an approved source as described in Materials I.M. 409 and meeting the following requirements.

- A minimum of 50% of the stone is to be composed of beds or slabs more than 5 inches (125 mm) thick.
- A minimum of 10% of the beds or slabs are to be thick enough to produce the required weight (mass) of either the stone or concrete, with the greatest dimension not more than two times the smallest dimension.

B. When the source test plot or service history is not available, meet the requirements of Table 4130.01-1 for virgin stone crushed to 3/4 inch to 1 1/2 inch (19 mm to 37.5 mm) nominal sizes. Abrasion loss for all revetment stone is not to exceed 50% when tested according to AASHTO T 96.

Table 4130.01-1: Virgin Stone Requirements

Revetment Type	Revetment Quality	Test Limits (max)	Test Method
Class A, B, C, & E revetment	Alumina	0.7	Iowa 222
	A Freeze	10	Iowa 211, Method A
	Secondary Pore Index	25	Iowa 219
Class D revetment	C Freeze	10	Iowa 211, Method C
Note: Revetment may pass either Alumina or A Freeze for compliance.			

C. Recycled PCC pavement or broken concrete meeting the requirements of Materials I.M. 210 may be used with the approval of the Engineer.

- All reinforcement material is to be cut flush with the flat surface of the concrete.
- A minimum of 50% of the broken concrete revetment is to be composed of slabs more than 5 inches (125 mm) thick.
- A minimum of 10% of the slabs are to be thick enough to produce the required weight (mass) of the concrete with the greatest dimension not more than 2 times the smallest dimension.
- No petroleum based or HMA material is to be included in revetment.

4130.02 REVETMENT GRADATION.

A. Engineer will determine gradation compliance by visual inspection. After visual inspection and prior to loading, the Engineer may designate material as too fine or too coarse.

1. Class A Revetment.

- Nominal top size of 400 pounds (180 kg).
- At least 75% of the stones are to weigh more than 75 pounds (35 kg).
- None less than 50 pounds (25 kg).
- Stones are to have at least one flat face with one dimension at least 15 inches (375 mm).

2. Class B Revetment.

- Nominal top size of 650 pounds (300 kg).

- At least 20% of the stones are to weigh more than 500 pounds (225 kg).
- At least 50% of the stones are to weigh more than 275 pounds (125 kg).
- At least 90% of the stones are to weigh more than 25 pounds (10 kg).

3. Class C Revetment.

- Nominal top size of 450 pounds (205 kg).
- At least 50% of the stones weighing more than 275 pounds (125 kg).
- At least 90% of the stones weighing more than 75 pounds (35 kg).

4. Class D and Class E Revetment.

- Nominal top size of 250 pounds (115 kg).
- At least 50% of the stones are to weigh more than 90 pounds (40 kg).
- At least 90% of the stones are to weigh more than 5 pounds (2 kg).
- The Engineer may approve using revetment containing material larger than 250 pounds (115 kg).

B. Additional processing is not required for Class D material. Mechanically process Class E material to remove material 3 inches (75 mm) and less.

4130.03 EROSION STONE DESCRIPTION.

Broken limestone, dolomite, quartzite, granite, or broken concrete with steel removed.

4130.04 EROSION STONE GRADATION.

Engineer will determine gradation compliance by visual inspection. After visual inspection and prior to loading, the Engineer may designate material as too fine or too coarse.

- Nominal 6 inch (150 mm) size.
- 100% passing the 9 inch (225 mm) screen.
- 100% retained on the 3 inch (75 mm) screen.

4130.05 EROSION STONE QUALITY.

Except for recycled concrete, meet the requirements of Table 4130.05-1. There are no quality requirements for recycled concrete.

Table 4130.05-1: Aggregate Quality (Erosion Stone)

Aggregate Quality	Maximum Percent Allowed	Test Method
C Freeze	15	Office of Materials Test Method No. Iowa 211, Method C
Abrasion	50	AASHTO T 96
Clay Lumps and Friable Particles	5	Materials I.M. 368
Note: Perform tests on product crushed to 3/4 inch (19 mm) or 1 inch (25 mm) maximum size.		

4130.06 GABION STONE DESCRIPTION.
Broken stone or gravel boulders meeting the requirements below. Use stone and boulders from sources similar in geological origin.

4130.07 GABION STONE AND MATTRESS GRADATION.
Process stone or boulders for gabions and mattresses to sizes ranging from 4 inches to 8 inches (100 mm to 200 mm) in nominal dimensions. Three inches to 5 inches (76.0 mm to 127 mm) is recommended for mattresses.

4130.08 GABION STONE QUALITY.
Meet requirements of Table 4130.08-1. Sources with Revetment A, B, or E approvals need not meet these requirements.

TABLE 4130.08-1

Aggregate Quality	Maximum Allowed Percent	Test Method
Alumina A Freeze	0.7 10	Office of Materials Test Method No. Iowa 211, Method A
Abrasion	50	AASHTO T 96
Note: Pass either Alumina or A Freeze for compliance (alumina does not apply to gravel). Perform tests on product crushed to 3/4 inch (19 mm) or 1 inch (25mm) maximum size.		

Section 4131. Porous Backfill Material

4131.01 DESCRIPTION.
Gravel or crushed stone.

4131.02 GRADATION.
Meet the requirements of Gradation No. 29 of the Aggregate Gradation Table, Article 4109.02.

4131.03 QUALITY.
No visible clay lumps, friable particles, and clay coatings. Meet the requirements of Table 4131.03-1:

Table 4131.03-1: Aggregate Quality (Porous Backfill Material)

Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	50	AASHTO T 96
Alumina[(a)]	0.7	Office of Materials Test Method No. Iowa 222
A Freeze	10	Office of Materials Test Method No. Iowa 211, Method A
Shale	5	Materials I.M. 345
(a) If the Alumina value fails, determine the A Freeze value for specification compliance. Office of Materials Test Method No. Iowa 222 does not apply to gravel.		

Section 4132. Special Backfill Material

4132.01 DESCRIPTION.
- Crushed stone, crushed PCC, crushed composite pavement, or reclaimed HMA,
- Mixtures of gravel, sand, and soil, or
- Uniformly blended combinations of the above.

4132.02 GRADATION.
Meet the gradations of Tables 4132.02-1 and 4132.02-2:

Table 4132.02-1: Gradation Requirements for Special Backfill Material

Material	Gradation (Aggregate Gradation Table, Article 4109.02)
Crushed Stone Crushed PCC Crushed Composite Pavement	No. 30
Gravel or Gravel Blends with Crushed Stone, PCC or Composite	No. 31

Table 4132.02-2: Gradation Requirements for Reclaimed HMA Used for Special Backfill Material

Material	Gradation
Reclaimed HMA	Nominal top size of 2 inches (50 mm)

4132.03 QUALITY.
For gravel mixture, comply with the following:

A. Plasticity Index.
Not to exceed 10%. Test according to Office of Materials Test Method No. Iowa 109.

B. Carbon Content.
Not to exceed 1.0%. Test according to Office of Materials Test Method No. Iowa 111.

Section 4133. Granular Backfill Material

4133.01 DESCRIPTION.
Crushed stone or natural sand and gravel.

4133.02 GRADATION.
Meet the requirements for Gradation No. 32 of the Aggregate Gradation Table, Article 4109.02, except when used as backfill material under flowable mortar or as floodable backfill material.

4133.03 QUALITY.
For crushed stone, meet the requirements of Table 4133.03-1:

Table 4133.03-1: Aggregate Quality (Granular Backfill Material)

Coarse Aggregate Quality	Maximum Percent Allowed	Test Method
Abrasion	55	AASHTO T 96
C Freeze	20	Office of Materials Test Method No. Iowa 211, Method C
Total of Abrasion & C Freeze	65	---
Clay Lumps and Friable Particles	4	Materials I.M. 368

4133.04 BACKFILL MATERIAL UNDER FLOWABLE MORTAR.
Use one of the following:

A. Natural sand complying with the requirements for Gradation No. 1 of the Aggregate Gradation Table, Article 4109.02, with a maximum of 4% passing the No. 200 (75 µm) sieve.

B. Porous Backfill Material complying with Section 4131.

C. Floodable Backfill Material complying with Section 4134.

D. Granular Subbase Material complying with Section 4121.

Section 4134. Floodable Backfill Material

4134.01 DESCRIPTION.
Uncrushed natural sand and gravel or natural sand.

4134.02 GRADATION.

A. For natural sand and gravel use Gradation No. 1 or Gradation No. 35 of the Aggregate Gradation Table, Article 4109.02.

B. For natural sand use Gradation No. 36 of the Aggregate Gradation Table, Article 4109.02.

Section 4136. Joint Fillers, Sealers, and Seals

4136.01 GENERAL REQUIREMENTS.
Use the type of joint fillers and sealers required in the contract documents.

4136.02 CONTRACTION JOINT SEALERS AND SEALS.
Meet the following requirements:

A. Poured Joint Sealer.
Approved sources for poured joint sealers are listed in Materials I.M. 436.01, Appendix A.

1. Hot poured: Use sealers composed of petropolymers supplied in solid form and meeting the requirements of ASTM D 6690, Type IV.

2. Cold applied: Use sealers that meet the above physical requirements.

B. Backer Rod.
Approved backer rod sources are listed in Materials I.M. 436.04, Appendix A and B. If used in conjunction with joint sealers, obtain the Engineer's approval for composition. Use backer rod meeting the following requirements:

1. When used with hot poured sealers, is capable of withstanding, without damage, the high temperatures inherent to the sealers.

2. Has a maximum of 5% absorption when immersed in water for 24 hours with the ends sealed.

3. Is of a size that compression is required for installation in the joint, so that it maintains its position during the sealing operation.

4. Is dry and kept dry during installation.

5. Is inspected and accepted according to Materials I.M. 436.04.

C. Preformed Elastomeric Joint Seal.
Apply AASHTO M 220, including requirements for lubricant adhesive. Obtain Engineer's approval for the dimensions and shape.

4136.03 EXPANSION JOINT FILLERS AND SEALS.

Fill expansion joints with one of the following material types. When the type is not specified, use resilient filler.

A. Resilient Filler.

1. Meet requirements of AASHTO M 213.

2. Furnish in strips of dimensions shown in the contract documents.

3. When the self expanding type is specifically required, use material meeting the requirements of AASHTO M 153, Type III. Use an accompanying sealer that meets the requirements of Article 4136.02, A.

4. Approved resilient filler sources are listed in Materials I.M. 436.03, Appendix A.

5. The Engineer may approve other resilient fillers.

B. Flexible Foam Expansion Joint Filler.

1. Use the size designated in the contract documents.

2. Ensure material is resistant to petroleum derivatives.

3. Comply with the requirements of ASTM D 1752, Sections 5.1 to 5.4, with Section 5.3 modified to 10 psi (0.069 MPa) minimum and 25 psi (0.173 MPa) maximum when tested in accordance with AASHTO T 42.

4. Approved sources for flexible foam expansion joint fillers are listed in Materials I.M. 436.05, Appendix A.

5. Use sealer that meets the requirements of Article 4136.02, A.

C. Tire Buffings Expansion Joint Filler.
When designated in the contract documents, use tire buffings to fill expansion joints. Comply with the following:

1. Use buffings from the tire retreading industry. Approved sources for tire buffings for expansion joints are listed in Materials I.M. 436.06, Appendix A.

2. Ensure tire buffings are clean, dry, and without any contamination.

3. Place loose and strike off level.

4. Remove compacted material and replace with loose material.

5. Use sealer that meets the requirements of Article 4136.02, A. Approved sources for sealers are listed in Materials I.M. 436.01, Appendix A.

D. Elastomeric Joint Seals.

1. Use elastomeric joint seals of the size designated in the contract documents and of a shape approved by the Engineer. Approved sources for elastomeric joint seals are listed in Materials I.M. 436.02, Appendix A. For the seal and the lubricant adhesive, meet the requirements of AASHTO M 220.

2. Seals with splices will be acceptable only when splices are made using factory type methods the Engineer approves. Comply with the following:
- Do not locate splices within 1 foot (0.3 m) of a sharp bend, when placed in final position, and
- Do not use more than one splice per finished piece.

Section 4137. Asphalt Binder

4137.01 GENERAL REQUIREMENTS.

A. Meet the requirements for the type and grade specified in the contract documents.

B. Determine performance grade according to AASHTO R 29.

C. Do not add acids to modify asphalt binders.

D. For asphalt binder grades with a temperature spread of 92° or greater, use binders that meet the PG+ requirements established by the Combined State Binder Group as follows:

Table 4137.01-1: PG+ Requirements

Temperature Spread[1, 2]	92	98	104
Elastic Recovery: AASHTO T 301 at 77° F. (RTFO Aged AASHTO T 240)	65% min.	65% min.	65% min.
DSR Phase Angle; degrees (original binder)	77.0 max.	75.0max.	73.0 max.

1 Temperature spread is determined by subtracting low temperature from high temperature; for example PG 64-28: 64 - (-28) = 92

2 When a grade change is required to compensate for binder in recycled materials, the virgin binder provided shall meet the above requirements for the original grade specified in the contract documents.

Section 4138. Cutback and Liquid Asphalts

4138.01 GENERAL REQUIREMENTS.

A. Use the grade specified. Meet the following requirements:
- Rapid Curing (RC) AASHTO M 81
- Medium Curing (MC) AASHTO M 82
- Slow Curing (SC) AASHTO M 140

B. The spot test indicated in AASHTO M 81, M 82, and M 140 will not be required.

C. When using antistrip additive with cutback asphalt, (as required in Article 2307.02, B, 2 or when specified otherwise) use an additive approved according to Materials I.M. 491.16. Add at the approved dosage rate. Ensure the treated cutback asphalt produces a positive result when tested according to Office of Materials Test Method No. Iowa No. 629.

D. In Table 1 of AASHTO M 81, the distillation test requirements are as follows: Distillate, by volume to 374°F (190°C), to be a minimum of 4% of the total distillate to 680°F (360°C).

Section 4139. Liquid Sealing Materials for Portland Cement Concrete Surfaces

4139.01 GENERAL REQUIREMENTS.

A. Meet the requirements for the type specified.

B. Use the type recommended by the manufacturer for this use, subject to approval of the Engineer. Acceptance will be according to Materials I.M. 491.12.

Section 4140. Emulsified Asphalt

4140.01 GENERAL REQUIREMENTS.

A. Meet the requirements of AASHTO M 140, M 208, and M 316 for the grade required with the following modifications, unless specified otherwise:

	Min.	Max Percent
Sieve Test	-	0.3

B. Perform inspection and acceptance of emulsified asphalt according to Materials I.M. 437.

4140.02 ADDITIONAL REQUIREMENTS.

For work described in Sections 2307 and 2544, comply with Paragraphs A, B, and C below.

A. Aggregate Compatibility.
Provide emulsified asphalt compatible with project aggregate when tested according to Office of Materials Test Method No. Iowa No. 630.

B. Absolute Viscosity.
Between 600 poises (60 Pa·s) and 1200 poises (120 Pa·s) when tested according to Iowa DOT Materials Laboratory Test No. 622 in lieu of a penetration test.

C. Modification for CRS-2P Emulsion.

Table 4140.02-1: Modification for CRS-2P Emulsion

	CRS-2P			CRS-2	
	Min.	**Max.**		**Min.**	**Max.**
Storage Stability (note 1) Cure Test (note 2)	Passes Passes				
Distillation (note 3): Oil Distillate, by Volume of Emulsion, %	-	1.0			1.0
Tests on Residue from Distillation Test: Penetration @ 77°F (25°C) @ 0.1 mm Ductility @ 39°F (4°C) 5 cm/min., cm	100 30 (300)	 150 -		100	150
Elastic Recovery (Materials Method Test No. Iowa 631)	55	-			
Solubility in trichloroethylene, %	delete			97.5	

Note 1: Examine the CRS-2P storage stability test sample after it has been allowed to stand undisturbed for 24 hours. The surface of the test sample must show no white, milky colored substance, but is to be homogeneous brown clear throughout.

Note 2: The cure test is performed as follows: Pour approximately 1 gram of CRS-2P emulsion onto a metal surface (lid of a 3 ounce (90 ml) ointment tin). Allow the test sample to cure at temperatures of at least 80°F (27°C) under a heat light for 4 hours. The outdoors sunlight may be used as a testing site. After the 4 hour curing period, the CRS-2P emulsion must show no tackiness or tendency to stick to the fingers when pressed.

Note 3: The distillation test for CRS-2P emulsion is to comply with AASHTO T 59, 8-12 except the second sentence in 11.5 is to be deleted and replaced with the following: ensure the distillation temperature is what the emulsion manufacturer recommends.

Section 4141. Corrugated Steel Culvert Pipe

4141.01 GENERAL REQUIREMENTS.

A. Unless specified otherwise, meet the requirements of AASHTO M 36/M 36M for the following:
- Circular corrugated steel culvert pipe, Type I.
- Pipe arch shapes, Type II.
- Coupling bands, special fittings, and associated hardware.

B. The minimum sheet thickness will be shown in the contract documents.

C. When the diameter of round pipe is elongated, increase one diameter by approximately 5%. Permanently mark each piece at least once inside and once outside to indicate the top.

D. Types of approved coupling devices are described in Materials I.M. 441. Joint types are standard and positive, and the type may be designated in the contract documents. When not designated, either type may be used.

4141.02 COATED CORRUGATED PIPE.

A. Use pipe coated by either of the following methods:

1. Meet the requirements of Article 4141.01 and AASHTO M 245/M 245M, Type I. The polymeric coating is to have a minimum thickness of 0.010 inch (254 µm) on inside surfaces and 0.003 inch (76 µm) on outside surfaces.

2. Aluminized pipe meeting requirements of Article 4141.01 may be furnished.

B. Repair, to the Engineer's satisfaction, breaks or damage to the coating that occur during handling or installation.

Section 4143. Subdrain Pipe

4143.01 GENERAL REQUIREMENTS.

Use the size and type shown in the contract documents. When not designated, meet the following requirements:

A. Pipe for Horizontal Drains.
Use plastic pipe complying with the requirements of ASTM D 1785, Schedule 80. Comply with the following:

1. Unless specified otherwise, 3 rows of slots, 0.010 inch ± 0.005 inch (254 µm ± 127 µm) wide, on 120 degree centers around the circumference.

2. Minimum of 0.75 square inch (1588 mm^2) of slot opening per linear foot (meter).

3. Provide with a suitable cap at the inlet end. Obtain Engineer's approval for caps and couplings.

B. Pipe for Longitudinal Subdrains.

1. Use perforated corrugated PE tubing and fittings manufactured and marked according to AASHTO M 252 with the following modification:

   Use tubing perforated with slots according to AASHTO M 252. Circular perforations will not be approved.

2. Outlet subdrains using one of the following options:
   - **a.** Corrugated metal pipe meeting the requirements of Article 4141.01, including tapered ends when required.
   - **b.** Corrugated PE pipe, type S, approved per Materials I.M. 443 Appendix A, Part B.
   - **c.** Corrugated PVC pipe, Type S, approved per Materials I.M. 443 Appendix A, Part C.

3. When special connections are required for subdrain outlets, they will be detailed in the contract documents.

4. Cover outlet with a rodent guard meeting the requirements of Materials I.M. 443.01. Attach as shown in the contract documents. Engineer will inspect and accept according to Materials I.M. 443.01.

C. Standard Subdrains.

1. Use one of the following:
   - Subdrain meeting the requirements of AASHTO M 196/M 196M or M 36/M 36M Type I or Type III.
   - Drain tile (Section 4148) or Plastic Pipe (Section 4146).
   - Polyethylene tubing meeting the requirements of Article 4143.01, B.

2. If furnishing subdrains that comply with AASHTO M 196/M 196M, use a specified sheet thickness of 0.048 inch (1.22 mm) for 6 inch (150 mm) diameter and 0.060 inch (1.52 mm) for larger diameters. If furnishing subdrains that comply with AASHTO M 36/M 36M, use a specified sheet thickness of 0.052 inch (1.32 mm) for 6 inch (150 mm) diameter and 0.064 inch (1.63 mm) for larger diameters.

3. Use perforated subdrains only when specified. As an option, AASHTO M 36/M 36M subdrains may be perforated with slots formed on the outside crests of helical corrugations, approximately 1 inch (25 mm) in length and 0.1 inch (2.5 mm) in width, spaced at 2 inches (50 mm) on centers.

4. When corrugated steel subdrains are specified, coated subdrains may also be specified. If so, ensure the coating complies with Article 4141.02.

5. If using plastic pipe meeting the requirements of ASTM F 758, D 3034, or D 2751, ensure perforations are as specified in ASTM F 758. Plastic pipe meeting the requirements of ASTM F 949 with slots may also be used.

6. If embedding the subdrain in granular or porous backfill material, use slotted plastic pipe meeting the requirements of ASTM F 949 or perforated, corrugated polyethylene (PE) tubing meeting the requirements of Article 4143.01, B.

D. Patch Subdrains.
Follow requirements for Article 4143.01, B, except that subdrain outlets will not be required.

Section 4144. Structural Plates for Pipe, Pipe Arches, and Arches

4144.01 DESCRIPTION.
Structural units of corrugated metal of the specified thickness.

4144.02 GENERAL REQUIREMENTS.

A. Meet the requirements of AASHTO M 167/M 167M for steel or AASHTO M 219/M 219M for aluminum, except as modified in this section.

B. Connect plates at longitudinal and circumferential seams with bolts. Stagger joints so that no more than three plates come together at any one point. Curve each plate to one or more circular arcs.

4144.03 FORMING AND PUNCHING PLATES.

A. Curve each plate to the proper radius so the cross-sectional dimensions of the finished structure will be as indicated in the contract documents.

B. Ensure the diameter of the bolt holes in longitudinal seams, except those at plate corners, does not exceed the diameter of the bolt by more than 1/8 inch (2 mm). If elongated structural plate pipe is specified or called for in the contract documents, form the plates so the finished pipe is elliptical in shape with the vertical diameter approximately 5% greater than the nominal diameter of the pipe.

4144.04 ASSEMBLY PARTS.
Use bolts that meet the requirements of ASTM A 449 or ASTM A 325, or are an approved equal. Use galvanized bolts and nuts.

Section 4145. Concrete Culvert Pipe

4145.01 GENERAL REQUIREMENTS.

These specifications cover reinforced and nonreinforced concrete pipe intended for construction of culverts, sanitary sewers, and storm sewers. Furnish pipe manufactured according to the contract documents and produced by a plant for which the method of manufacture and the quality of product have been approved by the Engineer.

4145.02 CLASSIFICATION.

A. Furnish concrete pipe according to strength (class). These will be designated as 1500D (Class II), 2000D (Class III), 3000D (Class IV), and 3750D (Class V) (75D, 100D, 150D, and 175D) pipe. These designations indicate the D load (test load in pounds per linear foot of length per foot of inside diameter or Newtons per meter of length per millimeter of inside diameter) to produce the ultimate load specified. Table 4145.02-1 shows the D load and the corresponding class.

Table 4145.02-1: D Load and Corresponding Class

D load-ultimate	Class
1500D (75D)	Class II
2000D (100D)	Class III
3000D (150D)	Class IV
3750D (175D)	Class V

B. Ensure the class, design, date of manufacture, and trademark are plainly marked or stenciled on the inside of the pipe near the tongues no later than 24 hours after fabrication. If a manufacturer operates two or more plants, ensure the markings they use include a separate distinctive designation for each plant. Renew all markings made using paint before the original markings become unreadable. When the strength of pipe is related to its orientation because of design or reinforcement, permanently mark each piece, at least once inside and once outside on opposite walls, to indicate the top.

4145.03 MATERIALS.

Comply with the applicable requirements of Division 41.

4145.04 DESIGN.

A. For circular pipe, comply with the following for details of the shell, design, and distribution of reinforcement:

- Diameter less than 12 inches (300 mm): AASHTO M 86/M 86M.
- Diameter 12 inches (300 mm) or larger: AASHTO M 170/M 170M.

B. Apply AASHTO M 198 or AASHTO M 315 when circular pipe with gaskets is specified.

C. Apply AASHTO M 206/M 206M when reinforced concrete arch pipe is specified.

D. Apply AASHTO M 207/M 207M when reinforced concrete elliptical pipe is specified.

E. If furnishing AASHTO design pipe, ensure it complies with the following:
- Minimum thickness of any part of the joint no less than 30% of the computed wall thickness
- Length of any part of the joint no less than shown in Table 4145.04-1.

Table 4145.04-1: Minimum Joint Length

Computed Wall Thickness	Minimum Length of Joint
3" (75 mm) or Less	87% of computed wall thickness
3" to 6" (75.1 mm to 150 mm)	75% of computed wall thickness but not less than 2 3/4" (70 mm)
6" to 9" (150.1 mm to 225 mm)	61% of computed wall thickness but not less than 4 1/2" (115 mm)

F. Compute wall thickness based on the following: No more than 1 inch per foot (25 mm per 300 mm) of pipe diameter or equivalent diameter, plus 1 inch (25 mm).

4145.05 STRENGTH.

A. Furnish pipe that has the strength specified for the design used, including both ultimate load and load to produce a 0.01 inch (0.3 mm) crack.

B. Meet the requirements of AASHTO M 170/M 170M for pipe, except the load to produce a 0.01 inch (0.3 mm) crack will not be measured for nonreinforced pipe.

C. All strength tests will be conducted according to AASHTO T 280.

D. The barrel section of aprons shall be 1500D (75D) (Class II) or better for 1500D (75D) (Class II) pipe installations and 2000D (100D) (Class III) or better for 2000D (100D) (Class III) and greater pipe installations.

4145.06 MANUFACTURE.

The term "cast pipe" refers to pipe manufactured by placing concrete of plastic consistency between forms and consolidating it by vibration.

A. General Requirements.

1. Comply with the following:
- Store cement, measure materials, and mix concrete according to the applicable requirements of Article 2301.02, C, 2, 3, and 4.

- Follow the requirements of Article 2301.02, C, 4 for use of ready mixed concrete.
- Obtain the Engineer's approval for use of admixtures.
- Store and handle aggregate to avoid contamination and frequent variations of specified gravity, gradation, and moisture content.
- When cages are to be made by resistance welding, house the reinforcement in a weatherproof building and ensure it is not in contact with the ground. Apply Article 2404.03, A, to reinforcement.

2. The Engineer may also approve procedures for concrete placement at low temperatures based on applicable requirements of Article 2403.03, F, and facilities to be used.

B. Casting Base.
Ensure cast pipe forms rest on a clean, smooth, and level concrete base when the concrete is placed.

C. Construction of Reinforcement Cages.

1. Form welded wire fabric reinforcement cages using a machine designed for this purpose. Construct and operate the machine to produce cages accurately formed to the required shape and dimensions. Either discard reinforcement fabric that has been kinked from tight winding or other causes, or straighten it to the extent that a true shaped cage can be formed from it. Ensure the lengths of all laps of circumferential reinforcement are no less than 40 diameters of the wire. No lap will be required for groove hoop wires in single line pipe.

2. Weld the circumferential wires to hold cages in the desired shape. Circumferential wires may be welded to transverse wires with resistance welds, or circumferential wires may be welded together within the laps by arc welds. If resistance welds are used, construct no less than one weld on each circumferential wire. Distribute these welds alternately between the two transverse wires in the lap, except when normal spacing is such that two transverse wires will not fall within the lap. Ensure these welds do not reduce strength of the wire below 70,000 psi (480 MPa).

3. Ensure arc welds are long enough to hold the wires firmly together and to withstand handling and placing. Reweld all broken welds in cages prior to placing the outside form. Position the weld near the center of the lap. Ensure the strength of the two wires welded together is no less than 70,000 psi (480 MPa), based on the cross sectional area of one wire in square inches (square millimeters). Place a minimum of 1 arc weld per foot (0.3 meter) of length of cage, plus one weld.

4. For 3000D (150D) (Class IV) pipe 54 inches (1350 mm) in diameter and larger, tie inner and outer cages together using clips or other approved methods. If using clips, place in no less than one circumferential row per foot (300 mm) of length of cage plus one. Space each row no more than 8 inches (200 mm) along the outer cage within 45 degrees of the top

and bottom of the pipe. Use clips fabricated from no smaller than No. 6 (4.877 mm diameter) wire.

D. Forms.
Use forms that are smooth and true to shape and dimensions and are maintained in good condition.

E. Placing Concrete.
If the concrete is not consolidated during placement using a machine designed for that purpose, then consolidate it by vibration. Apply external vibrators to the forms to prevent denting and deforming the forms.

F. Lift Holes.

1. Pipe may be furnished with lift holes. No more than two lift holes will be allowed. Limit the lift holes to no larger than 2 1/2 inches (65 mm) in diameter. Cast (or form) them in a manner so that there are no breaks of the circumferential reinforcing of single cage reinforced pipe or of the inner cage of double cage reinforced pipe. When practical, bend circumferential wires slightly to provide for the lift holes.

2. Cutting of circumferential wire in lift hole locations will be permitted if the pipe satisfies the 0.01 inch (0.3 mm) crack test requirements of AASHTO M 170/M 170M for the specified strength (class) of pipe.

G. Curing.
Cure pipe using one of the wet methods specified in AASHTO M 170/M 170M or by some other method approved by the Engineer which will:
- Give uniform and consistent curing, and
- Will produce pipe which will meet the strength requirements.

H. Yarding.
Place lines of pipe in storage yards at least 2 feet (0.6 m) apart with both ends of each pipe readily accessible to facilitate inspection.

I. Tongue and Groove.
Ensure the tongue and groove are compatible so that when the pipe is laid, it will be possible for the contractors to comply with Article 2416.03, D, 5.

J. Pipe Connectors.
When pipe connectors are required, use connectors of the design shown in the contract documents or an approved alternate.

K. Special Shapes.
The contract documents may require pieces of special design. If not specified, the strength (class) specified will indicate reinforcement requirements.

4145.07 REJECTION.
In addition to causes for rejection as listed in AASHTO M 170/M 170M or AASHTO M 86/M 86M, failure to meet the requirements specified above is sufficient cause for

withdrawing approval of a manufacturer. Withdrawal or approval of a manufacturer may apply to certain specific sizes or to all sizes of pipe.

Section 4146. Plastic Pipe

4146.01 GENERAL REQUIREMENTS.

A. For all plastic pipe, comply with the following:
- Marked as required by the specification noted.
- Of the diameter specified.
- Manufactured from PE, PVC or ABS material.

B. For an interconnected installation, use pipe and fittings that:
- Are the same type of material (except when connecting to an existing pipe),
- Are the size specified, and
- Meet one of the specifications allowed by this section.

C. Approval and acceptance will be based on sampling and testing or on the producer's certification subject to monitor testing as provided in Materials I.M. 443 and Materials I.M. 446.

4146.02 CORRUGATED POLYETHYLENE PIPE.

A. Comply with the following:

1. **Pipe and fittings:** maximum diameter of 48 inches (1.2 m) and meeting the requirements of AASHTO M 294.

2. **Perforated pipe 12 inch I.D.:** perforations according to AASHTO M 294, except circular perforations will not be allowed.

3. **Perforated pipe larger than 12 inch (300 mm) I.D.:** perforations according to AASHTO M 294 and wrap the pipe with engineering fabric meeting the requirements of Article 4196.01, B, 2.

B. Aprons or other special end sections may also be specified. Use aprons and special end sections as for corrugated steel culverts, meeting requirements of Section 4141. Adapt them to couple to the sections of polyethylene pipe. When end sections are not specified, attach coupling fittings to the ends of polyethylene culverts to be exposed in the finished structure in order to form a double thickness of polyethylene for the full length of the fitting.

4146.03 SEWER PIPE.

Apply Articles 4149.02 and 4149.03.

Section 4147. Pipe and Manhole Rehabilitation Materials

4147.01 PIPE REHABILITATION.

A. Polyethylene and Polyolefin Manufactured Pipe for Sliplining.

1. Pipe.

- **a.** Comply with ASTM D 3035, minimum pipe stiffness of 46 psi (320 kPa).
- **b.** Polyethylene complying with ASTM D 1248, Type III, Class C, Category 5, Grade P 34 or ASTM D 3350 Cell Classification PE 335434C.
- **c.** Maximum outside diameter as specified in the contract documents.

2. Joints.

- **a.** Joined into continuous length on job site.
- **b.** Fuse butt joints according to the pipe manufacturer's recommendations with approved equipment and complying with ASTM D 2657.

B. Polyvinyl Chloride Pipe Corrugated Pipe 12 Inch to 36 Inch (300 mm to 900 mm) for Sliplining.

1. Pipe.

- **a.** Comply with ASTM F 949, minimum pipe stiffness, 46 psi (320 kPa).
- **b.** PVC plastic complying with ASTM D 1784, Cell Classification 12454.

2. Joints.

Gasketed joints complying with ASTM F 477 and ASTM D 3212.

C. Polyvinyl Chloride Pipe Closed Profile Pipe 21 Inch to 48 Inch (525 mm to 1200 mm) for Sliplining.

1. Pipe.

- **a.** Comply with ASTM F 1803, minimum pipe stiffness, 46 psi (320 kPa).
- **b.** PVC plastic complying with ASTM D 1784, Cell Classification 12364.

2. Joints.

Gasketed joints complying with ASTM F 477 and ASTM D 3212.

D. Centrifugally Cast Fiberglass Reinforced Polymer Mortar Pipe (CCFRPM) 18 Inch to 48 Inch (450 mm to 1200 mm) for Sliplining.

1. Pipe.

Comply with ASTM D 3262.

2. Joints.
Gasketed joints complying with ASTM D 4161.

E. Resin-Impregnated Tube for Cured-in-place Pipe (CIPP) Lining.

1. Pipe Lining.
- **a.** Comply with ASTM F 1216.
- **b.** Use one or more layers of flexible needled felt or equivalent non-woven material.
- **c.** Stretch material to fit irregular pipe and negotiate bends.
- **d.** Outside layer plastic coated with a translucent flexible material. No delamination of plastic coating.
- **e.** Fabricated to a size that when installed tightly fits length without joints.
- **f.** Designed as per Equation X-1, ASTM F 1216.

2. Resin and Catalyst.
- **a.** Unsaturated, styrene-based, thermoset resin and catalyst system or an epoxy resin and hardener that is compatible with the inversion process.
- **b.** Cure in the presence of water with temperature greater than 150ºF (66ºC) and less than 180ºF (82ºC).
- **c.** Initial structural properties complying with ASTM F 1216. Comply with Table 4147.01-1.

Table 4147.01-1: CIPP Lining Properties

CIPP Properties	ASTM Test Method	Minimum Value
Flexural Strength	D 790	4500 psi (31 MPa)
Flexural Modulus of Elasticity	D 790	250,000 psi (1725 MPa)

3. CIPP Lining Dimensions.
- **a.** Use nominal internal diameter and length such that CIPP forms to internal circumference and length of original pipe.
- **b.** Field verify diameter and length.
- **c.** Use one continuous length without joints.

F. Deformed/Reformed High Density Polyethylene Pipe Lining (DRP-HDPE).

1. Pipe Lining.
- **a.** Manufactured in deformed shape from HDPE pipe compound complying with ASTM D 1248, Class C, Category 5 and Grade P 34.
- **b.** Comply with long term hydrostatic strength rating of 1600 psi (11 MPa) or more according to ASTM D 2837.
- **c.** Environmental stress crack resistance (ESCR) less than 2,000 hours in 100% solution, Igepal CO-630 at 100ºC before failure according to ASTM D 1693, Condition C.

d. Comply with Table 4147.01-2 for minimum DRP lining structural standards.

Table 4147.01-2: DRP-HDPE Lining Properties

FIPP Properties	ASTM Test Method	Minimum Value
Flexural Strength	D 790	3300 psi (22.75 MPa)
Flexural Modulus of Elasticity	D 790	136,000 psi (938 MPa)
Tensile Strength	D 638	3200 psi (22.1 MPa)

2. DRP Lining Dimensions.

a. Nominal internal diameter and length of existing pipe as specified in the contract documents.
b. Field verify diameter and length.
c. Outside diameter fabricated to fit tightly.
d. Use one continuous length without joints between manholes.
e. Minimum wall thickness complying with SDR as specified in the contract documents.

G. Folded/Formed Polyvinyl Chloride Pipe Lining.

1. Pipe Lining.

a. Manufacture in deformed shape complying with ASTM D 1784, Cell Classification 12454 B. Compounds with different cell classifications because one or more properties are superior to those specified are acceptable.
b. Performance requirements complying with ASTM D 3034.
c. Comply with Table 4147.01-3 for FPP lining structural properties.

