Increased Density to Improve Pavement Durability Demonstration Project - NDOT 3716

Image Source: University of Nevada Reno

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Abstract

The fact that Department of Transportation (DOT) specifications always include compaction provisions reflects that asphalt pavement technologists have recognized the impact of in place density on pavement performance for many decades. However, an increase in durability related performance issues in the mid 2010's placed renewed focus on it. A recent literature review summarized past lab and field work which conservatively showed a 1 percent increase in density improves pavement life by 10 percent. It included information from the WesTrack project in Nevada that showed a 1 percent increase in density resulted in an improvement in rutting performance of 7 to 66 percent and 8 to 44 percent improvement in fatigue performance. The Federal Highway Administration (FHWA) has supported an *Increased In-Place Density Initiative* since 2015 with focus on communicating and providing education on the benefits of increasing in-place density of asphalt concrete pavements that State DOTs could volunteer to participate in.

This report describes a density demonstration project conducted by the Nevada Department of Transportation (NDOT). The project scope included two test sections for the typical roadway reconstruction under special provisions that increased the NDOT standard specification in-place mat density minimum requirements by one percent and two percent, respectively. A control section was also constructed. The contractor had the flexibility to make operational and equipment changes in the two test sections to improve in place density. Collectively, use of intelligent compactors, additional density QC staff, additional roller coverages and potentially an increase in asphalt content above the JMF target led to increased mat density and improved consistency when compared to the control data.

Key Words: In-place density, in-place air voids, asphalt pavement, pavement performance

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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Introduction

The fact that Department of Transportation (DOT) specifications always include compaction provisions reflects that asphalt pavement technologists have recognized the impact of density on pavement performance for many decades. However, an increase in durability related performance issues in the mid 2010's placed renewed focus on it. A recent literature review by the National Center for Asphalt Technology (NCAT) summarized past lab and field work which conservatively showed a 1 percent increase in density improves pavement life by 10 percent (1). It included information from the WesTrack project in Nevada that showed a 1 percent increase in density resulted in an improvement in rutting performance of 7 to 66 percent and 8 to 44 percent improvement in fatigue performance. The Asphalt Institute (AI) used the 1 percent increase in density to illustrate that a typical pavement expected to last 20 years when constructed to 93 percent density, would only last 18 years if constructed to 92 percent density. Furthermore, with the 2-year increase in service life a DOT would see a life cycle cost analysis (LCCA) net present value cost savings of $88,000 on a $1,000,000 paving project (8.8 percent) by increasing field density 1 percent (2).

The Federal Highway Administration (FHWA) has supported an Increased In-Place Density Initiative since 2015 with focus on communicating and providing education on the benefits of increasing in-place density of asphalt concrete pavements (3). The primary activities associated with the initiative have included:

- One-day workshops for DOTs and contractors describing the significant improvement in durability and reduction in life cycle cost that can be achieved with small increases in in-place density,
- Support of DOT demonstration projects that incorporate techniques that could lead to a 1 percent increase in density, and
- Communication of the demonstration project outcomes and techniques adopted by DOTs to increase in-place density.

This report describes a density demonstration project conducted by the Nevada Department of Transportation (NDOT) on SR 160 between Las Vegas and Pahrump Nevada. The project scope included two test sections, each representing one day of paving, for the typical roadway reconstruction under special provisions that increased the NDOT standard specification in-place mat density minimum requirements by 1 percent and 2 percent, respectively (4). The special provisions, presented in Appendix A, included a potential bonus incentivizing the contractor to achieve these requirements of $2500 per lift and $3500 per lift for the 1 percent and 2 percent increases, respectively. Quality assurance test results obtained during construct that included asphalt content, gradation, theoretical maximum specific gravity (G_{mm}) and in-place density were used to assess how effective changes made by the contractor were at improving in-place density.

Objectives

The primary objective of the demonstration project was to determine if a 1 or 2 percent increase in the current NDOT in-place density specifications could be reasonably achieved by means within a typical NDOT contractor's control. In order to do so the following had to take place:

- A special provision had to be developed defining the demonstration project requirements and incentive payment which incorporated large enough test sections to give the contractor a reasonable opportunity to meet the requirements,
- An upcoming project had to be selected to incorporate the special provision.
- Upon award of the project to the low bidder, a demonstration project workshop had to be conducted with NDOT, FHWA and contractor representatives present,
- A pre-construction meeting had to be held on the project site, at which NDOT, FHWA and contractor representatives discussed specific actions the contractor could take to meet the primary demonstration project objective,
- The contractor had to provide a written plan to NDOT outlining the changes that would be made for each test section, and
- The test sections had to be constructed with the necessary quality control (QC) and quality assurance (QA) inspection, sampling and testing performed with the results of it analyzed to assess conformance to the special provision.
- Important information from the effort had to be documented.

Project Information

A general description of the project follows along with a description of pre-construction activities which were important to the successful construction of the demonstration project test sections.

Location and Specifications

The density demonstration test sections were included in a NDOT project by special provision. They were constructed on a portion of the NDOT contract 3716 project located west of Las Vegas Nevada. The project limits are SR 160, Blue Diamond Road, from the west edge of Mountain Springs Community to the beginning of mountainous area SR 160 Blue Diamond Road, and from 1.03 Miles North of Mountain Springs Summit to the Clark County / Nye County Line. The project site plans are presented in Appendix B. The milepost limits are CL 16.51 to CL 22.20 and CL 21.96 to NY 0.95 with a project length of 28 miles. The project was awarded to Aggregate Industries SWR, Inc. on July 9, 2018 for $58,561,165.00. All contract details, documents and award information can be found at the following NDOT website: https://appss.nevadadot.com/EBiddingPortalClient/Contract/ViewContractDetails.aspx?contractId=10400# (5). The project included 505,855 yd^3 of roadbed modification, 269,911 tons of Type 2C plantmix bituminous surface, and 30,134 tons of plantmix open-grade surface. The density demonstration test sections were constructed on a portion of east bound SR 160 just east of the Nye Clark County border.

The roadway width is 36 feet, consisting of two travel lanes and a shoulder all with a 2 percent cross slope to the shoulder. The pavement section was a complete reconstruction consisting of 8 inches of roadbed modification on existing subgrade covered with 6 inches of plantmix bituminous surface (placed in two 3 inch lifts) topped with ¾ inch of plantmix open-grade surface. The NDOT standard specification sections for the roadbed modification, plantmix bituminous surface and plantmix open-grade surface are 305, 402 and 403, respectively. (6). The roadbed modification consists of pulverizing the existing bituminous mixture, aggregate and in some cases subgrade to a depth of 12 inches, with four inches removed and the remaining 8 inches modified with 2 percent portland cement prior to compaction. The plantmix bituminous surface was ¾" Type 2C with 15% reclaimed asphalt pavement (RAP) defined in specification section 705. Both the plantmix bituminous surface and plantmix open-grade surface incorporated PG76-22NV asphalt binder. An "E-prime" prime coat was applied to the roadbed modification at an application rate of 0.25 gallons per square yard. An application of SS-1H is then applied to the roadbed modification at a rate of 0.05 gallons per square yard prior to paving. A tack coat of SS-1H was applied between the lifts of plantmix bituminous surface at a rate of 0.06 gallons per square yard. The NDOT standard specification section for asphalt binder, prime coat and tack coat is 703. The ¾" Type 2C with 15% RAP mix design is presented in Appendix C.

Pre-planning Activities

Pre-planning activities included a 1-day workshop and preconstruction meeting. The 1-day workshop, focused on best practices for improving in-place density, was presented by Asphalt Institute staff in Las Vegas on March 14, 2017 with key NDOT, Aggregate Industries SWR, Inc., and FHWA staff present. The demonstration test section construction was originally planned for the 2018 construction season but was delayed to the 2019 construction season. So, a WebEx was held January 30, 2019 with key NDOT, Aggregate Industries SWR, Inc., FHWA, and UNR staff participating to discuss the 2019 planning.

On March 27, 2019 a preconstruction meeting was held on the project site with key NDOT, Aggregate Industries SWR, Inc., FHWA and UNR staff present. A review of best practices for improving in-place density was presented by Timothy Aschenbrener of FHWA along with examples of what techniques contractors building other demonstration projects had used to successfully increase in-place density by at least 1 percent. Aggregate Industries staff provided initial thoughts on what techniques would be used on the test sections which was followed up with a written proposal May 6, 2019. A subsequent phone call with key NDOT, Aggregate Industries SWR, Inc., and UNR staff participating refined the plan to what is presented in Table 1. In summary, for the test section number 1 (plus 1 percent density) the techniques included all new intelligent compactors (IC) and doubling of on-site QC staff. For the section number 2 (plus 2% density) the techniques planned for test section 1 would be used along with an asphalt binder content increase of 0.1 percent and an increase in roller passes. Test section number 2 was placed directly on top of test section number 1. So, test section 1 was the bottom 3-inch lift and test section 2 were the top 3-inch lift.

Table 1. Pre-construction Techniques Planned for Test Section Construction

Test Section	Staff changes	Material changes	Equipment changes	Operational changes
1 (plus 1% density)	Increase QC density technicians from 1 to 2	None	All new Caterpillar breakdown, intermediate, and finish roller equipped with Intelligent Compaction technology	None
2 (plus 2% density)	Increase QC density technicians from 1 to 2	Increase asphalt binder 0.1%	All new Caterpillar breakdown, intermediate, and finish rollers equipped with Intelligent Compaction technology	Increase roller passes

Construction

Density test section number 1 was constructed June 26, 2019, and test section number 2 was construction June 28, 2019. It was originally planned that they would be constructed over two consecutive days, but a mechanical issue at the asphalt plant on the afternoon of June 26th led to a day between the two test sections. A description of mix production and transportation follows along with a summary of placement and compaction.

Mix Production and Transportation

The Type 2C plantmix surface was produced at the Aggregate Industries AWR, Inc. Sloan Pit facility located at 5300 Sloan Road, in Sloan Nevada south of Las Vegas. Figure 1 shows the location of the Sloan Pit and density test section located between to Las Vegas and Pahrump.