Table 4147.01-3: FPP Lining Properties

FIPP Properties	ASTM Test Method	Minimum Value
Tensile Modulus of Elasticity	D 638	350,000 psi (2415 MPa)
Tensile Strength	D 638	6000 psi (41.4 MPa)

2. FPP Lining Dimensions.

a. Nominal internal diameter and length of existing pipe as specified in the contact documents.
b. Field verify diameter and length prior to manufacturing.
c. Use one continuous length without joints between manholes.
d. Outside diameter fabricated to fit tightly.
e. Minimum wall thickness complying with the specified SDR as specified in the contract documents and complying with ASTM F 1216.

H. Pipe Repair Couplings for Spot Repairs by Pipe Replacement.

1. Style.
Full circle, fully lined, bolted.

2. Length.
12 inches (300 mm), minimum.

3. Materials and Manufacturer.
- **a.** Shells, armors, side bars, lugs, Turner lifting bars, bolts, and nuts complying with ASTM A 240, Type 304 stainless steel.
- **b.** MIG welds, fully passivated.
- **c.** Rubber gasket complying with ASTM D 2000, AA415 with full coverage and grid pattern.
- **d.** Stainless steel armor bonded to gasket to bridge lug area.

4. Nuts and Bolts.
1/2 inch or 5/8 inch (12.5 mm or 15.9 mm), Teflon coated threads.

I. Sewer Main Pipe (For Spot Repairs).

1. Apply Section 2504.

2. Use materials for pipe replacement as specified in the contract documents or approved by the Engineer.

4147.02 MANHOLE REHABILITATION.

A. Rubber Chimney Seal.
Apply Article 4149.02, J, for external and internal rubber chimney seals.

B. Urethane Chimney Seal.

1. Use only when specified in the contract documents.

2. Comply with Table 4147.02-1 for the physical properties:

Table 4147.02-1: Physical Properties

Property	ASTM Test Method	Acceptable Value
Elongation	D 412	800%, minimum
Tensile Strength	D 412	1150 psi (8 MPa), minimum
Adhesive Strength	D 903	175 lb/in (3 kg/mm), minimum
Pressure Resistance	C 1244/C 1244M	2 minutes

C. In-Situ Manhole Replacement, Cast-in-place Concrete.

1. Forming System.
Provide an internal forming system capable of forming a new and structurally independent manhole wall within the existing manhole, with the specified thickness and conforming to the general shape of the existing manhole.

2. Concrete.
Type I/II Portland cement with 5/8 inch (16 mm) minus coarse aggregate with fiber reinforcement and water reducer, 4000 psi (28 MPa) minimum 28 day compressive strength or as approved by the Engineer.

3. Plastic Liner.
When specified, provide a PVC or PE plastic liner resistant to degradation by sulfuric acid. Use a liner capable of being attached to the exterior of the forming system during erection of the forms. Use a plastic liner with a ribbed or studded exterior surface suitable for anchoring to the newly formed interior wall.

4. Casting.
Provide new casting. Apply Article 4149.02, I.

D. Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal.

1. Cementitious Lining.
a. Use a high-strength, high-build, corrosion-resistant mortar, based on Portland cement fortified with micro silica. Mixed mortar is to have a paste-like consistency that may be sprayed, cast, pumped, or gravity-flowed into any area 1/2 inch (13 mm) and larger.
b. Comply with Table 4147.02-2 for physical properties:

Table 4147.02-2: Physical Properties

Property	Value
Unit Weight	125 pcf (2000 kg/m^3)
Set Time at 70° F (21° C) ASTM C 403/C 403M Initial Set / Final Set	240 minutes / 440 minutes
Modulus of Elasticity ASTM C 469 24 hours / 28 days	180,000 psi / 1,150,000 psi (1240 MPa / 7930 MPa)
Flexural Strength ASTM C 293 24 hours / 28 days	650 psi / 800 psi (4.5 MPa / 5.5 MPa)
Compressive Strength ASTM C 109/C 109 M 24 hours / 28 days	3000 psi / 10,000 psi (21 MPa / 70 MPa)

Tensile Strength ASTM C 307	600 psi (4 MPa)
Shear Bond ASTM C 882/C 882M	>1000 psi (7 MPa)
Shrinkage ASTM C 157/C 157M	None
Chloride Permeability ASTM C 1202	<550 Coulombs

c. Use a lining containing a liquid admixture for the prevention of micro-biologically induced corrosion.

2. Corrosion-Resistant Epoxy Lining.

a. Use a two-component 100% solids epoxy formulated for use in sewer systems.

b. Comply with Table 4147.02-3 for physical properties:

Table 4147.02-3: Physical Properties

Property	Value
Dry Time	4-6 hours at 75° F (24° C)
Compressive Strength ASTM D 695	16,800 psi (116 MPa)
Flexural Strength ASTM D 790	13,900 psi (96 MPa)
Tensile Strength ASTM D 638	12,400 psi (86 MPa)
Hardness ASTM D 2240	68-72 Shore D
Heat Distortion ASTM D 648	220°F (104° C)
Ultimate Elongation ASTM D 638	4.5 %
Adhesive Shear ASTM C 882/C 882M	1000 psi (7 MPa)

3. Casting.

Provide new casting. Apply Article 4149.02, I.

Section 4148. Drain Tiles

4148.01 GENERAL REQUIREMENTS.

Meet the requirements of AASHTO M 178/178 M, standard quality, extra quality, or special quality, as specified, or AASHTO M 179, standard, extra quality, or heavy duty, as specified. When the quality is not specified, use extra quality tile in roadway embankments, and use standard or standard quality tile in other locations.

Section 4149. Sanitary and Storm Sewer Pipe and Structures Materials

4149.01 DESCRIPTION.

A. Materials for constructing sanitary and storm sewer.

B. Materials for constructing sanitary and storm sewer structures.

4149.02 SANITARY SEWER PIPE.

A. Sanitary Sewer (Gravity Mains).

1. Solid Wall Polyvinyl Chloride Pipe 8 inch to 15 inch (200 mm to 375 mm).

- **a.** Comply with ASTM D 3034, SDR 26, unless SDR 35 is specified.
- **b.** Pipe Stiffness per ASTM D 2412.
  - **1)** SDR 26: Minimum pipe stiffness of 115 psi (795 kPa).
  - **2)** SDR 35: Minimum pipe stiffness of 46 psi (320 kPa).
- **c.** PVC plastic meeting ASTM D 1784, Cell Classification 12454 or 12364. Do not exceed 10 parts by weight (mass) per 100 of PVC resin in the compound for additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, and colorants.
- **d.** Integral bell and spigot type with elastomeric seals complying with ASTM D 3212 and ASTM F 477.

2. Solid Wall Polyvinyl Chloride Pipe 18 inch to 27 inch (450 mm to 675 mm).

- **a.** Comply with ASTM F 679.
- **b.** Minimum pipe stiffness of 46 psi (320 kPA) as per ASTM D 2412.
- **c.** PVC plastic meeting ASTM D 1784, Cell Classification 12454 or 12364. Do not exceed 10 parts by weight (mass) per 100 of PVC resin in the compound for additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, and colorants.
- **d.** Integral bell and spigot type with elastomeric seals complying with ASTM D 3212 and ASTM F 477.

3. Corrugated Polyvinyl Chloride Pipe 8 inch to 36 inch (200 mm to 900 mm).

- **a.** Comply with ASTM F 949, smooth interior, corrugated exterior.
- **b.** Pipe stiffness per ASTM D 2412.
  - **1)** 8 inch to 10 inch (200 mm to 250 mm): Minimum pipe stiffness of 115 psi (795 kPa), unless 46 psi (320 kPa) is specified.
  - **2)** 12 inch to 36 inch (300 mm to 900 mm): Minimum pipe stiffness of 46 psi (320 kPa).
- **c.** PVC resin meeting ASTM D 1784, Cell Classification 12454. Do not exceed 10 parts by weight (mass) per 100 of PVC resin in the compound for additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, and colorants.
- **d.** Integral bell and spigot joints with elastomeric seals complying with ASTM D 3212 and ASTM F 477.

4. Closed Profile Polyvinyl Chloride Pipe 21 inch to 36 inch (525 mm to 960 mm).

- **a.** Comply with ASTM F 1803.
- **b.** Pipe stiffness per ASTM D 2412, 46 psi (320 kPa).
- **c.** PVC plastic meeting ASTM D 1784, Cell Classification 12364. Do not exceed 10 parts by weight (mass) per 100 of PVC resin in the compound for additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, and colorants.

d. Integral bell and spigot joints with elastomeric seals complying with ASTM D 3212 and ASTM F 477.

5. Polyvinyl Chloride Composite Pipe (truss type) 8 inch to 15 inch (200 mm to 375 mm).

a. Comply with ASTM D 2680. Pipe constructed with truss type structure between inner and outer PVC walls with voids filled with lightweight concrete.

b. Pipe stiffness per ASTM D 2412, 200 psi (1380 kPa).

c. PVC plastic meeting ASTM D 1784, Cell Classification 12454. Do not exceed 10 parts by weight (mass) per 100 of PVC resin in the compound for additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, and colorants.

d. Integral bell and spigot joints with elastomeric seals complying with ASTM D 3212 and F 477.

6. Reinforced Concrete Pipe 18 inch to 144 inch (450 mm to 3650 mm).

a. General.

1) Comply with ASTM C 76/C 76M (AASHTO M 170/M 170M).

2) Minimum Class IV (3000 D), Wall B.

3) Tongue and groove joints.

4) Rubber O-ring flexible joint complying with ASTM C 443/C 443M (AASHTO M 315/M 315M).

b. Pipe Lining.

1) Coat interior pipe barrel and all joint surfaces with two-component coal-tar epoxy-polyamide black paint or approved equal.

2) Lining Material: SSPC Specification No. 16, Table 1.

a) Minimum epoxy resin content 34% to 35% by dry film weight.

b) Minimum sag resistance 40 mils (1 mm).

c) Minimum solids 80% by volume.

3) Apply according to the lining material manufacturer's recommendations.

7. Ductile Iron Pipe (DIP) 8 inch to 54 inch (200 mm to 1350 mm).

a. General.

1) Comply with AWWA C151.

2) Minimum thickness Class 52.

b. Interior Linings.

1) Provide interior lining for ductile iron pipe and fittings used for all gravity sewers and drop connections.

2) Use linings specifically designed for sanitary sewer applications, which may include calcium aluminate, polyethylene, ceramic epoxy, and coal tar epoxy. Other lining types may be allowed upon approval of the Engineer.

3) Apply lining to interior of unlined ductile iron pipe and fittings according to the published specifications from the manufacturer.

4) Seal all cut ends and repair field damaged areas according to the manufacturer's recommendations.

c. **Exterior Coating.**
Asphalt.

d. **Joints.**
Push-on complying with AWWA C111.

e. **Fittings.**
Mechanical complying with AWWA C110 or AWWW C153.

f. **Polyethylene Encasement.**
1) Comply with AWWA C105.
2) Minimum thickness of 8 mils (200 µm).
3) Use for all ductile iron pipe and fittings in buried service.

8. **Vitrified Clay Pipe 8 inch to 42 inch (200 mm to 1050 mm).**
a. Pipe and fittings complying with ASTM C 700.
b. Compression joints complying with ASTM C 425 for plain end pipe or bell and spigot pipe.
c. Test according to ASTM C 301.

B. Sanitary Sewer Force Mains.

1. **Ductile Iron Pipe 4 inch to 54 inch (100 mm to 1350mm).**
Apply Article 4149.02, A, 7. If joint restraints are specified, apply Article 4150.02, C.

2. **Polyvinyl Chloride Pipe.**
Apply Article 4150.02, A, for PVC pipe. Provide restrained joints when specified.

3. **Sewage Air Release Valve.**
a. **General.**
Consists of an elongated tapered or conical body with outward-slanting walls and a float to operate (open and close) under pressure without spillage. Use a float with a flexible connection to the seal plug assembly to prevent irregular air release and protect the connecting rod. Ensure the bottom of the valve is sloped or funnel-shaped to encourage the accumulated sewage and solids to drain from the valve. Preserve a volume of air at all times between the liquid sewage and the seal plug assembly.

b. **Materials.**
1) **Body and Cover:** Stainless steel, fiberglass-reinforced nylon, or other corrosion-resistant materials.
2) **Internal Metal Components:** Stainless steel.
3) **Float:** Stainless Steel, ASTM A 240/A 240M, Type 304, or foamed polypropylene.
4) **Seal Plug Assembly:** Stainless steel, foamed polypropylene, EPDM rubber, and reinforced nylon.

c. **Tapping Saddle.**
Stainless steel or nylon.

d. **Pit.**
Construct according to the contract documents.

4. Tracer Wire.
Apply Article 4150.02, E, 2. Tracer wire will be required on all force mains.

5. Tracer Wire Station.
- **a.** Two internal terminals with shunt.
- **b.** Five to six foot (1.5 to 1.8 meter) plastic post (color as specified by the Engineer).
- **c.** Removable top cap with lock.
- **d.** Decals indicating: “Sewer Force Main” or similar language.

C. Casing Pipe.
Apply Article 2553.02, C, for casing pipe requirements.

D. Sanitary Sewer Services.

1. Connection to Main.
- **a. PVC Main.**
  - **1)** Preformed wye or tee service fitting with integral bell and spigot joints with elastomeric seals complying with ASTM D 3034 or ASTM F 949.
  - **2)** Preformed saddle wye or saddle tee for service tap complying with ASTM D 3034 or ASTM F 949.
  - **3)** PVC plastic meeting ASTM D 1784, Cell Classification 12454.
- **b. PVC Composite Main.**
  - **1)** Preformed wye or tee service fitting with integral bell and spigot joints with elastomeric seals complying with ASTM D 3212.
  - **2)** Preformed saddle wye or saddle tee for service tap complying with ASTM D 2680.
- **c. RCP Main.**
  Preformed saddle wye or saddle tee service tap designed for use with RCP.
- **d. VCP Main.**
  - **1)** Precast VCP wye or tee service fitting complying with ASTM C 700 for pipe and ASTM C 425 for compression joints.
  - **2)** Preformed saddle wye or saddle tee service tap designed for use with VCP.
- **e. DIP Main.**
  - **1)** Use DIP wye or tee fittings complying with AWWA C110 or AWWA C153.
  - **2)** Preformed saddle wye or tee services tap designed for use with DIP. Cut the hole for the tap with equipment designed for that application.

2. Wye and Tee Pipe Stop.
All saddle wye or saddle tee fittings must provide an integrally molded pipe stop in the branch for positive protection against service pipe insertion beyond the inside of sewer main pipe wall.

3. Service Pipe.
Use products as required by local plumbing code or regulations, if applicable. Otherwise use the following:

a. PVC.

1) Comply with ASTM D 3034, minimum thickness SDR 23.5; minimum pipe stiffness of 153 psi (1055 kPa) as per ASTM D 2412.

2) PVC plastic meeting ASTM D 1784, Cell Classification 12454.

3) Integral bell and spigot type rubber gasket joint complying with ASTM D 3212.

b. DIP.
As specified for sanitary sewer force main, including polyethylene encasement.

4. Connection to Existing Service.
Apply Article 4147.01, H.

E. Sanitary Sewer Service Relocations.

1. Apply the requirements of Article 4149.02, D, for all materials used for sanitary service relocation.

2. Use the same nominal size as the existing service being relocated.

4149.03 STORM SEWER PIPE.

A. Reinforced Concrete Pipe.

1. Comply with ASTM C 76/C 76M.

2. Minimum Class 2000D (Class III, Wall B).

3. Tongue and groove joints with cold applied bituminous or rubber rope jointing materials, unless otherwise specified. If specified, use rubber O-ring or profile gasket complying with ASTM C 443/C 443M (AASHTO M 315/M 315M).

4. If specified, wrap exterior of each joint with engineering fabric.

B. Reinforced Concrete Arch Pipe.

1. Comply with ASTM C 506/C 506M.

2. Minimum Class 2000D (A-III).

3. Use tongue and groove joints with cold applied bituminous or rubber rope gasket jointing materials, unless specified otherwise.

4. If specified, wrap exterior of each joint with engineering fabric.

C. Polyvinyl Chloride Pipe.
Use pipe complying with the following:

1. Types of PVC pipes:
- **a.** Corrugated exterior, smooth interior, ASTM F 949.
- **b.** Solid wall, ASTM D 3034 or ASTM F 679.
- **c.** Closed profile, ASTM F 1803.
- **d.** Composite, ASTM D 2680.

2. PVC plastic meeting ASTM D 1784, Cell Classification 12454. Do not exceed 10 parts by weight (mass) per 100 of PVC resin in the compound for additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, and colorants.

3. Minimum pipe stiffness of 46 psi (320 kPa).

4. Integral bell and spigot joints with elastomeric seals according to ASTM D 3212 and ASTM F 477.

D. High Density Polyethylene Pipe.
Use pipe complying with the following:

1. AASHTO M 294, Type S corrugated exterior and smooth interior.

2. ASTM D 3350 minimum resin Cell Classification 335420 C.

3. Minimum pipe stiffness at 5% deflection complying with ASTM D 2412.

4. Integral bell and spigot joints with elastomeric seals complying with ASTM F 477.

5. Maximum 5% deflection of the average inside diameter by testing after installation according to Article 2504.03, L, 5.

E. Jointing Material for Concrete Apron.

1. Bituminous Jointing Material.
Use a cold-applied mastic sewer joint sealing compound recommended by the manufacturer for the intended use and approved by the Engineer. Comply with AASHTO M 198.

2. Rubber Rope Gasket Jointing Material.
Comply with ASTM C 990/C 990M.

3. Rubber O-Ring or Profile Gasket.
Comply with ASTM C 443/C 443M (for RCP) or ASTM C 361/C 361M (for RCPP).

F. Bituminous Joint Primer.
Material intended for use in priming concrete joints. Comply with the requirements of ASTM D 41.

G. Engineering Fabric.
Apply Article 4196.01.

H. Non-Shrink Grout.
Apply Materials I.M. 491.13.

I. Casing Pipe.
Apply Article 2553.02 for casing pipe requirements.

4149.04 SANITARY AND STORM SEWER STRUCTURES.

A. Concrete.

1. Precast: Comply with ASTM C 478/C 478M

2. Cast-in-place: Use Class C concrete. Apply Section 2403.

B. Reinforcement.
Apply Section 2404.

C. Non-shrink Grout.
Comply with Materials I.M. 491.13.

D. Precast Riser Joints.

1. Joint Ends.
- **a.** Use tongue and groove ends.
- **b.** If cast-in-place base is used, provide bottom riser with square bottom edge.

2. Joint Sealant.
- **a. Sanitary Sewers.**
  - **1) Rubber O-ring or Profile Gasket:** Flexible joint complying with ASTM C 443/C 443M.
  - **2) Bituminous Jointing Material:** Use a cold-applied mastic sewer joint sealing compound recommended by the manufacturer for the intended use and approved by the Engineer. Comply with AASHTO M 198.
  - **3) Butyl Sealant Wrap:** Comply with ASTM C 877/C 877M.
- **b. Storm Sewers.**
  All joint sealants used on sanitary sewers may also be used for storm sewers. The following may also be used.
  - **1) Rubber Rope Gasket Jointing Material:** Comply with ASTM C 990/C 990M.
  - **2) Engineering Fabric Wrap:** If specified in the contract documents, supply engineering fabric wrap complying with Article 4196.01.

E. Manhole or Intake Top.

1. Capable of supporting HS-20 loading.

2. Use eccentric cone on sanitary sewer manholes unless otherwise specified or allowed.

F. Base.

1. **Sanitary Sewer Manhole.**
   a. **Circular Manhole:** Integral base and lower riser section according to ASTM C 478/C 478M.
   b. **All Other Manholes:** Use precast or cast-in-place concrete base.

2. **Storm Sewer Manhole.**
   Use precast or cast-in-place concrete base.

3. **Intake.**
   Use precast or cast-in-place concrete base.

G. Pipe Connections.

1. **Flexible Watertight Gasket.**
   Comply with ASTM C 923/C 923M.

2. **Non-shrink Grout.**
   Comply with Materials I.M. 491.13.

3. **Waterstop.**
   Provide elastomeric gasket that surrounds pipe and attaches with stainless steel bands and is designed to stop the movement of water along the interface between a pipe and a surrounding concrete collar.

H. Manhole or Intake Adjustment Rings (Grade Rings).

1. Use one of the following methods for grade adjustments of manhole or intake frame and cover assemblies:
   a. **Reinforced Concrete Adjustment Rings.**
      Comply with ASTM C 478/C 478M. Provide rings free from cracks, voids, and other defects.
   b. **High Density Polyethylene Adjustment Rings.**
      Comply with ASTM D 1248 for recycled plastic.
      1) Test and certify material properties by the methods in Table 4149.04-1:

Table 4149.04-1: Test Methods

Property	Test Method	Acceptable Value
Melt Flow Index	ASTM D 1238	0.3 to 30 g/10 min.
Density	ASTM D 792	0.94 to 0.98 g/cm^3
Tensile Strength	ASTM D 638	2000 to 5000 psi (14 to 35 MPa)

2) Do not use polyethylene grade adjustment rings when they are exposed to HMA pavement.

3) When used in a single configuration, provide tapered adjustment ring with thickness that varies from 1/2 inch to 3 inches (13 mm to 75 mm).

4) Install adjustment rings on clean, flat surfaces according to the manufacturer's recommendations with the proper butyl rubber sealant/adhesive.

2. Ensure the inside diameter of the adjustment ring is not less than the inside diameter of the manhole frame or not less than the inside dimension of the intake grate opening.

3. Construct manholes and intakes with the following adjustment ring stack heights:

a. Minimum: 4 inches (100 mm) for new manholes and intakes.

b. Maximum: 12 inches (300 mm) for new manholes and intakes; 16 inches (400 mm) for existing manholes and intakes.

I. Castings (Ring, Cover, Grate, and Extensions).

1. Gray Cast Iron.
Comply with AASHTO M 306.

2. Load Capacity.
Standard duty unless specified otherwise.

a. Standard Duty: Casting certified for 40,000 pound (18,150 kg) proof-load according to AASHTO M 306.

b. Light Duty: Casting certified according to requirements of AASHTO M 306 for a 16,000 pound (7260 kg) proof-load (HS-20). 40,000 pound (18,150 kg) proof-load is not required.

3. Casting Types.

a. Manholes.
Refer to the contract documents.

b. Intakes.

1) Refer to the contract documents.

2) Castings may include environmental symbols or messages, or both, such as “DUMP NO WASTE, DRAINS TO RIVER.”

c. Manhole Casting Extension Ring.

1) Match the dimensions of the existing ring and cover with an allowable diameter tolerance of -1/4 inch (6 mm) for the frame ridge and +1/4 inch (6 mm) for the cover recess.

2) Provide extension ring with height as required to raise the top of the casting to make it level or no more than 1/4 inch (6 mm) below the finished pavement surface. Maximum ring height is 3 inches (75 mm).

J. Additional Materials for Sanitary Sewer Manholes.

1. Chimney Seal.

a. External Rubber Seal.

1) Rubber Sleeve and Extension.

a) Corrugated; minimum thickness of 3/16 inches (5mm), according to ASTM C 923/C 923M.

b) Minimum allowable vertical expansion of at least 2 inches (50 mm).

2) Compression Bands.

a) One-piece band assembly to compress sleeve or extension against manhole and casting surfaces.

b) 16 gage ASTM A 240/A 240M, Type 304 stainless steel, minimum 1 inch (25 mm) width, minimum adjustment range of 4 inches (100 mm) more than the manhole outside diameter.

c) For standard two-piece castings, shape top band to lock sleeve to manhole frame's base flange. For three-piece adjustable castings, shape top band to lock sleeve to upper piece of adjustable frame.

d) Stainless steel fasteners complying with ASTM F 593 and ASTM F 594, Type 304.

b. Internal Rubber Seal.

1) Rubber Sleeve and Extension.

a) Double pleated, minimum thickness 3/16 inch (5 mm) thick, according to ASTM C 923/C 923M.

b) Minimum allowable vertical expansion of at least 2 inches (50 mm).

c) Integrally formed expansion band recess top and bottom with multiple sealing fins.

2) Expansion Bands.

a) One-piece band assembly to compress sleeve or extension against manhole and casting surfaces.

b) 16 gage ASTM A 240/A 240M, Type 304 stainless steel, minimum 1 3/4 inch (45 mm) width, minimum adjustment range of 2 inches (50 mm) more than the manhole inside diameter.

c) Stainless steel locking mechanism of studs and nuts complying with ASTM F 593 and ASTM F 594, Type 304.

2. Riser Section Coating.

a. Exterior: When exterior waterproof coating is specified, provide bituminous or coal tar coating.

b. Interior: When interior manhole lining is specified, provide lining according to Article 4149.02, A (lined, reinforced concrete pipe).

K. Invert.

1. Cast-in-place Structure.

Provide cast-in-place invert with concrete meeting the requirements of Section 2403.

2. Precast Base Section.

a. For sanitary sewers, provide a precast invert, unless allowed otherwise by the Engineer. Apply Article 2435.03, A.

b. For storm sewers, provide a cast-in-place invert with concrete meeting the requirements of Article 4149.04, A.

L. Steps.

1. Provide steps in all circular precast manholes unless specified otherwise in the contract documents.

2. Comply with ASTM C 478/C 478M.

3. Manufacture using polypropylene encased steel.

4. Uniformly space steps at 12 to 16 inches (300 to 400 mm).

5. Align with vertical side of eccentric top section.

6. Place first step no more than 36 inches (900 mm) from top of casting.

M. Precast Concrete Tee.

1. Tee and Eccentric Reducers.
Comply with ASTM C 478/C 478M.

2. Composite Tee.
Refer to the contract documents. May be substituted for pipe diameters less than 48 inches (1200 mm).

N. Anchor Bolts.

1. Material: Stainless steel or hot-dipped galvanized.

2. Diameter: Minimum 1/2 inch (13 mm) diameter.

3. Length: As required to pass through adjusting rings and into manhole or intake structure to embedment depth recommended by anchor manufacturer.

O. Excavation and Backfill Materials.
Apply Section 2552 for bedding and backfill materials.

Section 4150. Water Main, Valve, Fire Hydrant, and Appurtenance Materials

4150.01 DESCRIPTION.

A. Pipe and fittings for constructing water mains.

B. Valves, fire hydrants, and appurtenances associated with water main construction.

4150.02 PIPE AND FITTINGS.

A. Water Main.

1. Polyvinyl Chloride Pipe.
Comply with AWWA C900 or AWWA C905 with gray iron pipe equivalent outside diameters.

a. Minimum Wall Thickness.
1) 4 inch (100 mm) through 24 inch (600 mm) sizes: DR 18.
2) Sizes over 24 inch (600 mm): As specified in the contract documents.

b. Joint Type.
Use push-on joint type, except as otherwise required in the contract documents or as authorized by the Engineer.
1) Push-on: According to AWWA C900 or AWWA C905.
2) Integral Restrained Joint: AWWA C900 or AWWA C905 pipe with restraining system manufactured integrally into pipe end.
3) Mechanical Restrained Joint: Ductile iron mechanical device designed for joint restraint of AWWA C900 or AWWA C905 pipe complying with the requirements of ASTM F 1674.

c. Markings on Pipe.
1) Name of manufacturer.
2) Size and class.
3) Spigot insertion depth gage.
4) National Sanitation Foundation (NSF) seal.

2. Ductile Iron Pipe.

a. Minimum Thickness Class:
1) 4 inch (100 mm) through 24 inch (600 mm) sizes: Special thickness Class 52 according to AWWA C151.
2) Sizes over 24 inches (600 mm): As specified in the contract documents.

b. Cement-mortar Lined: According to AWWA C104 with asphalt seal coat.

c. External coating: Asphalt according to AWWA C 151.

d. Joint Type: Use push-on type, except as otherwise required in the contract documents or as authorized by the Engineer.
1) Push-on: According to AWWA C111.
2) Mechanical: According to AWWA C111.
3) Restrained, Buried: Pipe manufacturer's standard field removable system.

4) **Restrained, in Structures:** Restraining gland, flanged or grooved.
5) **Flanged:** According to AWWA C111.
6) **Grooved:** According to AWWA C606.
7) **Gaskets:** According to AWWA C111.

e. **Markings on Pipe:**
1) Name of manufacturer.
2) Size and class.
3) Spigot insertion depth gage.

B. Bolts for Water Main and Fittings.
Use corrosion resistant bolts.

1. Tee-bolts and Hexagonal Nuts for Mechanical Joints.
a. High strength, low alloy steel manufactured according to AWWA C111.
b. Provide ceramic filled, baked on, fluorocarbon resin coating for bolts and nuts.
c. Include factory applied lubricant that produces low coefficient of friction for ease of installation.

2. Other Bolts and Nuts.
a. Stainless steel.
b. Ductile iron.
c. Zinc, zinc chromate, or cadmium plated.

C. Fittings.

1. DIP and PVC Pipe.
a. Comply with AWWA C110 (ductile iron or gray iron) or AWWA C153 (ductile iron).
b. Joint Type:
1) For pipe sizes 16 inches (400 mm) and less, use mechanical joint complying with AWWA C111.
2) For pipe sizes greater than 16 inches (400 mm), use restrained mechanical joint system. Provide follower gland using breakaway torque bolts to engage thrust restraint.
a) Minimum pressure rating same as connecting pipe. For fittings between dissimilar pipes, the minimum pressure rating is the lesser of the two pipes.
b) Suitable for buried service.
c) Joint restraint system to be field installable, field removable, and re-installable.
3) Use of alternate restraint systems must be approved by the Engineer.
c. Cement mortar lined complying with AWWA C104 with asphalt coating.
d. Wall Thickness: Comply with AWWA C153.
e. Gaskets: Comply with AWWA C111.

2. **Flange Adapter.**
   a. **Body:** Ductile iron complying with ASTM A 536.
   b. **End Rings (Follower Rings):** Ductile iron complying with ASTM A 536.
   c. **Gaskets:** New rubber compounded for water service and resistant to permanent set.
   d. **Bolts and Nuts:** High strength, low alloy corrosion resistant steel or carbon steel bolts complying with ASTM A 307.

3. **Pipe Coupling.**
   a. **Center Sleeve (Center Ring):** Steel pipe or tubing complying with ASTM A 53/A 53M or ASTM A 512, or formed carbon steel with a minimum yield of 30,000 psi (207 MPa).
   b. **End Ring (Follower Ring):** ductile iron complying with ASTM A 536, or steel meeting or exceeding the requirements of ASTM A 576, grade 1010-1020.
   c. **Gaskets:** New rubber compounded for water service and resistant to permanent set.
   d. **Bolts and nuts:** High strength, low alloy corrosion resistant steel.

D. Concrete Thrust Blocks.

1. Use Class C concrete.

2. Refer to the contract documents for dimensions and installation of thrust blocks.

3. Use for all pipe sizes 16 inches (400 mm) in diameter or smaller when specified.

E. Pipeline Accessories.

1. **Polyethylene Wrap.**
   a. Comply with AWWA C105.
   b. Provide tubes or sheets with 8 mil (200 µm) minimum thickness.

2. **Tracer System.**
   Refer to the contract documents for details.
   a. **Tracer Wire:** #12 AWG solid single copper conductor.
      1) Insulation Material: Linear low-density polyethylene (LLDPE) installation suitable for direct burial applications.
      2) Insulation Thickness: 0.045 inches (1 mm), minimum.
   b. **Ground Rod:** 3/8 inch (10 mm) diameter, 60 inch (1.5 m) steel rod uniformly coated with metallically bonded electrolytic copper.
   c. **Ground-rod Clamp:** High-strength, corrosion-resistant copper alloy.
   d. **Splice Kit:** Inline resin splice kit with split bolt for 1 kV and 5 kV. Insulates and seals single conductor and unshielded cable splices for direct bury and submersible applications.
   e. **Tracer Wire Station:** Comply with the contract documents.

F. Special Gaskets.

1. For soils contaminated with gasoline, use neoprene or nitrile gaskets.

2. For soils contaminated with volatile organic compounds, use nitrile or fluorocarbon gaskets.

3. For other soil contaminants, contact the Engineer for the required gasket.

G. Water Service Pipe and Appurtenances.

1. Controlling Standards.
Local plumbing and fire codes.

2. Materials.
a. Copper Pipe.
1) Comply with ASTM B 88.
2) Wall Thickness: Type K.
b. DIP.
As specified in Article 4150.02, A. Polyethylene wrap is required.
c. PVC Pipe.
ASTM D 1785, SDR 21, Schedule 80, Type S joints.
d. Brass Pipe.
Red, seamless, according to ASTM B 43.
e. Polyethylene Pipe.
Class 200, according to AWWA C901.

3. Corporations, Stops, and Stop Boxes.
Contact the Engineer for requirements.

H. Non-shrink Grout.
Comply with Materials I.M. 491.13

I. Casing Pipe.
Apply Section 2553.

4150.03 VALVES.

A. General.

1. Valve Body: Manufacturer's name and pressure rating cast on valve body.

2. Direction of Opening: The opening direction is counterclockwise as viewed from the top, unless specified otherwise in the contract documents or as directed by the Engineer.

3. Joints.
a. For buried installations, use mechanical joints per AWWA C111. Apply Article 4150.02, B, for joint nuts and bolts.

b. For installation within structures, flanged with dimensions and drillings according to AWWA C110 or ANSI B16.1 Class 125.

B. Gate Valves.

1. Standards: Comply with AWWA C509 (gray iron or ductile iron) or AWWA C515 (ductile iron) and NSF 61

2. Stem Seals: Double O-rings permanently lubricated between seals. Lubricant certified for use in potable water.

3. External Bolts and Hex Nuts: Stainless steel according to ASTM A 240/A 240M, Type 304.

C. Butterfly Valves.

1. Standards: Comply with AWWA C504 Class 150B (gray iron or ductile iron) and NSF 61.

2. Stem: Stainless steel according to ASTM A 240/A 240M, Type 304, turned, ground, and polished.

3. For Seat on Body Valves:
- **a. Disc:** Ductile iron or gray iron with plasma applied nickel-chromium edge or stainless steel edge according to ASTM A 240, Type 316, and mechanically fixed stainless steel pins.
- **b. Seat:** Synthetic rubber compound mechanically retained to the body.

4. For Seat on Disc Valves:
- **a. Disc:** Ductile iron according to ASTM A 536 with synthetic rubber compound seat mechanically retained to the disc.
- **b. Seat:** Continuous Type 316 stainless steel seat.

5. External Bolts and Hex Nuts: Stainless steel according to ASTM A 240/A 240M, Type 304.

D. Tapping Valve Assemblies.
Use tapping valve assemblies only where specified in the contract documents.

1. Tapping Valve.
Gate valve complying with AWWA C509 or AWWA C515.

2. Sleeve.
- **a.** Minimum 14 gage.
- **b.** Stainless steel according to ASTM A 240/A 240M, Type 304.
- **c.** Working pressure 150 psi (1035 kPa).
- **d.** Must fully surround pipe.
- **e.** Flanged with dimensions and drillings according to AWWA C110 or ANSI B16.1 Class 125.

3. **Minimum Sleeve Length.**
   Apply Table 4150.03-1

Table 4150.03-1: Minimum Sleeve Length

Outlet Flange Size, inches (mm)	Minimum Sleeve Length, inches (mm)
4 (100)	15 (375)
6 (150)	15 (375)
8 (200)	20 (500)
10 (250)	25 (625)
12 (300)	25 (625)
over 12 (300)	As approved by the Engineer

4. **Gasket.**
   a. To completely surround pipe.
   b. Minimum thickness 0.125 inch (3 mm).
   c. Use nitrile rubber.

5. **Outlet Flange.**
   a. Stainless steel, according to ASTM A 240/A 240M, Type 304.
   b. ANSI B16.1, 125 pound pattern.

6. **Hex Nuts and Bolts.**
   Stainless steel according to ASTM A 240/A 240M, Type 304.

4150.04 FIRE HYDRANT ASSEMBLY.

A. Material.
Comply with AWWA C502.

B. Manufacturers.
As allowed in the contract documents.

C. Features.

1. **Breakaway Items:** Stem coupling and breakaway flange.

2. **Inlet Nominal Size:** 6 inch (150 mm) diameter.

3. **Inlet Connection Type:** Mechanical joint.

4. **Hose Nozzles:** Two, each 2 1/2 inches (63 mm) in diameter.

5. **Direction of Opening:** Counterclockwise, unless specified otherwise.

6. **Items to be Specified:** The following items will be specified in the contract documents.
   a. Operating nut.

b. Pumper nozzle.
c. Nozzle threads.
d. Main valve nominal opening size.