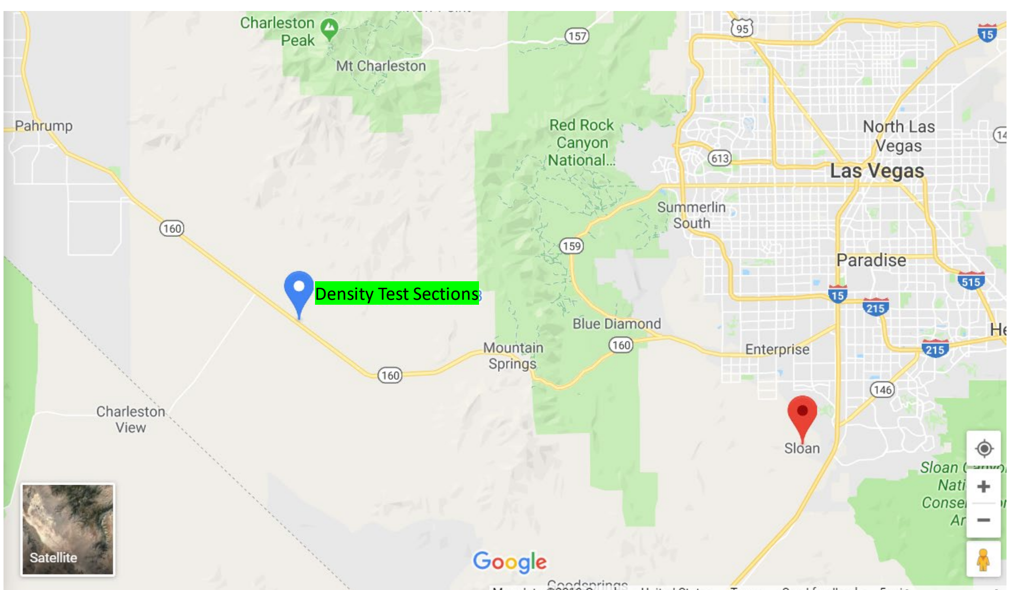

Figure 1. Sloan Pit and Density Test Section Locations (Google Earth)

Image Source: Google Earth

There are aggregate, hot mix asphalt and ready-mix concrete production at this location which is south of Las Vegas. The hot plant on site is an Astec Double Barrel Drum plant with six storage silos. Figure 2 is a picture of the hot plant type used to produce the Type 2C plantmix that was typically operated at 300 tons per hour.

Image Source: Adam Hand

Figure 2. Astec Double Barrel Drum Plant

Consistent with NDOT requirements, the plant was calibrated in January 2019 and an inspector visited the plant during the test section production. Production at the plant started each day at 1:30am with the first truck loading out at 3:00am. This allowed adequate haul time for paving to begin at 5:00am each day. The target mix production temperature was 330°F and was typically with 10°F of this. Only bottom dump haul trucks were used, with most having two trailers carrying approximately 38 tons per truck. All 27 trucks used were tarped to help retain mix temperature during the haul. The haul distance from the hot plant to the test section location was approximately 50 miles. There is a significant grade between the plant and test section location which resulted in an average haul time of about 90 minutes.

Image Source: University of Nevada

Figure 3. Typical Bottom Dump Haul Trucks

Placement and Compaction

The test sections were placed on a divided section of SR160 in the eastbound direction. The roadway width is 36 feet, consisting of two travel lanes and a shoulder. For both test sections the plantmix was placed in 3 passes in the eastbound direction, starting with the shoulder which was located at the bottom of the 2 percent cross slope. Figure 4 is a diagram of the paving which was repeated for each lift (test section) with the longitudinal joints offset by 6 to 12 inches.

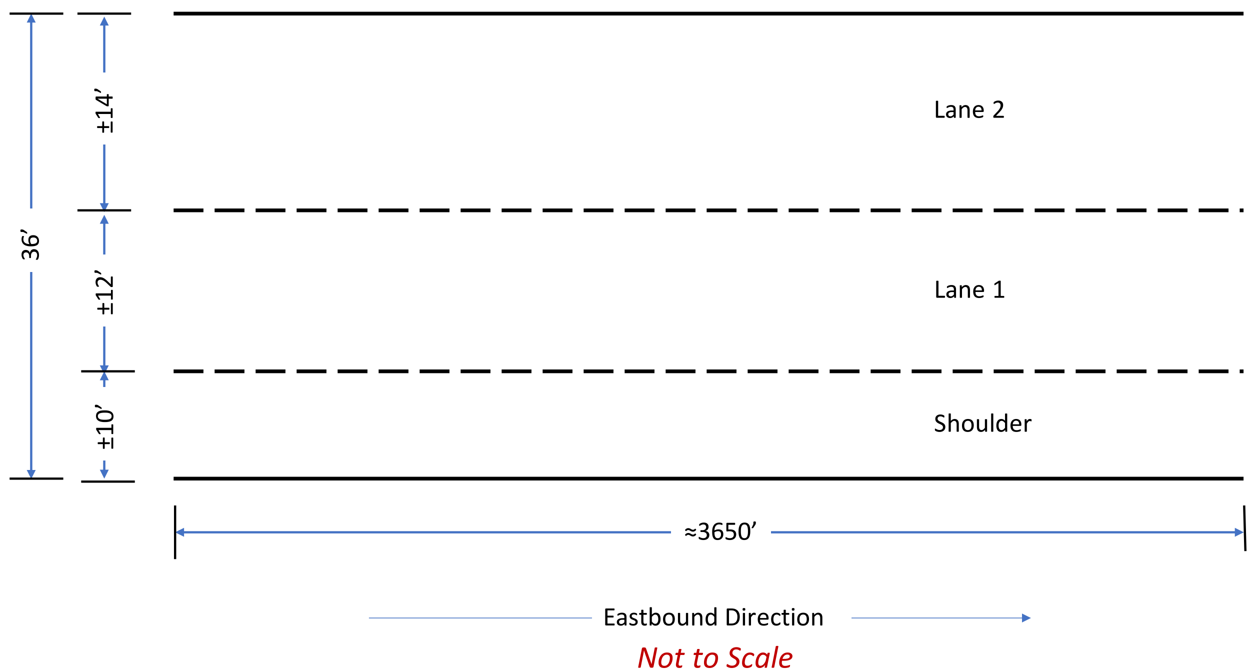

Figure 4. Test Section Pavement Lane Layout and Approximate Dimensions

The equipment used for the test section construction is presented in Table 2. All of the same equipment was used for both test sections. The Caterpillar compactors were all brand new and equipped with intelligent compaction (IC) technology. The roller weights are included in Table 2. Note that ballast was not added to the CW34 pneumatic rollers. An intelligent compactor is a compactor equipped with the addition of the following capabilities:

- GPS based location mapping,
- Compaction surface temperature measurement,
- Compaction measurement value determination if a vibratory compactor, and
- On-board monitor/controller/data collection system

IC utilizes the Global Navigation Satellite System (GNSS) to correlate measurements to a physical location. Using a base station at the project location with a GPS receiver and transmitter improves precision of the positioning with real time kinematics (RTK). Figure 5 shows an onsite base station with a GPS receiver and transmitter. Post processing of IC data can be performed using Vela software which is available at http://www.intelligentcompaction.com/veta/ (7). IC temperature and mapping features were used for the test section compaction. Representatives from Caterpillar and Sitech were on-site to provide roller operator training and GPS setup and support the day prior to and during construction of the test sections.

Table 2. Placement and Compaction Equipment

Equipment	Model	Units	Use/Notes
BearCat Distributor		1	Prime and tack coat
Roadtec Material Transfer Vehicle	SB2500	1	With windrow pickup
Caterpillar Paver	AP1055F	1	With automated grade controls and hopper extension
Caterpillar Steel Drum Roller	CB66B (14.5 ton)	1	Breakdown rolling with IC
Pneumatic Tire Roller with IC	CW34 (11 ton)	2	Intermediate rolling with IC, No additional ballast
Caterpillar Steel Drum Roller	CB66B (14.5 ton)	1	Finish rolling with IC
Volvo Steel Drum Roller	DD25B (2.8 ton)	1	Transverse joint construction only
Blaw Knox Kick Broom	CB-90	1	Sweeping prior to prime and tack coats

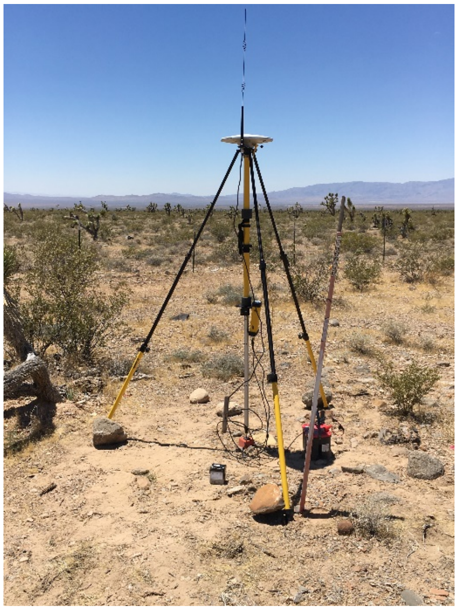

Image Source: University of Nevada Reno

Figure 5. GPS with RTK for Location Positioning to Generate Accurate Mapping

Prior to placement of the 3-inch bottom lift Type 2C plantmix a prime coat was applied with the BearCat asphalt distributor shown in Figure 6. The prime coat was uniformly applied.

Image Source: University of Nevada Reno

Figure 6. Asphalt Distributor Applying Prime Coat

Paving was initiated at 5am and completed by 3:30pm each day. Weather conditions during test section construction are summarized in Table 3. Paving initiated in the eastbound direction. Trucks dumped plantmix in a windrow and the Roadtec MTV was used to pick it up and mix it prior to discharging into the hopper on the Caterpillar AP1055F paver as shown in Figure 7. Breakdown rolling initiated immediately behind the paver with the Caterpillar CB66B roller using both vibratory and static compaction modes. A pair of tandem Caterpillar CW34 intermediate rollers followed the breakdown roller as shown in Figure 8. Finish rolling was accomplished with a second Caterpillar CB66B roller. Longitudinal joints were compacted from the cold side first as illustrated in Figure 9. It is important to note that joint density requirements were not included in the test section specifications. Roller coverages and plantmix temperatures during compaction are summarized in Table 4. Table 5 contains the stationing identifying the beginning and ending of paving along tonnage placed and plantmix loose mix sampling locations testing frequencies.