D. Painting.

1. Shop coating according to AWWA C502.

2. Above grade exterior coating type and color will be selected by the Engineer.

E. External Bolts and Hex Nuts.
Stainless steel according to ASTM A 193/A 193M, Grade B 8.

F. Gate Valve.
Apply Article 4150.03.

G. Pipe and Fittings.
Apply Article 4150.02.

4150.05 APPURTENANCES.

A. Flushing Device (Blowoff): As specified in the contract documents.

B. Valve Box.

1. Applicability: For all buried valves.

2. Manufacturer: As specified in the contract documents.

3. Type:
a. In paved areas, use a slide type.
b. In all other areas, use a screw extension type.

4. Material: Gray iron.

5. Cover: Gray iron, labeled "WATER"

6. Wall Thickness: 3/16 inch (4.8 mm), minimum.

7. Inside Diameter: 5 inches (125 mm), minimum.

8. Length: Adequate to bring top to finish grade, including valve box extensions, if necessary.

9. Factory Finish: Asphalt coating.

10. Valve Box Centering Ring: Include in installation.

C. Valve Stem Extension.
For all buried valves, provide as necessary to raise 2 inch (50 mm) operating nut to within 3 feet (1 m) of the finish grade. Stem diameter according to valve manufacturer's recommendations, but not less than 1 inch (25 mm).

Section 4151. Steel Reinforcement

4151.01 DESCRIPTION.
Use the size and type specified in the contract documents. Meet the requirements for the type and use specified. Use chairs, bolsters, and other support devices, either plastic or steel, that meet the requirements of Materials I.M. 451.01.

4151.02 PAVEMENT REINFORCEMENT.
Meet the requirements of Article 4151.03, and where mesh is specified, Article 4151.04.

A. Pavement Tie Bars.

1. Use epoxy coated bars coated according to Article 4151.03, C. Cut or sheared ends need not be recoated.

2. Use deformed bars meeting requirements of ASTM A 615/A 615M, Grade 40 or 60 (300 or 400) if the pavement tie bars are to be bent and later straightened. Bend the tie bars back reasonably straight. Replace tie bars broken during rebending by drilling a hole and setting the bar in epoxy, at no additional cost to the Contracting Authority.

B. Pavement Dowel Bars.

1. Use plain round bars meeting requirements of:
- ASTM A 663/A 663M, Grade 60 (415) or higher,
- ASTM A 675/A 675M, Grade 60 (415) or higher, or
- ASTM A 615/A 615M, Grade 40 (300) or higher.

2. Approved manufacturers and suppliers of load transfer dowels and dowel assemblies are listed in Materials I.M. 451.03, B, Appendix C.

3. Furnish dowels, with the exceptions of end of run and header joints, in approved assemblies, suitable for skewed or perpendicular joints as shown in the contract documents. Ensure all dowels, including end of run and header dowels, have an epoxy coating. Ensure the coating is applied by the electrostatic spray method complying with the requirements of AASHTO M 254, Type B, with a minimum coating thickness of 6 mils (150 µm) after cure. Epoxy powders approved for use are listed in Materials I.M. 451.03, B, Appendix B.

4. The ends of dowels may be saw cut or sheared. The sawed and sheared ends need not be coated. If the dowel bars are saw cut, ensure they are free of burrs and projections. Also ensure the deformation of

the bars from true round shape does not exceed 0.04 inches (1 mm) in diameter or in thickness.

5. Prior to delivery to the work site, the assemblies are to be dipped in a bond breaker meeting the requirements of Section 4137, 4138, or 4140. The bond breaker may be bituminous or paraffin.

C. Reinforcement For Bridge Approach Sections, Reinforced Paved Shoulders, and Full-Width Reinforcement of Pavements.
Comply with the following:

- Deformed bars meeting the requirements of ASTM A 615/A 615M, Grade 40 0r 60 (300 or 400); or ASTM A 706/A 706M, Grade 60,
- Epoxy coated, and
- Meet the requirements of Article 4151.03, except that cut or sheared ends need not be recoated.

4151.03 REINFORCEMENT FOR STRUCTURES.

A. General.

1. Unless otherwise specified, use deformed bars meeting the requirements of ASTM A 615/A 615M, ASTM A 706/A 706M or ASTM A 996/A996M. Use bars fabricated according to Article 2404.03, B.

2. Spirals of No. 5 (15) bars or smaller and any bars No. 3 (10) or smaller for stirrups or hoops of a specified shape may, at the Contractor's option, be:

- Material meeting requirements of ASTM A 82 reinforcement specified above, or
- Steel meeting physical and chemical requirements of ASTM A 615/A 615M, Grade 40 (300).

3. For spirals in precast and prestressed concrete piling and all wire ties, use steel wire with a minimum tensile strength of 40,000 psi (300 MPa), with other properties such as to permit bending as shown in the contract documents.

B. Galvanized Reinforcement.

1. Perform cutting and bending prior to galvanizing and according to the requirements of Section 2404. After cutting and bending, galvanize all reinforcement required to be galvanized according to the requirements of ASTM A 123. Take precautionary measures to prevent loss in the height of the deformation pattern.

2. Apply a chromate conversion coating immediately after galvanizing. This may be accomplished by either: 1) quenching the bars, immediately after galvanizing, in a solution containing at least 0.2% (by weight (mass)) of sodium dichromate in water; or 2) quench chromating in a minimum 0.2% chromic acid solution. The quench water should be at least 90°F (32°C). Proprietary chromate solutions of equivalent

effectiveness may be substituted for the above procedure. If the reinforcing material is allowed to cool before chromate treating as specified above, 0.5% to 1.0% concentration of sulfuric acid should be added as an activator to the chromate solution.

3. Galvanize tie wires and wire or pressed steel chairs to be used with galvanized reinforcing steel. Either turn up or coat the ends of chairs which may be exposed in the finished concrete. Stainless steel chairs, plastic coated carbon steel chairs, or other types of chairs may be approved by the Engineer. Galvanizing of hangers is optional (required only when to remain exposed), according Article 2412.03, A.

4. Handle bars in a manner to prevent damage to the galvanized coating.

C. Epoxy Coated Reinforcement.

1. Ensure reinforcement (deformed and plain) required to be epoxy-coated has a protective coating of epoxy applied by electrostatic spray method according to the requirements of ASTM A 775/A 775M.

2. Acceptance and handling of epoxy-coated reinforcing steel reinforcement bars at the project site are to be according to the requirements of these specifications and the requirements of Materials I.M. 451.03B.

D. Surface Preparation.

1. Thoroughly blast (near-white) clean reinforcing steel surfaces to be coated. Remove mill scale, rust, and foreign matter. Ensure the blast media produces a suitable anchor pattern profile (a depth of 2.0 to 4.0 mils (50 µm to 100 µm)). Apply the coating within 0.5 hour after cleaning.

2. Ensure blast media meets the requirements of Materials I.M. 451.03B.

E. Repair to Damage Incurred During Fabrication.
Ensure coating damage due to fabrication or handling at the fabricator facility is repaired using patching material meeting the requirements of Section 3.1 of ASTM D 3963/D 3963M. The fabricator is responsible for the repair.

F. Repair of Damage Incurred during Shipment and Handling at the Job Site.
Comply with the following:

1. Repair visible damage incurred during shipment, storage, and /or placement of epoxy-coated bars at the job site.

2. Use coating patch materials of organic composition consisting of a two-component liquid properly mixed that hardens to a solid form upon

curing. Approved repair/patch compounds are listed in Materials I.M. 451.03B.

3. Repair damage to the coating caused by shipment, storage, and/or placement at the job site.

4. Ensure sheared ends/saw-cut ends of the coated bars have adequate coating, have no signs of surface rust or damage, and are repaired and/or coated with the same patching material that is used for repairing damaged coating.

5. The maximum amount of repaired, damaged areas is not to exceed 2% of the total surface area in each 1.0 linear foot (0.3 m) of the bar. Should the amount of damage exceed the 2% in 1.0 linear foot (0.3 m), then remove that bar and replace with an acceptable bar. Coating the cut ends will not be included in the repair percentage.

6. Apply a minimum coating thickness of 7 mils (175 µm) to areas to be repaired.

7. Allow patches to cure (dry to the touch) before placing concrete over the coated bars.

8. Prepare the surface, repair it, and apply patches according to the resin manufacturer's recommendations.

G. Storage, Handling, and Placement at the Job Site.

1. Comply with the following:
   - **a.** Store coated bars or bundles above ground on wooden or padded supports with padded timbers placed between bundles when stacking is necessary. Place supports to prevent sags in the bundles.
   - **b.** Ensure systems for handling (loading, unloading, storing) the coated bars at the job site have padded contact areas. Do not drop or drag coated bars or bundles.
   - **c.** Store coated and uncoated steel reinforcing bars separately.
   - **d.** Minimize handling and re-handling of the coated bars.
   - **e.** Tie coated bars using tie wire coated with epoxy, plastic, Nylon, or other non-conductive Materials that will not damage or cut the coating.
   - **f.** Use a non-conductive Material compatible with concrete to coat or fabricate bar supports or spacers.

2. Use a non-transparent material to cover coated bars if they will be exposed for 2 months or more. Ensure adequate ventilation is provided to minimize condensation under the cover.

4151.04 WIRE MESH REINFORCEMENT.

Use the size and spacing shown in the contract documents. Ensure it meets the requirements of ASTM A 185.

4151.05 STEEL FOR PRESTRESSING CONCRETE.
Comply with one of the following classifications, as required by the contract documents:

A. Uncoated Seven Wire Stress Relieved Strand.
Meet the requirements of AASHTO M 203, except furnish a load elongation curve for each heat number delivered. Low relaxation strand described in the AASHTO M 203 Supplement may be furnished at the Contractor's option.

B. Uncoated Stress Relieved Wire.
Meet the requirements of AASHTO M 204.

C. High Strength Alloy Steel Reinforcement.
Meet the requirements of AASHTO M 275.

Section 4152. Structural Steel

4152.01 GENERAL REQUIREMENTS.
Meet the following requirements unless alloy steel is specified in the contract documents. For alloy steel, meet the requirements specified in the contract documents for each project on which such steel is specified.

4152.02 STRUCTURAL STEEL.

A. Use the type and quality designated in the contract documents. When not specifically designated, use structural carbon steel meeting the requirements of ASTM A 709/A 709M Grade 36 (250). Miscellaneous items not commonly rolled from steel meeting these requirements may be furnished in other grades of steel with the Engineer’s approval.

B. Unless noted otherwise, apply Charpy V-notch toughness requirements of Table 4152.02-1 to the following members. Ensure members are sampled and tested according to AASHTO T 243/T 243M (ASTM A 673/A 673M).

1. Flange and web plates of welded plate girders.

2. Rolled section main beams, stringers, and welded cover plates.

3. Flange and web splice plates.

4. Rolled or welded floor beams, abutment diaphragms, and cross frames carrying direct live loads, and all parts, except shear connectors, welded to each of these members.

5. Lateral bracings and connecting gusset plates in horizontally curved bridges.

C. The contract documents may also designate other members to which toughness requirements apply.

Table 4152.02-1: Non-Fracture Critical Impact Test Requirements

Grade	Thickness (in.)(mm) and Joining Method	Minimum Average Energy, ft.lbf. at °F (Joules at °C)
36T[(a)] (250T[(a)])	to 4 (100), mechanically fastened or welded	15 at 40 (20 at 4)
50T[(a, b)] (345T[(a, b)]) 50WT[(a, b)] (345WT[(a, b)])	to 2 (50), mechanically fastened or welded over 2 to 4 (50.1 to 100), mechanically fastened over 2 to 4 (50.1 to 100), welded	15 at 40 (20 at 4) 15 at 40 (20 at 4) 20 at 40 (27 at 4)
100T[(c)] (690T[(c)]), 100WT[(c)] (690WT[(c)])	to 2 1/2 (65), mechanically fastened or welded over 2 1/2 to 4 (65.1 to 100), mechanically fastened over 2 1/2 to 4 (65.1 to 100), welded	25 at 0 (34 at -18) 25 at 0 (34 at -18) 35 at 0 (48 at -18)

(a) CVN-impact testing of "H" heat frequency testing according to ASTM A 673/A 673M.

(b) If the yield point of the material exceeds 65 ksi (450 MPa), reduce the testing temperature for the minimum average energy required by 15°F (8°C) for each increment of 10 ksi (70 MPa) above 65 ksi (450 MPa). The yield point is the value given on the certified "Mill Test Report".

(c) CVN-impact testing of "P" plate frequency testing according to ASTM A 673/A 673M.

Section 4153. Miscellaneous Iron and Steel

4153.01 STEEL FORGINGS.

A. Meet the requirements of ASTM A 688/A 688M, Class C for forgings, from which pins, rollers, trunnions, or other forged parts 7 inches (175 mm) or more in diameter are made. Forgings of this class may also be used for production of pins and rollers smaller than 7 inches (175 mm) in diameter.

B. For forgings intended for welding, limit the maximum carbon content (product analysis) to 0.35%.

4153.02 COLD FINISHED STEEL.

A. Pins and rollers less than 7 inches (175 mm) in diameter may be made from cold finished steel meeting requirements of ASTM A 108, Grades 1016 to 1030 inclusive, with the additional requirement of Rockwell Hardness not less than B-80.

B. Steels which show Rockwell Hardness less than B-80 may be accepted provided they show an ultimate tensile strength not less than 66,000 psi (455 MPa) and a yield point no less than 33,000 psi (230 MPa).

4153.03 STEEL CASTINGS.

Meet the requirements of ASTM A 27/A 27M, Grade 65-35 (450-240), supplemented by the following provisions:

A. Quality of Work.
True to pattern in form and dimension, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended.

B. Blow Holes.
No blow holes exceeding 1/2 square inch (320 mm^2) in area or 1 inch (25 mm) in length. Total length of cavity cut by a straight line laid in any direction not to exceed 1 inch in 1 foot (25 mm in 300 mm).

C. Defects.
If the Engineer requires, suspend large castings and hammer all over. Ensure no cracks, flaws, or other defects appear after such treatment.

D. Unfilleted Corners.
No unfilleted angles or corners.

4153.04 IRON CASTINGS.

A. Either gray iron castings meeting requirements of ASTM A 48 or ductile (nodular) iron castings meeting requirements of ASTM A 536, as specified in the contract documents. Unless specified otherwise, comply with the following:
- Gray iron castings, bridge rockers, and shoes: meet the requirements of Class 35B.
- Ductile iron castings: meet the requirements of Grade 65-45-12.

B. Ensure castings are:
- Boldly filleted at angles, and arises are sharp and perfect.
- True to pattern in form and dimensions.
- Free from pouring faults, sponginess, cracks, blow holes, or other defects in positions affecting their strength for service intended.

C. With the Engineer's approval, minor defects may be welded by an approved process if:
- The depth is not greater than 5% of the thickness at the point of occurrence,
- The length is not greater than 25% of the thickness at the point of occurrence, and
- The defects do not impair the strength.

D. Castings which have been welded without the Engineer's permission may be rejected. Ensure frames and grates for drainage openings are straight and fit properly together so traffic will not cause them to rattle. Rough spots which prevent suitable fitting may be removed by grinding.

4153.05 WELDED STEEL PIPE.
Unless specified otherwise, standard weight black pipe meeting requirements of ASTM A 53, Grade B.

4153.06 BOLTS, NUTS, WASHERS AND FASTENERS.
Ensure bolts, nuts, and washers for bolted connections of steel structures comply with the type specified in the contract documents and meet the following requirements for the type designated:

A. Non-High Strength Bolts and Nuts.
Ensure the following:

1. Bolts and nuts meet the requirements of ASTM A 307, Class A, with full diameter body. Hexagonal bolt heads and nuts.

2. Threads meet the requirements of ANSI B1.1, Unified Coarse Thread Series, Class 1A and Class 1B fit.

3. Where galvanized fasteners are specified, zinc is applied by hot dipped galvanizing to meet the requirements of ASTM F 2329. Fasteners may be mechanically galvanized to meet the requirements of ASTM B 695, Class 50 Type 1.

B. High Strength Fasteners.

1. Ensure the following:
- **a.** High strength bolts, nuts, and washers meet the requirements of the appropriate ASTM Specifications as follows:

bolts	A 325
nuts	A 563 Grade DH3
washers	F 436

- **b.** For galvanized high strength fasteners, the fasteners meet the requirements of ASTM B 695, Class 50 Type I.
- **c.** For weathering steel, bolts are ASTM A 325 Type III, nuts are ASTM A 563 Grade DH3, and washers are ASTM F 436 Type III.

2. Furnish all high strength bolts, nuts and washers according to this specification, which includes:
- The appropriate ASTM Specifications,
- In certain instances, modifications of the requirements of ASTM Specifications, and
- In certain instances, additional requirements in excess of the ASTM Specification.

3. **NOTE:** ASTM A 490 bolts are specifically excluded from this specification.

4. The applicable ASTM test method specifications are as follows:
- **a. General.**
  - **1)** ASTM F 606, Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers and Rivets.
  - **2)** ASTM A 370, Standard Methods and Definitions of Mechanical Testing of Steel Products.
  - **3)** Article 7.2 of ASTM A 325 is changed to read as follows:
    "Threads shall be the Unified Coarse Thread Series as specified in ANSI/ASME B1.1 and shall have Class 2A tolerances."
- **b. Specifications for Nuts.**
  - **1)** ASTM A 563, Carbon and Alloy Steel Nuts.

2) Proof load tests (ASTM F 606 Paragraph 4.2) are required. Galvanizing, if required, completed prior to proof load testing. Minimum frequency of tests according to ASTM A 563 Paragraph 9.3.

c. Specifications for Bolts.

1) ASTM A 325, High Strength Bolts for Structural Steel Joints.

2) Proof load tests (ASTM F 606, Method 1), are required. Galvanizing, if required, completed prior to proof load testing. The minimum frequency of tests according to ASTM A 325 Paragraph 9.5.1.

3) In determining bolt length, calculate the grip as for a riveted joint. To compensate for thickness of the nut, one washer, and the bolt point, add the values shown under bolt size in Table 4153.06-1. If other than the preferred thickness of washer is used, adjust the necessary length to the next longer 1/4 inch (6 mm) increment.

Table 4153.06-1: Add to Grip

Bolt Size inches (mm)	1/2 (12.7)	5/8 (15.9)	3/4 (19.0)	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)	1 1/4 (31.8)
Add to Grip inches (mm)	15/16 (24)	1 1/16 (27)	1 3/16 (30)	1 5/16 (33)	1 7/16 (36)	1 9/16 (40)	1 11/16 (43)

d. Specifications for Washers.

ASTM F 436, Specifications for Hardened Steel Washers.

e. Rotational-Capacity Certification Requirements.

The supplier's Rotational-Capacity Certification requirements are as follows:

1) Ensure the supplier subjects the fastener assembly (bolt, nut, and washer) to rotational-capacity tests prior to shipment to ensure compatibility of the fastener assembly, according to Materials I.M. 453.06B.

2) Ensure each combination of production lots (bolt, nut, and washer) has a unique Rotational-Capacity Lot number. Ensure this number is included on the certified test report and the shipping containers for bolts, nuts, and washers.

f. High Strength Fasteners.

Ensure high strength fasteners are manufactured to the following requirements:

1) Bolts.

a) Ensure bolts of diameters 1/2 inch to 1 inch (12.7 mm to 25.4 mm), inclusive, meet the following hardness requirements:

Table 4153.06-2: Hardness Number

	Minimum	**Maximum**
Brinell	248	311
Rockwell C	24	33

b) Black bolts shall be "oily" to the touch when installed. Clean and re-lubricate dry or rusted bolts prior to installation.

2) Nuts.

a) Grades 2H, DH, or DH3 and shall be "oily" to the touch when installed. Clean and re-lubricate dry or rusted nuts prior to installation.

b) Galvanized nuts: clean, dry, and lubricated as per ASTM A 563 Supplementary Requirements S1 and S2.

3) Markings.

a) Ensure bolts, nuts, and washers are marked with a symbol identifying the manufacturer as required by ASTM specifications.

b) Ensure the supplier includes with the certification documents the symbol and address of each manufacturer of bolts, nuts, and washers supplied for the project.

5. Unless specified otherwise, install all high strength bolts according to Article 2408.03, S, 5.

4153.07 HARDWARE FOR TIMBER STRUCTURES.

A. Bolts and Nuts.

1. Ensure all bolts used with timber structures have a full diameter body.

2. Ensure bolts and nuts meet the requirements of ASTM A 307, Grade A.

3. Bolt heads and nuts may be either square, hexagonal, or heavy hexagonal style. Ensure they meet the requirements of ASTM A 307 and ASTM A 563.

B. Washers.

1. Washers may be cast iron, malleable iron, or mild steel.

2. Flange bolts and flange nuts may be used in place of separate washers.

3. Ensure cast iron washers, flange bolts, and flange nuts have a diameter no less than 3.5 times the diameter of the bolt with which they are used.

4. Ensure Type A plain washers, before galvanizing, comply with the dimensions in ANSI B18.22.1.

C. Galvanizing.

Ensure all bolts, nuts, and washers are zinc coated to meet the requirements of ASTM F 2329.

D. Nails.

1. Use round or oval galvanized wire nails meeting the requirements of FSS FF-N-105(2) and of the size designated.

2. Obtain the Engineer's approval for double pointed nails.

3. Ensure all nails holding floor plank, backing plank, or sway bracing are ring shanked prior to galvanizing.

4. Ensure the galvanized coating meets the requirements of F 2329.

E. Lag Bolts.
Use lag bolts meeting the requirements of ANSI B18.2.1, galvanized according to 2329.

F. Floor Clips.
Use floor clips shown in the contract documents. When not shown, ensure they are galvanized metal, no thinner than 10 gage (3.4 mm), shaped to fit the flanges.

Section 4154. Fence Materials

4154.01 DESCRIPTION.

A. Materials covered by this section include woven wire farm field fabric, chain link fabric, barbed wire, steel fence posts, wood fence posts, tie and brace wire, gates, and special fittings.

B. Use material of the size and type designated in the contract documents. Use new material meeting the requirements of the following provisions.

4154.02 FIELD FENCE AND DEER FENCE.

A. Field Fence.

1. Use fabric meeting the requirements of ASTM A 116, Class 3 coating.
- For Type 47 fence, the fabric design is ASTM Design Number 1047-6-11 grade 60 wire or 1047-6-12 1/2 grade 125 wire.
- For Type 39 fence, the fabric design is ASTM Design Number 939-6-11 grade 60 wire or 939-6-12 1/2 grade 125 wire.

2. When the type is not designated, furnish one of the above 1047 fabrics.

3. Fabric may be furnished in lengths greater than 20 rods (100 m).

4. Use galvanized (as determined by visual inspection) steel rod for splicing fence material.

B. Deer Fence

Use woven wire fence fabric that:

- Meets the requirements (excluding wire spacing and fence height) for 12.5 gage wire according to ASTM A 116, and
- Has wires spaced horizontally and vertically as shown in the contract documents or closer.

4154.03 CHAIN LINK FABRIC.

A. When chain link fence is specified in the contract documents, use either:

- Zinc coated fabric meeting the requirements of ASTM A 392, Class 2 coating, or
- Aluminum coated fabric meeting the requirements of ASTM A 491.

B. Knuckle the salvage top and bottom, except as indicated. Use material 72 inches (1.8 m) high (unless specified otherwise) and fabricated from No. 9 (3.76 mm diameter) wires.

4154.04 BARBED WIRE.

Use barbed wire meeting the requirements of ASTM A 121 for 950 pounds (4.23 kN) force minimum strand breaking strength and 4 barbs at nominal 5 inch (125 mm) centers. Ensure the zinc coating is at least 0.80 ounce per square foot (244 g/m^2).

4154.05 BRACE WIRE, TENSION WIRE, AND TIE WIRE.

A. Use galvanized wire meeting requirements of ASTM A 116, Class 3 coating, or an aluminum coated steel wire with a coating of not less than 0.25 ounce per square foot (76 g/m^2). Use tension wire at the bottom of chain link fence that meets the requirements of ASTM A 641/641 M, hard grade, with a Class 3 zinc coating or an aluminum coating of no less than 0.25 ounce per square foot (76 g/m^2).

B. Unless designated otherwise, use wire sizes no smaller than the following diameters:

Table 4154.05-1: Wire Sizes

Use	Wire Size
Tension wire Brace wire Tie wires or clips for fastening field fence to steel posts	No. 7 (4.49 mm) No. 9 (3.76 mm) No. 12 (2.68 mm)
Use tie wires for chain link fence that are the size and type the manufacturer recommends, but no smaller than No. 9 (3.76 mm) diameter for post ties or No. 12 (2.68 mm) diameter for rail and brace ties. Equivalent steel clips or aluminum wires or clips may be used if the Engineer approves.	

4154.06 STAPLES.

Use plain, class 3 zinc coated, No. 9 (3.76 mm), 1 3/4 inch (45 mm) long wire staples, unless specified otherwise in the contract documents. Obtain Engineer's approval for the staples to be used.

4154.07 WOOD POSTS.

A. Use pine posts that:

- Meet the requirements of Section 4164 with pressure preservative treatment meeting the requirements of Section 4161.
- Are of the size and length designated in the contract documents.

B. Unless specified otherwise, use round stock posts of the following sizes and lengths:

Table 4154.07-1: Post Sizes and Lengths

Use	Length, feet (meters)
Line posts, 4 inch (100 mm) top End, corner, gate, pull, angle, and brace posts, 6 inch (150 mm) top	7 (2.1 m) 8 (2.4 m)

C. If contemplating driving the line posts, the tip of the post may have a blunt point made before treatment and located near the center line of the post.

4154.08 BRACES FOR FIELD FENCE.

A. Use steel angle (or other approved bracing systems) weighing (with a mass of) no less than 1.94 pounds per foot (2.9 kg/m).

B. Use angles no less than 2 inches by 1 1/2 inches by 3/16 inches (50 mm by 40 mm by 5 mm). Use braces shown in the contract documents.

C. Ensure ends are flattened to fit squarely against the posts with brace approximately horizontal.

D. For steel line posts, use coated braces as required.

4154.09 STEEL LINE POSTS FOR FIELD FENCE.

A. Use T-section (or other approved sections) steel posts as line posts with wood posts, as shown in the contract documents. Do not use them for corner, brace, pull, end, or gate posts.

B. Only one type of steel post may be used in any installation 1,000 feet (300 m) or less in length.

C. Equip posts with lugs or other approved means to prevent the fence fabric from moving vertically.

D. Use posts that weigh (have a mass of) no less than 1.3 pounds per foot (1.9 kg/m), exclusive of anchor plate.

E. Provide each post with a steel anchor plate of adequate size, firmly attached. After the anchor plate is attached, completely paint the finished post with a prime coat and an enamel finish coat, with no limitation on color or tip identification except as provided for 1,000 foot (300 m) installations. Ensure the paint is thoroughly dry before posts are bundled for shipment.

Unless specified otherwise, use steel line posts that are 7 feet (2.1 m) in length.

4154.10 STEEL POSTS, BRACES, AND RAILS FOR CHAIN LINK FENCE.

A. Use galvanized standard weight (schedule 40) pipe meeting the requirements of ASTM F 1083 of the lengths designated in the contract documents. Posts, braces, and rails of alternate cross sectional shape, material, or protective coating may be used if approved according to Materials I.M. 454.10. Ensure similar parts with different shapes or protective coatings are not intermingled within the project limits.

B. Ensure protective coatings for steel posts, braces, and rails of alternate shapes or alloys comply with one of the following methods. Other protective coatings, including polymeric, metallic, or combinations of the two, that provide protection equivalent to a zinc coating meeting ASTM A 123, may be approved.

1. Zinc coatings meeting the requirements of ASTM A 123.

2. Hot dipped pure aluminum coating with a minimum coating of 0.75 ounce per square foot (228 g/m^2) of surface, triple spot test, 0.70 ounce per square foot (213 g/m^2) of surface, single spot test, as measured according to ASTM A 428. Both outer and inner surfaces of pipe or tubing coated with a chromate chemical treatment and a thin resin film for protection during storage or handling.

C. With the posts, provide approved caps that, for 3 inch and 4 inch (75 mm and 100 mm) posts, either:

- Make a driving fit over the upper 1/2 inch (13 mm) of the post, or
- Have other approved means for holding the cap securely in place.

4154.11 SPECIAL FITTINGS FOR CHAIN LINK FENCE.

A. Comply with the following:

1. Attach braces to posts using fittings which will hold both the post and brace rigidly.

2. Use diagonal tension rods of 3/8 inch (9.5 mm) diameter, round steel rods with an appropriate commercial means for tightening.

3. Furnish a locknut or other device to hold the tightening device in place.

4. Use wire ties meeting requirements of Article 4154.05.

5. Furnish a suitable sleeve or coupling device, recommended by the manufacturer, to connect sections of top rail and to provide for expansion and contraction.

6. Use stretcher bars no less than 3/8 inch (9.5 mm) diameter, or equivalent cross section area, with suitable clamps for attaching fabric to corner, end, or gate posts.

B. Ensure all special fittings, except aluminum fittings, have a galvanized coating of no less than 0.8 ounce per square foot (244 g/m^2) applied by the hot dip process.

4154.12 GATES.

A. Field Fence and Chain Link Fence.

1. Ensure gates provide the width of opening shown in the contract documents. Install a vertical stay in gates more than 6 feet (1.8 m) wide. Where the width of opening specified is:

- 16 feet (5 m) or less, provide a single gate frame.
- More than 16 feet (5 m), provide two gate frames using a drop bar locking device allowing operation as a double gate.

2. Ensure each gate is furnished complete with necessary hinges, latch, and other special fittings recommended for the type of gate and gate post being installed.

3. For chain link fence gates, use the pipe size shown in the contract documents or approved by the Engineer. When size is not shown in the contract documents, use:

- 1 1/2 inch (40 mm) nominal diameter pipe for gates 6 feet (1.8 m) wide or more, and
- 1 1/4 inch (30 mm) nominal diameter pipe for gates less than 6 feet (1.8 m) wide.

4. Use gate fabric similar to that used for the fence. Attach using stretcher bars.

5. Use adjustable rods to cross truss gates 6 feet (1.8 m) wide or more.

6. Ensure materials are galvanized with no less than 0.8 ounce per square foot (244 g/m^2) of surface. Gates for field fence may be painted with a prime coat and an enamel finish coat.

B. Deer Fence.

Furnish the following, galvanized according to Article 4154.10:

1. Tines molded in one piece of steel with no welds.

2. Structural steel tubes with wall thickness of 0.1875 inches (4.75 mm) and unit weight of 4.32 pounds per foot (6.43 kg/m).

3. Support plates, hinges, and top braces.

Section 4155. Guardrail

4155.01 GENERAL REQUIREMENTS.

Provide guardrail materials meeting the requirements for the type of guardrail specified. Provide guardrail posts of wood or steel as specified in the contract documents.

4155.02 STEEL BEAM GUARDRAIL.

Comply with the following:

A. Rail elements, and terminal sections: meet the requirements of AASHTO M 180, Class A, 12 gauge (2.67 mm thickness), Type I, unless a greater thickness is required.

B. Bolts used to attach steel beam guardrail to concrete barrier or bridge rail: full-length galvanized and meet the requirements of ASTM A 325 or A 449, Type 1.

C. All other bolts: meet the requirements of ASTM A 307, Grade A.

D. Washers used to attach steel beam guardrail to concrete barrier or bridge rail: meet the requirements of ASTM F 436.

E. All other washers: meet the requirements of ASTM F 844.

F. Nuts used to attach steel beam guardrail to concrete barrier or bridge barrier rail: heavy hex, Class 2B meeting the requirements of ASTM A 563, DH.

G. All other nuts: meet the requirements for ASTM A 563, Grade A, hex.

H. Galvanizing: meet the requirements of ASTM A 153, Class C F 2329 or B 695 Class 50, Type I Coating.

4155.03 CABLES.

A. Cable Rail.

1. Meet the requirements of AASHTO M 30, Type I, Class A.

2. For high tension cable guardrail, meet the manufacturer's requirements.

B. Anchor Cable.
Meet the requirements of AASHTO M 30, Type II, Class A.

4155.04 POSTS.

A. Wood Posts.
Use posts sawed to the dimensions shown in the contract documents and meeting the requirements of Section 4164.

B. Steel Posts.

1. Use steel posts of the dimensions shown in the contract documents and that meet the requirements of ASTM A 36/A 36M structural steel.

2. Ensure bolt holes comply with Article 2408.03, S, 2.

3. Ensure steel posts and blocks are galvanized according to the requirements of ASTM A 123. Ensure galvanizing is done after fabrication and after all bolt holes have been drilled.

4155.05 BLOCKOUTS.

A. For wood blockouts, meet the requirements for wood posts.

B. Blockouts manufactured from alternate materials that have received FHWA acceptance for use on the National Highway System may be substituted for wood blockouts.

C. Ensure galvanizing is done after fabrication and after all bolt holes have been drilled.

4155.06 MISCELLANEOUS ITEMS.

A. Ensure the following:

1. All miscellaneous items and materials are of the type, size, and dimension shown in the contract documents.

2. All metal parts are galvanized. However, any items or parts of items to be covered with 2 inches (50 mm) or more of concrete need not be galvanized.

3. All cable fittings required for cable guardrail installation are designed and fabricated so as to develop the full strength of a single cable or the multiple cable assembly, as applicable.

B. Internal threads of fasteners may be oversize, tapped after galvanizing.

C. When specific requirements are not stated in the contract documents, obtain the Engineer's approval for anchor angles, anchor cable, turnbuckles, hook bolts, compensating devices, and any other fittings or special hardware which may be required.

Section 4160. Wood Preservatives

4160.01 GENERAL REQUIRMENTS.

Meet the requirements for the material specified. Meet the requirements of all Federal, State, and local regulations.

A. Creosote.
Meet the requirements of AASHTO M 133 (AWPA P1).

B. Pentachlorophenol.
Meet the requirements of AASHTO M 133 (AWPA P8). Ensure petroleum solvent meets the requirements of AWPA P9 for Hydrocarbon Solvent Type A.

C. Copper Naphthenate.
Meet the requirements of AASHTO M 133 (AWPA P8). Ensure petroleum solvent meets the requirements of AWPA P9 for Hydrocarbon solvent Type A.

D. Ammoniacal Copper Zinc Arsenate (ACZA).
Meet the requirements of AASHTO M 133 (AWPA P5).

E. Chromated Copper Arsenate (CCA).
Meet the requirements of AASHTO M 133 (AWPA P5), Type A, Type B, or Type C.

Section 4161. Preservative Treatment

4161.01 GENERAL REQUIREMENTS.
Meet the requirements of applicable sections within these specifications for preservative treatment of timber, lumber, piling and posts. Unless specified otherwise, meet the requirements of this section for treatment process and results.

4161.02 PRESERVATIVES.
Meet the requirements of Section 4160. Unless specified otherwise, treatment may be with creosote, pentachlorophenol, copper naphthenate, ammoniacal copper zinc arsenate (ACZA), or chromated copper arsenate (CCA).

4161.03 TREATMENT.

A. Except as provided herein, follow the requirements and recommendations of AWPA Standards U1 and T1 and the applicable AWPA Commodity Specifications listed in Tables 4161.03-1 and 4161.03-2 for various materials and usages:

Table 4161.03-1: Minimum Preservative Retention Requirements
(lb./cu. ft. of wood)
(kg/m^3 of wood)

	Retention					
Material and Usage	**Creosote[a]**	**Pentachloro-phenol[a]**	**Copper Napthenate[a]**	**ACZA[b]**	**CCA[b, c]**	**AWPA UC-Section-Special Req.**
Lumber and Timber for Structures[d]	AWPA U1	AWPA U1	AWPA U1	AWPA U1	AWPA U1	AWPA U1
Piles for Foundation:						
Douglas Fir	17 (272)	0.85 (13.6)	0.14 (2.2)	-	-	UC4C-E
Southern Pine	12 (192)	0.60 (9.6)	0.10 (1.6)	-	-	
Guardrail Posts, and Spacer Blocks:						
Sawed Four Sides	-	0.6 (9.6)	0.075 (1.2)	0.5 (8.0)	0.5 (8.0)	UC4A-A-4.3
Fence, Guide, and Sign Posts:						
Round	-	0.4 (6.4)	0.055 (0.88)	0.4 (6.4)	0.4 (6.4)	UC4A-B
Sawed Four Sides	-	0.5 (8.0)	0.060 (0.96)	0.4 (6.4)	0.4 (6.4)	UC4A-A-4.3

[a] Oil type preservatives.
[b] Waterborne preservatives.
[c] Do not use for the treatment of Douglas Fir.
[d] Retentions based on AWPA Use Category and Commodity Specifications for different applications.

Table 4161.03-2: Minimum Preservative Retention Requirements
inches (mm) of wood and/or % of sapwood penetration

	Penetration[1]		
Material and Usage	**Southern Pine**	**Douglas Fir**	**AWPA Material Standard Section**
Lumber and Timber for Structures(a)	AWPA U1, T1	AWPA U1, T1	AWPA U1, T1
Piles for Foundation:	3.0 in. (75 mm) or 90%	0.75 in. (19 mm) and 85% up to 1.6 in. (40 mm) and 85%	T1-8.5
Guardrail Posts and Spacer Blocks:			
Sawed Four Sides	2.5 in. (63 mm) or 85%	**Under 5 in. (125 mm) thick:** 0.4 in. (10 mm) and 90% **5 in. (125 mm) and thicker:**	T1-8.1

		0.5 in. (13 mm) and 90%	
Fence, Guide, and Sign Posts:			
Round	2.0 in. (50 mm) or 85%	3/8 in. (9 mm) and 100% up to 1 in. (25 mm) or 85%	T1-8.2
Sawed Four Sides	2.5 in. (63 mm) or 85%	**Under 5 in. (125 mm) thick:** 0.4 in. (10 mm) and 90% **5 in. (125 mm) and thicker:** 0.5 in. (13 mm) and 90%	T1-8.1
(a) Penetrations based on AWPA Use Category and Commodity Specifications for different applications.			

B. Meet the following requirements for other aspects of the treatment process:

1. Incising.
Incise Coastal Douglas Fir lumber.

2. Seasoning.
- **a.** When sawed material is treated with waterborne preservatives (ACZA, CCA), ensure the moisture content prior to treatment, as determined by resistance type moisture meter, is no more than 20% if kiln dried or no more than 23% if air dried.
- **b.** Measure moisture content at a depth equivalent to the required penetration up to a maximum of 1.5 inches (38 mm).
- **c.** After treatment, unless specified otherwise, dry all lumber that is 2 inches (50 mm) or less in nominal thickness and is treated with a waterborne preservative. Dry the lumber to a moisture content of no more than 20% if kiln dried or no more than 23% if air dried.

3. Special Treatment for Guardrail and Sign Posts Treated With Oil Type Preservative.
Before removing sign and guardrail posts from the treatment cylinder, further subject them to live steam at a maximum pressure of 13 psi (90 kPa). Following that, subject the posts to an additional period of vacuum to ensure that the surface of the wood is free from accumulation of oil type preservative.

4. Method of Treatment.
- **a.** Use same preservative for all of the product furnished for each contract item or order.
- **b.** Unless specified otherwise, use the empty cell process with initial air pressure for creosote, pentachlorophenol, or copper naphthenate treatments.

c. Use the full cell process for ACZA and CCA treatments.

5. Results of Treatment.

a. Ensure retention and penetration of preservatives complies with Tables 4161.03-1 and 4161.03-2, unless specified otherwise.

b. Use the assay method to determine preservative retentions.

c. Ensure other treatment requirements are in accordance with AWPA Standards U1 and T1 and the applicable AWPA Specifications listed in Tables 4161.03-1 and 4161.03-2.

6. Handling Treated Products.

Follow AWPA Standard M4 regarding care and handling of preservative treated wood products.

7. Product Marking.

a. Ensure individual pieces of inspected, treated material bear a legible identification mark that is either hammer or heat branded, die stamped, or metal tagged. For material treated with waterborne preservatives, the identification mark may be ink stamped provided the information is clearly visible and legible. Ensure the identification mark, as a minimum, indicates the treater, the species of wood, the preservative treatment type, and the retention level. Acceptable brands or marks are to be similar to the general guidelines for brands listed in AWPA M1 and M6.

b. Ensure all treated wood material that requires a grade, with the exception of 45 inch (1145 mm) Terminal Posts[1], dispays a quality grade mark of an accredited grade monitoring and inspection agency approved under the American Lumber Standards Committee (ALSC).

[1] In the event that Terminal Posts 45 inches (1145 mm) in length to be used for Guardrails can not be stamped with a quality grade mark due to sizing of material, ensure Terminal Posts are instead stamped "MFG No. 1" to indicate that the Terminal Posts were cut from an original piece graded as a No. 1. Wane requirements will be waived.

c. Material less than 3 feet (1 m) in length does not require a grade mark; however, ensure a statement from the mill/processor certifying the grade of the material is provided. See Documentation Section of Materials I.M. 462. Round wood posts, round wood piles, and round wood poles do not require a grade, since the grading rules apply only to sawn material.

d. Ensure each bundle of treated wood products has at least one plastic tag identifying the charge number for the bundle.

8. Inspection.

Furnish white and treatment inspections, certifications, and test reports for each shipment according to Materials I.M. 462.

Section 4162. Untreated Timber and Lumber

4162.01 GENERAL REQUIREMENTS.

A. Use structural class timber for timber parts supporting definite traffic loads, namely posts of framed bents and stringers.

B. Use common class timber and lumber for all other timber parts, including caps, backing plank, floor plank, wing plank, nailers, fillers, sway bracing, rail posts, post blocks, bridging curbs, scupper blocks, rails, and laminated floor, unless otherwise designated.

C. Arrange inspection according to Materials I.M. 462. Include the cost of inspection in the unit price bid for the material specified.

4162.02 DEFINITION OF TERMS.

Terms used in these specifications are to be interpreted according to ASTM D 9 and rules approved by the Board of Review of the American Lumber Standards Committee.

4162.03 MINIMUM ACCEPTABLE SIZES.

A. Furnish material that complies with the dimensions specified for rough or surfaced stock. Unless specified otherwise in the contract documents, furnish rough material. Materials are classified in Table 4162.02-1, according to use:

Table 4162.02-1: Material Classification

Light Framing	
Nominal thickness Nominal widths Dressed thickness Dressed widths	2" to 4" (50 mm to 100 mm) 2" to 4" (50 mm to 100 mm) S1S or S2S S1E or S2E
Joist and Plank	
Nominal thickness Nominal widths Dressed thickness Dressed widths Rough	2", 3", and 4" (50 mm, 75 mm, and 100 mm) 6" (150 mm) and wider in multiples of 2" (50 mm) S1S or S2S S1E or S2E
Beams and Stringers	
Nominal thickness Nominal widths Dressed sizes Rough	5" (125 mm) and thicker, rectangular Widths more than 2" (50 mm) greater than thickness S1S, S1E, S2S, or S4S

B. Manufacture.
Ensure pieces are fully milled and processed. Unless specified otherwise, ensure all ends are neatly cut at right angles to the specified length. Reject miscut, tapered, wedge cut, or bull end pieces.

C. Dimensions.
Ensure material for tongue and groove bridge floors has either the dimensions specified or the Engineer's approval. Unless specified otherwise, ensure that the dimensions of all other material comply with the industry standards approved by the Board of Review of the American Lumber Standards Committee for rough or surfaced stock for the species furnished.

4162.04 SPECIES OF WOOD.

A. Use Douglas Fir (coast region) or Southern Pine in all structural class timber parts and in all common class timber parts with a nominal thickness of 2 inches (50 mm) or more.

B. Construction parts less than a nominal thickness of 2 inches (50 mm) including all boards, strips, and sheathing may be Douglas Fir (coast region), Southern Pine, West Coast Hemlock, Ponderosa Pine, Idaho White Pine, Sugar Pine, or White Fir.

4162.05 STRESS GRADE TIMBER AND LUMBER.

A. Furnish either Douglas Fir (coast region) or Southern Pine. Ensure the material is graded as provided in ASTM D 245 and by rules of associations as approved by the American Lumber Standards Committee.

B. Use material of the grade specified for each species. Ensure Douglas Fir (Coastal Region) is graded according to the grading rules published by the Western Wood Products Association or the West Coast Lumber Inspection Bureau. Ensure Southern Pine is graded according to the grading rules published by the Southern Pine Inspection Bureau. When a stress grade is identified as structural, apply Table 4162.05-1. When a stress grade is identified as common class, apply Table 4162.05-2. Unless specified otherwise, the material may be either Douglas Fir or Southern Pine.

Table 4162.05-1: Material Grades (Structural Class)

Structural Class[(a)]	Grade
Light Framing:	
Douglas Fir	Dense No. 2
Southern Pine	No. 2 Dense
Joists and Plank:	
Douglas Fir	Select Structural or Dense No. 1
Southern Pine	Dense Structural 72
Beams and Stringers:	
Douglas Fir	Dense Select Structural
Southern Pine	Dense Structural 86
Posts and Timbers:	
Douglas Fir	Dense Select Structural
Southern Pine	Dense Structural 72

(a) Structural class is based on a nominal extreme fiber stress in bending of 1,900 psi (13 MPa) (minimum 1,850 psi (12.8 MPa)) for light framing, joists, and plank in a repetitive member use; and for beams and stringers in a single member use. Structural class for posts and timbers is based on a compression stress parallel to the grain of 1,100 psi (7.6 MPa) when used as a column. When used as a beam in a single member use, the minimum extreme fiber stress in bending is 1,750 psi (12 MPa). Use is assumed in a location where the moisture content will not exceed 19% for an extended period of time. Treatment for durability (Section 4161) is also assumed, where specified.

Table 4162.05-2: Material Grades (Common Class)

Common Class[(a)]	Grade
Light Framing:	
Douglas Fir	No. 2
Southern Pine	No. 2 Dense
Joists and Plank:	
Douglas Fir	No. 1
Southern Pine	Dense Structural 65
Posts and Timbers:	
Douglas Fir	Select Structural
Southern Pine	Dense Structural 65

(a) Common class is based on a nominal extreme fiber stress in bending of 1,500 psi (10.3 MPa) (minimum 1,450 psi (10 MPa)) for light framing, joists, and plank in a repetitive member use. Common class for posts and timbers is based on a compression stress parallel to grain of 1,000 psi (7 MPa) when used as a column. When used as a beam in single member use, the minimum extreme fiber stress in bending is 1,450 psi (10 MPa). Use is assumed in a location where the moisture content will not exceed 19% for an extended period of time. Treatment for durability (Section 4161) is also assumed, where specified.

C. Ensure that untreated wood material that requires a grade, with the exception of 45 inch (1145 mm) Terminal Posts, is stamped with the identifying quality grade mark of an accredited grade monitoring and inspection agency approved by the American Lumber Standards Committee (ALSC) under the Untreated Wood Program. If, due to sizing of material, 45 inch (1145 mm) Terminal Posts to be used for guardrail can not be stamped with a quality grade mark, ensure they are stamped "MFG No. 1" to indicate that the posts were cut from an original piece graded as a No. 1. Wane requirements will be waived.

D. Material less than 3 feet (1 m) in length does not require a grade mark; however, the grade of the material is required to be certified by the certification statement from the mill/processor according to Materials I.M. 462. Round wood posts, round wood piles, and round wood poles do not require a grade, since the grading rules apply only to sawn material.

4162.06 COMMON BOARD AND SHEATHING.

Ensure common lumber less than a nominal 2 inches (50 mm) in thickness complies with the requirements of the American Lumber Standards for the species and grade specified.

Section 4163. Treated Timber and Lumber

4163.01 GENERAL REQUIREMENTS.

A. For rough or surfaced, treated timber and lumber, furnish new and unused material meeting the requirements of Section 4162 for the size and lengths specified in the contract documents.

B. In timber structures, use the class of timber or lumber meeting the requirements of Section 4162 for use according to position in the structure.

C. Arrange inspection according to Materials I.M. 462. Include the cost of inspection in the unit price bid for the material specified.

4163.02 SPECIES OF WOOD.

A. Unless specified otherwise, treat only Douglas Fir (coast region), Northern Pine, and Southern Pine.

B. Incise Douglas Fir before treatment according to Article 4161.03, B, 1.

C. On timber structures, accurately bore all holes required in stringers, rail posts, post blocks, and scupper blocks before treatment wherever practical.

4163.03 PRESERVATIVE TREATMENT.

Unless specified otherwise, full pressure preservative treatment, according to Section 4161, is required for all timber and lumber.

Section 4164. Treated Wood Posts

4164.01 GENERAL REQUIREMENTS.

A. Ensure posts when dried, whether kiln dried or air dried, are free from bends in more than one plane and free from short or reverse bends. Ensure a straight line from the centers of the ends of a spot does not deviate from the longitudinal axis of the post at any point by more than 0.5% of the length of the post.

B. Furnish posts that meet the requirements for one of the classes listed below, as specified in the contract documents:

- Round Wood Posts
- Sawed Wood Posts
- Wood Sign Posts

C. Arrange inspection according to Materials I.M. 462. Include the cost of inspection in the unit price bid for the material specified.

4164.02 ROUND WOOD POSTS.

A. General.

1. Furnish posts that are cut from live sound, solid trees and contain no unsound knots. Sound knots will be permitted provided the width of the knot does not exceed 30% of the diameter of the piece at the point where it occurs, or a maximum of 2 1/2 inches (65 mm). Ensure posts are free from decayed wood, rot, red heart, ring shake, season checks more than 1/4 inch (6 mm) wide, and splits in the end.

2. Ensure that when measured over the outer 2 inches (50 mm) of a radial line from the pith:

- Douglas Fir posts show at least five annual rings per inch (25 mm).
- Pine posts show at least three annual rings per inch (25 mm) and at least 30% summerwood.

3. Ensure posts show no spiral grain exceeding one quarter turn in 10 feet (3 m). Groups of knots, or any combination of defects which impair the strength more than maximum size knots, will not be permitted.

B. Species.

1. Use what is called for in the contract documents.

2. Unless specified otherwise, use:

- Pine for fence posts.
- Either Douglas Fir (coast region) or Southern Pine for other posts.

C. Size.

1. The size of posts will be specified by nominal 1 inch (25 mm) increments of diameter at the tip.

2. Posts will be accepted only when the tip diameter equals the specified dimension or exceeds it by no more than 1 inch (25 mm). The diameter is determined by dividing the circumference, after peeling, by pi (3.14).

D. Length.
Furnish round wood posts in the length specified, ± 2%.

E. Straightness.

1. Ensure posts are free from short or reverse bends and bends in more than one plane.

2. Ensure a straight line from center of tip to center of butt does not deviate from the center of the post by more than 2% of the length of the post.

F. Quality of Work.

1. Ensure posts are peeled for their full length, and bark and inner skin is removed.

2. Ensure the portion of the post which will remain out of the ground is shaved clean and free from glazed surface left by dried sap.

3. Shave knots or projections smooth and flush with the surface of surrounding wood.

4164.03 SAWED WOOD POSTS.

A. Furnish posts that:
- Conform to the shape and nominal dimensions for rough stock, and
- Meet the applicable requirements of Section 4162.

B. Ensure 5 inch by 5 inch (125 mm by 125 mm) and larger treated, sawed wood guardrail posts are a minimum Grade No. 1 or better Douglas Fir (coast region) or No. 1 or better Southern Pine, according to the minimum strength requirements of AASHTO M 168.

4164.04 WOOD SIGN POSTS.

A. Furnish either Douglas Fir (coast region) or Southern Pine posts graded as provided in ASTM D 245 according to rules approved by the Board of Review of the American Lumber Standards Committee.

1. Use Douglas Fir posts free of heart centers and of the following nominal sizes and grades:

- 4 inch by 4 inch (100 mm x 100 mm) - "No. 2" - Structural Light Framing.
- 4 inch by 6 inch (100 mm x 150 mm) - "Dense No. 2" - Structural Joist and Plank.

2. Use Southern Pine posts of the following nominal sizes and grades:
- 4 inch by 4 inch (100 mm x 100 mm) - No. 2 Dense.
- 4 inch by 6 inch (100 mm x 150 mm) - No. 1 Dense.

B. Nominal 4 inch by 4 inch (100 mm by 100 mm) sign posts in lengths up to 14 feet (4.3 m) may be furnished in species Northern Pine (Norway, Red Pine), Grade No. 1, according to the Northeastern Lumber Manufacturer's Association Rules.

C. Furnish posts in the size and length specified complying with the following for the size designated:

1. Nominal 4 inch by 4 inch (100 mm by 100 mm) Posts.
- S4S posts sawn square at both ends.
- 10 holes 7/16 inch (11 mm) in diameter bored at 6 inch (150 mm) spacing (center to center) with the first hole being 3 inches (75 mm) from one end of the post.
- Spacing and alignment of holes within 1/16 inch (2 mm) of true center line and distance.

2. Nominal 4 inch by 6 inch (100 mm by 150 mm) Posts.
- S4S posts sawn square at both ends.
- 15 holes 7/16 inch (11 mm) in diameter bored through the 6 inch (150 mm) thickness at 6 inch (150 mm) spacing (center to center) with the first hole being 3 inches (75 mm) from one end of the post.
- Spacing and alignment of holes within 1/16 inch (2 mm) of true center line and distance.

4164.05 PRESERVATIVE TREATMENT.
Complete boring and framing before treatment. Unless provided otherwise, apply Section 4161.

4164.06 INSPECTION.

A. Inspect posts before treatment. Follow Materials I.M. 462 for inspection and acceptance. Inspect for quality and straightness before accepting for treatment. Do not allow posts not meeting the quality and straightness requirements to be treated.

B. The treating process will be inspected at the treating plant. Posts will be inspected after treatment for straightness. Posts not meeting the requirements will be rejected. Posts rejected after treatment may be subjected to steam treatment in the treating chamber while loaded in such manner as to remove or minimize the bends and bows. They will be

inspected for straightness again. Posts so steamed will be accepted if they comply with the requirements for straightness.

Section 4165. Timber Piles

4165.01 GENERAL REQUIREMENTS.

A. Furnish timber piles fabricated from round sections of the trunks of trees trimmed, peeled, and with or without preservative treatment. Meet the requirements for the class of piles specified in the contract documents. Unless otherwise specified, timber piles shall meet the requirements of ASTM D 25.

B. Arrange inspection according to with Materials I.M. 462. Include the cost of inspection in the unit price bid for the material specified.

4165.02 CLASSIFICATION.

Piles are classified as follows according to their intended use:

A. Untreated Timber Piles.
May be used for falsework or temporary construction.

B. Treated Timber Foundation Piles.
Use for permanent foundations and permanent wood substructures above ground water level, unless treated timber trestle piles are specified in the contract documents.

C. Treated Timber Trestle Piles.
Use for permanent wood trestle. May be specified for piers and abutments of substructures, where the more restrictive straightness requirements of this class are desirable.

4165.03 UNTREATED TIMBER PILES.

Allowable materials included: White Oak, Burr Oak, Cypress, Tamarack, Douglas Fir, Southern Pine, or other wood which will satisfactorily withstand driving. Ensure the piles meet the following requirements:

A. General Quality.

1. Cut above the ground swell from live, sound, solid trees.

2. A gradual taper from point of butt measurement to tip.

3. Free from ring shakes, decay or rot, unsound knots, soft red heart, splits, and other defects which will impair their strength or durability.

4. Cypress piles showing "peck" more than a single spot equal to 3% of the area of the end will not be accepted.

5. Free from excessive checks at the tip which would cause splits in driving.

B. Knots.

1. No unsound knots.

2. Sound knots permitted provided the diameter of any single knot is no larger than 4 inches (100 mm) or one sixth the circumference of the pile at the point where it occurs, whichever is smaller. Cluster knots will be considered a single knot, and the sum of all knots in the cluster shall not be greater than the permitted size for a single knot.

3. The sum of diameters of all knots in any 1 foot (0.3 m) length of pile not to exceed 2 times the diameter of the allowable knot.

4. Diameters of knots measured in a plane perpendicular to the long axis of the pile.

C. Rate of Growth.

1. When measured at the tip, over the outer 50% of a radial line from the pith, no less than the number of annual rings and percentage of summerwood specified in Table 4165.03-1 for the respective species:

Table 4165.03-1: Summerwood

Species	Rings per Inch (25 mm)	Minimum
Douglas Fir	6 or More	33%
Douglas Fir	less than 6	50%
Southern Pine	6 or More	33%
Southern Pine	less than 6	50%
Other species	6	33%

2. When the number of annual rings varies along different radii, use the average of two or more measurements along representative radii.

D. Holes and Scars.

Permitted if:

- Less than 1/2 inch (13 mm) in average diameter,
- They do not penetrate more than 20% the diameter at the point where they occur, and
- The sum of the average diameters of all holes in any square foot (0.1 m^2) of pile surface does not exceed 1 1/2 inches (38 mm).
- Turpentine scars undamaged by decay or insect attack will be permitted provided the depth of the scar is not more than one fifth the diameter of the pile at the location of the scar.

E. Twist of Grain.
Free of twist in grain exceeding 50% the average circumference in a 20 foot (6 m) length.

F. Length.
Furnish in the length specified in the contract documents or as directed by the Engineer. A variation of 6 inches (150 mm) in length will be permitted. Average length for piles of any one lot at least equal to the specified length.

G. Straightness.

1. Free from sweep in two planes (double sweep).

2. Free of short crooks. In measuring for short crooks in any 5 foot (1.5 m) section, verify the distance from the center of the pile at the point of greatest deviation to a line stretched from the center of the pile above the bend to the center of the pile below the bend does not exceed 4% of the length of the bend, or a maximum of 2 1/2 inches (65 mm).

3. Sweep in one direction and in one plane: the center of the pile not to deviate from a straight line connecting the center of butt with the center of the tip by more than 1.0% of the length of the pile, or 4 inches (100 mm), whichever is greater, with a maximum deviation of 6 inches (150 m) for lengths over 50 feet (15 m).

4. Piles with sweep in two directions in the same plane (reverse sweep): may be accepted, provided the reversal is within the middle half of the length, and provided the deviation of the center of the pile from a straight line connecting the center of the butt with the center of the tip does not exceed 2 inches (50 mm).

5. Within 25% of the length of the pile, but not less than 10 feet (3 m) nearest the tip, the center of the pile not to deviate more than 1 inch (25 mm) from a line drawn from the center of the pile above this length to the center of the tip.

H. Dimensions.

1. At least 95% of the pieces of one length in any one shipment to comply with the dimensions in Table 4165.03-2 for the species of wood specified. The remaining 5% of the pieces may be deficient in diameter at tip or 3 feet (1 m) from butt by not more than 1/2 inch (13 mm).

Table 4165.03-2: Dimensions

	Min. Diameter 3 Feet (1 m) From Butt		
Length feet (m)	**Fir & Pine inches (mm)**	**Other Species inches (mm)**	**Min. Tip Diameter inches (mm)**
20 and shorter (6.0)	10[(a)] (250[(a)])	10[(a)] (250[(a)])	8 (200)
25 to 30 (7.5 to 9.5)	11 (275)	11 (275)	8 (200)
35 (10.5)	12 (300)	13 (325)	8 (200)
40 (12.0)	12 (300)	13 (325)	7 (175)
40 to 60 (13.5 to 18.0)	13 (325)	14 (350)	7 (175)
over 60 (18.0)	13 (325)	14 (350)	6 (150)
(a) Measured at the butt.			

2. The diameter of the piles, at the butt, not to exceed 20 inches (500 mm). When oversize piles are specified, verify the diameters 3 feet (1 m) from the butt and at the tip are 2 inches (50 mm) larger than the dimension listed above for the length of piles specified, unless other diameters are specified.

I. Quality of Work and Finish.

1. The tips and butts of all piles cut square with the axis of the piece.

2. All knots and limbs trimmed smoothly and cut flush with the surface of the piles.

3. On all species, all of the outer bark removed.

4. All piles marked plainly on the butt with the length in feet (meters).

J. Inspection and Acceptance.

1. Inspection and acceptance according to Materials I.M. 462. The inspector will make a thorough examination of each pile. Each pile will be judged without regard to decisions on others of the same lot. Piles too muddied for ready examination will be rejected. Piles turned over as inspected. The producer is to furnish, at no additional cost, the necessary tools and labor to turn piles.

2. The diameter of tip and butt will be determined by measuring the circumference of each and dividing by 3.14 respectively.

3. If the piles indicate there is a possibility of deterioration, the inspector may require that each pile be re-cut on both butt and tip, no less than 2 inches (50 mm) from the original end, to provide a freshly cut section for examination. The appearance of any incipient decay on a fresh section is sufficient cause for rejection of the pile.

4165.04 TREATED TIMBER FOUNDATION PILES.
Meet the requirements for untreated timber piles, Article 4165.03, and the following additional requirements:

A. Species.
Either Southern Pine or Douglas Fir (coast region).

B. Peeling.

1. Peel all piles by removing all rough bark and at least 80% of the inner bark.

2. Ensure no strip of inner bark remaining on the pile is over 3/4 inch (20 mm) wide or over 8 inches (200 mm) long.

3. Verify there is at least 1 inch (25 mm) of clean wood surface between any two such strips.

4. Verity at least 80% of the surface of any circumference is clean wood.

C. Sapwood Requirement.

1. Douglas Fir piles: no less than a 3/4 inch (20 mm) ring of sapwood at the butt end

2. Southern Pine piles: no less than a 2 inch (50 mm) ring of sapwood at the butt end.

D. Preservative Treatment.
Creosote, pentachlorophenol, or copper naphthenate treatment complying with Section 4161. Ring shakes, checks, water bursts, or similar defects which develop during the treating process, will be considered cause for rejection.

E. Inspection and Acceptance.
According to Materials I.M. 462.

4165.05 TREATED TIMBER TRESTLE PILES.
Meet the requirements for treated timber foundation piles, Article 4165.04, for piles to be used in construction of permanent wood trestles, and when specified for piers or abutments with wood backing plank, except meet the following requirements for the straightness of pieces:

A. Free of sweep in two directions in one plane (reverse sweep) and in two planes (double sweep).

B. Free of short crooks. In measuring short crooks, verify the distance from the center of the pile at the point of greatest deviation to a line stretched from the center of the pile above the bend to the center of the pile below the bend does not exceed 4% of the length of the bend, or a maximum of 2 inches (50 mm).

C. In sweep in one direction in one plane, verify the center of the pile does not deviate from a straight line connecting the center of the tip with the center of the butt by more than 3 inches (75 mm) for lengths 30 feet (9 m) and less, and by more than 0.8% of the length of the piles for lengths over 30 feet (9 m), with a maximum of 5 inches (125 mm) for lengths over 50 feet (15 m). Within 25% of the length of the pile, but no less than 10 feet (3 m) nearest the tip, verify the center of the pile does not deviate more than 1 inch (25 mm) from a line drawn from the center of the pile above this length to the center of the tip.

Section 4166. Concrete Piles

4166.01 GENERAL REQUIREMENTS.

A. Furnish or fabricate concrete load bearing piles and concrete sheet piles of the form, dimensions, and reinforcement specified in the contract documents.

B. Apply Section 2407.

Section 4167. Steel Piles

4167.01 GENERAL REQUIREMENTS.

A. Steel H-Piles.
Furnish steel H-piles rolled from steel meeting the requirements of ASTM A 572/A 572M Grade 50 (345) with cross section dimensions meeting the requirements of ASTM A 6/A 6M for the section number designated. Only field welding will be allowed. Complete welding according to Article 2408.03, B.

B. Pipe Piles.

1. When pipe piles are allowed in the contract documents as an option to steel H-piles, furnish pipe piles of the dimensions shown, manufactured within the physical and chemical requirements of ASTM A 252, Grade 2 or 3. Furnish test results from at least one random sample taken from pieces furnished to the project. Ensure the chemical analysis indicates no more than 0.05% phosphorous.

2. Only field welds will be permitted, and only at air temperatures above 0°F (-18°C). Ensure all welding is done by welders certified by the Department. When welding, the surfaces of the pipe being welded, within 3 inches (75 mm) laterally and in advance of welding, must be preheated to a minimum of 50°F (10°C). Maintain this temperature during welding. Weld the joint with a prequalified AWS Joint B-U2a. For manual shielded metal arc welding, use an E701.8 electrode and for semi-automatic Flux Core Arc welding, use an E71T-X electrode. Use a backup ring of the same steel as that of the pipe.

C. Steel Sheet Piles.
Furnish steel sheet piles of the interlocking type (interlock type approved by the Engineer) with a section modulus no less than that specified. Meet the requirements of ASTM A 328/A 328M for piles and welding required thereon. Unless specified otherwise, furnish piling furnished with a web thickness no less than 3/8 inch (10 mm).

4167.02 PILE POINTS FOR STEEL H-PILES.

A. When required in the contract documents, use pile points for steel H-piles that are cast-in-one-piece steel meeting the requirements of ASTM A 27/A 27M, Grade 65-35 (450-240) or an approved equal. Provide the points with sufficient flange and continuous web vertical back-ups to assure proper alignment and fitting to the piles. Ensure the pile points provide full bearing for the piles and are attached to the piles to ensure full transmission of the driving energy to the points.

B. The manufacturer is to submit detail drawings of pile points showing material, weight (mass), and dimensions for the Engineer's approval. Approved pile points are listed in Materials I.M. 467.02.

Section 4169. Erosion Control Materials

4169.01 DESCRIPTION.
All materials required to be furnished and described in this section.

4169.02 SEEDS.

A. Furnish seeds approved for use according to requirements of this section, including specified purity and germination, as shown in Tables 4169.02-1 and 4169.02-2.

Table 4169.02-1: Seeds (Common Names, Scientific Names, Purity, and Germination)

Common Name	Scientific Name	Purity (%)	Germination (%)
DOMESTIC GRASSES			
Bluegrass, Kentucky	Poa pratensis	85	80
Bluegrass, Ky. RAM-1	Poa pratensis-RAM-1	95	85
Bluegrass, Ky. PARK	Poa pratensis-PARK	95	85
Brome, smooth-LINCOLN	Bromus inermis	90	85
Fescue, tall, FAWN	Festuca arundinacea-FAWN	98	85
Fescue, chewings, red	Festuca rubra var. commutate	98	90
Fescue, creeping, red	Festuca rubra	98	85
Fescue, red-PENNLAWN	Festuca rubra PENNLAWN	98	85
Fescue, Tall, Olympic (Fineleaf)	Festuca arundinacea-Olympic	98	85
Fescue, Tall, Rebel (Fineleaf)	Festuca arundinacea	98	85
Fescue, Sheeps	Festuca ovina	98	85
Orchardgrass	Dactylis glomerata	90	90
Red top	Agrostis alba	92	85
Reed Canarygrass	Phalaris arundinacea	98	70
Wildrye, Canada	Elymus Canadensis	95	85
Wildrye, Russian	Elymus junceus	95	85
Ryegrass, Perennial	Lolium perenne	95	90
Timothy	Phleum pratense	99	85
LEGUMES			
Alfalfa, RANGER/VERNAL	Medicago sativa	99	90[(a)]
Alfalfa, Travois	Medicoa spp.	99	90[(a)]
Birdsfoot Trefoil EMPIRE	Lotus corniculatus	98	85[(a)]
Crownvetch, Emerald	Coronilla varia	98	70[(a)]
Hairy Vetch	Vicia villosa	96	85[(a)]
Lespedeza, Korean	Lespedeza stipulacea	98	80[(a)]
Red Clover, medium	Trifolium pretense	99	90[(a)]
Alsike Clover	Trifolium hybridum	99	90[(a)]
White Clover	Trifolium repens	98	90[(a)]
NURSE CROP OR STABILIZING CROP			
Oats	Avena sativa	97	90
Rye	Secale cereale	97	90
Sudangrass, PIPER	Sorghum vulgare var. sudanese	98	85

[(a)] Includes hard seed.

Table 4169.02-2: Seeds (Common Names, Scientific Names, and PLS)

Common Names	Scientific Names	PLS (%)
*Furnish seed certified as Source Identified Class (Yellow Tag) Source G0-Iowa. **NATIVE GRASSES**		
Big Bluestem*	Andropogon gerardii	30
Little Bluestem*	Andropogon scoparius	30
Switchgrass*	Panicum virgatum	63
Indiangrass*	Sorghastrum nutans	30
Sideoats Grama*	Bouteloua curtipendula	30
Western Wheatgrass*	Agropyron smithii	56
Buffalograss*	Buchloe dactyloides	60
Sand Bluestem*	Andropogon gerardii, var. paucipilus	30
Blue Grama	Bouteloua gracilis	30
Intermediate Wheatgrass	Agropyron intermedium	70
Slender Wheatgrass	Agropyron trachycaulum, var. unilaterale	70
Prairie Dropseed	Sporobolus heterolepis	65
Sand Dropseed	Sporobolus cryptandrus	65
Sand Lovegrass	Eragrostis trichodes	65
Weeping Lovegrass	Eragrostis curvula	65
Hairy Wood Chess	Bromus purgans	60
Blue-joint grass	Calamagrostis Canadensis	47
Bottlebrush sedge	Carex comosa	62
Tussock sedge	Carex stricta	78
Fox sedge	Carex vulpinoidea	64
Virginia wild-rye	Elymus virginicus	60
Reed manna grass	Glyceria grandis	50
Fowl manna grass	Glyceria striata	72
Common rush	Juncus effuses	80
Rice Cut Grass	Leesia oryzoides	62
Rye grass, annual	Lolium italicum	89
Fowl bluegrass	Poa palustris	72
Green bulrush	Scirpus atrovirens	45
Wool grass	Scirpus cyperinus	78
Soft-stem bulrush	Scirpus vallidus	78
Indian grass	Sorghastrum nutans	60
Spike Rush	Eleocharis palustris	71

FORBS		
Canada anemone	Anemone Canadensis	72
Marsh milkweed	Asclepias incarnate	25
New England aster	Aster novae-angliae	25
Swamp aster	Aster puniceus	25
Showy tic-trefoil	Desmodium canadense	25
Joe-pye weed	Eupatorium maculatum	66
Boneset	Eupatorium perfoliatum	41
Ox Eye sunflower	Heliopsis helianthoides	38
Blue-flag iris	Iris virginica-shrevii	19
Meadow blazingstar	Liatris ligulistylis	24
Tall blazingstar	Liatris pycnostachya	24
Great blue lobelia	Lobelia siphilitica	13
Reed manna grass	Glyceria grandis	50
Fowl manna grass	Glyceria striata	72
Common Rush	Juncus effuses	80
Rice Cut Grass	Leesia oryzoides	62

B. Furnish all seeds, including grass, legume, forbs, and cereal crop seeds, from an established seed dealer or certified seed grower. Ensure they meet requirements of the Iowa Department of Agriculture regulations (Iowa Seed Law) and are labeled accordingly. Ensure the test date to determine the percentage of germination requirement was completed within a 9 month period exclusive of the calendar month in which the test was completed. Ensure the seed analysis on the label is mechanically printed.

C. Approval of all seed for use will be based on the accumulative total of PLS specified for each phase of the work, so that the PLS is not less than the accumulative total of the PLS specified. PLS is obtained by multiplying purity times germination.

D. If the seed does not comply with minimum requirements for purity and germination and such seed cannot be obtained, the Engineer may approve use of the seed on a basis of PLS or may authorize a suitable substitution for the seed specified.

E. The accumulative total of Pure Live Seed (PLS) is the product obtained by multiplying the pounds (kilograms) of each seed by the purity and germination percentages expressed as decimals. Calculations will be based on test results of samples taken by the Contracting Authority. If the seeds were not sampled or if these test results are not available, the PLS will be calculated from information shown on the label.

4169.03 FERTILIZER.

Furnish fertilizer of the grade, type, and form specified and that complies with Iowa Department of Agriculture rules and the following requirements:

A. Fertilizer grade will be identified according to the percent nitrogen (N), percent available phosphoric acid, (P_2O_5), and percent water soluble potassium, (K_2O), in that order. Approval will be based on that identification.

B. Furnish all fertilizer from an established fertilizer dealer. Ensure guaranteed analysis is provided either through mechanically printed commercial fertilizer bags or through a manufacturer's (not a distributor's) bill of lading.

C. Fertilizer inspection and acceptance will be according to Materials I.M. 469.03.

D. Furnish fertilizer of a type that can be uniformly distributed by the application equipment. Fertilizer may be chemically combined or may be furnished as separate ingredients. If supplying chemically combined fertilizer, have each unit of fertilizer chemically combined. Ensure the manufacturer's guarantee indicates compliance with this agreement. If supplying fertilizer as separate ingredients, comply with the following:

- Each of the separate ingredients of uniform size,
- Analysis guaranteed by the manufacturer.
- Mixed using a drum mixer, grinder mixer, or other mechanical mixers.
- Mixed only by the fertilizer dealer.

E. When 6-24-24 chemically combined commercial fertilizer has been specified, a combination of ammoniated phosphate (either monoammonium phosphate (11-52-0) or diammonium phosphate (18-46-0)), muriate of potash (granular form), and urea (granular form) may be used.

F. When 13-13-13 chemically combined commercial fertilizer has been specified, a combination of ammoniated phosphate (either monoammonium phosphate (11-52-0) or diammonium phosphate (18-46-0)), muriate of potash (granular form), and urea (granular form) may be used.

G. Fertilizer may be furnished in a dry or liquid form.

H. Furnish a list of the number of containers and a corresponding scale ticket from an approved scale for the fertilizer to be used in the work.

I. Official samples taken by the Contracting Authority may be tested. A tolerance of minus 1.0 percentage point from the guaranteed analysis for each nutrient will be considered substantial compliance.

J. Ground limestone is to be of the type known as No. 1 fine (70% passing No. 200 (75 µm) sieve) with an analysis of elemental calcium of no less than 37% or no more than 40%.