Table 3. Weather Conditions During Test Section Construction

Test Section	Date Constructed	Ambient Temperature Range (°F)	Relative Humidity Range (%)	Wind Speed (mph)	Cloud Cover
1	06/26/19	73-102	low	5-18	none
2	06/28/19	71-101	low	5-10	none

Image Source: University of Nevada Reno

Figure 7. Windrow pickup, Discharge into the Paver Hopper and Breakdown Compaction

Image Source: University of Nevada Reno

Figure 8. Tandem Intermediate Pneumatic Rollers

Table 4. Plantmix Temperatures, Roller Coverages and Modes

Operation	Location	Temperature Range (°F)	Coverages and mode (Test section no. 1)	Coverages and mode (Test section no. 2)
Asphalt Plant	Discharge	325-355	n/a	n/a
Dumping	Windrow	300-320	n/a	n/a
Breakdown rolling	Behind paver	290-300	2.5 vibratory 0.5 static	3 vibratory 1 static
Intermediate rolling	multiple	200-290	4	4
Finish rolling	multiple	175-195	2 vibratory 2 static	2 vibratory 3 static

Table 5. Important Project Stations and Tonnage.

Test Section	Shoulder Stationing	Lane 2 Stationing	Lane 1 Stationing	Plantmix Tonnage	Density Lots / Sublots per Lot	Plantmix Lots / Sublots per Lot	Plantmix Mat Sample Stations
1	LE 300+15 to 233+16	LE 304+20 to 236+50	LE 304+20 to 238+68	2431	3 / 5	1 / 3	LE 286+00, LE 286+50
2	LE 300+15 to 233+16	LE 300+15 to 233+16	LE 300+15 to 233+16	2380	3 / 5	1 / 3	LE 252+00, LE 257+00

Image Source: University of Nevada Reno

Figure 9. Longitudinal Joint Compaction

Quality Control and NDOT Acceptance Sampling and Testing

NDOT performs all acceptance sampling and testing on its projects. Contractors perform quality control (QC) testing, though it does not have to be reported to NDOT. NDOT typically performs asphalt content, gradation and theoretical maximum specific gravity tests on loose mix sampled from the mat behind the paver as illustrated in Figure 10. On this project NDOT performed these tests in a field lab located not far from the project. One exception on this project was that gradations were performed on coldfeed samples taken at the asphalt plant. The reason for this is the aggregate has a tendency to breakdown excessively in the ignition oven. Aggregate Industries SWR, Inc. performed the same tests on mixture sampled at the Sloan Pit asphalt plant location and on split samples taken with NDOT from the mat.

Image Source: University of Nevada Reno

Figure 10. NDOT and Contractor Staff Obtaining Plantmix Samples from the Mat

Each test section represented a lot of plantmix. For each plantmix lot 3 sublot samples were obtained and tests performed. Per the special provisions each test section included 3 density lots randomly selected by NDOT during the paving operations. The selection of locations and nuclear density testing were performed in accordance with Test Method Nev. T335, which includes a correlation with drilled cores (8). For each lot 5 mat density tests were performed using a calibrated nuclear density gage. Density is reported in percent relative to theoretical maximum specific gravity of the plantmix, which is determined in accordance with Test Method Nev. T325B (8). Each test section was a plantmix lot which included 3 sublots. Theoretical maximum specific gravity tests were performed on 2 of the sublot samples per test section. Both NDOT and contractor personnel used Troxler 4640B nuclear density gauges.

The contractor had two QC density technicians on the project full time, which is one more technician than normal. This made it possible for one technician to always be working with paver operator and the roller operators, with primary focus being on monitoring the breakdown compaction. The second technician worked with the other roller operators and assisted NDOT staff with mat sampling. Although the contractor does not formally report QC test results, Aggregate Industries staff did share results verbally and by writing them on the mat next to nuclear density gauge test locations as they were performed. At the first density test location the NDOT and contractor technicians performed density tests next to each other as an informal means of comparing nuclear gage performance/calibration at the start of the day.

Results

The NDOT quality assurance plantmix test reports are presented in Appendix D. The plantmix test reports include asphalt content (%AC), gradation, and theoretical maximum specific gravity. For each test section (day of paving one lift) three plantmix samples were obtained. Table 6 is a summary of plantmix test results. Note that theoretical maximum specific gravities were measured on the first two sublot samples each day of paving and were the basis for reported percent relative density. Individual gradation test results for each sample are presented in the appendix only. All asphalt and gradation test results were within specification tolerances. One of the actions the contractor planned to improve density was to increase asphalt content by 0.1 percent on test section 2. The JMF target was 4.2 percent. The average asphalt content observed on both test sections was 4.5 percent, so the actual increase was greater than planned and the same for both test sections.

Table 6. NDOT QA Plantmix Test Result Summary

Test Section	Sublot	Asphalt Content (%)	Theoretical Maximum Specific Gravity (pcf)
1	1	4.4	160.9
1	2	4.4	160.9
1	3	4.6	-
1	Average	4.5	160.9
2	1	4.4	160.7
2	2	4.6	160.6
2	3	4.6	-
2	Average	4.5	160.7

The NDOT quality assurance density test reports are presented in Appendix E. Table 7 is a summary of mat density results for both test sections showing individual sublot and the lot average values. The sublot values ranged from 93 to 95 percent relative density and all lot averages were 94 percent, with the exception of test section 1 lot 1. This is positive since the standard specification lower density limit is 92 percent.

Table 8 shows the percent within limits (PWL) and pay factors calculated for each lot with the standard specification and both test section special provision mat density requirements applied. Note that the values in bold and italic are the actual values for the two test sections. The other data is simply presented for those curious what the PWL and pay factors would be with each of the different specifications applied. It is important to recognize that when the standard specification is applied the pay factors for five of the six lots are 100 percent and the corresponding pay factors are all 105 percent with the except of one lot which is 99 percent. This illustrates that what the contractor did on both test sections to increase density led a very good quality per the current NDOT standard specifications. Appendix E Table E1, Table E2 and Table E3 show the four readings for each of the five individual sublot density test results reported along with lot averages for test section 1 and Table E4, Table E5 and Table E6 show the four readings for each of the five individual sublot density test results reported along with lot averages for test section 2.

Close review of Table 8 reveals that when the lower density specification limit was raised by 1.0% (test section 1) the observed PWL values were 69 to 95 percent and averaged 80 percent. The corresponding pay factors were 90 to 103 percent and averaged 97 percent. When the lower density specification limit was raised by 2.0% (test section 2) the observed PWL values were 19 to 60 percent and averaged 41 percent. The corresponding pay factors were 64 to 85 percent and averaged 75 percent. One could interpret the test section 2 data to suggest that an increase in mat density lower specification limit of 2 percent would be unreasonable, especially with the extra effort placed on test section 2. Interestingly though, when the test section 1 special provision is applied to the test section 2 observed densities it appears that a 1 percent increase in mat density lower specification limit might be reasonable. This statement is based on the observed PWL values of 87 to 100 percent and average of 91 percent. The corresponding pay factors were 98 to 105 percent and averaged 101 percent. Because asphalt contents were similar among the test sections, the only real operational difference between the test sections was additional breakdown and finish roller coverages.

Table 7. Test Section QA Density Test Results Summary

Test Section	Lot	Sublot 1 Relative Density (pcf)	Sublot 2 Relative Density (pcf)	Sublot 3 Relative Density (pcf)	Sublot 4 Relative Density (pcf)	Sublot 5 Relative Density (pcf)	Lot Average Relative Density (pcf)	Standard Deviation
1	1	93.2	93.2	93.5	94.4	93.0	93.5	0.57
1	2	94.3	93.1	95.2	93.8	94.3	94.1	0.75
1	3	94.8	96.0	92.8	94.2	92.7	94.1	1.41
1	Average	94.1	94.1	93.8	94.1	93.3	93.9	0.91
2	1	94.4	93.1	93.1	93.9	94.8	93.9	0.78
2	2	93.3	93.5	94.3	93.0	93.7	93.6	0.49
2	3	93.7	94.6	93.8	93.8	94.3	94.1	0.41
2	Average	93.8	93.8	93.7	93.6	94.3	93.8	0.56

Table 8. Test Section Percent Within Limits and Pay Factor Summary by Specification Type

Test Section	Lot	Standard Spec. PWL 92-96%	Standard Spec. Pay Factor 92-96%	Special Provision 1 PWL 93-96%	Special Provision 1 Pay Factor 93-96%	Special Provision 2 PWL 94-96%	Special Provision 2 Pay Factor 94-96%
1	1	100	105	***79***	***95***	21	65
1	2	100	105	***99***	***105***	54	82
1	3	95	102	***71***	***91***	47	79
1	Average	98	104	***83***	***97***	41	75
2	1	100	105	88	99	***46***	***78***
2	2	100	105	91	100	***23***	***66***
2	3	100	105	100	105	***58***	***84***
2	Average	100	105	93	101	***42***	***76***

One of the objectives of the density demonstration projects is to compare the density that was being achieved by the contractor, under its normal operations, prior to applying the techniques planned for the demonstration project test section construction. Recall that the techniques select were to use all IC compactors, add a density technician and increase asphalt content (see Table 1 for more detail). The density being achieved under normal operations is referred to as a "Control" section. Table 9 is a summary of 28 density lots obtained on the same project using the same paving crew, asphalt plant and mixture prior to construction of the density demonstration test section. Individual sublot values range from 92 to 96 percent and the lot averages are 93 to 94 percent. The average for all Control lots is 94 percent.

Table 9. Control Relative Densities Prior to Density Demonstration Project Test Sections

Lot	Sublot 1 Relative Density (pcf)	Sublot 2 Relative Density (pcf)	Sublot 3 Relative Density (pcf)	Sublot 4 Relative Density (pcf)	Sublot 5 Relative Density (pcf)	Lot Average (pcf)	Standard Deviation
1	92.4	92.9	92.6	92.7	94.0	92.9	0.62
2	92.7	93.6	93.1	93.9	93.5	93.4	0.49
3	94.2	92.7	94.4	94.2	94.4	94.0	0.74
4	94.0	94.9	94.3	92.4	93.3	93.8	0.96
5	94.2	92.9	93.9	93.5	93.5	93.6	0.46
6	93.3	93.7	93.9	94.3	92.9	93.6	0.53
7	92.3	92.5	92.9	93.8	93.2	92.9	0.59
8	93.3	94.8	93.6	94.6	93.9	94.1	0.63
9	94.5	94.8	93.5	94.3	94.4	94.3	0.46
10	93.4	93.4	93.9	93.4	94.2	93.7	0.37
11	93.6	93.3	93.8	95.7	93.3	93.9	0.99
12	94.2	93.0	93.9	93.3	92.6	93.4	0.64
13	93.6	93.1	93.8	94.0	94.2	93.7	0.44
14	93.4	95.0	92.8	94.5	93.4	93.8	0.88
15	92.7	93.1	93.8	92.9	92.8	93.1	0.42
16	93.3	92.6	94.0	95.3	95.1	94.1	1.16
17	93.7	94.2	93.9	94.7	93.8	94.0	0.41
18	94.3	95.2	95.9	93.2	93.2	94.3	1.20
19	93.4	93.3	93.1	93.9	93.2	93.4	0.32
20	94.4	92.5	93.2	93.0	93.0	93.2	0.70
21	92.8	93.4	93.0	92.8	92.6	92.9	0.32
22	94.0	93.9	93.4	94.0	94.2	93.9	0.28
23	92.8	93.8	95.2	95.1	94.7	94.3	1.03
24	94.0	93.9	92.9	92.6	92.6	93.2	0.69
25	93.0	93.7	94.4	93.1	94.0	93.7	0.58
26	94.6	93.7	93.6	93.9	92.6	93.7	0.72
27	93.2	93.1	92.8	93.2	93.1	93.1	0.18
28	93.3	93.0	92.1	94.7	91.8	93.0	1.14
29	94.0	91.8	91.9	93.1	93.0	92.8	0.89
Average	93.5	93.5	93.6	93.8	93.5	93.6	0.65

Table 10 shows a summary of the percent within limits (PWL) and pay factors calculated for the control and both test sections with the standard specification and special provision mat density requirements applied. Under the standard specification the PWL and pay factor for the control are slightly higher than test section 1 and slightly lower than test section 2. Under special provision 1 (+1 percent) the techniques used by the contractor resulted both test section 1 and test section 2 having higher PWL and pay factors than the control section. The same observation is made under special provision 2. The PWL increases from 77 to 91 and the corresponding pay factor increases from 94 to 101 percent under special provision 1. The PWL increases from 27 to 41 percent and the pay factor increases from 69 to 75 percent under special provision 2. The reason for the improved test section 1 and test section 2 PWL and pay factors is the densities observed in the test sections are more consistent than those observed for the control, which in turn positively impacts PWL and pay factor. If one only looks at the average density between the control and test sections 1 and 2 they appear to be the same. It is particularly interesting to note the significant difference in PWL and pay factors between the control and test section 2 under special provision 1, as this data also suggests that it may be reasonable to consider increasing the minimum density specification by 1.0%.

Table 10. Comparison of Control and Test Section Percent Within Limits and Pay Factors

Test Section	Standard Spec. PWL 92-96%	Standard Spec. Pay Factor 92-96%	Special Provision 1 PWL 93-96%	Special Provision 1 Pay Factor 93-96%	Special Provision 2 PWL 94-96%	Special Provision 2 Pay Factor 94-96%
Control	98	104	78	94	28	69
Test Section 1	98	104	83	97	41	75
Test Section 2	100	105	93	101	42	76

Summary and Conclusions

A density demonstration project with a primary objective of determining if a 1 or 2 percent increase in the current NDOT in-place density specifications could be reasonably achieved by means within a typical NDOT contractor's control was performed. The special provisions for the project included significant bonus potential opportunity to incentivize the contractor to increase density. Different techniques were used by the contractor to try to meet the increased density levels on two test sections, each representing a day of paving (approximately 2500 tons). For the 1 percent increase all rollers were equipped with intelligent compaction technology and two, rather than one, QC density technicians were on the project fulltime. For the 2 percent increase these same techniques were used along with an increase in roller coverages and a planned increase in asphalt content.

NDOT acceptance test results showed that all plantmix properties were within specification tolerance and that the asphalt binder content measured during production was 0.3 percent above the job mix formula target value for both test sections. Mat density sublot values ranged from 93 to 95 percent relative density and all but one lot averages were 94 percent. This is very positive since the lot averages were typically 2 percent higher than the NDOT standard specification lower limit of 92 percent.

An analysis of PWL and pay factors when applying the NDOT standard specification and two project special provisions was performed. When the standard specification was applied the pay factors for five of the six lots were 100 percent and the corresponding pay factors were all 105 percent with the except of one lot which was 99 percent. This illustrates that what the contractor did on both test sections to increase density led to good quality per the current NDOT standard specifications. When the lower density specification limit was raised by 1.0% (test section 1) the observed PWL values were 69 to 95 percent and averaged 80 percent. The corresponding pay factors were 90 to 103 percent and averaged 97 percent. When the lower density specification limit was raised by 2.0% (test section 2) the observed PWL values were 19 to 60 percent and averaged 41 percent. The corresponding pay factors were 64 to 85 percent and averaged 75 percent.

Even though it is a limited data set, the test section 2 data suggests that an increase in mat density specification limit of 2 percent would be unreasonable, especially with the extra effort placed on test section 2 by this contractor. Interestingly though, when the test section 1 special provision is applied to the test section 2 observed densities it appears that a 1 percent increase in mat density lower specification limit may be reasonable. This statement is based on the observed PWL values of 87 to 100 percent and average of 91 percent with corresponding pay factors of 98 to 105 percent, averaging 101 percent. A comparison of a control section consisting of 29 density lots, obtained on the same project prior to the density demonstration test section construction, showed that similar average density values were obtained between the control and test sections, but the test section data was less variable resulting in higher PWL and pay factor values.

Because asphalt contents were similar among the test sections, the only real operational difference between the test sections was additional breakdown and finish roller coverages. Collectively, use of intelligent compactors, additional density QC staff, additional roller coverages and potentially an increase in asphalt content above the JMF target led to increased mat density and improved consistency when compared to the control data. Other factors that contributed to improved density were the production per shift was relatively low (≈2500 tons) and equipment manufacture support was on site because all compactors used were brand new. With the resources available the time needed to achieve the required compaction did not slow down paving operations. Trucking was the limit factor on production rate.

References

1. Tran, N., Turner, P., and Shambley, J., "Enhanced Compaction to Improve Durability and Extend Pavement Service Life: A Literature Review," NCAT Report No. 16-02R, National Center for Asphalt Technology, Auburn University, Auburn, AL, 2016.
2. Horan, B., "Improved Durability Prolongs Pavement Life," Asphalt Magazine, Asphalt Institute, Lexington, KY, Fall 2016.
3. Federal Highway Administration website, https://www.fhwa.dot.gov/pavement/asphalt/density/index.cfm
4. "Contract 3716 Special Provisions," Nevada Department of Transportation, Carson City, NV, 2018, file:///C:/Users/adamhand/Downloads/3716%20Special%20Provisions%20(3).pdf.
5. "Standard Specifications for Road and Bridge Construction," Nevada Department of Transportation, Carson City, NV, 2014.
6. Nevada Department of Transportation Website, https://appss.nevadadot.com/EBiddingPortalClient/Contract/ViewContractDetails.aspx?contractId=10400#
7. Veta Intelligent Compaction Software version 5 download website, http://www.intelligentcompaction.com/veta/
8. Materials Test Manual, Nevada Department of Transportation, Carson City, NV, https://www.nevadadot.com/doing-business/about-ndot/ndot-divisions/operations/materials-section/materials-test-manual

Appendices

Appendix A - Special Provision Excerpt

402.03.06 Compaction. Perform compaction according to “Method B.”

The reference to Test Method No. Nev. T324 in the last sentence of the fourth paragraph on page 163 of the Standard Specifications is hereby changed to Test Method No. Nev. T325.

From station “XE2” 1144+42.70 to station “XE2” 1250+02.70, the third paragraph on page 163 of the Standard Specifications is hereby deleted and the following substituted therefore:

> Each lift of each course of bituminous material will be divided into six “Test Sections” with three test sections located between station “XE2” 1144+42.70 and station “XE2” 1197+22.70 and three test sections located between station “XE2” 1197+22.70 and station “XE2” 1250+02.70.

From station “XE2” 1144+42.70 to station “XE2” 1197+22.70, the fourth paragraph on page 163 of the Standard Specifications is hereby deleted and the following substituted therefore:

1. Compaction Requirements of Test Sections. The density of each test section will be evaluated based on the results of 5 nuclear tests taken at randomly selected locations within the sections as described in Test Method No. Nev. T335. The mean density of the 5 nuclear tests shall not be below 93% nor above 96% (with no single test below 91% nor above 97%) of the “Target” density achieved in the Department’s Field Laboratory using Test Method No. Nev. T325. The Contractor will receive an additional $2,500 per lift for each test section (3 total) meeting these requirements.

From station “XE2” 1197+22.70 to station “XE2” 1250+02.70, the fourth paragraph on page 163 of the Standard Specifications is hereby deleted and the following substituted therefore:

1. Compaction Requirements of Test Sections. The density of each test section will be evaluated based on the results of 5 nuclear tests taken at randomly selected locations within the sections as described in Test Method No. Nev. T335. The mean density of the 5 nuclear tests shall not be below 94% nor above 96% (with no single test below 92% nor above 97%) of the “Target” density achieved in the Department’s Field Laboratory using Test Method No. Nev. T325. The Contractor will receive an additional $3,500 per lift for each test section (3 total) meeting these requirements.