4169.04 INOCULANT FOR LEGUMES.

An inoculant is a culture of bacteria specifically formulated for legume seeds (alfalfa, clovers, lespedeza, birdsfoot trefoil, hairy vetch, and crownvetch). Ensure the manufacturer's container indicates the specific legume seed to be inoculated and the expiration date. Use inoculant that meets the requirements of the Iowa Seed Law. Follow the safety precautions specified on the product label.

4169.05 STICKING AGENT.

A sticking agent is a commercial material recommended by the manufacturer to improve adhesion of inoculant to the seed. For quantities less than 50 pounds (25 kg), the sticking agent need not be a commercial agent; however, the Engineer's approval is required. Apply separately prior to application of inoculant. Follow safety precautions specified on the product label. A sticking agent is not required if a liquid formulation of inoculant is used.

4169.06 SOD.

A. Use sod consisting of approximately 1 inch (25 mm) of well established turf consisting of live Kentucky bluegrass, unless otherwise specified. Ensure sod is free from roots of trees or brush, stones, and other objectionable materials. Ensure sod is free from all noxious weeds and reasonably free of all other weeds.

B. Ensure sod is cut in strips of uniform width and thickness with ends square. The Engineer may order the thickness adjusted to meet the sod conditions. Cut sod to the length specified for the use intended. If not specified, cut to a minimum length of 3 feet (1 m). Mow sod areas to a height of approximately 1 1/2 inches (40 mm) to 2 inches (50 mm) prior to cutting.

C. Ensure sod was regularly maintained prior to cutting. Apply pre-emergence weed control chemicals and weed control chemicals for broadleaf weeds.

D. Roll or stack sod within 1 hour after being cut. The Engineer may approve other methods of handling sod. Take precautions to prevent drying or heating. Do not use sod damaged by heat or dry conditions, or sod cut more than 18 hours before being incorporated into the work.

E. Sod will be subject to inspection by the Engineer at the job site, and approval of the work constitutes approval of the material.

4169.07 MULCH.

A. Straw Mulch.
Material used as mulch may consist of dry cereal straw or native grass straw. Use Certified Noxious Weed Seed Free Mulch certified by the Iowa Crop Improvement Association or other state's Crop Improvement Associations.

B. Hydraulic Mulches.

1. Wood Cellulose Fiber.

a. Natural or cooked cellulose fiber processed from whole wood chips, or a combination of (50%-50%) cellulose fiber produced from whole wood chips and recycled fiber from sawdust, recycled paper, chipboard, or corrugated cardboard.

b. Contains a colloidal polysaccharide tackifier adhered to the fiber to prevent separation during shipment and avoid chemical coagglomeration during mixing.

c. Forms a homogeneous slurry of fibers, tackifier, and water that can be applied with standard hydraulic mulching equipment and be dyed green to facilitate visual metering during application.
d. Contains no growth or germination inhibiting factors, and has a minimum pH of 4.8.

2. Bonded Fiber Matrix.
a. Long-strand wood fibers held together by organic tackifiers and bonding agents that, when dry, become insoluble and non-dispersible.
b. Upon curing (24 to 48 hours) forms a continuous, 100% coverage, flexible, absorbent, erosion-resistant blanket that encourages seed germination.
c. Manufactured to be applied with standard hydraulic mulching equipment and dyed green to facilitate visual metering during application.
d. Contains no growth or germination inhibiting factors.
e. Physical Properties:
1) Fibers: Virgin wood, greater than 88% by volume.
2) Organic Material: Greater than 96% by volume.
3) Tackifier: 8 to 10%.
4) pH: 4.8 minimum.
5) Moisture Content: 12% ±3%.
6) Minimum Water Holding Capacity: 1.2 gallons per pound (10 L/kg).

3. Mechanically-Bonded Fiber Matrix.
a. Long-strand wood fibers and crimped, interlocking synthetic fibers.
b. Upon curing (2 hours) forms a continuous, 100% coverage, flexible, absorbent, porous, erosion-resistant blanket that encourages seed germination.
c. Manufactured to be applied with standard hydraulic mulching equipment and dyed green to facilitate visual metering during application.
d. Contains no growth or germination inhibiting factors.
e. Physical Properties:
1) Virgin Wood Fibers: 73% minimum.
2) Crimped, Interlocking Synthetic Fibers: 5% ±1%.
3) Tackifier: 10% ±1%.
4) Moisture Content: 12% ±3%.
5) Minimum Water-Holding Capacity: 1.2 gallons per pound (10 L/kg).
6) pH: 4.8 minimum.

4169.08. COMPOST.

A. Use an organic substance produced by the biological and biochemical decomposition of source-separated compostable materials separated at the point of waste generation. Organic substances may include, but are not limited to:
- Leaf and yard trimmings,

- Food scraps,
- Food processing residues,
- Manure and/or other agricultural residuals,
- Forest residues and bark, and
- Soiled and/or unrecyclable paper and biosolids.

B. Compost is to contain no visible admixture of refuse or other physical contaminants nor any material toxic to plant growth. Compost is to meet the additional requirements below. All physical requirements are to comply with the United States Composting Council, "Testing Methods for the Examination of Composting and Compost" (TMECC).

1. Minimum organic material: 30% (dry weight (mass) basis) as determined by loss on ignition.

2. Moisture content: 30% to 60%. Organic material shall be loose and friable and not dusty.

3. Soluble salts: less than 5.0 ds/m.

4. Stability: Carbon dioxide evolution rate less than 8 according to TMECC 5.08-B. Growth screening: Emergence a minimum of 80% for all compost to be vegetated.

5. pH: 6.0 - 8.0.

6. Fecal Coliform: Comply with TMECC 07.01-B.

7. Heavy Metals: Comply with TMECC 04.06 and TMECC 04.13-B.

8. Comply with the following for particle size:
- **Pneumatic Seeding (Urban):** 100% passing the 1/2 inch (12.5 mm) screen.
- **Pneumatic or Mechanical Seeding (Rural):** 100% passing the 1 inch (25 mm) screen, 80% to 90% passing the 3/4 inch (19 mm) screen, and 70% to 80% passing the 1/2 inch (12.5 mm) screen.
- **Filter Sock, Filter Berm, and Filter Blanket:** 100% passing the 2 inch (50 mm) screen, 70% to 90% passing the 1 inch (25 mm) screen, and 50% to 70% passing the 1/2 inch (12.5 mm) screen.

4169.09 STAKES FOR HOLDING SOD.

Use either wood or metal wire stakes for holding sod. Use wood stakes in sandy soils or when the Engineer requires.

A. Wood Stakes.
- 1 inch (25 mm) to 1 1/2 inches (40 mm) wide, 1/4 inch (6 mm) to 1/2 inch (13 mm) thick, and 12 inches (300 mm) long.
- Where this length of stake does not provide firm bearing, the Engineer may require stakes of sufficient length to secure firm bearing.

B. Wire Stakes.

- Staples made from No. 11 (3.06 mm diameter) wire or heavier and with a minimum 2 inch (50 mm) flat spread on the top of the sod.
- Legs at least 6 inches (150 mm) long. The Engineer may require wire legs longer than 6 inches (150 mm).

4169.10 SPECIAL DITCH CONTROL, TURF REINFORCED MAT, AND SLOPE PROTECTION.

For plastic netting, wood excelsior mat, coconut fiber mat, straw-coconut mat, straw mat, and wire staples, comply with the following and meet the requirements of Materials I.M. 469.10.

A. Wire Staples.

Meet the following requirements for wire staples for holding special ditch control wood excelsior mat and special ditch control jute mesh over sod:

1. U-shaped wire staples.

2. Each leg a minimum of 6 inches (150 mm) long. In sandy soil conditions the Engineer may require the length of each leg to be a minimum of 12 inches (300 mm).

3. No. 11 (3.06 mm) diameter wire.

4. Staples of sufficient hardness to facilitate installation without bending.

B. Special Ditch Control.

1. Wood Excelsior Mat.

A mat of interlocking wood fibers. Meet the following requirements:

- Plastic netting applied to both sides for holding the excelsior in place.
- Nontoxic to growth of plants and germination of seeds.
- Minimum dry weight (mass) of 0.68 pounds per square yard (334 g/m2) according to ASTM D 6475.
- Furnished in rolls with a uniform width of 48 inches (1.2 m), with a tolerance of minus 1 inch (25 mm) and a minimum length of 80 feet (24 m).
- Furnished in plastic bags or otherwise protected to prevent damage from weather and handling.

2. Coconut Fiber Mat.

At the Contractor's option, coconut fiber mat may be substituted for wood excelsior mat for special ditch control. Meet the following requirements:

- Uniform thickness with the coconut fiber evenly distributed over the entire area of the mat.
- Both sides of the mat covered with polypropylene netting attached with cotton thread.

- Minimum dry weight (mass) of 0.40 pounds per square yard (182 g/m^2) according to ASTM D 6475.
- Furnished in rolls with a uniform width of 48 inches (1.2 m) with a tolerance of minus 1 inch (25 mm) and a minimum length of 80 feet (24 m).
- Furnished in plastic bags or otherwise protected to prevent damage from weather and handling.

C. Slope Protection.

Wood excelsior mat, coconut fiber mat, straw mat, or straw coconut mat may be used for slope protection.

1. Wood Excelsior Mats.

A mat of interlocking wood fibers meeting the requirements of Article 4169.10, B, 1. with the following exceptions:

- Plastic netting applied to one or both sides for holding the excelsior in place. Mats without netting where the excelsior is mechanically stitched together to hold it in place may be allowed.
- Minimum dry weight (mass) of 0.50 pounds per square yard (246 g/m2) according to ASTM D 6475.

2. Straw Mat, Straw-Coconut Fiber Mat, or Coconut Fiber Mat.

At the Contractor's option straw mat, straw-coconut fiber mat, or coconut fiber mat may be substituted for wood excelsior mat for slope protection. Meet the following requirements:

- Consistent thickness with the straw, straw-coconut fiber, or coconut fiber evenly distributed over the entire area of the mat.
- The top side of the mat covered with polypropylene netting attached with cotton thread.
- Minimum dry weight (mass) of 0.40 pounds per square yard (182 g/m^2) according to ASTM D 6475.
- Furnished in rolls with a uniform width of 48 inches (1.2 m), with a tolerance of minus 1 inch (25 mm) and a minimum length of 80 feet (24 m).
- Furnished in plastic bags or otherwise protected to prevent damage from weather or handling.

D. Netting.

1. Comply with the following mesh netting sizes. A tolerance of plus or minus 0.10 inch (2.5 mm) applies to netting size.

- Netting applied on wood excelsior mats: no more than 1 inch by 2 inches (25 mm by 50 mm).
- Netting applied on coconut fiber only mats for channel and slope: no more than 3/4 inch by 3/4 inch (19 mm by 19 mm).
- Netting applied on the top side of straw and straw-coconut fiber mats for slopes only: no more than 1/2 inch by 1/2 inch (13 mm by 13 mm).

2. A minimum weight of 9 pounds per 1000 square yards (44 g/m^2) is required for netting for special ditch control or slope protection.

E. Turf Reinforcement Mat (TRM).

1. **Type 1 TRM:** constructed of a web of mechanically or melt-bonded polymernetting, or monofilaments fibers entangled to form a strong and dimensionally stable mat. Bonding methods include polymer welding, thermal or polymer fusion, or the placement of synthetic fibers between two high-strength, biaxially-oriented nets, mechanically bound by parallel stitching with polyolefin thread. Products may contain a degradable component.

2. **Type 2 and 3 TRM:** constructed of a web of mechanically or melt-bonded polymer netting, or monofilaments, or fibers that are entangled to form a strong and dimensionally stable mat. Non-woven bonding methods include polymer welding, thermal or polymer fusion, or the placement of fibers between two high-strength, biaxially oriented nets, mechanically bound by parallel stitching with polyolefin thread. Components are to be 100% synthetic and resistant to biological, chemical, and ultraviolet degradation.

3. **Type 4 TRM:** a high performance/survivability TRM composed of monofilament yarns woven into a resilient uniform configuration. Use mats consisting of a matrix exhibiting very high interlock and reinforcement capacities with both soil and root systems and demonstrating a high tensile modulus. TRMs manufactured from discontinuous or loosely held together by stitched or glued, netting, or composites will not be allowed in this category. Components are to be 100% synthetic and resistant to biological, chemical, and ultraviolet degradation. Use this category when field conditions exist with high loading and/or high survivability requirements.

4. Comply with Table 4169.10-1 for minimum material property and performance requirements:

Table 4169.10-1: Minimum Material Property and Performance Requirements

Property	Property	Test Method	Type 1	Type 2	Type 3	Type 4
Material	Thickness	ASTM D 6525	0.25 in (6.25 mm)	0.25 in (6.25 mm)	0.25 in (6.25 mm)	0.25 in (6.25 mm)
Material	Tensile Strength[a, b)]	ASTM D 6818	125 lb/ft (186 kg/m)	240 lb/ft (357 kg/m)	750 lb/ft (1116 kg/m)	3000 lb/ft (4465 kg/m)
Material	UV Resistance	ASTM D 4355	80% @ 500 hrs	80% @ 1000 hrs	80% @ 1000 hrs	90% @ 3000 hrs

Performance	Maximum Shear Stress (Channel Applications)[c]	ASTM D 6460	7-9 lb/ft^2 (34.2 - 43.9 kg/m^2)	10-11 lb/ft^2 (48.8 - 53.7 kg/m^2)	12-14 lb/ft^2 (58.6 - 68.4 kg/m^2)	15-16 lb/ft^2 (73.2 - 78.1 kg/m^2)
Performance	Maximum Slope Gradient (Slope Applications)	N/A	1:1 (H:V) or flatter	1:1 (H:V) or flatter	1:1 (H:V) or greater	1:1 (H:V) or greater

a. Minimum Average Roll Values, machine direction only.
b. Tensile Strength of structural components retained after exposure.
c. Maximum shear stress that fully-vegetated TRM can sustain without physical damage or excess erosion (1/2 inch (12.5 mm) soil loss) during a 30 minute flow event in large scale testing. Acceptable large scale testing protocol includes ASTM D 6460 or independent testing conducted by the Texas Transportation Institute, Colorado State University, Utah State University, or other approved testing facility. Bench scale testing is not acceptable.

4169.11 FILTER FABRIC.

Furnish nonwoven polypropylene, UV stabilized filter fabric complying with Table 4169.11-1.

Table 4169.11-1: Filter Fabric Properties

Property	Typical	Minimum
Tensile Strength, lbs (metric)	130 (metric)	115 (metric)
Grab Elongation, %	70	50
Trapezoidal Tear Strength, lbs (metric)	60 (metric)	50 (metric)

4169.12 PERIMETER AND SLOPE SEDIMENT CONTROL DEVICE.

A. Wattles and Sediment Logs.
Wood excelsior or straw contained in a tube of photodegradable open weave fabric (synthetic netting). Install according to manufacturer's recommendations.

B. Filter Socks.
Continuous, tubular, knitted mesh netting with 3/8 inch (10 mm) opening fabricated using 5 mil (0.125 mm) thickness photodegradable HDPE and filled with a filter material consisting of compost from an approved source meeting Article 4169.08. Fill sock by blowing filter material into tube with a pneumatic blower truck or similar device. Hand filling will not be allowed. Install according to manufacturer's recommendations.

C. Approved perimeter and slope sediment control devices are listed in Materials I.M. 469.10, Appendix E.

Section 4170. Landscape Plant Materials

4170.01 DESCRIPTION.

Trees, shrubs, and vines used in roadside development.

4170.02 MATERIALS.

A. By submitting a proposal and accepting award of the contract, the Contractor acknowledges that it has investigated the supply of planting stock available and has obtained firm commitment from suppliers assuring delivery of the specified plant stock as required for completion of the contract. A list of suppliers and the materials to be furnished by each of them will be required at the preconstruction conference.

B. Meet the minimum requirements of size and grade in the American Standard for Nursery Stock ANSI Z 60.1. Sizes and grades for bare root nursery grown trees and shrubs and balled and burlapped (B & B) trees and shrubs as set forth in ANSI Z 60.01 are listed below:

1. Bare Root Nursery Grown Trees.
Meet the minimum requirements for diameter, height range, maximum height, and minimum root spread. Measure the diameter of the trunk 6 inches (150 mm) above ground level up to and including 4 inch (100 mm) diameter, and 12 inches (300 mm) above ground level for larger sizes.

Table 4170.02-1: Minimum Requirements (Nursery Grown Trees)

Diameter inches (mm)	Height Range feet (m)	Maximum Height feet (m)	Minimum Root Spread inches (mm)
1/2 (15)	5 - 6 (1.5 - 1.8)	8 (2.5)	12 (300)
3/4 (20)	6 - 8 (1.8 - 2.5)	10 (3.0)	16 (400)
1 (25)	8 - 10 (2.5 - 3.0)	11 (3.5)	18 (450)
1 1/4 (30)	8 - 10 (2.5 - 3.0)	12 (3.8)	20 (500)
1 1/2 (40)	10 - 12 (3.0 - 3.7)	14 (4.4)	22 (550)
1 3/4 (45)	10 - 12 (3.0 - 3.7)	14 (4.4)	24 (600)
2 (50)	12 - 14 (3.8 - 4.4)	16 (5.0)	28 (700)
2 1/2 (60)	12 - 14 (3.8 - 4.4)	16 (5.0)	32 (800)
3 (80)	14 - 16 (4.4 - 5.0)	18 (5.6)	38 (950)

2. Bare Root Nursery Grown Shrubs.
Meet the following minimum requirements:

Table 4170.02-2: Minimum Requirements (Nursery Grown Shrubs)

Size (height) of Plant feet (m)	Min. Root Spread inches (mm)
1 1/2 (0.50)	10 (250)
2 (0.60)	11 (275)
3 (0.90)	14 (350)
4 (1.25)	16 (400)
5 (1.50)	18 (450)
6 (1.80)	20 (500)

3. Balled and Burlapped Trees and Shrubs.
Meet the minimum requirements shown in Table 4170.02-3 for number of transplantings and sizes of balls:

Table 4170.02-3: Minimum Requirements

Size	Transplantings	Ball Diameter
Prostrate and Spreading Types (Pfitzer, Savin, etc.)		
(Height) feet (m)		Inches (mm)
1 1/2 (0.50)	2	10 (250)
2' (0.60)	3	12 (300)
2 1/2' (0.80)	4	14 (350)
3 1/2' (1.00)	4	18 (400)
Upright, Medium Height Types (Chinese, Column, Canaert, etc.)		
(Height) feet (m)		Inches (mm)
1 1/2' (0.50)	2	10 (250)
2' (0.60)	3	12 (300)
3' (0.90)	3	13 (350)
4' (1.25)	4	14 (350)
5' (1.50)	4	16 (400)
Large Tree Types (Pine, Spruce, etc.)		
(Height) feet (m)		Inches (mm)
3' (0.90)	3	14 (350)
5' (1.50)	4	20 (350)
6' (1.80)	4	22 (400)
Shrubs and Small Trees (Hawthorn, Redbud, Amur Maple, etc.)		
(Height) feet (m)		Inches (mm)
2' (0.60)	3	10 (250)
3' (1.50)	3	12 (300)
4' (1.25)	3	14 (350)
5' (1.50)	4	16 (400)

Large Shade Trees (Maple, Oak, Hackberry, etc.)		
(Dia. of Trunk) Inches (mm) 1 (25) 1 1/4 (30) 1 1/2 (40) 1 3/4 (45) 2 (50)		 Inches (mm) 16 (400) 18 (450) 20 (500) 22 (550) 24 (600)

4. Container Grown Plant Material.

a. Container grown plant material may be substituted for the same size, transplantings, and variety of B & B plant material as specified without any additional compensation. Submit a certification to the Engineer stating that container grown material has been grown in the container for no less than 1 year.

b. Ensure the container is of a size to permit development of a fibrous root system without the plant becoming root bound. No circling of the root system will be accepted.

c. Removal of the plant from the container will be required regardless of the container composition.

5. Quality of Plant Material.

a. Furnish only nursery grown stock, unless specified otherwise, that has been transplanted or root pruned two or more times according to the kind and size of plants.

b. Furnish plants typical of their species or variety.

c. Ensure plants are free from objectionable deformities, injurious insects or other plant pests, plant diseases, moldy or dried roots, or serious damage to the trunk, bark, roots, branches, or leaders which, in the judgment of the Engineer, will not allow the plant to develop properly to its natural shape. The Engineer will reject all plant material which fails to comply with these specifications. Immediately remove these materials from the project.

d. When possible, furnish plant material from stock grown in the same plant hardiness zone as Iowa or in a zone north of Iowa. Evergreen plant material that has approximately 1 inch (25 mm) or greater candle growth will not be accepted. Furnish bare root material that is in a dormant condition at the time of planting. Container grown or balled & burlapped material may be furnished in leaf, but care should be given to protect material from late frost.

6. Substitution.

Where evidence is submitted that a specified plant can not be obtained, substitution may be made with the Engineer's approval.

4170.03 TAGGING OF MATERIALS.

A. All stock furnished must be true to name and legibly tagged as to name, size, and number of transplants, according to the nursery standards of practice as recommended by the American Association of Nurserymen.

B. Verify nomenclature complies with the latest edition of Standard Plant Names published by the American Joint Committee on Horticultural Nomenclature prior to the date of the award of contract.

4170.04 INSPECTION OF PLANT MATERIAL.
Inspection of plant material may be made at the nursery or collecting field by an authorized representative of the Contracting Authority. Final acceptance will not be made until the material has been delivered and installed.

4170.05 SAMPLES.
The Engineer may require samples to be submitted before stock is shipped from the nursery to the planting site.

4170.06 GOVERNMENT INSPECTION.

A. Furnish only plant material complying with Federal and State laws with respect to inspection for plant disease and infestation. Provide all inspection certificates required by law to this effect with each shipment, invoice, or order of stock. On arrival, file the certificate with the Engineer.

B. Comply with rules and regulations of the State Entomologist of Iowa, relative to nursery inspection of nursery stock according to current provisions of the Iowa Administrative Code.

4170.07 PREPARATION OF PLANTS FOR SHIPMENT.

A. Furnish plants, except container grown material, from the nursery row, dug with reasonable care and skill.

B. Avoid unnecessary damaging or removing fibrous roots.

C. Take precautions customary in good trade practice to ensure arrival of the plants at their destination in good condition for successful growth.

D. Lift B & B plants from the nursery row with a firm ball so as to retain as many fibrous roots as possible.

4170.08 SHIPMENT OF PLANTS.

A. Pack material in such manner to ensure adequate protection against climatic, seasonal, or other damages during transportation.

B. Place bare root trees and shrubs in bundles. Carefully protect roots with wet straw, moss, or other suitable material which will assure arrival of plants at destination with roots in a moist, healthy condition.

C. Protect evergreens during transportation with wet straw, moss, or other suitable material.

D. Further protect plant material with a tarpaulin when being transported in an open vehicle.

4170.09 INCIDENTAL MATERIALS FOR PLANT INSTALLATION.

Meet the requirements for materials of the following types to be furnished for the proper installation of plant materials:

A. Topsoil.

1. High quality soil consisting of the top 6 inches (150 mm) of field or pasture loam containing a good supply of humus and a high degree of fertility. Do not use surface soils from ditch bottoms, drained ponds, and eroded areas, or soils which are supporting growth of noxious weeds or other undesirable vegetation.

2. A pH value from 6.0 to 7.5.

3. Free from hard clods, rocks, and other debris larger than 2 inches (50 mm) in diameter.

B. Fertilizer.

1. Initial application of 0-46-0 triple super phosphate.

2. Second application of 20-10-10 chemically combined commercial fertilizer.

C. Staking and Guying and Anchoring.

1. Stakes.
- **a.** Use either:
  - Yard lumber of 2 inches by 2 inches (50 mm to 50 mm) nominal dimension, permitting small knots that do not impair serviceability, or
  - Steel posts meeting requirements of Article 4154.09.
- **b.** Cut to the length specified in Article 2610.03, F.

2. Guys.
- **a.** Good commercial quality No. 11 (3.06 mm diameter) wire or approved equal.
- **b.** Use pieces of new fabric reinforced garden hose or an approved equal to protect the plants from damage by guys.

3. Anchors.
Steel of the sizes specified in Article 2610.03, F, as approved by the Engineer.

D. Mulch.
As specified in the contract documents.

E. Tree Wrap.
Crinkle type, kraft, tree wrap paper 4 inches (100 mm) wide, or a tree wrap approved by the Engineer.

Section 4182. Paints for Steel Bridges and Structures

4182.01 GENERAL REQUIREMENTS.
Meet the requirements specified in the contract documents for the respective material.

4182.02 ZINC RICH PAINT.
Comply with Materials I.M. 482.02 for inspection and acceptance of zinc rich paints.

4182.03 WATERBORNE ACRYLIC PAINTS.
Comply with Materials I.M. 482.05 for inspection and acceptance of waterborne acrylic paints.

4182.04 FILLED HIGH SOLIDS EPOXY PAINTS.
Comply with Materials I.M. 482.04 for inspection and acceptance of aluminum filled high solids epoxy paint.

4182.05 MOISTURE CURED POLYURETHANE PAINT SYSTEM.
Comply with Materials I.M. 482.06 for inspection and acceptance of Moisture Cured Polyurethane Paint System.

Section 4183. Traffic Paints and Pavement Markings

4183.01 DESCRIPTION.
These specifications cover pavement marking tape and two types of fast dry traffic paint: VOC compliant solvent borne, and waterborne. Article 2527.03, A, 2, lists the temperature and date restrictions for the use of these paints.

4183.02 FAST DRY, VOLATILE ORGANIC CONTENT COMPLIANT, SOLVENT BORNE TRAFFIC PAINT.

A. General Requirements.

1. This paint is intended for use in the early and late part of the construction season when the temperature is too cold for waterborne traffic paint.

2. Use a VOC compliant solvent borne paint that:
- Is capable of being heated and spray applied up to a temperature of 122°F (50°C) without damaging the paint or the striping equipment.
- Is not damaged or deteriorated when reheated or if held under heated conditions for 6 hours.
- Provides proper anchorage and refraction for glass beads when the beads are applied at a rate of 6 pounds of beads per gallon (0.72 kg/L) of paint.
- Shows no evidence of excessive settling, gelling, skinning, spoilage or livering upon storage in sealed containers within a 12 month period in the sealed delivery container.

B. Specific Requirements.

1. Composition.

Use VOC compliant solvent borne paint with a volatile organic content of 1.25 pounds per gallon (150 g/L) or less. Ensure yellow pigment is free from lead, chrome, and other heavy metals as defined by the EPA.

a. Pigment Constituents.

1) **Titanium Dioxide:** comply with the latest revision of the specification for titanium dioxide pigments, ASTM D 476, Type II, Rutile.
2) **Organic Yellow:** pigment yellow C.I. #75 or pigment yellow C.I. #200.
3) **Calcium Carbonate:** comply with the latest revision of the specification for calcium carbonate pigments, ASTM D 1199, Type GC, Grade I with minimum of 95% calcium carbonate.
4) **Magnesium Silicate:** comply with the latest revision of the specification for magnesium silicate pigments, ASTM D 605.
5) **Silica:** at least 99.5% SiO_2 in the 30 to 40 micron (30 µm to 40 µm) size range.
6) **Yellow Iron Oxide:** meet the latest revision of ASTM D 768.
7) **Rheological Additives:** one of the following self-activating organic clays:

Benton SD-2	NL Chemicals, Inc.
Claytone APA or HY	Southern Clay Products
Tixogel MP-250	United Catalyst, Inc.

b. Vehicle Constituents.

1) **Resins:** acrylic copolymer. Use either of the two listed in Tables 4183.02-1 and 4183.02-2 or any combination of the two to achieve the desired properties:

Table 4183.02-1: Resin 1
Poly (methyl methacrylate/n-butyl methacrylate/methacrylic acid) [MMA/NBMA]

Appearance		White, non-dusting beads
Percent Nonvolatiles		98.5% minimum
Acid Value (mgKOH/g)		3.0 maximum
Molecular Weight		60,000
Glass Transition Temperature		122ºF (50ºC)
Properties of Solution (40% by weight (mass) in toluene)	Color (Gardner)	2 maximum
	Viscosity @ 77°F (25°C)	300 - 400 cps (0.3 - 0.4 Pahs)

Table 4183.02-2: Resin 2
l-butyl methacrylate-diethyl aminoethyl methacrylate copolymer

Appearance	White, non-dusting beads
Percent Nonvolatiles	99.0% minimum
Acid Value (mgKOH/g)	0.7 - 1.7
Molecular Weight	60,000
Glass Transition Temperature	122°F (50°C)
Viscosity (40% by weight (mass) in toluene) @ 77°F (25°C)	300 - 400 cps (0.3 - 0.4 Pahs)
Color, Gardner (20% by weight (mass) in toluene)	2 maximum

2) **Soya Lecithin:** of suitable quality for use in the manufacturing of paint.
3) **Acetone:** comply with the latest revision of the specification for acetone ASTM D 329.
4) **Plasticizer:** Dioctal Phthalate or other suitable plasticizer giving similar results.
5) **Chlorinated Paraffin:** comply with the latest revision of Military Specification MIL C-429, Type I.

2. Formulation Guide for White Paint.

Table 4183.02-3: Formulation Guide

	Pounds	Kilograms
Dioctal Phthalate	12	5.4
Xylene	60	27.2
Acetone	270	122.4
Soya Lecithin	10	4.5
Chlorinated Paraffin	20	9.1
Anti-Skin Agent	3	1.4
Acrylic Copolymer	170	77.1
Anti-Settle Agent	6	2.7
Calcium Carbonate	400	181.4
Magnesium Silicate	50	22.7
Silica	100	45.4
Titanium Dioxide	100	45.4
Total	**1201**	**544.7**

3. White Control Tolerances.

Table 4183.02-4: Tolerances

Property	Value	Test Method
Viscosity, KU	75 - 90	ASTM D 562
Density	11.90 ± 0.2 lb/gal (1.42 ± 0.02 kg/L)	Federal Test 141-4271
Reflectance	83% minimum	ASTM E 1349
Dry Opacity @ 6 mils (0.15 mm) wet	0.95 minimum	Federal Test 141-4121
Dry to no pick-up @ 6 mils (0.15 mm) wet	4 minutes maximum	ASTM D 711
Total Solids	71% minimum	Federal Test 141-4041
Percent Pigment	53 - 57%	Federal Test 141-4021
Non-volatile vehicle	37% minimum	Federal Test 141-4053
Hegman Grind	2 minimum	ASTM D 1210

4. Yellow Formulation Guide.

Table 4183.02-5: Formulation Guide

	Pounds	Kilograms
Dioctal Phthalate	12	5.4
Xylene	60	27.2
Acetone	270	122.4
Soya Lecithin	10	4.5
Chlorinated Paraffin	20	9.1
Anti-Skin Agent	3	1.4
Acrylic Copolymer	170	77.1
Anti-Settle Agent	4	1.8
Calcium Carbonate	400	181.4
Magnesium Silicate	50	22.7
Yellow Iron Oxide	2	0.9
Titanium Oxide	30	13.6
Organic Yellow	35	15.9
Silica	100	45.4
Total	**1166**	**528.8**

5. Yellow Control Tolerances.

Table 4183.02-6: Tolerances

Property	Value	Test Method
Viscosity, KU	80 - 90	ASTM D 562
Density	11.5 ± 0.2 lb/gal (1.38 ± 0.02 kg/L)	Federal Test 141-4271
Reflectance	50% minimum 59% maximum	ASTM E 1349
Dry Opacity @ 6 mils (0.15 mm) wet	0.92 minimum	Federal Test 141-4121
Dry to no pick-up @ 6 mils (0.15 mm) wet	4 minutes maximum	ASTM D 711
Total Solids	70% minimum	Federal Test 141-4041
Percent Pigment	50 - 55%	Federal Test 141-4021
Non-volatile vehicle	37% minimum	Federal Test 141-4053
Hegman Grind	2 minimum	ASTM D 1210
Color @ 2 degree Observer, Illuminant C, 45/0 or 0/45 geometry.	x 0.4706 - 0.5307 y 0.4282 - 0.4828	ASTM E 1164

6. Volatile Organic Content.
Ensure the volatile organic content of the finished paint contains less than 1.25 pounds (150 g) of volatile organic matter per gallon (liter) of total non-volatile paint material according to ASTM D 3960.

C. Field Service Requirements.

1. Paint Pigment.
- **a.** Use well ground pigment properly dispersed in the vehicle.
- **b.** Ensure the pigment does not cake or thicken in the container, and does not become granular or curdled.
- **c.** If pigment settles in the paint, the result is to be a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment is to be easily redispersed with minimum resistance to the sideways manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency.
- **d.** Do not use paint that cannot be easily redispersed, as a result of excessive pigment settlement as described above, or any other cause.

2. Specified Properties.
- **a.** Ensure the paint retains all specified properties under normal above freezing, outside storage conditions for 12 months after acceptance and delivery.

b. The vendor is responsible for all costs and transportation charges incurred in replacing paint that is unfit for use.
c. Ensure replacement paint properties remain satisfactory for 12 months from the date of acceptance and delivery.

3. Glass Spheres.
Ensure the glass spheres for use in VOC compliant, solvent borne traffic paint are uncoated and meet the requirements of Section 4184.

D. Inspection and Acceptance.
Comply with Materials I.M. 483.03 for inspection and acceptance of paint.

4183.03 FAST DRY WATERBORNE TRAFFIC PAINTS.

A. General Requirements.

1. Use paint that:
a. Is capable of being heated and spray applied up to a temperature of 140°F (60°C) without damaging the formulation or serviceability of the product and the traffic striping equipment.
b. Is not damaged or deteriorates when reheated or if held under heated conditions for 6 hours.
c. Provides proper anchorage and refraction for glass beads when the beads are applied at the rate of 6 pounds per gallon (0.7 kg/L).
d. Is free of heavy metals as defined by the US EPA.
e. Free of skins, pigment agglomerates, and foreign matter.
f. Shows no evidence of excessive settling, gelling, skinning, spoilage, or livering upon storage in sealed containers under normal above freezing temperatures within a 12 month period in the sealed delivery container.

2. When the air temperature is below the freezing point (32°F (0°C)), ship or store the paint in an insulated vehicle or storage building with heating capability to ensure the inside temperature is held above freezing.

B. Specific Requirements.

1. Composition.
The composition of the paint is left to the discretion of the manufacturer as long as the finished product meets the following requirements and applicable Federal, State, or local regulations for products of this type.
a. Pigment Content.
Percent pigment by weight (mass) of the finished product to be from 45.0% to 55.0% by weight (mass) for white and 55.0% to 58.0% by weight (mass) for yellow as tested by ASTM D 3723.
b. Resin Solids.
Composed of 100% acrylic emulsion polymer (Rohm & Haas E 3427, Dow Chemical DT 250, or an approved equal). Low Temperature Paint to use Rohm & Haas XSR Resin.

c. Nonvolatile Vehicle.

1) No less than 43.0% by weight (mass) for white paint and no less than 45.0% by weight (mass) for yellow paint.

2) Use the the following formula for calculating nonvolatile vehicle (NVV):

NVV= (N-P)/(100-P)

Where:

N = the percent by weight (mass) of non-volatiles as determined by ASTM D 2369

P = the percent weight (mass) of pigment as determined by ASTM D 3723

d. Volatile Organic Compounds.

Not to exceed 1.25 pounds per gallon (150 g/L) excluding water and VOC exempt solvents. Use ASTM D 3960 to determine the level of VOCs.

e. Flash Point.

Closed cup flash point is to be no less than 100°F (38°C) as tested by ASTM D 56.

f. Density.

A minimum of 12 pounds per gallon (1400 g/L), with the density of the production batches not varying by more than ± 0.2 pounds per gallon (25 g/L) from the density of the qualification samples. Use ASTM D 1475 to measure density.

2. Laboratory Test Requirements.

a. Color.

1) For white, the color after drying is to be a flat white, free from tint, furnishing good opacity and visibility under both daylight and artificial light.

2) For yellow, the color is to be within the following CIE chromaticity limits when measured with an instrument having a 2 degree observer, using a standard C illuminant, and 45/0 or 0/45 geometry.

Table 4183.03-1: CIE Chromaticity Limits

CIE Data Limits	Y	x	y
Minimum	0.5400	0.462	0.428
Maximum	0.5910	0.501	0.455

3) The yellow color chip with chromaticity readings can be obtained from the Office of Materials for correlation.

b. Viscosity.

1) For white: no less than 80 or no greater than 90 Krebs Units at 77°F (25°C).

2) For yellow: no less than 75 Kreb Units or no greater than 85 Krebs Units at 77°F (25°C).

3) Use ASTM D 562 to measure viscosity.

c. No-Pick-Up Time.

1) Less than 5 minutes.