Appendix B - Project Site Plans

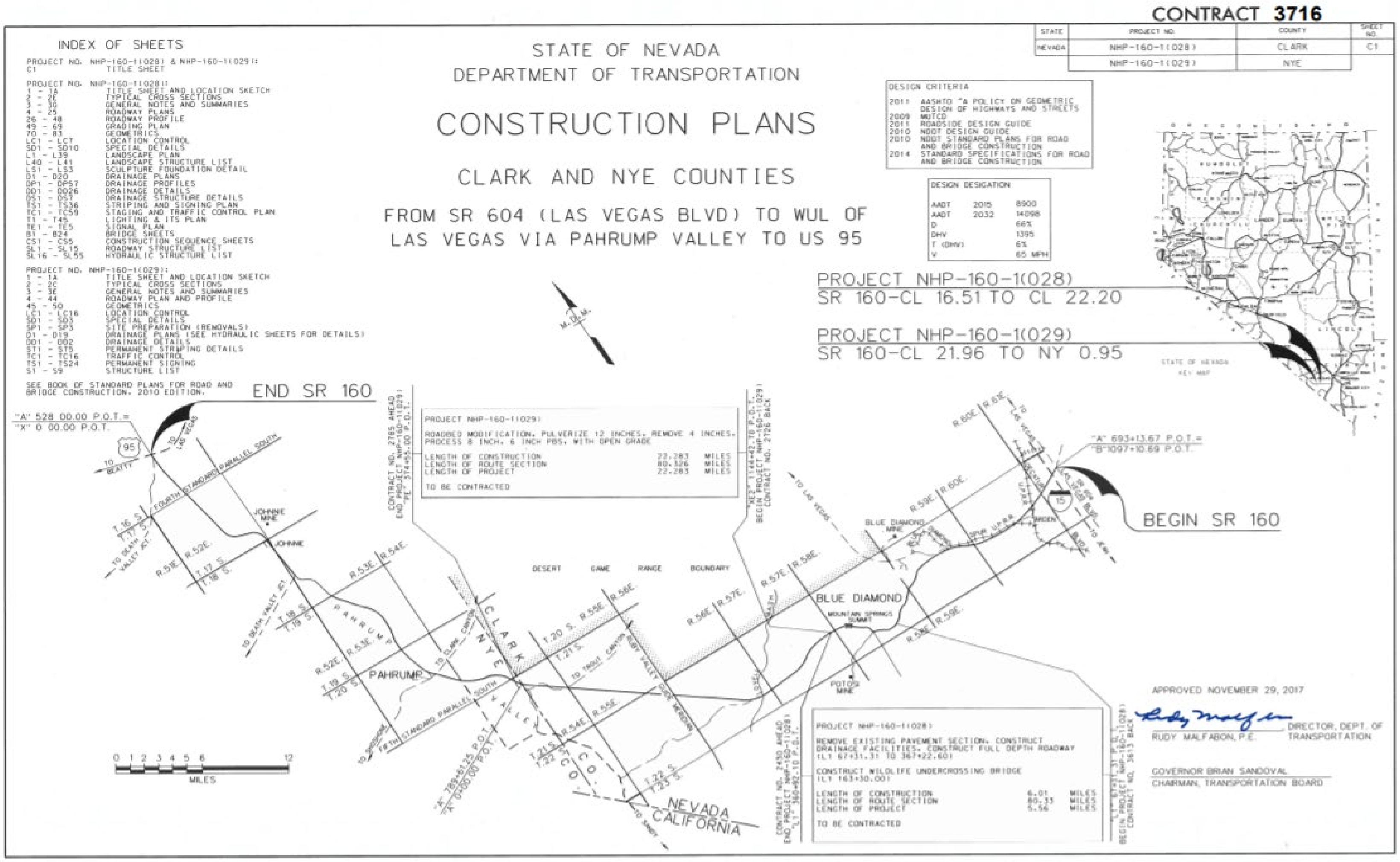

Figure B.1. Project Site Plan Sheet 1.

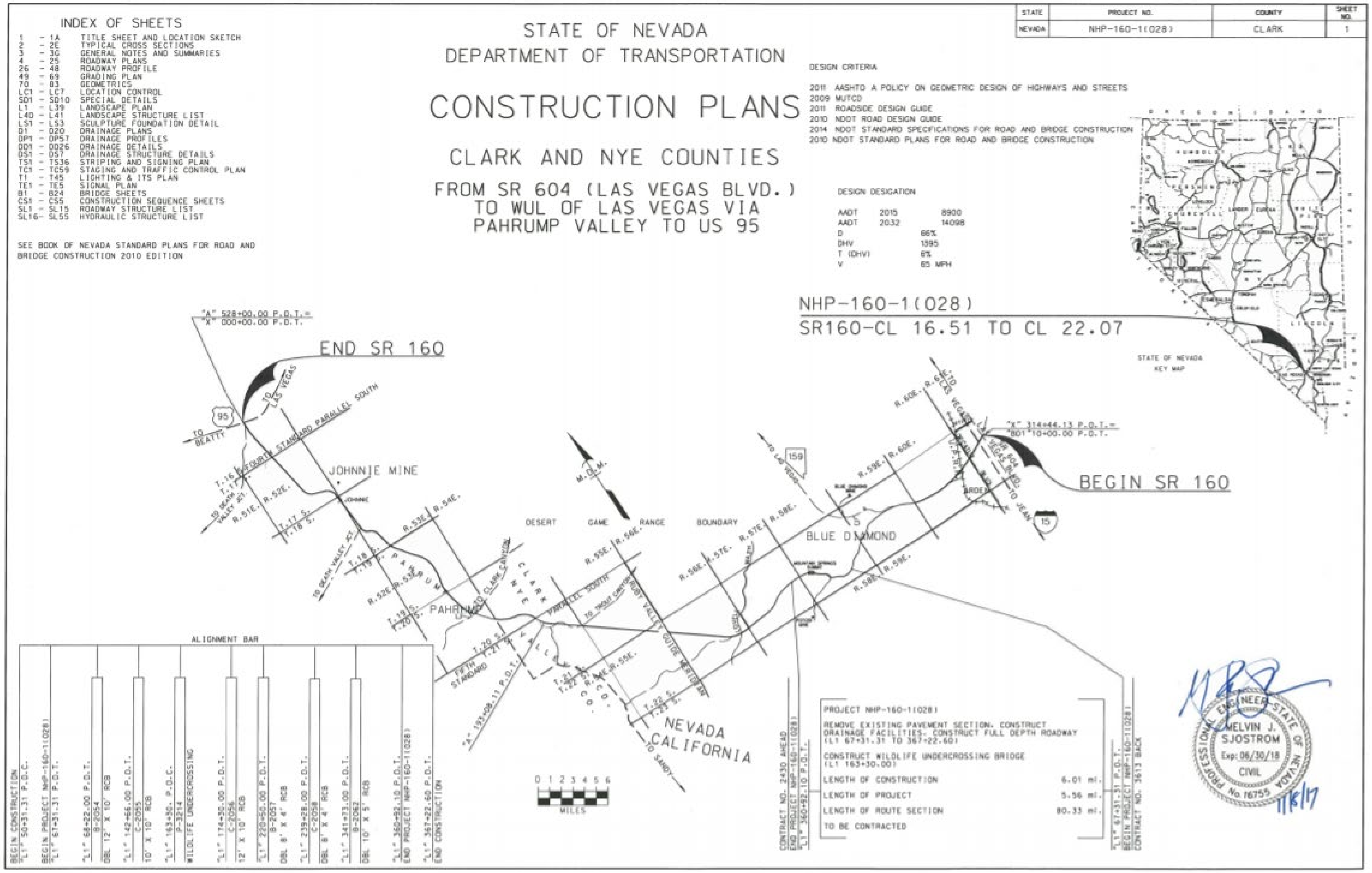

Figure B.2. Project Site Plan Sheet 2.

Appendix C - Type 2C with 15% RAP Job Mix Formula

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

District One
123 East Washington Avenue
Las Vegas, NV 89101
(702) 486-6677
FAX (702) 486-6680

Steve Sisolak
Governor

Kristina Swallows, P.E.
Director

March, 2019

Mr. Ron Adair, Project Manager
Aggregate Industries SWR Inc.
4675 Teco Ave, Suite 140
Las Vegas, NV 89118

Contract No.3716
Project No. NHP-160-1(028) and NHP-160-1(029)
Plantmix Surfacing (Type 2C)(Wet) w/RAP
Mix Design No. BF19-013
Job Mix Formula No. 2

Dear Sir:

The following is **Job-Mix Formula No. 2** for the Plantmix Surfacing (Type 2) (Wet) to be used on Contract No. 3716. The hot plant is owned and operated by Aggregate Industries and is located in Sloan Pit. The mix design represents aggregates sampled in December 2018 from Sloan Pit mixed with PG 76-22NV supplied by **Alon**. Any modifications to the job-mix formula must be approved by the Engineer.

Sieve Size	Percent Passing	Job-Mix Range	Specification Range
1-Inch	100	100	100
¾-Inch	93	88-95	88-95
½-Inch	81	74-85	70-85
3/8-Inch	72	65-78	60-78
No. 4	53	46-60	43-60
No. 10	31	30-35	30-44
No. 40	14	12-18	12-22
No.200	7	5-8	3-8

The bitumen ratio to be added shall be 3.6% (± 0.4% operational tolerance, Subsection 401.02.02) **Alon** Asphalt Cement, Grade PG 76-22 NV. The bitumen ratio of the recycled asphalt pavement (RAP) shall be 0.6%. The total bitumen ratio (after the ignition oven) shall be 4.2%. Do not use the ± 0.4% operational tolerance as a means to alter the bitumen ratio target value.

All aggregates with the exception of the recycled asphalt pavement (RAP) shall be marinated per Standard Specification Subsection 401.03.08 (Marination Method), using 1% lime for coarse aggregates and 2% lime for fine aggregates. The combined lime for the above bin percentages shall be 1.5%.

The Bin percentages shall be as follows:

19mm (3/4")	10% Sloan Pit
12.5mm (1/2")	20% Sloan Pit
9.5mm (3/8")	12% Sloan Pit
Chips	13% Sloan Pit
Crusher Fines	30% Sloan Pit
1/2" RAP	15% Agg Industries

Appendix D - NDOT Plantmix Quality Assurance Test Results

Mr. Ron Adair, Project Manager
Aggregate Industries SWR Inc.
March 7, 2019

Contract No.3716
Project No. NHP-STP-0160(028), (029)
Plantmix Surfacing (Type 2C)(Wet) w/Rap
Mix Design No. BF17-13
Job Mix Formula No. 2

No baghouse fines are allowed to be introduced into the mix, until that material is included in the plant calibration. If included in the plant calibration, the baghouse fines will not exceed 2% by dry mass of the aggregate and must remain consistent.