2) Test according to the requirements of ASTM D 711, except with a test stripe having a wet film thickness of 6 mils (150 µm) as measured by an Interchemical et film thickness gage and no air movement.

d. Directional Reflectance (without Glass Spheres).

1) For white: 84.0% minimum.

2) For yellow: 50.7% minimum.

e. Dry Opacity.

1) For white: a minimum contrast ratio of 0.955

2) For yellow: a minimum contrast ratio of 0.930.

3) Test according to the requirements of Federal Test 141a Method 4121. Use a test stripe with a wet film thickness of 7 mil (178 µm) as measured by an Interchemical Wet Film Thickness Gage.

f. Flexibility.

No cracking or flaking shows when tested according to Federal Specification TT-P-1952b.

g. Pigment Particle Size.

Grind of no less than 3 on a Hegman Grind Gage when measured according to ASTM D 1210.

3. Field Service Requirements.

a. Paint Pigment.

1) Use well ground pigment properly dispersed in the vehicle.

2) Ensure the pigment does not cake or thicken in the container, and does not become granular or curdled.

3) If pigment settles in the paint, the result is to be a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment is to be easily redispersed with minimum resistance to the sideways manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency.

4) Do not use paint that cannot be easily redispersed as a result of excessive pigment settlement as described above, or any other cause.

b. Specified Properties.

1) Ensure the paint retains all specified properties under normal above freezing, outside storage conditions for 12 months after acceptance and delivery.

2) The vendor is responsible for all costs and transportation charges incurred in replacing paint that is unfit for use.

3) Ensure replacement paint properties remain satisfactory for 12 months from date of acceptance and delivery.

4. Packaging and Marking.

a. Ensure each container is plainly marked with the gross, tare, net weight, the lot number, producer's name, the date of manufacture, and the type of paint.

b. Provide MSDS.

c. Ensure each container is filled with the volume in liters corrected to 77°F (25°C) as specified in the contract documents.

C. Inspection and Acceptance.
Comply with Materials I.M. 483.03 for inspection and acceptance of paint.

4183.04 DURABLE PAINT PAVEMENT MARKINGS.

Meet the requirements of Materials I.M. 483.04.

4183.05 TESTING AND ACCEPTANCE.

A. Ensure the latest methods prescribed by ASTM, Federal Test Method Standard No. 141, or other recognized standard methods are used to test the ingredients and paints.

B. Infrared spectroscopy, gas chromatography, and x-ray spectroscopy may be used to confirm vehicle composition.

C. The material will be accepted if, upon analysis, the composition of ingredients of paint is found to be within ± 1% of the specified percentages.

4183.06 PAVEMENT MARKING TAPE.

A. Removable Marking Tape.
Comply with Materials I.M. 483.06 and meet the following requirements:

1. Thickness.
Average thickness of the film, including glass spheres, no less than 30 mils (0.76 mm) or more than 70 mils (1.78 mm).

2. Retroreflectance.
For white or yellow tapes, meet the following initial minimum retroreflectance values at 1.05 degree observation angle and 88.76 degree entrance angle, measured by a LTL 2000 retroreflectometer:

	White	Yellow
Specific luminance, mcd/sq.ft./ft.-cdl. (lux•m^2)	550	325

B. Regular Marking Tape.
Comply with Materials I.M. 483.06 and meet the following requirements:

1. Thickness.
Average thickness of the film, including glass spheres, no less than 15 mils (0.38 mm) or more than 50 mils (1.27 mm).

2. Retroreflectance.
For white or yellow tapes, meet the following initial minimum retroreflectance values at 1.05 degree observation angle and 88.76 degree entrance angle, measured by a LTL 2000 retroreflectometer:

	White	Yellow
Specific luminance, mcd/sq.ft./ft.-cdl. (lux•m^2)	550	325

C. Preformed Polymer Marking Material.
Comply with Materials I.M. 483.06 and meet the following requirements:

1. **Color.**
   White or yellow, complying with standard highway markings.

2. **Thickness.**
   Marking film thickness from 60 mils (1.52 mm) to 90 mils (2.29 mm), as measured to include adhesive and glass beads.

3. **Retroreflectance.**
   For white or yellow tapes, meet the following initial minimum retroreflectance values at 1.05 degree observation angle and 88.76 degree entrance angle, measured by a LTL 2000 retroreflectometer.

	White	Yellow
Specific luminance, mcd/sq.ft./ft.-cdl. (lux●m2)	325	150

D. Removable, Preformed, Nonreflective Tape.
Comply with Materials I.M. 483.06 and meet the following requirements:

1. **Color.**
   Dark grey or black in order to blend with the pavement surface color.
2. **Thickness.**
   Average film thickness no less than 30 mils (0.76 mm).

3. **Reflectance.**
   No nighttime reflective characteristics.

E. Profiled Pavement Marking Tape.
Comply with Materials I.M. 483.06 and meet the following requirements:

1. **Color.**
   White or yellow, complying with standard highway markings.

2. **Thickness.**
   Profiled surface. Thickness of the tape including glass beads no less than 30 mils (0.76 mm) or greater than 100 mils (2.54 mm). Height of the profiles (measured from lowest point to highest point) no less than 35 mils (0.89 mm).

3. **Retroreflectance.**
   For white and yellow films, meet the following initial minimum retroreflectance values at 1.05 degree observation angle and 88.76 degree entrance angle, measured by a LTL 2000 retroreflectometer.

	White	Yellow
Specific luminance, mcd/sq.ft./ft.-cdl. (lux●m2)	700	350

F. Intersection Marking Tape.
Intersection marking tape is intended for cross walks, gore lines, and symbols at intersections where marking tape is subjected to high shear from turning traffic. Comply with Materials I.M. 483.06 and meet the following requirements:

1. Color.
White or yellow, complying with standard highway markings.

2. Initial Skid Resistance.
Initial skid resistance a minimum of 55 British Pendulum Number (BPN) when tested according to ASTM E 303.

3. Retroreflectance.
For white or yellow tapes, meet the following initial minimum retroreflectance at 1.05 degree observation angle and 88.76 degree entrance angle, measured by a LTL 2000 retroreflectometer.

	White	Yellow
Specific luminance, mcd/sq.ft./ft.-cdl. (lux●m2)	150	100

Section 4184. Reflectorizing Spheres for Traffic Paint

4184.01 DESCRIPTION.

A. This specification covers two types of glass spheres, dual coated and uncoated, for the production of reflectorized pavement markings.
- Waterborne and VOC compliant solvent borne traffic paint: use dual coated beads (silicone and silane).
- Epoxy pavement markings: use silicone only coated beads (no silane).

B. The glass beads shall not exhibit a characteristic of toxicity, relative to heavy metals. Glass beads shall not contain more than 200 ppm total of lead, antimony, or arsenic. Manufacturer shall provide a certificate of analysis stating total lead, antimony, and arsenic content for each batch of glass beads supplied. Use transparent, clear, colorless glass spheres that are:
- Free from milkiness, dark particles, and excessive air inclusions.
- Essentially clear from surface scarring or scratching.
- Free of hard lumps and clusters
- Readily dispensed under any conditions suitable for paint striping.

4184.02 SPECIFIC REQUIREMENTS.

A. Gradation.
Meet the gradation requirements of Table 4184.02-1.

Table 4184.02-1: Gradation Requirements (Glass Spheres)

Sieve Size	Percent Passing
16 (1180 µm)	100
20 (850 µm)	90-100
30 (600 µm)	50-75
40 (425 µm)	15-45
50 (300 µm)	0-15

B. Roundness.
Minimum of 80% true spheres.

C. Refractive Index.
Minimum refractive index of 1.50.

D. Properties of Dual Coated Spheres.

1. Coated with a dual coating that has both a moisture resistant silicone coating and an adhesion promoting silane coating.

2. Passes the moisture resistance test and the adherence coating test.

E. Properties of Silicone Coated Spheres.

1. Coated only with a silicone coating (no silane).

2. Passes the moisture resistance test and test negative for the adherence coating test.

4184.03 METHODS OF TEST.
Test the specific requirements according to Office of Materials Test Method No. Iowa 814.

Section 4185. Highway Lighting Materials

4185.01 DESCRIPTION.

A. Furnish materials for highway lighting of the size and type specified.

B. When more than one unit of any item is required for installation, furnish units that are all the same make and design. Furnish apparatus and materials that meet the following:
- Are new products of manufacturers regularly engaged in production of items of this type,
- Are the manufacturer's latest approved design,
- Carry the UL seal of approval, if listed, and
- Are recommended by the manufacturer for the intended use.

4185.02 POLES AND SUPPORTS.

A. General.

1. Furnish steel, aluminum, or wood poles of the size and type specified.

2. Each lighting pole is to include provisions for supporting the luminaire or luminaires. If furnishing metal poles, furnish poles consisting of:
- A tapered round shaft, complete with a base, and removable pole top,

- Nameplate or other identification displaying the manufacturer's name, type, height, and shop order number, and
- Appurtenant supporting devices.

3. Dimensions and other details will be shown in the contract documents. Furnish poles and mastarms meeting the mounting height and mastarm length shown in the contract documents. Ensure the structural design of the light pole is based on the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

4. The assembled lighting unit, consisting of the pole and all attachments including mastarms, luminaires, and breakaway base or slip base, as specified, complete and in place in the footing anchor bolts, is required to withstand windloading equal to a wind of 80 mph (130 km/h) without fracture or apparent deformation of components. Furnish poles in one section. Ensure each standard is designed for a luminaire dead load of 75 pounds (35 kg) and a projected area of 1.5 square feet (0.10 m^2), except that in the case of twin mastarms, these values are applied to each mastarm.

5. Furnish castings incidental to poles that are smooth and clean, with all details well defined and true to pattern.

6. Furnish pole bases that telescope the pole shaft and are attached to the pole shaft by two welds (top and bottom) subject to approval of the Engineer. Ensure bases other than slip base poles have four anchor bolt holes located 90 degrees apart in the bolt circle. If slip bases are furnished, ensure they have three anchor bolt holes located 120 degrees apart in the bolt circle, oriented as shown in the contract documents. For poles with mastarms, ensure the centers of two adjacent anchor bolt holes are on a line parallel with the neutral plane of the pole shaft with respect to one mastarm, designated as the standard mastarm.

7. Obtain a template from the manufacturer for placement of anchor bolts.

8. With the pole, furnish metal ornamental covers for the upper ends of the anchor or attachment bolts for breakaway base poles.

9. Provide a wiring handhole, no less than 4 inches by 6 inches (100 mm by 150 mm), with a weatherproof metal cover, for all metal poles not mounted on transformer bases, or as shown in the contract documents. Center the handhole on a point no less than 14 inches (350 mm) or no more than 18 inches (450 mm) above the bottom surface of the pole base mounting flange, and 90 degrees clockwise from the center line of the standard mastarm, as viewed from above. Ensure the pole shaft has a J-hook at the top for supporting cables.

10. Ensure each pole has an approved grounding lug. When a handhole is furnished, ensure the grounding lug is readily accessible through the

handhole. Ensure grounding lugs for breakaway base poles are accessible from the bottom of the pole shaft.

B. Anchor Bolt and Slip-Base Plate Fasteners for Lighting Poles.

1. Furnish all bolts, nuts, and washers for pole attachment and anchoring according to the details in the contract documents. Ensure assembled fasteners are capable of withstanding the forces corresponding to a moment that will cause failure of the pole, transformer base, or other applicable mounting device.

2. Furnish anchor bolts that:

- Meet the requirements of ASTM F 1554, Grade 105 (724 MPa),
- Are full-length galvanized according to ASTM F 2329, and
- Are Unified Coarse Thread Series with Class 2A tolerance.

3. Color code the end of each anchor bolt intended to project from the concrete in red to identify the grade.

4. If slip bases are furnished, furnish 1 inch by 4 1/2 inch (25 mm by 112 mm) bolts slip base plate that:

- Are high-strength bolts meeting the requirements of ASTM A 325, and
- Are fully mechanically galvanized to ASTM B 695, Class 50, Type 1.

5. Furnish washers that:

- Meet the requirements of ASTM F 436, and
- Are galvanized.

6. Furnish nuts that:

- Meet the requirements of ASTM A 563, DH,
- Are heavy hex, and
- Are galvanized according to the requirements of ASTM A 153, Class C, or ASTM B 695, Class 50.

7. Nuts may be over-tapped according to the allowance requirements of ASTM A 563. Nuts may be tapped oversize only enough to provide a finger free fit.

C. Mastarms and Accessories.

1. When indicated in the contract documents, furnish single or twin mastarms as luminaire supports. The contract documents will show the horizontal span of the mastarm and the included angle between the center lines of twin mastarms. Such angles are defined as rotating from the standard mastarm, as viewed from above.

2. Furnish mastarms meeting the following requirements:

a. Aluminum tube or galvanized steel to match the pole, with smooth openings into the pole shaft to provide an electrical raceway.
b. Capable of accommodating a 2 inch (50 mm) slipfitter type luminaire.
c. **Type A mastarms:** no braces or truss members.
d. **Type B mastarms:** a single underbrace attached to the mastarm at no less than two locations.

3. Furnish mastarm bolts, nuts, and washers that are stainless steel and meet the requirements of Article 4187.01.

D. Breakaway (Transformer) Base.
Furnish bases meeting the following requirements:

1. Cast aluminum meeting requirements of ASTM B 108, 356-T6 or B 26, 356-T6 aluminum alloy.

2. Compliance with AASHTO breakaway criteria.

3. Capable of withstanding an applied moment at the top equal to the design moment of the applicable pole, and no less than 35,000 foot-pounds (47,500 N·m).

4. Yields to an applied momentum of 1,100 pound-seconds (4.9 kNs) when tested with an automobile or 400 pound-seconds (1.8 kN·s) when tested with a solid mass. The manufacturer should conduct the tests and certify the results to comply with requirements of current AASHTO requirements for breakaway luminaire supports.

5. Equipped with a weatherproof access door with door opening area of no less than 100 square inches (0.065 m^2), unless shown otherwise.

E. Steel Poles.

1. Furnish poles meeting the following requirements:
a. Shafts manufactured with a taper of approximately 0.14 inch per foot (12 mm/m) of length.
b. Steel that is no less than 11 gage (3.03 mm), with a minimum yield strength of 48,000 psi (330 MPa), after fabrication.
c. Steel galvanized according to ASTM A 123. Steel 1/8 inch (3 mm) thick or less shall be galvanized to comply with requirements for 1/8 inch (3 mm) thick steel as described in ASTM A 123.

2. Furnish Type A and B mastarms meeting the following:
a. Fabricated from standard weight, welded steel, 2 inch (50 mm) pipe meeting the requirements of ASTM A 53, Grade B, and galvanized according to ASTM A 123.
b. Underbrace for a Type B mastarm complying with requirements of the mastarm and connected to the mastarm by welded steel braces to form a truss type assembly.
c. Mastarm to shaft brackets that provide a water tight connection.

F. Aluminum Poles.

1. Furnish poles meeting the following requirements:
- **a.** Fabricated from ASTM B 221 6063-T6 or 6061-T6 aluminum alloy tube or ASTM B 209 5086-H34 aluminum sheet.
- **b.** Minimum nominal wall thickness of 3/16 inch (5 mm) unless indicated otherwise in the contract documents.
- **c.** Shafts tapered approximately 0.14 inch per foot (12 mm/m) of length.
- **d.** Castings of ASTM A 356/A 356M-T6 aluminum alloy meeting the requirements of Article 4187.01.
- **e.** Approved dampening device included.
- **f.** Blocked and paper-wrapped prior to shipment.

2. Furnish Type A and B mastarms meeting the following:
- **a.** Fabricated from alloy complying with requirements for the pole shaft.
- **b.** Types A and B mastarms fabricated from tubing or pipe with a minimum outside diameter of 2.375 inches (60.325 mm), and swaged, when required, to accommodate a 2 inch (50 mm) slipfitter type luminaire.
- **c.** Welded braces used to connect the underbrace for a Type B mastarm to the mastarm in order to form a truss type assembly.

G. Wood Poles.

1. Furnish poles meeting the following requirements:
- **a.** ANSI 05.1, Group D.
- **b.** Pressure treated with pentachlorophenol according to AASHTO M 133.

2. The size and class of wood poles will be specified in the contract documents.

4185.03 LUMINAIRES.

A. Roadway Luminaire.

1. Furnish roadway luminaire assemblies consisting of the following:
- **a.** A weatherproof, die cast aluminum or aluminum alloy housing and slipfitter with internally mounted ballast.
- **b.** A hinged, detachable, glass refractor manufactured from high-transmission-factor, highly shockproof, prismatic glass.
- **c.** A snap-in aluminum reflector.
- **d.** A high grade porcelain enclosed socket and terminal block with pressure type terminals for connecting leads entering from the mounting bracket or mastarm.

2. Fit a heat resistant gasket between the reflector and a shoulder in the socket support plate to seal the optical system at this point.

3. Furnish a slipfitter that consists of bracket clamps and provides for vertical adjustment and horizontal leveling of the luminaire. Arrange the slipfitter to accommodate a 2 inch (50 mm) standard pipe bracket.

4. Furnish a weatherproof, hinged, access door for quick access to the terminal block and mounting arrangement. Ensure exposed metal parts are made from nonferrous metal or stainless steel.

5. With the high pressure sodium lamp, furnish a regulated high-power-factor type ballast with starting current lower than operating current. Ensure it will maintain lamp wattage within 10% variation with a line voltage regulation of ± 10%, with no less than 90% power factor. Ballast for use with other light sources will be specified in the contract documents.

6. The contract documents will specify the luminaire according to the type of lamp to be used and its size in watts. Unless specified otherwise, furnish only the light sources for roadway luminaires listed in Table 4185.03:

Table 4185.03-1: High Pressure Sodium Lamp

400 Watt	ANSI Code S51WA-400
250 Watt	ANSI Code S50VA-250
200 Watt	ANSI Code S66MN-200
150 Watt	ANSI Code S55SC-150
100 Watt	ANSI Code S54SB-100
70 Watt	ANSI Code S62ME-70
Furnish high pressure sodium lamps for appropriate burning positions, as required by the luminaire.	

B. Low Mounting Height Luminaires.

1. Furnish complete low mounting height luminaires consisting of the following:
- **a.** An optical train which includes a single piece, prismatic refractor mounted in an aluminum door assembly.
- **b.** An asymmetric, specular processed aluminum reflector.
- **c.** An anodized aluminum visor.
- **d.** An attached or integral ballast housing.
- **e.** A cast aluminum luminaire housing.
- **f.** When specified, an adaptor mount and shield for sign lighting.

2. Furnish a door assembly equipped with noncorrosive metal pressure latches, hinges, and safety chain.

3. Furnish a luminaire housing complete with:
- Captive neoprene and felt double gasketing,
- A rear access hole in a gasketed aluminum cover plate, and
- Tapped conduit entries as shown in the contract documents.

4. Furnish a refractor that meets the following:
- **a.** Fabricated from molded, high-transmission-factor, thermal shock resisting, crystal glass.
- **b.** Is of adequate size to properly house the specified lamp and to produce the required light distribution.
- **c.** Inner and outer surface are covered with an array of reflecting and refracting prisms and diffusing flutes which are designed to provide an asymmetric light distribution.

5. With a high pressure sodium lamp, furnish a regulated high-power-factor type ballast with starting current lower than operating current. Ensure it will maintain lamp wattage within 10% variation with a line voltage regulation of ± 10%, with no less than a 90% power factor. The contract documents will specify the ballast for use with other light sources.

6. Ensure maximum luminous intensity (candela) output occurs at 60 degrees from the vertical. Ensure the unit provides a 180 degree horizontal spread in the maximum luminous intensity (candela) plane.

7. Ensure entire luminaire is designed to be attached to a wall outlet box mounted to a stud, a metal channel framing, or a sign lighting adaptor and shield. Unless specified otherwise in the contract documents, furnish the light source for the luminaire listed in Table 4185.03-2:

Table 4185.03-2: High Pressure Sodium Lamp

250 Watt 150 Watt 100 Watt 70 Watt	ANSI Code S50VA-250 ANSI Code S55SC-150 ANSI Code S54SB-100 ANSI Code S62ME-70
Furnish high pressure sodium lamps for appropriate burning positions, as required by the luminaire.	

4185.04 GROUND RODS.

A. Furnish approved, copper clad, steel rods of the diameter and length designated in the contract documents.

B. Unless designated otherwise, furnish rods of a minimum nominal 5/8 inch (16 mm) diameter, and a minimum length of 12 feet (3.6 m) for control stations and 8 feet (2.4 m) for installations at lighting units.

C. Include pressure type clamps and bonding jumpers as required. Unless shown otherwise in the contract documents, furnish bare solid conductor copper wire, No. 6 AWG or larger, bonding jumpers.

4185.05 CONTACTORS.

A. Lighting contactors may be housed within control cabinets as shown in the contract documents.

B. Meet the following requirements for contacts:

1. Two pole, single throw, magnetically held, normally open relays rated at 480 volts AC or greater.

2. Double break, self cleaning type with interrupting ratings as shown in the contract documents.

3. Material designed for lighting ballast loads and requiring no maintenance, such as filing, burnishing, or dressing at any time the contactor is in service.

4. A permanent instruction contained within the cabinet housing stating, "Contacts shall not be filed, burnished, or dressed".

5. Movable contact holders of one piece, molded construction. Opening action obtained by free fall from gravitational forces or by use of noncorrosive springs. The Contractor may use pivots of the hardened, knife edge type.

C. Meet the following requirements for operating coils:

1. A 60 hertz frequency supply.

2. Removable from the front of the contactor assembly without disturbing other components or wiring.

3. Each designed to prevent any expansion, bubbling, or melting that would render the remainder of the unit inoperative in event of a coil burnout.

4185.06 PHOTO-ELECTRIC CONTROL.

Furnish controls meeting the following requirements:

A. Weatherproof.

B. Fits the standard 3 prong EEI/NEMA twist-lock socket.

C. Operates with a 60 hertz frequency control circuit.

D. Designed so that any failure under normal conditions will cause the lighting circuits to be energized.

E. All ratings in compliance with the control requirements of the contactor.

F. Time delay type set to turn on at 2.0 footcandles (20 lux) and off at 6.0 footcandles (60 lux).

4185.07 CONTROL CABINETS.

A. Furnish cabinets meeting the following requirements:

1. Type 304 stainless steel minimum 14 gage, or 0.125 inch (3.17 mm) aluminum, weatherproof NEMA Type 3R enclosures.

2. Full-sized door gasket.

3. Drip shield.

4. Top-mounted 3 prong photo-electric control socket.

5. Insect-proof breather.

6. Labyrinth type breather drain.

7. An internal back panel for component mounting.

8. Door with a single external padlock handle to operate a door latch. Latch mechanism to include no less than two approved roller latches.

9. Cabinet size adequate to provide access to all components for maintenance and replacement without disturbing other components or wiring.

10. Unless detailed otherwise in the contract documents, space provided for no less than one line (main) circuit breaker and four branch circuit breakers, one contactor, two surge suppressors, and a test switch.

11. Each pole-mounted cabinet equipped with pole mounting brackets, conduit, and hubs.

12. Each pad-mounted cabinet equipped with a removable bottom plate and an internal flange with hold-down clamps for attachment to a concrete base.

B. The contract documents will show the location, type, and other details of control cabinets.

C. Include the following appurtenances:

1. A line circuit breaker that may also serve as main disconnect means.

2. A photo-electric control.

3. Two surge suppressors.

4. A maintained contact, three position switch (with all functions labeled as shown in the contract documents) to provide a means of overriding automatic operation of the lighting system for testing purposes.

D. The contract documents will show the quantity and ratings of circuit breakers and other details of individual installations.

4185.08 HANDHOLES.

A. Precast Handholes.

1. Ensure the body of the precast handhole meets requirements for Class 1500D (75D) concrete pipe.

2. For the handhole cover, furnish a heavy duty cast iron frame and lid that sits inside the pipe end.

3. The contract documents will show handhole locations and other details.

B. Preformed Handholes.
Furnish handholes meeting the following requirements.

1. Constructed to the dimensions shown in the contract documents.

2. Constructed with mortar consisting of sand, gravel, and polyester resin reinforced by a woven glass fiber mat or of resin mortar and fiberglass.

3. Constructed to withstand a load of 20,000 pounds (9,000 kg).

4. Each handhole equipped with a bolt-down cover of the same material.

5. Lock down bolts of stainless steel with penta head.

4185.09 JUNCTION BOXES.

A. Preformed Junction Boxes.
Furnish boxes meeting the following requirements:

1. Constructed to the dimensions shown in the contract documents.

2. Constructed with mortar consisting of sand, gravel, and polyester resin reinforced by a woven glass fiber mat or of resin mortar and fiberglass.

3. Each junction box equipped with a bolt-down cover of the same material.

4. Stainless steel screws.

B. Cast Iron Junction Boxes.

1. Furnish boxes meeting the following requirements:

a. Cast iron boxes and covers galvanized according to ASTM A 153.
b. Boxes classified by the manufacturer as meeting the requirements for NEMA 4, Watertight.
c. UL approved boxes.
d. Apply applicable provisions of Article 370 of the current NEC.
e. Raised buttons (blind drilled, tapped, and fitted with screws as specified) of the specified size and location cast into the surface of the box floor and cover for grounding purposes.
f. Neoprene gaskets used.

2. The contract documents will show locations and other details.

4185.10 CONDUIT AND FITTINGS.

A. General.

1. The type, size, and location of all conduit will be indicated in the contract documents. Do not substitute types of conduit material.

2. Furnish weatherproof fittings of identical or compatible material to the conduit. Use standard factory elbows, couplings, and other fittings when possible.

3. Limit the inside radius of all field bends to no less than 6 times the internal diameter of the conduit. Bend so as not to kink, flatten, or otherwise significantly reduce the effective cross sectional area of the conduit.

B. Rigid Steel Conduit.

Furnish conduit meeting the following requirements:

1. Compliance with ANSI C80.1.

2. Identified with the manufacturer's name and trade mark and the words "rigid steel conduit" or "rigid metal conduit."

3. Weatherproof expansion fittings with galvanized, malleable iron, fixed and expansion heads jointed by rigid steel conduit sleeves. As an option, the fixed head may be integral with the sleeve, forming a one piece body of galvanized malleable iron.

C. Rigid Aluminum Conduit.

Furnish conduit meeting the requirements of ANSI C80.5.

D. Plastic Conduit and Fittings.

Furnish conduit and fittings meeting the following requirements:

1. PVC Schedule 40 and 80 plastic conduit and fittings meeting the requirements of NEMA TC-2, TC-3, and UL 651 for Schedule 40 heavy wall type.

2. Solvent welded, socket type fittings, except where indicated otherwise in the contract documents.

3. Threaded adaptors for jointing plastic conduit to rigid metal ducts.

4. Compliance with applicable requirements of NEMA TC-3 and UL 514 and the manufacturer's recommendation for all materials and methods for attaching and making fittings. Obtain the Engineer's approval.

4185.11 CONNECTOR ASSEMBLIES.

Details of connector assemblies will be shown in the contract documents. Furnish connectors with complete instructions, assembly devices, and silicone lubricant for all mating surfaces. Meet the following requirements for the type specified:

A. Type Y-1 Connector.

1. Furnish fused Y-1, quick disconnecting type tap connectors consisting of:

a. Two spring loaded, fully annealed copper contacts of 90% minimum conductivity suitable for gripping a 13/32 inch by 1 1/2 inch (10.3 mm by 38 mm) midget fuse, two terminal lugs, a bolt, and a locknut.

- One contact adapted to be crimped to the cable and retained securely within a rubber load side tap housing.
- The second contact preassembled and retained in a rubber Y-insert-body with provision for connecting the terminal lugs securely in place.

b. A permanently marked, load side tap housing, a Y-insert-body, and a Y-housing, each made of water resistant synthetic rubber. Ensure the load side housing:

- Provides a section to form a watertight seal around the cable,
- Has an interior arrangement to suitably receive and retain one fuse contact,
- Is constructed to retain the fuse when disconnected, and
- Has a section to provide a watertight seal between itself and the Y-insert-body at the point of disconnection.

2. Ensure the Y-insert-body retains the second fuse contact and provides a watertight seal for the load side housing at the point of disassembly. Ensure the Y-housing provides sections to form a watertight seal around two cables and for Y-insert-body. When both through legs of the connection are not to be used, furnish an insulated plug with the same diameter as the cable to maintain an equivalent watertight seal.

B. Type Y-2 Connector.

1. Furnish unfused Y-2, quick disconnecting type tap connectors consisting of:

a. A copper pin to be crimped to the cable and a spring loaded copper receptacle, both of 90% minimum conductivity, two terminal lugs, a bolt, and a locknut. The receptacle and the crimping portion of the

pin are to be fully annealed. The pin is to be adapted to be retained securely within a rubber load side tap housing. The receptacle is to be preassembled and retained on a rubber Y-insert-body with provision for bolting the terminal lugs securely in place.

b. A permanently marked load side tap housing, a Y-insert-body, a Y-housing, each made of water resistant synthetic rubber. Ensure the load side housing:

- Provides a section to form a watertight seal around the cable,
- Has an interior arrangement to suitably receive and retain the pin, and
- Has a section to provide a watertight seal between itself and the Y-insert-body at the point of disconnection.

2. Ensure the Y-insert-body retains the receptacle and provides a watertight seal for the load side housing at the point of disconnection and a watertight seal for the Y-housing at the point of disassembly. Ensure the Y-housing provides sections to form a watertight seal around two cables and for the Y-insert-body. When both through-legs of the connection are not to be used, provide an insulated plug with the same diameter as the cable to maintain an equivalent watertight seal.

C. Type Y-3 Connector.

Furnish semi-permanent Y-3 tap connectors consisting of:

1. Three terminal lugs (each provided with a mounting hole by which all lugs are bolted securely together), a bolt, and a locknut.

2. A tap housing and a Y-housing, each made of water resistant synthetic rubber. Ensure the tap housing: 1) provides a section to form a watertight seal around the cable; and 2) includes a section to provide a watertight seal between itself and the Y-housing at the point of disassembly. Ensure the Y-housing provides sections to form a watertight seal around two cables and for the tap housing. When all legs of the connection are not to be used, provide an insulated plug with the same diameter as the cable to maintain an equivalent watertight seal.

D. Type L-1 Connector.

Furnish fused L-1, quick disconnecting in-line connectors consisting of:

1. Two spring loaded, fully annealed copper contacts of 90% minimum conductivity suitable for gripping a 13/32 inch by 1 1/2 inch (10.3 mm by 38 mm) midget fuse. Both contacts are to be adapted to be crimped to the cable and retained securely within rubber housings.

2. A permanently marked, load side and line side housing, each made of water resistant, synthetic rubber. Ensure each housing:

- Provides a section to form a watertight seal around the cable,
- Has an interior arrangement to suitably receive and retain the fuse contact, and

- Has a section to provide a watertight seal between the two housings at the point of disconnection.

E. Type L-2 Connector.
Furnish L-2, unfused, quick disconnecting in-line connectors consisting of:

1. A copper pin and a spring loaded copper receptacle, both fully annealed and of 90% minimum conductivity, to be crimped to the cable. Both the pin and receptacle are to be adapted to be retained securely in rubber housings.

2. A permanently marked, load side and line side housing, each made of water resistant, synthetic rubber. Ensure each housing:
- Provides a section to form a watertight seal around the cable,
- Has an interior arrangement to suitably receive and retain the pin or receptacle, and
- Has a section to provide a watertight seal between the two housings at the point of disconnection.

4185.12 WIRE AND CABLE.

Wire and cable construction types, conductor sizes, and working voltage ratings will be specified in the contract documents.

A. Single Conductor Wire and Cable.
Furnish wire and cable meeting the following requirements:

1. Insulation.
- Rated for 600 volts.
- Thermosetting, cross linked polyethylene meeting the requirements of ICEA S-66-524 (NEMA WC-7).
- Thickness meeting the requirements of Table No. 3-1 Column "A".
- Unless specified otherwise in the contract documents, comply with applicable requirements of UL Standard No. 44.
- UL listed for use at conductor temperatures of 167°F (75°C) or higher in wet or dry locations.

2. Wire and Cable.
- Bear required UL labeling repeated throughout their length.
- UL Listed Type USE-2 per UL Standard 854 and Type RHH or RHW-2 per UL Standard 44.

3. Conductors.
- Annealed copper meeting the requirements of ASTM B 3.
- Sizes smaller than No. 8 AWG, may be solid or stranded.
- Sizes No. 8 AWG and larger are to be stranded and are to meet the requirements of ASTM B 8, Class B.

B. Aerial Power Cable.
Furnish cable consisting of an assembly of individually insulated conductors with a messenger cable. The insulated conductors may be either laid about

the messenger or secured to the messenger with a flat binding strip. Meet the following requirements:

1. **Conductors.**
   Stranded aluminum or steel reinforced aluminum (ACSR).

2. **Messenger.**
   Steel or ACSR. If using steel, use steel protected with copper, aluminum, or zinc coating.

3. **Binding strip.**
   Copper, bronze, or steel. If using steel, use steel protected with copper, aluminum, or zinc coating.

4. **Insulation.**
   Meet the requirements of Article 4185.12, A.

C. Thermoplastic Wire and Cable.
Use only where specified in the contract documents. Use conductors that meet the requirements of UL Standard No. 83 and are UL listed for Type THW or Type THHN (THWN).

D. Control Cable.

1. Use only where specified in the contract documents. Furnish cable consisting of either:
   - An assembly of conductors individually covered with polyethylene insulation, or
   - Polyethylene insulation with polyvinyl chloride jacket together with suitable fillers covered overall with polyester tape and a polyvinyl chloride jacket.

2. Ensure the cable complies with requirements for Type B Control Cable as described in ICEA S-61-402 (NEMA WC-5).

E. Flexible Cord.
Use cord that is UL listed for Type SO and complies with applicable requirements of UL Standard No. 62 (Table 3.14).

F. Bare Copper Ground Wire.

1. Use soft drawn wire meeting the requirements of ASTM B 3, or medium hard drawn wire meeting requirements of ASTM B 2.

2. For direct burial installation, use solid wire for sizes smaller than No. 4 AWG and stranded wire for sizes of No. 4 AWG and larger. For installation in raceways or ducts, use solid wire for sizes smaller than No. 8 AWG and stranded wire for sizes of No. 8 AWG and larger. Ensure stranding meets the requirements of ASTM B 8, Class B.

4185.13 SURGE SUPPRESSOR.
Furnish suppressors meeting the following requirements:

A. Metal oxide varistor type suppressor, suitable for 120/240 volt single-phase line voltage, with a UL1449 Category B3 voltage rating of 500 volts (line-neutral).

B. Single-pulse (8/20 microsecond) maximum surge current rating of 50,000 amperes.

C. NEMA 1 enclosure included that is suitable for mounting inside a lighting control cabinet.

D. Each line fused and a visual indication light installed to show power and suppression status.

4185.14 TEST SWITCH.
Furnish switches meeting the following requirements:

A. Heavy duty maintained contact, three position switch.

B. 600V, 10 amperes, double break type contact.

4185.15 CIRCUIT BREAKER.
Furnish breakers meeting the following requirements:

A. Rated for 240 volts and 480 volts, with minimum interrupting ratings of 25,000 amperes, symmetrical, at 240 volts, and 18,000 amperes, symmetrical, at 480 volts.

B. Thermal magnetic trip mechanism with a trip-free toggle operator.

C. Frame and trip ratings as shown in the contract documents.

Section 4186. Signing Materials

4186.01 DESCRIPTION.

A. Ensure the following:

1. Only new and unused materials are used.

2. Materials are approved before incorporating into the work.

3. Samples taken as directed by the Engineer. As a convenience to the Contractor, samples may be taken at the point of production when arrangements are made with the Office of Materials.

4. Sufficient time is allowed for sampling and testing.

5. Access to the producing plant is available for the purpose of sampling.

B. In lieu of sampling and testing, the Engineer may require certifications of any material or tests specified for the material.

4186.02 SIGN PANELS.

Fabricate sign panels from sheet aluminum, galvanized steel, or when specified, plywood or flexible roll-up material.

A. Sheet Aluminum.

1. Meet the following requirements:
- **a.** Aluminum for Type A signs complies with ASTM B 209, Alloy 5052-H38.
- **b.** If the aluminum thickness is not specified in the contract documents, then the thickness is 0.080 inches (2 mm) for signs with the longest side of 36 inches (900 mm) or less, and 0.125 inches (3 mm) for signs with the longest side greater than 36 inches (900 mm). These thicknesses are subject to similar tolerances as specified in ASTM B 209 for a sheet having a width equal to the greatest dimension of the sign.

2. Before application of sheeting, degrease and etch the aluminum surface according to the sheeting manufacturer's recommendations. A conversion coating may be applied to the aluminum according to the sheeting manufacturer's recommendations. Remove all white rust present on the aluminum prior to application of the sheeting according to the sheeting manufacturer's recommendations.