Target temperature of the mixture in the hauling vehicle leaving the plant shall be a **minimum of 320 °F, although a higher temperature may be advisable for better workability and compaction, with a maximum temperature at the plant of 350 °F, and a maximum 20 °F drop in temperature from the time the mix leaves the plant until arriving at the paver drop.**

The minimum temperature at the site of placement shall not be below 300 °F.

All percentages are based on dry weight of aggregate and RAP.

Should you have any questions, please contact this office.

Sincerely,

DocuSigned by:
Don Christiansen P.E.

Don J. Christiansen, P.E.
Resident Engineer

pc: Sami Lompa, P.E., Assistant Construction Engineer; Mario Gomez, P.E., Assistant District Engineer; Darin Tedford, P.E., Chief Materials Engineer; Las Vegas Progress Lab; Jayson Vorce, Quality Assurance; District One Lab; PBS2C_J1 /BF19-013 3716

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

THEORETICAL MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES (FIELD METHOD)

Material Type:	TYPE 2C W/RAP	Date:	6/26/19
Tested By:	D. VALLEDOOR	Contract Number:	3776
Sampled By:	D. VALLEDOOR	Test Number (same as burn-off):	7-1-48
Sampled From Station:	"LE" 206+00	Time of Day:	7:30 AM
Lot / Sublot:			

FIELD RICE RESULTS

"A" = Mass of sample in air	2642.3
"B" = Mass of pycnometer and water	7745.7
"C" = Mass of evacuated sample, pycnometer and water	9363.4

APPARENT SPECIFIC GRAVITY

A / [(A + B) - C] = 2.579

DENSITY

S.G. x 1 Mg/m³ = 2.579 Mg/m³

S.G. x 62.4 lbs/ft³ = 160.9 lbs/ft³

Resident Engineer: [signature]

DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-030
08/10

Distribution: Headquarters Construction, District, Resident Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

THEORETICAL MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES (FIELD METHOD)

Material Type:	TYPE 2C W/RAP	Date:	6/26/19
Tested By:	D. VALLERDOR	Contract Number:	3716
Sampled By:	D. BUTLER	Test Number (same as burn-off):	7-2-48
Sampled From Station:	"LE" 206+50	Time of Day:	10:15 AM
Lot / Sublot:			

FIELD RICE RESULTS

"A" = Mass of sample in air	2684.5
"B" = Mass of pycnometer and water	7745.7
"C" = Mass of evacuated sample, pycnometer and water	9398.7

APPARENT SPECIFIC GRAVITY

$A / [(A + B) - C] =$ 2.578

DENSITY

S.G. x 1 Mg/m^3 = 2.578 Mg/m^3

S.G. x 62.4 lbs/ft^3 = 160.9 lbs/ft^3

Resident Engineer: [signature]

DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-030
08/10

Distribution: Headquarters Construction, District, Resident Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

THEORETICAL MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES (FIELD METHOD)

Material Type:	TYPE 2C W/RAP	Date:	6/28/19
Tested By:	D.VALLEDOUR	Contract Number:	3716
Sampled By:	D.VALLEDOUR	Test Number (same as burn-off):	7-1-49
Sampled From Station:	"LE" 257+00	Time of Day:	7:18 AM
Lot / Sublot:			

FIELD RICE RESULTS

"A" = Mass of sample in air	2654.6
"B" = Mass of pycnometer and water	7748.1
"C" = Mass of evacuated sample, pycnometer and water	9372.2

APPARENT SPECIFIC GRAVITY

A / [(A + B) - C] = 2.576

DENSITY

S.G. x 1 Mg/m^3 = 2.576 Mg/m^3

S.G. x 62.4 lbs/ft^3 = 160.7 lbs/ft^3

Resident Engineer: [signature]

DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-030
08/10

Distribution: Headquarters Construction, District, Resident Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

THEORETICAL MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES (FIELD METHOD)

Material Type:	TYPE 2C W/RAP	Date:	6/28/19
Tested By:	D. VALLADOR	Contract Number:	3716
Sampled By:	D. BUTLER	Test Number (same as burn-off):	7-2-49
Sampled From Station:	"LE" 252 +00	Time of Day:	10:40 Am
Lot / Sublot:			

FIELD RICE RESULTS

"A" = Mass of sample in air	2636.6
"B" = Mass of pycnometer and water	7748.1
"C" = Mass of evacuated sample, pycnometer and water	9360.5

APPARENT SPECIFIC GRAVITY

A / [(A + B) - C] = 2.574

DENSITY

S.G. x 1 Mg/m³ = 2.574 Mg/m³

S.G. x 62.4 lbs/ft³ = 160.6 lbs/ft³

Resident Engineer: [signature]

DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-030
08/10

Distribution: Headquarters Construction, District, Resident Engineer, Contractor

✓FG

Elapsed Time: 85:00
Sample Weight: 2539g
Weight Loss: 137.7g
Percent Loss: 5.42%
Temp Comp: 0.07%
Calib. Factor: 1.02%
Bitumen Ratio: 4.64%

Calibrated Asphalt Ctnt
4.33%

Filter Set Pt: 750 C
Chamber Set Pt: 482 C

Tested By: D. VALLADOR
Mix Type: TYPE 2C W/RAP
Sample ID: T-1-48
Time: 6:06:53
Date: 06-26-19

Elapsed Time: 86:00
Sample Weight: 2586g
Weight Loss: 133.7g
Percent Loss: 5.17%
Temp Comp: 0.09%
Calib. Factor: 1.02%
Bitumen Ratio: 4.35%

Calibrated Asphalt Ctnt
4.07%

Filter Set Pt: 750 C
Chamber Set Pt: 482 C

Tested By: D. VALLADOR
Mix Type: TYPE 2C W/RAP
Sample ID: T-2-48
Time: 10:36:06
Date: 06-26-19

Elapsed Time: 96:00
Sample Weight: 2620g
Weight Loss: 135.7g
Percent Loss: 5.18%
Temp Comp: 0.08%
Calib. Factor: 1.02%
Bitumen Ratio: 4.38%

Calibrated Asphalt Ctnt
4.10%

Filter Set Pt: 750 C
Chamber Set Pt: 482 C

Tested By: J. Flores
Mix Type: Type 2C w RAP
Sample ID: T-3-48
Time: 16:47:29
Date: 06-26-19

Page: 1 of 10
Report No.: 48
Contract No.: 3716
Contractor: AGG. INDUSTRIES

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
DAILY PLANT REPORT OF ASPHALT MIXTURES

FIELD TESTER'S REPORT

Date: 6/26/19 Sampled/Tested by: D.V. / D.B / J.F.

SIEVE ANALYSIS SAMPLES

Specification References: 705.03.01, 401.03.09, 401.02-02
Mix Design No.: BF19-13 Job-Mix Formula No.: 02
Type of mix: TYPE 2C W/RAP Job-Mix Bitumen Ratio: 4.2

	Sample Number			Job-Mix Range	Specification Limits
	T-1-48	T-2-48	T-3-48		
Bitumen Ratio	4.6	4.4	4.4	3.8-4.6	± 0.4
% Moisture (belt)	2.0	1.9	1.7		
% Moisture (mix)	0.00	0.00	0.00		1% Max.
Pass 1"	100	100	100	100	100
Pass 3/4"	93	90	93	88-95	88-95
Pass 1/2"	77	73	77	74-85	70-85
Pass 3/8"	73	69	72	65-78	60-78
Pass No. 4	57	54	56	46-60	43-60
Pass No. 10	32	31	31	30-35	30-44
Pass No. 16					
Pass No. 40	15	16	15	12-18	12-22
Pass No. 200	7	7	8	5-8	3-8

	Sample Number			Job-Mix Range	Specification Limits
Bitumen Ratio					± 0.4
% Moisture (belt)					
% Moisture (mix)					1% Max.
Pass 1"					
Pass 3/4"					
Pass 1/2"					
Pass 3/8"					
Pass No. 4					
Pass No. 10					
Pass No. 16					
Pass No. 40					
Pass No. 200					

Remarks: T-2-48 FAILED ON 1/2" SIEVE SCREEN

Distribution: HQ Construction, District, Resident Engeer, Contractor

PLANT INSPECTOR'S REPORT

Date: 6/26/19 Contract No.: 3716
Inspection by: D. Kalling
Type of plant: Dryer Drum
Location of plant: Aggregate (Sloan)
Source of asphalt cement: Alon
Type of asphalt cement: PG 76-22 NV
Source of coarse agg.: Aggregate
Source of fine agg.: Aggregate
Type of mineral filler: Hydrated Lime
Type of Mix: 2C w/Rap
Mix Design No.: BF 19-13
Job-Mix Formula No.: 02
Job-Mix Bitumen Ratio: 4.2%

REPORT OF ASPHALT QUANTITIES

Plantmix produced (before waste): 2431.06 tons
Plantmix wasted/rejected at plant: -0- tons
Reason for waste:

REPORT OF TEMPERATURES AT PLANT

Specified minimum asphalt cement temp: 320 F
JMF Mix temp. range: 320 to 350 F

Time	Asphalt	Plantmix	Time	Asphalt	Plantmix
1:40A	345°F				
2:30A	341°F				
3:30A	346°F				
4:30A	344°F				
5:35A	340°F				
6:30A	339°F				
7:30A	338°F				
8:25A	340°F				
9:25A	335°F				

Remarks:

Resident Engineer: [signature] DON CHRISTIANSEN, P.E. RESIDENT ENGINEER

STREET INSPECTOR'S REPORT

Date: 6.26.19 Contract No.: 3716
Inspection by: CJW
Weather Conditions: Sunny
Atmospheric temps: Low: 62 High: 97 °F
Surface temps: Low: 69 High: 134 °F

RUNNING YIELD CHECKS

Time	Line/Station	Length	TPS Field	TPS Plan	Yield %
8:30	RS 300+15				
	LS 265+85	3430'	18.95	18.72	101.3
4:30	LS 304+20				
	LS 272+50	3170'	30.64	29.98	102.2

TPS Field = Length x Width x Depth x lbs/ft³(dcs) x % compaction ÷ 2000
TPS Plan = Length x Width x Depth x lbs/ft³ (as shown in the plans) ÷ 2000
Yield % = TPS Field ÷ TPS Plan x 100

REPORT OF ASPHALT QUANTITIES

Total plantmix delivered to paver: 2431.59 tons
Total plantmix wasted at paver: 52.47 tons
Total plantmix placed: (delivered-wasted) 2378.59 tons
Reason for waste: Truck broke down, Test and End of the day excess