B. Galvanized Steel.

Meet the following requirements:

1. Galvanized steel for Type A signs complies with ASTM A 653/A 653M, light commercial coating.

2. Use phosphatized galvanizing.

3. For Type A signs with the longest side 30 inches (750 mm) or less, sheet thickness is 0.0785 inch (2 mm) with a minus tolerance of 20%. For all other Type A signs, sheet thickness is 0.1233 inch (3.123 mm) with a minus tolerance of 20%.

C. Plywood.

Furnish softwood plywood complying with the latest edition of the National Institute of Standards and Technology Voluntary Product Standard PS 1 for Structural Plywood. Use plywood that is 1/2 inch (12.5 mm) thick and is either medium density overlay (MDO) or high density overlay (HDO). The panel grades are:

1. Exterior HDO-Industrial B-B.

a. Overlaid both sides with a two step lay up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. No marks, blemishes, or damage of any kind on the overlay.

b. Panel faced veneers of a certified hardwood, tested and certified according to Section 5.8.7 of PS 1 by an International Accreditation Service (IAS) recognized inspection/testing agency or Douglas fir from Group 1 classification of species. Inner plies of Douglas fir. Grade C plugged or better.

2. Exterior MDO-General B-B.

a. Overlaid both sides with a two step lay up, sanded prior to overlay to reduce wood grain and repair show-through, and the overlay suitable for sign manufacture and compatible with the reflective sheeting adhesive. No marks, blemishes, or damage of any kind on the overlay.

b. Panel faced veneers from a Group 1 classification of species or equivalent, tested and certified according to Section 5.8.7 of PS 1 by an IAS recognized inspection/testing agency. Inner plies from either Group 1 or Group 2 classification of species. Grade C or better.

D. Structural Panels Used in Type B Signs.

Meet the following requirements:

1. Extruded aluminum highway sign panels are in 6 inch and 12 inch (150 mm and 300 mm) widths.

2. Each section is manufactured according to the details and dimensions shown in the contract documents.

3. Aluminum extrusions comply with ASTM B 221, Alloy 6063-T6.

E. Edge Trim Molding.

Meet the following requirements:

1. For Type B signs, edge trim molding is manufactured of aluminum, the same as used in the sign, according to details and dimensions shown in the contract documents.

2. Aluminum complies with ASTM B 221, Alloy 6063-T6.

3. Aluminum molding has a mill finish.

F. Flexible Roll-up Sign Faces.

Meet the requirements of ASTM D 4956 for Type VI sheeting with Class 5 backing, except as modified in this specification.

4186.03 RETRO REFLECTIVE SHEETING.

A. General.

1. Meet the requirements of ASTM D 4956, including supplementary requirements, except when modified in the contract documents or this specification. Comply with Materials I.M. 486.03 for inspection and acceptance of reflective sheeting.

2. Retro Reflective sheeting is to be uniform in color and reflectivity. In a single sign, or traffic control device, variations in color or reflectivity noticeable at a distance of 50 feet (15 m) or more, under daytime or nighttime lighting conditions, is cause for rejection of the sign.

3. Retro Reflective sheeting is classified as shown in Table 4186.03-1.

Table 4186.03-1: Retro Reflective Sheeting Classification

Type I	A medium retroreflective sheeting referred to as "engineering grade". This sheeting is typically enclosed lens glass bead material.
Type II	A medium high intensity retroreflective sheeting sometimes referred to as "super engineering grade". This sheeting is typically enclosed lens glass bead material.
Type III	A high intensity retroreflective sheeting. This sheeting is typically an encapsulated glass bead retroreflective material.
Type IV	A high intensity retroreflective sheeting. This sheeting is typically an unmetalized microprismatic retroreflective element material.
Type VI (Iowa)	A flexible, very high intensity retroreflective sheeting for use on roll-up signs. This sheeting is typically a microprismatic retroreflective material.
Type VII (Iowa)	A prismatic, very high intensity retroreflective sheeting. This sheeting is typically a microprismatic retroreflective material.

4. For Type VI (Iowa) and Type VII (Iowa) sheeting, meet the requirements of Materials I.M. 486.03.

B. Utilization of Reflective Sheeting.

Use Type III or IV sheeting for all signs with white background, unless specified otherwise.

1. Permanent Signs and Devices.

a. Meet the following requirements:

1) Type III or IV sheeting is used for all signs with yellow, green, red, blue or brown background, unless otherwise specified.

2) The legend on white and yellow signs is fabricated using black nonreflective sheeting that is applied directly, or by silk screening with black opaque ink.

3) The legend on green signs is fabricated using white Type III or IV sheeting that is applied directly.

4) The legend on red signs is fabricated using transparent red ink that is reverse silk screened on white Type III or IV sheeting, or is fabricated using white Type III or IV sheeting that is applied directly on a red Type III or IV sheeting background.

5) The legend on blue and brown signs is fabricated using transparent ink that is reverse silk screened on white Type III or IV sheeting, or white Type III or IV sheeting that is applied directly.

b. Use Type III or IV sheeting for permanent road closure barricades.

2. Work Zone Signs and Devices.

a. Interstate and Primary Highways.

Meet the following requirements:

1) Type VII (Iowa) sheeting is used for all rigid signs with orange backgrounds. The legend is fabricated using black nonreflective sheeting that is applied directly or by silk screening with black opaque ink.

2) Type VI (Iowa) sheeting is used for all flexible roll-up signs with orange backgrounds. The legend is fabricated by silk screening with black opaque ink.

3) Type VII (Iowa) sheeting is used for STOP/SLOW paddles. The black legend is fabricated using black nonreflective sheeting that is applied directly or by silk screening with black opaque ink on orange Type VII (Iowa) sheeting. The white legend is fabricated using transparent red ink that is reverse silk screened on white Type VII (Iowa) sheeting.

4) Type VII (Iowa) non-fluorescent sheeting is used for barricades, vertical panels, and all other work zone traffic control devices that use premanufactured barricade sheeting.

5) Type VII (Iowa) fluorescent orange and Type III or IV white sheeting is used for drums, 42 inch (1050 mm) channelizers, tubular markers, and all other work zone traffic control devices that use horizontal sheeting.

6) For reboundable traffic control devices, Type III or IV or Type VII (Iowa) sheeting designed for this application is used.

b. Other Highways.

1) Meet the following requirements:

a) Type III or IV sheeting is used for all rigid post mounted signs with orange backgrounds. Unless specified otherwise, Type I or II sheeting is used for all skid mounted signs with orange backgrounds. The legend is fabricated using black nonreflective sheeting that is applied directly or by silk screening with black opaque ink.

b) Type I or II sheeting is used for STOP/SLOW paddles. The black legend is fabricated using black nonreflective sheeting that is applied directly or by silk screening with black opaque ink. The white legend is fabricated using transparent red ink that is reverse silk screened on white retroreflective sheeting.

c) Type III or IV sheeting is used for barricades and vertical panels.

d) Type III or IV sheeting designed for reboundable devices is used for reboundable drums, tubular markers, and other reboundable markers.

2) At the Contractor's option, work zone signs and devices using retroreflective sheeting according to Article 4186.03, B, 2, a, above may be used on all other highways.

C. Durability of Reflective Sheeting.

Subject reflective sheeting to the following tests, and at the end of the testing period, ensure it meets the requirements for artificial weathering specified in ASTM D 4956 Section 7.4 and 7.5 and shows no evidence of mildewing or similar disfigurement:

1. **White, yellow, green, red, blue and brown reflective sheeting used for permanent signing and traffic control devices:** 3 year outdoor Iowa exposure at 45 degrees facing south.

2. **Orange and White reflective sheeting used for temporary traffic control signing and traffic control devices:** 1 year outdoor Iowa exposure at 45 degrees facing south.

4186.04 NONREFLECTIVE SHEETING.

Meet the following requirements:

- Adhesive and physical properties are the same as for reflective sheeting found in ASTM D 4956.
- Color properties are the same as for Type III reflective sheeting found in ASTM D 4956.

4186.05 INKS, CLEARS, AND THINNERS.

Use according to the sheeting manufacturer’s recommendations.

4186.06 SIGN FABRICATION.

A. General.

Meet the following requirements:

1. All sign blanks and panels are fabricated in a uniform and high quality manner.

2. All fabrication, including shearing, cutting, and hole punching or drilling, is completed before degreasing metal surface and applying reflective sheeting.

3. Sign blanks and panels are to size and shape and are free of buckles, warp, dents, cockles, burrs, and defects resulting from fabrication.

4. Type B signs are assembled using a maximum number of 12 inch (300 mm) wide structural panels, corresponding to the dimensions shown in the contract documents to keep the number of sign joints to a minimum.

If a 6 inch (150 mm) panel is required, it is used in the top panel of the completed sign.

5. Finished signs, both Type A and B, are smooth and flat and are free from blisters, wrinkles, cracks, tears, and delaminations

6. All letters are clean cut and sharp.

B. Application of Sheeting.

1. Meet the following requirements:
- **a.** Sheeting, reflective and nonreflective, is applied mechanically with the equipment and in a manner specified by the sheeting manufacturer or by a method which will produce an equivalent result.
- **b.** On extruded aluminum or formed steel sign panels, the sheeting is lapped over the longitudinal edges of each panel a minimum distance of 1/4 inch (6 mm).
- **c.** Sheeting is bonded to the panels using an accessory tool the sheeting manufacturer recommends or by a tool which will produce an equal result.

2. Whenever a sign face consists of two or more pieces or panels of reflective sheeting, they must be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and night. Signs with background color of adjacent sheets or panels not properly matched will be rejected.

3. At splices, overlap pressure sensitive adhesive sheeting no less than 3/16 inch (5 mm). Sheeting with heat activated adhesive may be spliced with overlap no less than 3/16 inch (5 mm), or butted with a gap not to exceed 1/32 inch (1 mm). Use only butt splices on screen processed signs with transparent color.

C. Letters, Numerals, Symbols, and Borders.
Meet the following requirements:

1. Letters, numerals, symbols, and borders comply with the contract documents.

2. The border strip on the left and right edges of each sign is set in far enough from the edge to accommodate installation of the required trim molding without reducing the border width.

D. Other Details.
Meet the following requirements:

1. All gaps on the edges of plywood signs are filled with a waterproof putty.

2. Signs are slip sheeted and packed to ensure they are not exposed to moisture and they arrive at their destination in an undamaged condition.

4186.07 SIGN IDENTIFICATION.

A. Mark the back of all finished signs with an identification sticker at the bottom edge of the sign that is visible when the sign is erected. Use a piece of nonreflective sheeting approximately 3 inches by 4 inches (75 mm by 100 mm) with the following information: the contractor's name, type of sheeting, and name of sheeting manufacturer. For Type A signs, include the erection date on the sticker.

B. For Type B signs, in addition to the above sticker, place the following information on the back side in 1 inch (25 mm) letters: the sign number, and the erection date. The 1 inch (25 mm) letters may be painted or stenciled on with black exterior grade paint, or printed on a sticker.

4186.08 FINISHED SIGN INSPECTION.

Visually inspect finished signs upon receipt for correct message, and conformity to the contract documents. Replace non-complying signs at no additional cost to the Contracting Authority.

4186.09 FASTENING ACCESSORIES.

Ensure the dimensions and tolerances for all bolts, nuts, and washers comply with ANSI standards for the size required, unless stated otherwise. Ensure the threads of all fastening accessories meet the requirements of ANSI B1.1, National Coarse Thread Series. Meet the following requirements:

A. Type A Signs.

1. Bolts.
The length required depends upon the type of post supplied by the Contractor (wood, steel, or aluminum). Use the minor thread diameter in determining stress area.
- **a.** Use bolts 3/8 inch (9.5 mm) in diameter with a hexagonal head.
- **b.** Thread fit is to conform to ANSI Class 2A.

2. Nuts.
- **a.** Use finished, finished thick, regular, or heavy hexagonal, self locking nuts for 3/8 inch (9.5 mm) bolts, but use nuts all of the same type.
- **b.** Axial tensile strength at room temperature is to be no less than 4,730 pounds (21 kN).

3. Self Locking Nuts.
- **a.** Use nuts approved by the Engineer.
- **b.** Thread fit is to be as recommended by the manufacturer.

4. Washers.
- **a.** Use washers made of a quality of material approved by the Engineer.
- **b.** Washers are to be 3/8 inch (9.5 mm) I.D. by 1 3/8 inch (35mm) O.D. by 0.125 inch (3mm).
- **c.** A thickness tolerance of ± 0.006 inch (0.15 mm) is allowed.

d. Neoprene washers are to be 3/8 inch (9.5mm) I.D. by 15/16 inch (24mm) O.D. by 1/8 inch (3 mm) thickness. (Neoprene washers are required when treated wood posts are used). Durometer hardness is to be 60 to 70, with a tolerance of ± 5.

5. Other Details.

a. Other details, including post clips on I-beam posts, etc., are shown in the contract documents.

b. Hardware may be furnished in stainless steel or galvanized steel as approved by the Engineer. Ensure galvanizing meets requirements of ASTM F 2329, or ASTM B 633, Class Fe/Zn 25, Type II or Type IV.

B. Type B Signs.

Ensure the fittings described in the paragraphs below, when combined with the aluminum sections and posts, form a complete, assembled sign unit that will meet the specified strength requirements. Though aluminum hardware is specified, equivalent hardware may be furnished in stainless steel or galvanized steel as approved by the Department. Galvanizing is to meet the requirements of ASTM F 2329, or ASTM B 633, Fe/Zn 25.

1. Bolts.

Use the minor thread diameter in determining stress area.

a. Use post clip bolts and panel bolts made from aluminum wire or rod meeting the requirements of ASTM B 211, Alloy 2024-T4.

- **Post clip bolts:** 3/8 inch (9.5 mm) in diameter and 1 3/4 inches (45 mm) in length, square or rectangular head, manufactured according to the dimensions and details shown in the contract documents.
- **Panel bolts:** 3/8 inch (9.5 mm) in diameter and 3/4 inch (19mm) in length with hexagonal head.

b. Thread fit is to conform with ANSI, Class 2A.

2. Nuts.

For Type B signs, use nuts manufactured from any aluminum alloy listed in ASTM B 211 or from stainless steel and meeting the following requirements:

a. Post clip nuts:

- Finished, finished thick, regular, or heavy hexagonal, self locking nuts for 3/8 inch (9.5 mm) bolts, but all nuts to be of the same type.
- Able to withstand a proof load, at room temperature, of 4,730 pounds (21 kN).

b. Self locking nuts: comply with Article 4186.09, A, 3.

c. Panel bolt nuts:

- Finished hexagonal nuts for 3/8 inch (9.5 mm) bolts. Able to stand a proof load of 4,200 pounds (18.7 kN).
- Thread fit is to conform with ANSI, Class 2B.

3. Washers.
- **a.** Use washers made of a quality of material approved by the Engineer.
- **b.** Post clip washers and panel bolt washers are to be flat 7/16 inch (11 mm) I.D. by 1 inch (25 mm) O.D. by 0.078 inch (2 mm).
- **c.** A thickness tolerance of ± 0.006 inch (0.15 mm) is allowed.

4. Post Clips.
- **a.** Use aluminum castings manufactured according to the contract documents.
- **b.** Ensure clips are able to withstand the load requirements of the bolt specified.

5. Edge Trim Molding.
Meet the following requirements:
- **a.** Molding is attached to the signs by means of self tapping, 300 series, stainless steel, machine screws, Size 8-32.
- **b.** Pan head, binding head, or truss head screen is used.
- **c.** A screw is installed 1/2 inch (13 mm) from the end of each section of molding. Intermediate screws are installed no more than 12 inches (300 mm) apart.

C. Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.

1. Fasten delineators to the post with a blind, pull through, aluminum rivet and washer. Use a 3/16 inch (5 mm) diameter rivet with a suitable grip range. Use washers:
- Made of a quality of material approved by the Engineer.
- With dimensions of 0.193 inch (4.9 mm) I.D. by 3/4 inch (19 mm) O.D. by 0.091 inch (2.3 mm) with a thickness tolerance of ± 0.006 inch (0.15 mm).

2. Fasten milepost markers and 6 inch by 6 inch (150 mm by 150 mm) route markers to the post as shown in the contract documents.

4186.10 SIGN POSTS.

Furnish sign posts of the following types for the sign or signs specified:

A. Wood Posts for Type A or B Signs.
Furnish the size and type shown in the contract documents. Ensure posts meet the requirements of Section 4164.

B. Steel Breakaway Posts for Type A and B Signs.

1. Furnish the size and type shown in the contract documents. Ensure the following:
- **a.** The steel meets the requirements of ASTM A 36/A 36M, unless otherwise specified.
- **b.** Fabrication is according to Section 2408.
- **c.** Posts are galvanized after fabrication, except as noted.

d. Galvanization is by the hot dip process, complying with ASTM A 123, Grade 85, and posts are cleaned and pickled before such application.

2. Use high strength bolts, nuts, and washers meeting requirements of Article 4153.06, B as fasteners for breakaway sign posts.

3. Furnish washers meeting the requirements of ANSI B18.22.1 for the bolts specified. Ensure washers are fabricated of steel capable of withstanding the specified minimum load of the bolt for which they will be used. The Engineer may approve washers with dimensions other than those specified.

4. Use heavy hexagonal, semi-finished nuts and jam nuts on the anchor bolts. Furnish nuts meeting the requirements of ANSI B18.2.2. Nuts may be tapped oversize only enough to produce finger free fit. Regular hexagonal jam nuts may be used if the Engineer approves.

5. Furnish bolts (including the entire length of the anchor bolts), nuts, and washers that are galvanized according to ASTM F 2329 or B 695 Class 50, Type I coating.

6. Ensure the following:
- **a.** Holes in the fuse plates and splice plates are fabricated by drilling.
- **b.** Notches in the base plates and fuse plates are provided so that no metal projects beyond any face of the plate and the edges of the notches are smooth and true.
- **c.** All bearing surfaces of base plate and fuse plate assembly are smooth and free of beads or runs.

7. For the fuse plate assembly, cut the post by sawing or flame cutting. The cut may be made before or after galvanizing of the post. If the cut is made after galvanizing, repair the damaged area by painting or smoldering.

8. Before fabrication, submit shop drawings for the steel breakaway sign posts according to Article 1105.03 for review.

C. Posts for Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.
Furnish the type and length designated in the contract documents. Use Type 1 posts for permanent roadside delineators. Use Type 1, Type 2, or Type 3 posts for temporary delineators.

1. Type 1 Posts.
Posts may be furnished pointed for driving. Meet the following requirements:
- **a.** Steel posts are galvanized after fabrication. The coating is applied by the hot dip process at a rate of not less than 2.0 ounces per square foot (610 g/m^2) of actual surface as provided in ASTM A 123.

b. Nominal weight of the posts is 2.00 pounds (3 kg) or more per foot (meter), before punching, although a variation of 3% under the specified weight (mass) is permitted.
c. Posts are U-shaped with flat flanges at the front or open end of the "U". The faces of the flanges are flat and in the same plane.
d. The back of the posts are flat or ribbed or otherwise provide for suitable sign or delineator bearing to a width of at least 1 1/8 inches (28 mm) parallel to the front flanges.
e. The front of the post has a width of 3 inches to 3 1/2 inches (75 mm to 90 mm).
f. The overall depth of the section is 1 13/32 inches to 1 17/32 inches (35 mm to 40 mm).
g. The cross section of the posts is symmetrical about the center axis perpendicular to the front and back, and the thickness of metal is reasonably uniform. The Engineer may allow minor deviations.
h. Posts are punched on center line with holes 7/16 inch (11 mm) in diameter on 1 inch (25 mm) centers. Posts are punched the entire length of the post. The top hole is 1 inch (25 mm) from the top of the post. Spacing and alignment of holes is within 1/16 inch (2 mm) of correct center line and distance. Punching is done so that no cracks radiate from the holes.

2. Type 2 Posts.
Meet the following requirements:
a. Steel posts galvanized after fabrication. The coating is applied by the hot dip process at a rate of not less than 1.0 ounce per square foot (305 g/m^2) of actual surface as provided in ASTM A 123.
b. The nominal weight of the posts is 1.12 pounds (1.67 kg) or more per foot (meter), before punching, although a variation of 3% under the specified weight (mass) will be permitted.
c. Posts are U-shaped with flat flanges at the front or open end of the "U". The faces of the flanges are flat and in the same plane.
d. The back of the posts are flat or ribbed or otherwise provide for suitable sign or delineator bearing to a width of at least 11/16 inch (18 mm) parallel to the front flanges.
e. The front of the post has a minimum width of 2 inches (50 mm).
f. The overall depth of the section is at a minimum of 7/8 inch (22 mm).
g. The cross section of the posts is symmetrical about the center axis perpendicular to the front and back, and the thickness of metal is reasonably uniform. The Engineer may allow minor deviations.
h. Posts are punched according to Article 4186.10, C, 1, h.

3. Type 3 Posts.
Meet requirements of Article 4186.10, C, 2, except posts may be painted in lieu of galvanizing. If painted, ensure they are painted with a prime coat and with a final coat of aluminum or green paint. Ensure posts are thoroughly dry before being bundled for shipment.

4186.11 DELINEATORS.

A. Furnish delineators meeting the following requirements:

1. Reflectors that are circular, hermetically sealed, and prismatic with a sealed optical system.

2. Permanent roadside delineators are to include an aluminum housing of 0.020 inch (0.508 mm), ASTM B 209, Alloy 5052.

3. Temporary delineators are to include either an aluminum or a plastic housing.

4. Delineators with aluminum housing are to have an aluminum grommet expanded within the mounting hole.

5. Delineators with plastic housing are to have a molded one piece reinforced plastic sleeve extending the thickness of the delineator.

6. A 3/16 inch (5 mm) diameter central mounting hole capable of withstanding the pressure of fastening without cracking or damaging the reflective surface is required.

7. A clear and transparent face of methyl methacrylate compound meeting requirements of ASTM D 788, Grade B, with a reflective lens area of approximately 7 square inches (4500 mm^2), and a backing fused to the lens under heat and pressure around the entire perimeter of the lens and the central mounting hole. Backing is to be aluminum foil or a white, opaque compound of the type specified for the face. The foil backing will be acceptable only when the delineator has an aluminum backing.

8. A colorless or yellow reflector, as specified.

9. A lens consisting of a smooth front surface, free from projections or indentations affecting reflectance other than a central mounting hole and identification, with a rear surface bearing a prismatic configuration so that it will effect a total internal reflection of light. Manufacturer's trademark molded legibly into the face of the lens.

B. Ensure the optical performance of each delineator reflector when tested according to Materials Test Method No. Iowa 905 is equal to or exceeds the minimum values listed in Table 4186.11-1:

Table 4186.11-1: Minimum Optical Performance

Observation Angle Degrees	Entrance Angle Degrees	Specific Intensity Candle Power Per Foot-Candle (Candela Per Lux)	
		White	Yellow
0.1 0.1	0 20	120 (11.0) 50 (4.6)	75 (7.0) 30 (2.8)
Select five test specimens for the specific intensity test. If all five specimens exceed the minimum values, the reflectance will be considered acceptable. If one of the five specimens fails to meet the minimum values, select an additional ten specimens selected for testing. These additional specimens must meet the minimum values. Reject the lot if two or more of the original five specimens, or one or more of the additional ten specimens fail to meet the minimum values.			

C. Test delineator reflectors for proper sealing against dust and water according to Materials Test Method No. Iowa 907, with no more than 2% of the specimens tested showing sealing test failure.

D. Test delineators for durability according to Materials Test Method No. Iowa 906.

E. Ensure the average loss in specific intensity is no greater than 10% of the average of the three specimens prior to the test. Ensure no more than one specimen is below the minimum values specified for unheated specimens.

4186.12 BARRIER MARKERS.

A. Furnish markers meeting the following requirements:

1. Suitably shaped marker body designed for attachment to a flat surface.

2. Reflective surface that presents at least 7 square inches (4500 mm^2) when viewed on a line parallel to the roadway center line.

3. Reflective surface of a flat acrylic plastic wide angle retroreflective lens of methyl methacrylate plastic meeting FSS LP-380C Type 1, Class C that is hermetically sealed or microprism sheeting mounted on a flat thermoplastic or PVC plastic body which is at least 70 mils (1.8 mm) thick.

4. Reflective surface exhibiting a minimum specific reflectance intensity listed in Table 4186.12-1:

Table 4186.12-1: Minimum Specific Reflectance Intensity

Observation Angle Degrees	Entrance Angle Degrees	Specific Intensity Candle Power Per Foot-Candle (Candela Per Lux)	
		White	Yellow
0.1 0.1	0 20	120 (11.0) 50 (4.6)	75 (7.0) 30 (2.8)

B. Approved markers are listed in Materials I.M. 486.08.

Section 4187. Materials for Support Structures

4187.01 GENERAL REQUIREMENTS.

Furnish materials for aluminum alloy or galvanized overhead sign support structures meeting the following requirements:

A. Material for Aluminum Alloy Superstructure.

1. Extruded Tubes.
Apply ASTM B 221/B 221M, Alloy 6061-T6.

2. Aluminum Plate.
Apply ASTM B 209 B/209M, Alloy 6061-T6.

3. Aluminum Casting Components.
- **a.** Apply ASTM B 26/B 26M, Alloy 356.0-T7, for components in which welding is involved.
- **b.** Apply ASTM B 26/B 26M, Alloy B 514.0 Temper F, for handrail pipe fittings.
- **c.** Apply ASTM B 26/B 26M, Alloy 356.0-T7, or Alloy B 443.0 Temper F, to all other aluminum castings.

4. Aluminum Structural Shapes.
Apply ASTM B 308/B 308M, Alloy 6061-T6.

5. Aluminum Catwalk Gratings.
- **a. Longitudinal (Bearing) Elements.**
  Apply ASTM B 221/F 221M, Alloy 6061-T6. Other aluminum alloys will be considered for approval.
- **b. Transverse (Cross) Elements.**
  Apply ASTM B 221/B 221M, Alloy 6063-T5. Other aluminum alloys will be considered for approval.

6. Aluminum Pipe.
Apply ASTM B 241/B 241M, Alloy 6063-T5.

7. Aluminum Weld Wire for Welding Electrodes.
Use AWS A5.10 electrode ER5356 or ER5556 when welding aluminum alloy 6061.

B. Materials for Galvanized Steel Superstructures.
Use the type and quality specified in the contract documents.

C. Fasteners for Aluminum Alloy and Galvanized Steel Superstructures and Anchor Bolts.

1. Material for Superstructure.

a. Stainless Steel Bolts and Studs.

1) Use the size specified in the contract documents. Meet the requirements of ASTM A 320/A 320M Type 304 or ASTM F 593 Alloy Group 1, 2, or 3 Condition A.

2) Use hexagonal bolt heads complying with ASTM A 320/A 320M. Threads are to comply with ANSI B1.1 for UNC thread series, Class 2A fit. Use the stress area to compute the tensile strength.

b. Stainless Steel Nuts.

1) Use the size specified in the contract documents. Meet the requirements of ASTM F 594 Group 1, 2, or 3. Meet a minimum proof load of 75,000 psi (517 MPa).

2) Use hexagonal nuts and jam nuts complying with the requirements of ASTM F 594. Threads are to comply with UNC thread series, Class 2B fit. In lieu of jam nuts, stainless steel lockwashers may be used.

c. Stainless Steel Washers.

1) Comply with ANSI B18.22.1 for the bolts specified.

2) The Engineer may approve washers with dimensions other than those specified.

d. Stainless Steel U-Bolts.

1) Use the size specified in the contract documents.

2) Meet the requirements of ASTM A 320/A 320M, Type 304 or ASTM F 593 Alloy Group 1, 2, or 3 Condition A.

2. Anchor Bolts, Nuts, and Washers.
Use bolts, nuts, and washers galvanized according to the requirements of ASTM F 2329 or ASTM B 695, Class 50, Type I coating. Meet the following requirements:

a. Anchor Bolts.

1) Use full-length galvanized bolts.

2) Comply with ASTM F 1554, Grade 105 (724 MPa).

3) Use Unified Coarse Thread Series.

4) Use Class 2A tolerance.

5) The end of each anchor bolt intended to project from the concrete is to be color coded in red to identify the grade.

6) Do not weld anchor bolts.

b. Nuts.

1) Comply with ASTM A 563, DH.

2) Use heavy hex.

3) Nuts may be over-tapped according to the allowance requirements of ASTM A 563.

c. Washers.
Comply with ASTM F 436.

D. Material for Substructure.

1. Concrete Footings.
Use Class C concrete meeting applicable requirements of Section 2403.

2. Reinforcing Steel.
Apply Section 4151.

E. Conduit.

1. Substructure.
Use one of the following:
- Rigid steel conduit meeting the requirements of Article 4185.10, B,
- Rigid plastic conduit meeting the requirements of Article 4185.10, D, or
- Bituminized fiber conduit meeting the requirements of FZS W-C-581, Type II.

2. Superstructure.
a. Use rigid steel conduit meeting the requirements of Article 4185.10, B, when the structure is fabricated from steel.
b. Use aluminum alloy conduit when the structure is fabricated from aluminum alloy.

Section 4188. Traffic Control Devices

4188.01 GENERAL REQUIREMENTS.
Meet the following material requirements for the type of traffic control devices specified.

4188.02 DRUMS.
Furnish reboundable drum channelizing devices made for use in traffic control zones. Submit drum type, manufacturer, model, and size to the Materials Engineer for approval. Ensure channelizing devices meet the requirements of the MUTCD, Part 6, Section 6F.67 and the following requirements:

A. Properties.

1. Drum body made from an impact resistant, flexible, and reboundable material that is highway orange meeting Federal Color Standards.

2. Material specifically formulated with ultraviolet stabilizers to provide satisfactory weatherability characteristics and resist fading.
3. Top of the body designed so that small signs can be securely affixed and stay attached upon impact.

B. Visibility.

1. Drums designed to allow a minimum of four horizontal, circumferential bands of 4 inch (100 mm) minimum width retroreflective sheeting.

2. The first (top) and third bands orange, and the second and fourth (bottom) bands white.

3. Nonreflectorized spaces between bands (if present) no wider than 2 inches (50 mm).

4. Retroreflective sheeting for the bands meeting the requirements of Article 4186.03 and recommended by the manufacturer for use on drums.

C. Stability.

1. Drums, when properly ballasted, are not to move, overturn, or separate due to air turbulence created by passing vehicles or moderate winds.

2. The ballast is to be of sand, recycled tire collar if applicable to the drum, or an Engineer approved material that will not present a hazard to motorists, workers, or pedestrians.

3. Apply the limitations specified in MUTCD Section 6F.67 for a drum weighted with ballast.

4. Anti-roll feature that prevents drums from rolling freely if overturned.

D. Acceptance.
Comply with Materials I.M. 488.02 for inspection and acceptance of reboundable traffic control drums.

4188.03 ORANGE MESH SAFETY FENCE.

A. Meet the following material requirements:

1. Height of 48 inches ± 2 inches (1.2 m ± 50 mm) and constructed of orange plastic mesh containing ultraviolet stabilizers to prevent degradation.

2. Remain flexible down to 0°F (-18°C).

3. Minimum tensile strength of 250 pounds per foot (3650 N/m) in the longitudinal direction and 150 pounds per foot (2190 N/m) in the vertical direction.

4. Maximum aperture opening of a nominal 4.5 square inches (290 mm^2).

5. Maximum porosity of 55% for the safety fence surface area.

6. Available in rolls of at least 50 feet (15 m) in length to minimize fence joints for an individual fence location.

B. Securely attach three horizontal nominal 1 inch (25 mm) bands of Type III or IV white retroreflective sheeting meeting the requirements of Article 4186.03 to the safety fence on the side facing traffic. Locate the bands at the mid-height and within 9 inches (225 mm) from the top and bottom of the fence fabric. Comply with Materials I.M. 488.03 for inspection and acceptance of orange mesh safety fence.

4188.04 42 INCH (1050 MM) CHANNELIZERS.

Furnish reboundable channelizing devices made for use in traffic control zones. Ensure channelizing devices meet the requirements of the MUTCD and the following requirements:

A. Properties.

1. Channelizer body is made from an impact resistant, flexible, and reboundable material that is highway orange meeting Federal Color Standards.

2. Material is specifically formulated with ultraviolet stabilizers to provide satisfactory weatherability characteristics and resist fading.

B. Visibility.

1. Minimum of two orange 6 inch (150 mm) bands of Type VII Iowa reflective sheeting and two white 6 inch (150 mm) bands of Type III or IV reflective sheeting.

2. Retroreflective sheeting for the bands meeting the requirements of Article 4186.03 and recommended by the manufacturer for use on drums.

3. The first (top) and third bands orange, and the second and fourth (bottom) bands white.

4. Nonreflective spaces between the bands no wider than 2 inches (50 mm).

C. Stability.

1. The channelizer, when properly ballasted, is not to move, overturn, or separate due to air turbulence created by passing vehicles or moderate winds.

2. The ballast is to be supplied by the manufacturer, is to weigh no less than 30 pounds (13.6 kg), and is not to present a hazard to motorists, workers, or pedestrians.

3. Anti-roll feature that prevents channelizers from rolling freely if overturned.

D. Acceptance.
Comply with Materials I.M. 488.04 for inspection and acceptance of channelizers.

Section 4190. Nonferrous Metals

4190.01 STRUCTURAL ALUMINUM.
Meet requirements specified in the contract documents. Fabricate welds using the metal inert gas (MIG) process, unless the Engineer approves otherwise.

4190.02 ALUMINUM FASTENERS.
Furnish aluminum bolts, nuts, and washers of the size shown in the contract documents. Ensure they meet the following requirements:

A. Bolts.

1. Made from rods meeting requirements of ASTM B 211, Alloy 2024-T4.

2. Unless specified otherwise, hexagonal heads complying with ANSI B18.2.1, except heavy hexagonal heads for bolts for fastening together structural aluminum parts.

3. Threads complying with ANSI B1.1 for Unified Coarse Thread Series, Class 2A fit.

B. Nuts.

1. Manufactured from stock meeting requirements of ASTM B 211, Alloys 6061-T6 or 6262-T9.

2. Unless specified otherwise, hexagonal conforming to ANSI B18.2.2, except heavy hexagonal nuts for fastening together structural aluminum parts.

3. Threads complying with ANSI B1.1 for Unified Coarse Thread Series, Class 2B fit.

4. Self locking nuts of a type and quality approved by the Engineer.

C. Washers.

1. Made from a material of a quality suitable for the intended use and approved by the Engineer.

2. Unless specified otherwise, dimensions meeting the requirements of ASTM F 436.

4190.03 BRONZE BEARING METAL.

A. Furnish bronze bearings of the shape and dimensions shown in the contract documents and meeting the following requirements:

1. Bearing surfaces finished to the degree specified.

2. Bronze metal for plain bearings meeting the requirements of ASTM B 22, Alloy UNS No. C91300 or C91100, or ASTM B 100.

B. When lubricated bronze bearings are specified, furnish bearings meeting the following requirements:

1. Bronze metal meeting the requirements of ASTM B 22, Alloy UNS No. C91300, C91100, or C86300, or ASTM B 100.

2. 24 to 35% of each bearing area to consist of dry lubricating inserts no less than 3/16 inch (5 mm) deep.

3. Dry lubricating inserts that are:
- Arranged in a geometric pattern such that successive rows overlap in the direction of movement and are distributed along the rows so that, in any two adjacent rows, the entire width of the bearing surface will be covered, except 1/4 inch (6 mm) at each margin, and
- Graphite type of lubricant held by a suitable lubricating binder which is firmly compacted into the recess.

C. Comply with the following tolerances:

1. **Sliding surface:** flat within 1/32 inch per foot (3 mm/m) on length or width.

2. **Radial, cylindrical, or spherical sliding surfaces:** not exceeding 0.010 inch (0.254 mm) on the radius.

3. **Convex surfaces:** positive radial tolerance not exceeding 0.010 inch (0.254 mm).

Section 4191. Keyway and Expansion Tubes

4191.01 DESCRIPTION.
Meet the following requirements:

A. Metal Keyway.

1. Coated or uncoated sheets of 24 gage (nominal 0.6 mm thick) iron or steel formed to produce a trapezoidal offset in the face of the concrete of 1 inch (25 mm) plus 1/4 inch (6 mm) or minus 1/8 inch (3 mm).

2. Dimension and installation details as required in the contract documents.

3. Keyway punched along the center line of the face, to receive the bars.

4. Furnished in lengths which are multiples of the bar spacing.

5. Keyways formed on the grade during the paving operation may be of coated or uncoated sheets of 26 gage (nominal 0.4 mm thick) iron or steel.