REPORT OF TEMPERATURES AT PAVER

JMF Minimum mix temperature at paver: 300 °F

Time	Plantmix	Time	Plantmix	Time	Plantmix
5:00	328	10:20	334	4:30	327
5:45	335	11:03	332		
6:25	331	1:20	335		
7:15	332	2:05	334		
8:45	327	2:55	331		
9:05	329	3:25	329		
9:50	328	3:55	329		

Remarks: Shoulder 10' width 3" depth
Lane 1 16' width 3" depth
160.9 am 160.9 pm

NDOT 040-011
Rev. 10/17

Elapsed Time: 85:00
Sample Weight: 2537g
Weight Loss: 130.3g
Percent Loss: 5.14%
Temp Comp: 0.05%
Calib. Factor: 1.02%
Bitumen Ratio: 4.35%

Calibrated Asphalt Ctnt
4.07%

Filter Set Pt: 750 C
Chamber Set Pt: 482 C

Tested By: D. VALLEDOR
Mix Type: TYPE 2C W/RAP
Sample ID: T-1-49
Time: 6:02:50
Date: 06-28-19

Elapsed Time: 86:00
Sample Weight: 2550g
Weight Loss: 138.2g
Percent Loss: 5.42%
Temp Comp: 0.07%
Calib. Factor: 1.02%
Bitumen Ratio: 4.64%

Calibrated Asphalt Ctnt
4.33%

Filter Set Pt: 750 C
Chamber Set Pt: 482 C

Tested By: D. VALLEDOR
Mix Type: TYPE 2C W/RAP
Sample ID: T-2-49
Time: 9:09:56
Date: 06-28-19

Elapsed Time: 98:00
Sample Weight: 2748g
Weight Loss: 148.4g
Percent Loss: 5.40%
Temp Comp: 0.05%
Calib. Factor: 1.02%
Bitumen Ratio: 4.63%

Calibrated Asphalt Ctnt
4.33%

Filter Set Pt: 750 C
Chamber Set Pt: 482 C

Tested By: J.F
Mix Type: Type 2C W/RAP
Sample ID: T-3-49
Time: 13:55:55
Date: 06-28-19

Page: 1 of 10
Report No.: 49
Contract No.: 3716
Contractor: AGG. INDUSTRIES

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
DAILY PLANT REPORT OF ASPHALT MIXTURES

FIELD TESTER'S REPORT

Date: 6/28/19 Sampled/Tested by: D.V./D.B/J.F., D.V

SIEVE ANALYSIS SAMPLES

Specification References: 705.03.01, 401.03.09, 401.02-02
Mix Design No.: BF19-13 Job-Mix Formula No.: 02
Type of mix: TYPE 2C W/RAP Job-Mix Bitumen Ratio: 4.2

	Sample Number T-1-49	T-2-49	T-3-49	Job-Mix Range	Specification Limits
Bitumen Ratio	4.4	4.6	4.6	3.8-4.6	± 0.4
% Moisture (belt)	1.9	1.5	1.3		
% Moisture (mix)	0.00	0.00	0.00		1% Max.
Pass 1"	100	100	100	100	100
Pass 3/4"	93	90	91	88-95	88-95
Pass 1/2"	79	76	75	74-85	70-85
Pass 3/8"	74	72	71	65-78	60-78
Pass No. 4	58	56	55	46-60	43-60
Pass No. 10	34	31	30	30-35	30-44
Pass No. 16					
Pass No. 40	17	16	15	12-18	12-22
Pass No. 200	8	8	8	5-8	3-8

	Sample Number			Job-Mix Range	Specification Limits
Bitumen Ratio					± 0.4
% Moisture (belt)					
% Moisture (mix)					1% Max.
Pass 1"					
Pass 3/4"					
Pass 1/2"					
Pass 3/8"					
Pass No. 4					
Pass No. 10					
Pass No. 16					
Pass No. 40					
Pass No. 200					

Remarks: Material met all required specs.

Distribution: HQ Construction, District, Resident Engeer, Contractor

PLANT INSPECTOR'S REPORT

Date: 6/28/19 Contract No.: 3716
Inspection by: D. Kalling
Type of plant: Dryer Drum
Location of plant: Aggregate (Sloan)
Source of asphalt cement: Alon
Type of asphalt cement: PG 76-22 NV
Source of coarse agg.: Aggregate
Source of fine agg.: Aggregate
Type of mineral filler: Hydrated Lime
Type of Mix: 2C W/Rap
Mix Design No.: BF 19-13
Job-Mix Formula No.: 02
Job-Mix Bitumen Ratio: 4.2%

REPORT OF ASPHALT QUANTITIES

Plantmix produced (before waste): 2379.80 tons
Plantmix wasted/rejected at plant: 0 tons
Reason for waste:

REPORT OF TEMPERATURES AT PLANT

Specified minimum asphalt cement temp: 320 F
JMF Mix temp. range: 320 to 350 F

Time	Asphalt	Plantmix	Time	Asphalt	Plantmix
1:40A	336°F				
2:30A	341°F				
3:30A	337°F				
4:35A	339°F				
5:30A	338°F				
6:25A	335°F				
7:30A	336°F				
8:25A	337°F				
9:35A	342°F				

Remarks:

Remarks:

Resident Engineer: [signature]
DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

STREET INSPECTOR'S REPORT

Date: 6.28.19 Contract No.: 3716
Inspection by: CJW
Weather Conditions: Sunny
Atmospheric temps: Low: 71 High: 100 °F
Surface temps: Low: 72 High: 130 °F

RUNNING YIELD CHECKS

Time	Line/Station	Length	TPS Field	TPS Plan	Yield %
7:45	"LS" 265+85				
	"LS" 233+16	3269'	18.89	18.88	100
1:30	"LS" 272+50				
	"LP" 238+68	3382'	29.72	30.20	98.4

TPS Field = Length x Width x Depth x lbs/ft³ (rice) x % compaction ÷ 2000
TPS Plan = Length x Width x Depth x lbs/ft³ (as shown in the plans) ÷ 2000
Yield % = TPS Field ÷ TPS Plan x 100

REPORT OF ASPHALT QUANTITIES

Total plantmix delivered to paver: 2379.80 tons
Total plantmix wasted at paver: 9.80 tons
Total plantmix placed: (delivered-wasted) 2370 tons
Reason for waste: Test and end of the day excess.

REPORT OF TEMPERATURES AT PAVER

JMF Minimum mix temperature at paver: 300 °F

Time	Plantmix	Time	Plantmix	Time	Plantmix
5:00	325	10:40	330		
5:45	339	11:30	335		
6:30	340	12:10	330		
7:25	339	12:55	329		
8:20	325	1:55	336		
8:50	332	2:35	338		
9:20	339				

Remarks: Shoulder 10' width 3" depth
Lane 1 16' width 3" depth
160.7 am 160.6 pm

NDOT 040-011
Rev. 10/17

Appendix E - NDOT Density Quality Assurance Test Results

Tables E1 through E6 show the four readings for each of the five individual sublot density test results reported along with lot averages.

Table E1. Test Section 1 Lot 1 Mat Density Test Results (06/26/19).

Test #	133-PM-1	133-PM-2	133-PM-3	133-PM-4	133-PM-5	**Average**
Station (nearest 25 ft.)	295+75	289+00	281+00	277+00	271+50	**n/a**
Distance from Edge (ft)	2	7	1	2	7	**4**
Left or Right	Left	Left	Left	Left	Left	**Left**
Reading #1 (pcf)	149.5	149.7	149.7	152.0	149.8	**150.1**
Reading #2 (pcf)	150.6	149.4	150.3	151.1	150.5	**150.4**
Reading #3 (pcf)	149.7	150.0	150.1	152.4	148.9	**150.2**
Reading #4 (pcf)	149.9	150.6	151.8	152.2	149.2	**150.7**
Average (pcf)	149.9	149.9	150.5	151.9	149.6	**150.4**
Correction Factor	1.0	1.0	1.0	1.0	1.0	**1.0**
Corrected Density (pcf)	149.9	149.9	150.5	151.9	149.6	**150.4**
% Relative Compaction	93	93	94	94	93	**93**

Table E2. Test Section 1 Lot 2 Mat Density Test Results (06/26/19).

Test #	134-PM-1	134-PM-2	134-PM-3	134-PM-4	134-PM-5	**Average**
Station (nearest 25 ft.)	303+50	291+00	286+50	276+50	271+25	**n/a**
Distance from Edge (ft)	3	4	8	5	4	**5**
Left or Right	Left	Left	Left	Left	Left	**Left**
Reading #1 (pcf)	151.7	149.9	152.6	150.1	150.3	**150.9**
Reading #2 (pcf)	150.9	150.3	153.9	151.8	152.5	**151.3**
Reading #3 (pcf)	152.3	150.0	152.8	150.8	152.2	**151.6**
Reading #4 (pcf)	151.7	149.0	153.2	150.8	151.7	**151.3**
Average (pcf)	151.7	149.8	153.1	150.9	151.7	**151.4**
Correction Factor	1.0	1.0	1.0	1.0	1.0	**1.0**
Corrected Density (pcf)	151.7	149.8	153.1	150.9	151.7	**151.4**
% Relative Compaction	94	93	95	94	94	**94**

Table E3. Test Section 1 Lot 2 Mat Density Test Results (06/26/19).

Test #	135-PM-1	135-PM-2	135-PM-3	135-PM-4	135-PM-5	**Average**
Station (nearest 25 ft.)	300+25	292+25	289+00	281+00	278+00	**n/a**
Distance from Edge (ft)	9	15	1	6	5	**7**
Left or Right	Left	Left	Left	Left	Left	**Left**
Reading #1 (pcf)	152.7	153.9	148.9	150.8	148.2	**150.9**
Reading #2 (pcf)	152.2	155.9	149.7	151.2	149.2	**151.6**
Reading #3 (pcf)	153.3	154.2	149.7	152.6	149.8	**151.9**
Reading #4 (pcf)	151.8	154.0	148.8	151.7	149.3	**151.1**
Average (pcf)	152.5	154.5	149.3	151.6	149.1	**151.4**
Correction Factor	1.0	1.0	1.0	1.0	1.0	**1.0**
Corrected Density (pcf)	152.5	154.5	149.3	151.6	149.1	**151.4**
% Relative Compaction	95	96	93	94	93	**94**

Table E4. Test Section 2 Lot 1 Mat Density Test Results (06/28/19).