B. Expansion Tubes to be used as Dowel Caps on Dowel Bars through Expansion Joints.

1. Noncollapsible metal or plastic tubes with one end closed.

2. Formed with a positive bar stop, capable of withstanding a push of more than 20 pounds (90 N).

3. The stop located at least 2 3/4 inches (70 mm) from the open end of the tube.

4. Internal diameter not more than 1/16 inch (2 mm) larger than the nominal diameter of the bar. That part of the tube having this diameter must extend beyond the stop a distance no less than the width of the expansion joint.

Section 4192. Caulking Compound

4192.01 GENERAL REQUIREMENTS.

A. Meet the following requirements:

1. Consistency known as knife grade.

2. Aluminum paste incorporated into the mixture.

3. Recommended by the manufacturer for the use intended.

B. Obtain the Engineer's approval for caulking compound.

Section 4193. Hydrated Lime for Soil Stabilization

4193.01 GENERAL REQUIREMENTS.

Meet the requirements of AASHTO M 216.

Section 4194. Calcium Chloride and Sodium Chloride

4194.01 CALCIUM CHLORIDE.

Meet the requirements of AASHTO M 144. Unless provided otherwise in the contract documents, at the Contractor's option, the calcium chloride may be furnished in either solid or liquid form.

A. Solid Form.
Furnish as a flake, pellet, or other granular calcium chloride containing no less than 77% calcium chloride.

B. Liquid Form.
Furnish as a water solution of calcium chloride containing no less than 32% calcium chloride.

4194.02 SODIUM CHLORIDE FOR DUST PALLIATIVE AND STABILIZATION.

Comply with requirements of AASHTO M 143. Comply with Office of Materials Test Method No. Iowa 801 for sampling and testing.

Section 4195. Bearing Pads

4195.01 LEAD.

Furnish sheet lead for bearing areas meeting the requirements of ASTM B 29.

4195.02 NEOPRENE BEARING PADS.

A. Fabricate the elastomer portion of the pad from new neoprene. Cast pads under heat and pressure. They may be individually molded to the size and shape specified in the contract documents, or they may be cut from pressure cast stock. Ensure cut edges are at least as smooth as ANSI 250 finish. Variations in dimensions shown are not to exceed the values in Table 4195.02-1:

Table 4195.02-1: Maximum Dimension Variations

	Nonlaminated	Laminated
Thickness	+ 1/16 inch (2 mm)	+ 1/8 inch (3 mm)
Width	- 1/8 inch, + 1/4 inch (-3 mm, + 6 mm)	- 1/8 inch, + 1/4 inch (-3 mm, + 6 mm)
Length	- 1/8 inch, + 1/4 inch (-3 mm, + 6 mm)	- 1/8 inch, + 1/4 inch (-3 mm, + 6 mm)

B. Furnish pads in one piece, not laminated in any manner, unless specified otherwise in the contract documents.

C. If pads are laminated, they are to have alternate laminations of neoprene and rolled steel sheets molded together as a unit. Unless required otherwise, meet the following requirements for pads:

1. The thickness of metal laminations: in the range of 14 gage to 1/8 inch (1.5 mm to 3.5 mm) inclusive.

2. Outer laminations of neoprene: 1/4 inch (6 mm).

3. Edges of all metal laminations covered by a minimum of 1/8 inch (3 mm) of neoprene, except at laminate restraining devices and around holes that will be entirely closed on the finished structure.

D. For the neoprene in laminated pads, meet the requirements in Table 4195.02-2, as specified by the Engineer. Compounds of nominal hardness between the values shown may be used, and test requirements interpolated. For homogeneous pads, the neoprene is to meet the requirements of Table 4195.02-2, using a durometer hardness of 70 unless the Engineer specifies otherwise.

Table 4195.02-2: Neoprene Requirements

ASTM Standard	Physical Properties	50 Duro.	60 Duro.	70 Duro.
D 2240	Hardness	50 + or - 5	60 + or - 5	70 + or - 5
D 412	Tensile Strength, minimum psi (MPA)	2250 (15.5)	2250 (15.5)	2250 (15.5)
	Ultimate elongation, minimum %	400	350	300
D 573 70 hr. 212°F (100°C)	**Heat Resistance** Change in durometer hardness, maximum points	+15	+15	+15
	Change in tensile strength, maximum %	-15	-15	-15
	Change in ultimate elongation, maximum %	-40	-40	-40
D 395 Method B	**Compressive Set** 22 hours @ 212°F (100°C), maximum %	35	35	35
D 1149 20% strain	**Ozone** 100°F ± 2°F (38°C ± 1°C), 100 hours 100 pphm ozone in air by volume	No Cracks	No Cracks	No Cracks

D 429, B	**Adhesion** Bond made during vulcanization minimum lbs. per inch (N/mm)	40 (7)	40 (7)	40 (7)
D 746 Procedure B	**Low Temperature Test** Brittleness at -40ºF (-40ºC)	No Failure	No Failure	No Failure
Ensure laminates are fabricated from rolled mild steel sheets conforming to ASTM A 1011/A 1011M, Grade 33; Grade 36, Type 1 and 2; or Grade 40, unless the Engineer specifies otherwise.				

E. When test specimens are cut from a finished product, a 10% variation in physical properties will be allowed.

Section 4196. Engineering Fabrics

4196.01 GENERAL REQUIREMENTS.

A. Meet the following requirements for engineering fabrics (known as geotextiles):

1. Permeable, synthetic textile materials suitable for use with soil, rock, or other geotechnical engineering related materials as an integral part of a highway project, structure, or system.

2. Mildew, rot, insect, and rodent resistant.

3. Inert to commonly encountered chemicals found in soil.

4. During all periods of shipment and storage, the fabric is maintained by wrapping in a heavy duty protective covering to protect the fabric from direct sunlight, ultraviolet rays, mud, dirt, dust, and debris.

5. Free of defects or flaws which significantly affect its physical properties.

B. Comply with Materials I.M. 496.01 for inspection and acceptance of engineering fabrics. Label each roll of fabric in a shipment with a number or symbol to identify the production run. Meet the following additional fabric requirements for the specific applications:

1. Silt Fencing.

a. Meet the following requirements:

1) Woven material with a minimum width of 36 inches (0.9 m).

2) Top edge of the fabric hemmed or modified otherwise so that a braided cord or woven belt can be suitably attached for loop tying to fence posts.

3) The cord or belt of minimum tensile strength of 150 pounds (670 N).

4) Fabric and any reinforcing plastic netting contains or is treated with ultraviolet stabilizers, sufficient to prevent damaging deterioration for 2 years of outdoor exposure.

5) Has the properties listed in Table 4196.01-1.

b. The fabric may be reinforced with plastic netting of nominal 3/4 inch (19 mm) strand spacing and a minimum three strand grab strength of 40 pounds (180 N) and 15 pounds (70 N) after the same accelerated weathering as required for the fabric. Fabric that is reinforced in this manner may have lower grab strengths as indicated.

Table 4196.01-1: Silt Fencing Fabric Properties

Property	Value	Test Method No.
Grab Strength, dry, minimum average fill direction run direction[(a)]	 100 lbs. (445 N) 150 lbs. (667 N)	ASTM D 4632
Ultraviolet Stability (Retained Strength)	70%	ASTM D 4355
Permittivity	0.05	ASTM D 4491
Apparent Opening Size, maximum	US mesh 30 (600 µm)	ASTM D 4751

(a) When plastic net reinforcing is used, ensure the minimum average grab strength requirement for fabric, before and after accelerated weathering, is 100 pounds (445 N) and 35 pounds (155 N), respectively. Apply the grab strength to both the fill and run direction.

2. Subsurface Drainage.

In subsurface drains, use fabric that:

- Is capable of withstanding normal installation stresses, and
- Has the properties listed in Table 4196.01-2.

Table 4196.01-2: Fabric for use in Subsurface Drains

Property	Value	Test Method
Grab strength, dry, minimum average value in either principal direction	90 lbs. (400 N)	ASTM D 4632
Elongation, dry, minimum average value in either principal direction	20%	ASTM D 4632

Permittivity	0.02 - 0.30	ASTM D 4491
Apparent Opening Size, maximum	US mesh 40 (450 µm)	ASTM D 4751

3. Embankment Erosion Control.

Under erosion stone or gabions used for embankment or erosion control, use fabric that:

- Is capable of withstanding normal installation stresses, and
- Has the properties listed in Table 4196.01-3.

Table 4196.01-3: Fabric for use under Erosion Stone

Property	Value	Test Method
Grab strength, dry, minimum average value in either principal direction	150 lbs. (667 N)	ASTM D 4632
Elongation, dry, minimum average value in either principal direction	20%	ASTM D 4632
Permittivity	0.02 - 0.30	ASTM D 4491
Apparent Opening Size, maximum	US mesh 40 (450 µm)	ASTM D 4751

4. Asphalt Overlay Fabric.

a. When placing fabric under asphalt mixtures to provide waterproofing and delay reflective cracking, ensure the fabric:

- Is capable of withstanding installation stresses,
- Is not damaged by temperatures common to asphalt mixtures, and
- Has the properties listed in Table 4196.01-4.

Table 4196.01-4: Fabric Placed under Asphalt Mixtures

Property	Value	Test Method
Grab strength, dry, minimum average value in either principal direction	90 lbs. (400 N)	ASTM D 4632
Elongation, dry, minimum average value in either principal direction	20%	ASTM D 4632
Grab Strength after 400°F (204°C) for 3 hr.[(a)] minimum average value in either principal direction	75 lbs. (335 N)	ASTM D 4632
(a) Applies only when asphalt temperatures exceeding 300°F (149°C) are anticipated.		

b. Ensure asphalt absorption is sufficient to produce a good bond between the overlay and the overlaid surface when a tack coat of 0.20 gallon to 0.25 gallon (0.9 L to 1.1 L) of asphalt binder per square yard (square meter) is used.

c. The Engineer may approve fabrics, such as fiberglass, which do not lend themselves to testing by some of the previously specified methods.

5. Subgrade Stabilization Material.

a. To stabilize a subgrade under pavement or pavement patches, use material that:

- Is capable of withstanding installation stresses, and
- Has the properties listed in Table 4196.01-5 for the type specified for use in the contract documents.

Table 4196.01-5: Fabric for use as Subgrade Stabilization (Polymer Grid)

Property	Value	Test Method
Minimum tensile strength at 2% strain. Both directions.	250 lbs./ft. (3650 N/m)	GRI Test Method GG1-87
Maximum aperture. Both directions.	2 in. (50 mm)	Internal Dimension Measuring Calipers
Minimum aperture. Both directions.	0.5 in. (13 mm)	Internal Dimension Measuring Calipers
Minimum Ultimate junction strength. Both directions.	800 lbs./ft. (11,675 N/m)	GRI Test Method GG2-87

b. Inspection and acceptance of polymer grid will be according to Materials I.M. 496.01.

6. Concrete and Stone Revetment and Bridge Abutment Backfill Fabric.

Use engineering fabric having properties listed in Table 4196.01-6.

Table 4196.01-6: Fabric for use under conc./stone revetment & abutment backfill

Property	Value	Test Method
Tensile Strength (at 5% Strain)	1356 lbs/ft (19.8 kN/m)	ASTM D 4595
Apparent opening size (AOS)	US Sieve #40 (0.43 mm)	ASTM D 4751
UV resistance (at 500 hours)	70% retained strength	ASTM D 4355
Flow Rate	18 gal./min./ft2 (733 L/min./m2)	ASTM D 4491

APPENDIX

Table 2501.03-1 (English Units)
Energy Values For Gravity And Diesel Hammers

Minimum Energy Required for Gravity Hammers (Ft. - Kips[(b)])									
Pile Length (ft.)	Wood Pile	Concrete Pile		Steel H-Pile					
		12" to 14"	16"	10 x 42	10 x 57	12 x 53	12 x 74	14 x 73	14 x 89
25' or less	15	25	27	23	23	23	25	25	32
26' to 40'	15	25	27	23	23	23	30	30	35
41' to 50'	15	25	27	25	25	25	30	30	36
51' to 65'	(a)	(a)	(a)	25	25	25	30	30	36
66' to 90'	(a)	(a)	(a)	30	30	30	33	33	36

Maximum Energy Allowed for Gravity Hammers (Ft. - Kips[(b)])									
Pile Length (ft.)	Wood Pile	Concrete Pile		Steel H-Pile					
		12" to 14"	16"	10 x 42	10 x 57	12 x 53	12 x 74	14 x 73	14 x 89
25' or less	25	34	36	28	28	28	35	35	42
26' to 40'	25	34	36	32	35	35	38	38	45
41' to 50'	25	34	36	38	38	42	42	42	48
51' to 65'	(a)	(a)	(a)	35	38	38	42	42	48
66' to 90'	(a)	(a)	(a)	35	38	38	42	42	50

Minimum Energy Required for Diesel Hammers (Ft. - Kips[b])									
Pile Length (ft.)	Wood Pile	Concrete Pile	Steel H-Pile						
		12" to 14"	16"	10 x 42	10 x 57	12 x 53	12 x 74	14 x 73	14 x 89
25' or less	17	23	28	22	24	24	29	29	33
26' to 40'	17	23	28	22	24	24	29	29	40
41' to 50'	17	23	28	22	26	26	33	33	40
>51' to 65'	[a]	[a]	[a]	22	26	26	33	33	40
66' to 90'	[a]	[a]	[a]	22	29	29	40	40	49
Maximum Energy Allowed for Diesel Hammers (Ft. - Kips[b])									
Pile Length (ft.)	Wood Pile	Concrete Pile	Steel H-Pile						
		12" to 14"	16"	10 x 42	10 x 57	12 x 53	12 x 74	14 x 73	14 x 89
25' or less	24	32	40	33	33	33	40	40	43
26' to 40'	24	32	40	33	33	33	40	40	47
41' to 50'	33	32	40	40	40	40	43	43	52
51’ to 65’	[a]	[a]	[a]	40	40	40	43	43	52

[a] Wave equation analysis.

[b] Ft. - Kips - 1,000 foot pounds.

For design bearings under 40 tons, minimum diesel hammer energies listed may be reduced by 20% for concrete pile and 10% for steel pile.

Table 2501.03-2 (Metric Units)
Energy Values For Gravity And Diesel Hammers

Minimum Energy Required for Gravity Hammers (kilojoules)									
Pile Length (meters)	Wood Pile	Concrete Pile		Steel H-Pile					
		305 mm to 356 mm	406 mm	250 x 62	250 x 85	310 x 79	310 x 110	360 x 108	360 x 132
7.5 or less	20	34	37	31	31	31	34	34	43
7.6 to 12.0	20	34	37	31	31	31	41	41	47
12.1 to 15.0	20	34	37	34	34	34	41	41	49
15.1 to 20.0	(a)	(a)	(a)	34	34	34	41	41	49
20.1 to 28.0	(a)	(a)	(a)	41	41	41	45	45	49
Maximum Energy Allowed for Gravity Hammers (kilojoules)									
Pile Length (meters)	Wood Pile	Concrete Pile		Steel H-Pile					
		305 mm to 356 mm	406 mm	250 x 62	250 x 85	310 x 79	310 x 110	360 x 108	360 x 132
7.5 or less	34	46	49	38	38	38	47	47	57
7.6 to 12.0	34	46	49	43	47	47	52	52	61
12.1 to 15.0	34	46	49	47	52	52	57	57	65
15.1 to 20.0	(a)	(a)	(a)	47	52	52	57	57	65
20.1 to 28.0	(a)	(a)	(a)	52	52	57	57	57	68

Minimum Energy Required for Diesel Hammers (kilojoules)									
Pile Length (meters)	Wood Pile	Concrete Pile		Steel H-Pile					
		305 mm to 356 mm	406 mm	250 x 62	250 x 85	310 x 79	310 x 110	360 x 108	360 x 132
7.5 or less	23	31	38	30	33	33	39	39	45
7.6 to 12.0	23	31	38	30	33	33	39	39	54
12.1 to 15.0	23	31	38	30	35	35	45	45	54
15.1 to 20.0	(a)	(a)	(a)	30	35	35	45	45	54
20.1 to 28.0	(a)	(a)	(a)	30	39	39	54	54	66
Maximum Energy Allowed for Diesel Hammers (kilojoules)									
Pile Length (meters)	Wood Pile	Concrete Pile		Steel H-Pile					
		305 mm to 356 mm	406 mm	250 x 62	250 x 85	310 x 79	310 x 110	360 x 108	360 x 132
7.5 or less	33	43	54	45	45	45	54	54	58
7.6 to 12.0	33	43	54	45	45	45	54	54	64
12.1 to 15.0	45	43	54	54	54	54	58	58	70
15.1 to 20.0	(a)	(a)	(a)	54	54	54	58	58	70
20.1 to 28.0	(a)	(a)	(a)	54	54	64	66	66	81

(a) Wave equation analysis. For design bearings under 355 kN, minimum diesel hammer energies listed may be reduced by 20% for concrete pile and 10% for steel pile.

Table 2550.02-1: Fabric Form Minimum Property Requirements

Property	Test Method	Units	Armor Unit	Articulating Block Mat
Composition of Yarns			Nylon or Polyester	Nylon or Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2 (g/m^2)	14 (470)	12 (403)
Thickness	ASTM D 5199	Mils (mm)	28 (0.7)	25 (0.6)
Mill Width		In (m)	76 (1.92)	76 (1.92)
Wide-Width Strip Tensile Strength -Machine - Cross	 ASTM D 4595 ASTM D 4595	 lbf/in (kN/m) lbf/in (kN/m)	 190 (33.2) 140 (24.5)	 140 (24.5) 110 (19.3)
Elongation at Break - Machine - Cross	 ASTM D 4595 ASTM D 4595	 % %	 20 30	 20 30
Trapezoidal Tear Strength - Machine - Cross	 ASTM D 4533 ASTM D 4533	 lbf (N) lbf (N)	 180 (800) 115 (510)	 150 (665) 100 (445)
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Std. Sieve (mm)	60 (0.250)	40 (0.425)
Flow Rate	ASTM D 4491	gal/min/ft^2 (l/min/m^2)	50 (2035)	90 (3665)

Notes:
a. Conformance of fabric to specification property requirements is based on ASTM D 4759.
b. All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Sample lots according to ASTM D 4354.

Table 2552.02-1: Class II Material

Class	Type	Soil Group Symbol ASTM D 2487	Description	Percentage Passing Sieve Sizes		
				1½ in. (37.5 mm)	No. 4 (4.75 mm)	No. 200 (75 μm)
II	Coarse-Grained Soils, clean	GW	Well-graded gravels and gravel-sand mixtures; little or no fines	100%	‹50% of "Coarse Fraction"	‹5%
		GP	Poorly-graded gravels and gravel-sand mixtures; little or no fines.			
		SW	Well-graded sands and gravelly sands; little or no fines.		›50% of "Coarse Fraction"	
		SP	Poorly-graded sands and gravelly sands; little or no fines.			
	Coarse-Grained Soils, borderline clean to with fines	e.g. GW-GC, SP-SM	Sands and gravels which are borderline between clean and with fines.	100%	Varies	5% to 12%

Table 2552.02-2: Class III Material

Class	Type	Soil Group Symbol ASTM D 2487	Description
III	Coarse-Grained Soils, with fines	GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.

Table 2552.02-3: Class IVA Material

Class	Type	Soil Group Symbol ASTM D 2487	Description
IVA	Fine-Grained Soils (inorganic)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clay, lean clays.

Table 2552.02-4: Class IVB Material

Class	Type	Soil Group Symbol ASTM D 2487	Description
IVB	Fine-Grained Soils (inorganic)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.

Table 2552.02-5: Class V Material

Class	Type	Soil Group Symbol ASTM D 2487	Description
V	Organic Soils (Unsuitable for backfill)	OL	Organic silts and organic silty clays of low plasticity.
		OH	Organic clays of medium to high plasticity, organic silts.
	Highly Organic (Unsuitable for backfill)	PT	Peat and other high organic soils.

AGGREGATE GRADATION TABLE - ENGLISH														
Grad. No.	**Section No.**	**Std. Sieve Sz.**	**1 1/2”**	**1.00”**	**3/4”**	**1/2”**	**3/8”**	**4**	**8**	**30**	**50**	**100**	**200**	
		Intended Use	**Percent Passing**											**Notes**
1	4110, 4125, 4133, 4134	PCC FA, Cover Agg.					100	90-100	70-100	10-60			0-1.5	1
3	4115 (57, 2-8)	PCC CA	100	95-100		25-60		0-10	0-5				0-1.5	2, 10
4	4115 (2-8)	PCC CA	100	50-100	30-100	20-75	5-55	0-10	0-5				0-1.5	10
5	4115 (67, 2-8)	PCC CA		100	90-100		20-55	0-10	0-5				0-1.5	10
6	4115.06 (Repair & Overlay)	PCC CA			100	97-100	40-90	0-30					0-1.5	10
7	4117 (Class V)	PCC FA & CA	100					80-92	60-75	20-40				
8	4117.03 (Class V)	Fine Limestone					100	90-100					0-30	
10	4120.02, 4120.03 (C gravel)	Granular Surface			100			50-80	25-60					3, 11
11	4120.02, 4120.04, 4120.05, 4120.07, (A, B Cr. St.)	Granular Surface & Shoulder		100	95-100	70-90		30-55	15-40				6-16	4, 5, 11
12a	4121 (Cr. St.)	Granular Subbase	100			40-80			5-25				0-6	6, 10
12b	4121 (Cr. Gravel)	Granular Subbase	100			50-80			10-30		5-15		3-7	7, 11
13	4122.02 (Cr. St.)	Macadam St. Base	3” nominal maximum size screened over 3/4” or 1.00” screen.											

14	4123	Modified Subbase	100		70-90				10-40				3-10	5, 7, 11
19	4125 (1/2") Cr. Gr. or Cr. St.)	Cover Aggregate			100	97-100	40-90	0-30	0-15				0-2	11
20	4125 (1/2" Scr. Gr.)	Cover Aggregate			100	95-100	40-80	0-15	0-7				0-1.5	11
21	4125 (3/8")	Cover Aggregate				100	90-100	10-55	0-20	0-7			0-1.5	11
22	4124	Fine Slurry Mixture					100	85-100	40-95	20-60	14-35	10-25	5-25	9, 11
23	4124 (Cr. St.)	Coarse Slurry Mixture					100	70-90	40-70	19-42			5-15	11
29	4131	Porous Backfill			100	95-100	50-100	0-50	0-8					11
30	4132.02 (Cr. St.)	Special Backfill	100						10-40				0-10	5, 11
31	4132.03 (Gravel)	Special Backfill		100	90-100	75-100			30-55				3-7	11
32	4133 (Sand/Gr./Cr. St.)	Granular Backfill	100% passing the 3" screen						10-100				0-10	8, 11
35	4134 (Natural Sand/Gr.)	Floodable Backfill	100						20-90				0-4	11
36	4134 (Natural Sand)	Floodable Backfill							100				0-2	11

Notes: (Gradations No. 2, 9, 15, 16, 17, 18, 24, 25, 26, 27, 28, 33, and 34 have been deleted)

1. For Section 4110, when the fine aggregate is sieved through the following numbered sieves - 4, 8, 16, 30, 50, and 100 - no more than 40% shall pass one sieve and be retained on the sieve with the next higher number.

2. When used in precast and prestressed concrete bridge beams, 100% shall pass the 1.00" sieve.

3. When compaction of material is a specification requirement, the minimum percent passing the No. 200 sieve is 6%.

4. See specifications for combination of gravel and limestone.

5. Unwashed air dried samples of crushed composite material shall be tested for gradation compliance except that no gradation determination will be made for material passing the No. 200 sieve.

6. The gradation requirement for the No. 8 sieve shall be 5% to 20% when recycled material is supplied.

7. For Section 4121 gravel, one fractured face on 30% or more of the particles retained on the 3/8 inch sieve. For Section 4123 gravel, one fractured face on 75% or more of the particles retained on the 3/8 inch sieve.

8. Crushed stone shall have 100% passing the 1½" sieve.

9. Gradation limitations for the 30, 50, and 100 sieves shall not apply when slurry mixture is applied by hand lutes, such as for slurry leveling.

10. Maximum of 2.5% passing the No. 200 sieve allowed if generated from the parent material when documented production is 1% or less as determined by the Office of Materials.

11. When Producer gradation test results are used for acceptance, test results representing at least 90% of the material being produced shall be within the gradation limits and the average of all gradation results shall be within the gradations limits. Stockpiled material not meeting the criteria may, at the District Materials Engineer's discretion, be resampled using Materials I.M. 301 procedures. One hundred percent of the stockpile quality control and verification test results shall be within the gradation limits.

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AGGREGATE GRADATION TABLE - METRIC														
Grad. No.	**Section No.**	**Std. Sieve Sz.**	**37.5 mm**	**25 mm**	**19 mm**	**12.5mm**	**9.5 mm**	**4.75 mm**	**2.36 mm**	**600 µm**	**300 µm**	**150 µm**	**75 µm**	
		Intended Use	**Percent Passing**											**Notes**
1	4110, 4125, 4133, 4134	PCC FA, Cover Agg.					100	90-100	70-100	10-60			0-1.5	1
3	4115 (57, 2-8)	PCC CA	100	95-100		25-60		0-10	0-5				0-1.5	2, 10
4	4115 (2-8)	PCC CA	100	50-100	30-100	20-75	5-55	0-10	0-5				0-1.5	10
5	4115 (67, 2-8)	PCC CA		100	90-100		20-55	0-10	0-5				0-1.5	10
6	4115.06 (Repair & Overlay)	PCC CA			100	97-100	40-90	0-30					0-1.5	10
7	4117 (Class V)	PCC FA & CA	100					80-92	60-75	20-40				
8	4117.03 (Class V)	Fine Limestone					100	90-100					0-30	
10	4120.02, 4120.03 (C gravel)	Granular Surface			100			50-80	25-60					3, 11
11	4120.02, 4120.04, 4120.05, 4120.07 (A, B Cr. St.)	Granular Surface & Shoulder		100	95-100	70-90		30-55	15-40				6-16	4, 5, 11
12a	4121 (Cr. St.)	Granular Subbase	100			40-80			5-25				0-6	6, 11
12b	4121 (Cr. Gravel)	Granular Subbase	100			50-80			10-30		5-15		3-7	7, 11

13	4122.02 (Cr. St.)	Macadam St. Base	75 mm nominal maximum size screened over 19 mm or 25 mm screen.											
14	4123	Modified Subbase	100		70-90				10-40				3-10	5, 7, 11
19	4125 (12.5mm Cr. Gr. or Cr. St.)	Cover Aggregate			100	97-100	40-90	0-30	0-15				0-2	11
20	4125 (12.5mm Scr. Gr.)	Cover Aggregate			100	95-100	40-80	0-15	0-7				0-1.5	11
21	4125 (9.5mm)	Cover Aggregate				100	90-100	10-55	0-20	0-7			0-1.5	11
22	4124.02B	Fine Slurry Mixture					100	85-100	40-95	20-60	14-35	10-25	5-25	9, 11
23	4124.02B (Cr. St.)	Coarse Slurry Mixture					100	70-90	40-70	19-42			5-15	11
29	4131	Porous Backfill			100	95-100	50-100	0-50	0-8					11
30	4132.02 (Cr. St.)	Special Backfill	100						10-40				0-10	5, 11
31	4132.03 (Gravel)	Special Backfill		100	90-100	75-100			30-55				3-7	11
32	4133 (Sand/Gr./Cr. St.)	Granular Backfill	100% passing the 76.2 mm screen						10-100				0-10	8, 11
35	4134 (Natural Sand/Gr.)	Floodable Backfill	100						20-90				0-4	11

36	41334 (Natural Sand)	Floodable Backfill							100				0-2	11

Notes: (Gradations No. 2, 9, 15, 16, 17, 18, 24, 25, 26, 27, 28, 33, and 34 have been deleted)

1. For Section 4110, when the fine aggregate is sieved through the following numbered sieves - 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm, and 150 µm - not more than 40% shall pass one sieve and be retained on the sieve with the next higher number.

2. When used in precast and prestressed concrete bridge beams, 100% shall pass the 25 mm sieve.

3. When compaction of material is a specification requirement, the minimum percent passing the 75 µm sieve is 6%.

4. See specifications for combination of gravel and limestone.

5. Unwashed air dried samples of crushed composite material shall be tested for gradation compliance except that no gradation determination will be made for material passing the 75 µm sieve.

6. The gradation requirement for the 2.36 mm sieve shall be 5% to 20% when recycled material is supplied.

7. For Section 4121 gravel, one fractured face on 30% or more of the particles retained on the 9.5 mm sieve. For Section 4123 gravel, one fractured face on 75% or more of the particles retained on the 9.5 mm sieve.

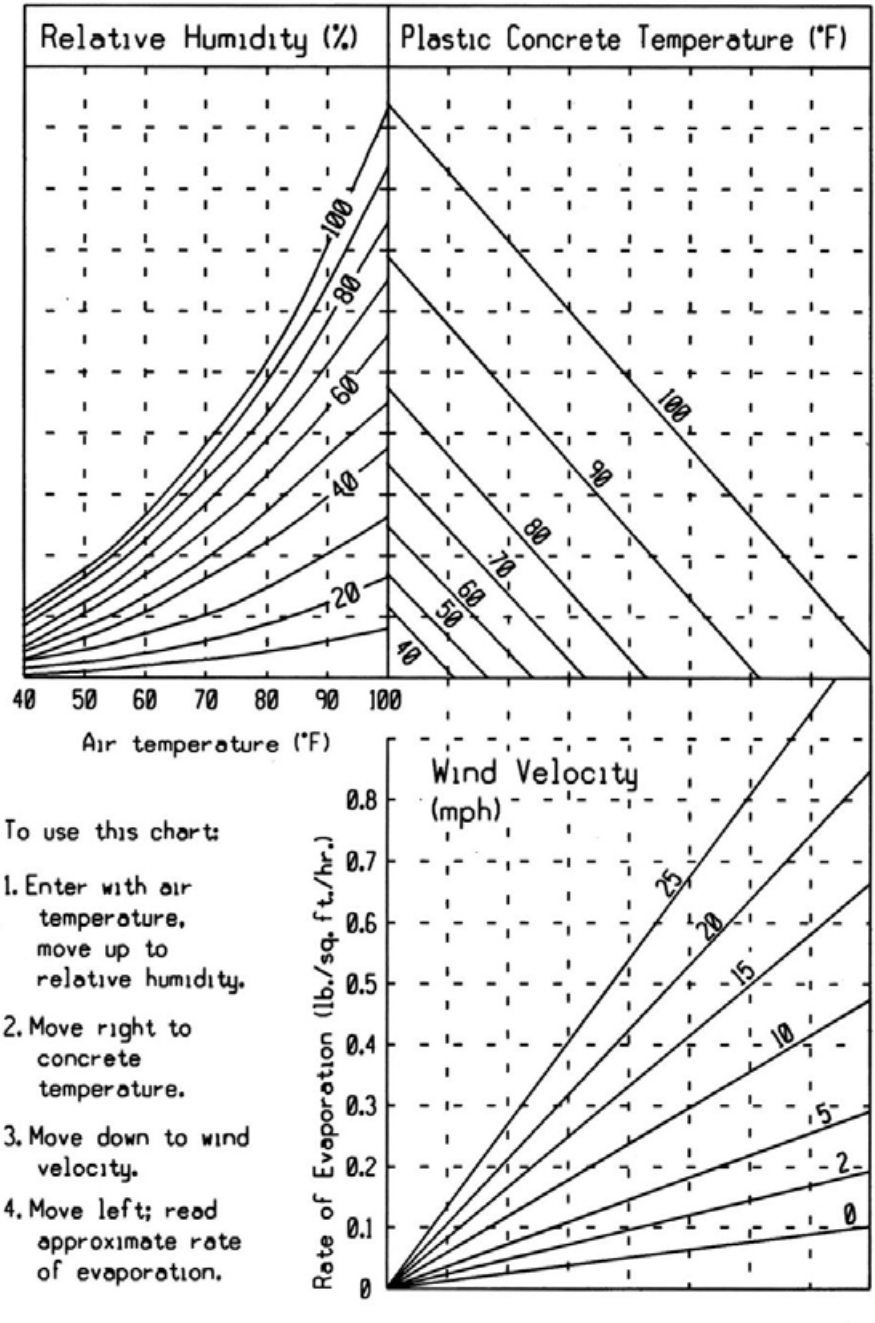
8. Crushed stone shall have 100% passing the 37.5 mm sieve.

9. Gradation limitations for the (600 µm, 300 µm, and 150 µm) sieves shall not apply when slurry mixture is applied by hand lutes such as for slurry leveling.

10. Maximum of 2.5% passing the 75 µm sieve allowed if generated from the parent material when documented production is 1% or less as determined by the Office of Materials.

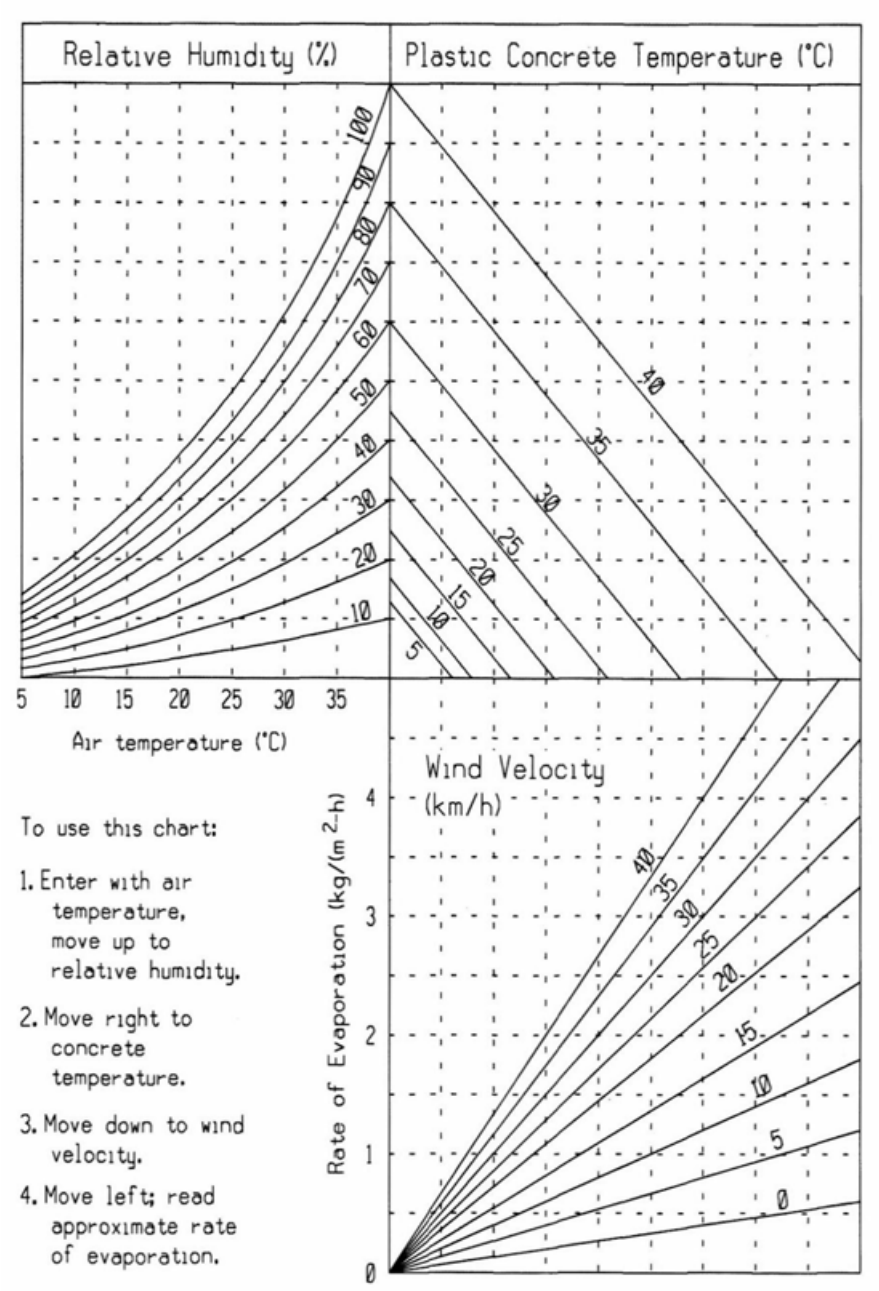
11. When Producer gradation test results are used for acceptance, test results representing at least 90% of the material being produced shall be within the gradation limits and the average of all gradation results shall be within the gradations limits. Stockpiled material not meeting the criteria may, at the District Materials Engineer's discretion, be resampled using Materials I.M. 301 procedures. One hundred percent of the stockpile quality control and verification test results shall be within the gradation limits.

THEORETICAL RATE OF EVAPORATION CHART (English Units)



APPENDIX

THEORETICAL RATE OF EVAPORATION CHART (Metric Units)



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