Test #	136-PM-1	136-PM-2	136-PM-3	136-PM-4	136-PM-5	**Average**
Station (nearest 25 ft.)	259+75	253+25	251+75	245+00	236+75	**n/a**
Distance from Edge (ft)	2	10	10	3	2	**5**
Left or Right	Left	Left	Left	Left	Left	**Left**
Reading #1 (pcf)	153.9	149.0	149.4	152.6	154.1	**151.8**
Reading #2 (pcf)	150.8	148.9	148.8	151.3	150.5	**150.9**
Reading #3 (pcf)	151.4	149.1	150.9	149.6	153.7	**150.6**
Reading #4 (pcf)	150.8	151.3	149.3	150.2	151.3	**150.8**
Average (pcf)	151.7	149.6	149.6	150.9	152.4	**150.8**
Correction Factor	1.0	1.0	1.0	1.0	1.0	**1.0**
Corrected Density (pcf)	151.7	149.6	149.6	150.9	152.4	**150.8**
% Relative Compaction	94	93	93	94	95	**94**

Table E5. Test Section 2 Lot 2 Mat Density Test Results (06/28/19).

Test #	137-PM-1	137-PM-2	137-PM-3	137-PM-4	137-PM-5	**Average**
Station (nearest 25 ft.)	266+25	257+50	251+75	244+00	237+00	**n/a**
Distance from Edge (ft)	1	3	6	4	4	**4**
Left or Right	Left	Left	Left	Left	Left	**Left**
Reading #1 (pcf)	149.4	150.6	152.2	149.0	150.5	**150.3**
Reading #2 (pcf)	149.8	151.1	151.1	149.3	150.2	**150.3**
Reading #3 (pcf)	149.9	149.1	151.2	149.9	150.7	**150.2**
Reading #4 (pcf)	150.8	150.4	151.4	149.4	150.9	**150.6**
Average (pcf)	149.9	150.3	151.5	149.4	150.6	**150.3**
Correction Factor	1.0	1.0	1.0	1.0	1.0	**1.0**
Corrected Density (pcf)	149.9	150.3	151.5	149.4	150.6	**150.3**
% Relative Compaction	93	94	94	93	94	**94**

Table E6. Test Section 2 Lot 3 Mat Density Test Results (06/28/19).

Test #	138-PM-1	138-PM-2	138-PM-3	138-PM-4	138-PM-5	**Average**
Station (nearest 25 ft.)	267+75	260+25	256+50	249+75	240+75	**n/a**
Distance from Edge (ft)	11	16	12	10	9	**12**
Left or Right	Left	Left	Left	Left	Left	**Left**
Reading #1 (pcf)	151.4	152.8	150.5	150.3	152.5	**151.5**
Reading #2 (pcf)	150.9	152.2	150.1	151.2	150.8	**151.0**
Reading #3 (pcf)	150.7	151.6	151.5	150.5	150.9	**151.0**
Reading #4 (pcf)	149.9	151.8	151.1	151.2	152.2	**151.2**
Average (pcf)	150.5	152.1	150.8	150.8	151.6	**151.2**
Correction Factor	1.0	1.0	1.0	1.0	1.0	**1.0**
Corrected Density (pcf)	150.5	152.1	150.8	150.8	151.6	**151.2**
% Relative Compaction	94	95	94	94	94	**94**

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
NUCLEAR THIN LAYER COMPACTION REPORT
FOR PLANTMIX BITUMINOUS PAVEMENTS

Material Type	PBS Type 2C w/RAP	Contract Number	3716
Lift, Lane & Direction	1st Lift, Lane 3 shoulder, EB	Date	6/26/19
Width and Depth	10' w x 3" D	Gauge Set Number	148
Lot/Sublot		Tested By	D. Butler

TEST SECTION

Sta. 295+79 Sta. 288+97 Sta. 280+91 Sta. 277+10 Sta. 271+45

300+15 | 293+29 | 286+43 | 279+57 | 272+71 | 265+85

Random Number Block: 31

Beginning Station "2E" 300+15
Ending Station "2E" 265+85

(A x length = longitudinal , B x width = transverse)

A					B				
686	x	0.636	=	436.3	10	x	0.195	=	2.0
686	x	0.630	=	432.2	10	x	0.673	=	6.7
686	x	0.804	=	551.5	10	x	0.112	=	1.1
686	x	0.360	=	247.0	10	x	0.193	=	1.9
686	x	0.183	=	125.5	10	x	0.651	=	6.5

TARGET DENSITY Mg/m³ (pcf) 160.9 From (RICE) test number T-1-48

TEST #	133-PM-1		133-PM-2		133-PM-3		133-PM-4		133-PM-5	
STATION nearest 10m (25 ft.)	295+75		289+00		281+00		277+00		271+50	
Distance from edge	2	* Joint	7	* Joint	1	* Joint	2	* Joint	7	* Joint
Left or Right	LT		LT		LT		LT		LT	
NUCLEAR 1	149.5		149.7		149.7		152.0		149.8	
DENSITY 2	150.6		149.4		150.3		151.1		150.5	
READINGS 3	149.7		150.0		150.1		152.4		148.9	
4	149.9		150.6		151.8		152.2		149.2	
Average Density	149.9		149.9		150.5		151.9		149.6	
Corrected Density	149.9		149.9		150.5		151.9		149.6	
% Relative Compaction	93		93		94		94		93	

Correction Factor 1.00

* Mean Test Section Density, Mg/m³ (pcf)= 150.4
* Mean Percent relative Compaction= 93

* Not Applicable to Partial Test Sections or Joint Densities

Special Provision spec.
Single: 91-97
Mean: 93-96

Remarks: Test section meets required spec plus special provisions spec 402.03.06

Joint Test Specification	Min.	90		
Single Test Specification	Min.	90	Max.	97
Mean Test Section Specification	Min.	92	Max.	96

Accepted ✓ Rejected ☐

Resident Engineer Signature [signature]
DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-017
Rev. 5/05

Distribution: Headquarters Construction, Resident Engineer, District Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
NUCLEAR THIN LAYER COMPACTION REPORT
FOR PLANTMIX BITUMINOUS PAVEMENTS

Material Type	PBS Type 2C w/RAP	Contract Number	3716
Lift, Lane & Direction	1st Lift, Lane 2, EB	Date	6/26/19
Width and Depth	12' w x 3" D	Gauge Set Number	148
Lot/Sublot		Tested By	D. Butler

TEST SECTION

Sta. 303+49.7 | Sta. 290+92.1 | Sta. 286+47.3 | Sta. 276+60.2 | Sta. 271+36.8

304+20 | 297+17.2 | 290+14.8 | 283+12.3 | 276+09.6 | 269+07

Random Number Block: 24

Beginning Station "LE" 304+20
Ending Station "LE" 269+07

(A x length = longitudinal , B x width = transverse)

A					B				
702.6	x	0.100	=	70.3	12	x	0.259	=	3.1
702.6	x	0.890	=	625.3	12	x	0.317	=	3.8
702.6	x	0.523	=	367.5	12	x	0.665	=	8.0
702.6	x	0.928	=	652.0	12	x	0.404	=	4.8
702.6	x	0.673	=	472.8	12	x	0.305	=	3.7

TARGET DENSITY Mg/m³ (pcf) 160.9 From (RICE) test number T-2-48

TEST #	134-PM-1		134-PM-2		134-PM-3		134-PM-4		134-PM-5	
STATION nearest 10m (25 ft.)	303+50		291+00		286+50		276+50		271+25	
Distance from edge	3	* Joint	4	* Joint	8	* Joint	5	* Joint	4	* Joint
Left or Right	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT
NUCLEAR DENSITY READINGS 1	151.7	148.0	149.9	149.4	152.6	148.5	150.1	149.2	150.3	148.0
2	150.9	151.2	150.3	149.0	153.9	149.9	151.8	148.4	152.5	144.4
3	152.3		150.0		152.8		150.8		152.2	
4	151.7		149.0		153.2		150.8		151.7	
Average Density	151.7	149.6	149.8	149.2	153.1	149.2	150.9	148.8	151.7	146.2
Corrected Density	151.7	149.6	149.8	149.2	153.1	149.2	150.9	148.8	151.7	146.2
% Relative Compaction	94	93	93	93	95	93	94	92	94	91

Correction Factor: 1.00

* Mean Test Section Density, Mg/m³ (pcf)= 151.4
* Mean Percent relative Compaction= 94

* Not Applicable to Partial Test Sections or Joint Densities

Special Provision spec
Single: 91-97
Mean: 93-96

Remarks: Test section meets required spec plus Special Provisions spec 402.03.06

Joint Test Specification	Min.	90		
Single Test Specification	Min.	90	Max.	97
Mean Test Section Specification	Min.	92	Max.	96

Accepted ✓ Rejected ☐

Resident Engineer Signature [signature]

DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-017
Rev. 5/05

Distribution: Headquarters Construction, Resident Engineer, District Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
NUCLEAR THIN LAYER COMPACTION REPORT
FOR PLANTMIX BITUMINOUS PAVEMENTS

Material Type	PBS Type 2C w/RAP	Contract Number	3716
Lift, Lane & Direction	1st Lift, Lane 1, EB	Date	6/26/19
Width and Depth	16' w x 3" D	Gauge Set Number	148
Lot/Sublot		Tested By	D. Butler

TEST SECTION

Sta. 300+26 | Sta. 292+32 | Sta. 288+91 | Sta. 280+95 | Sta. 278+03

304+20 | 297+86 | 291+32 | 285+18 | 278+84 | 272+50

Random Number Block: 17

Beginning Station: "LE" 304+20
Ending Station: "LE" 272+50

(A x length = longitudinal , B x width = transverse)

A					B				
634	x	0.622	=	394.3	16	x	0.548	=	8.8
634	x	0.873	=	553.5	16	x	0.964	=	15.4
634	x	0.412	=	261.2	16	x	0.064	=	1.0
634	x	0.667	=	422.9	16	x	0.356	=	5.7
634	x	0.127	=	80.5	16	x	0.284	=	4.5

TARGET DENSITY Mg/m³ (pcf) 160.9 From (RICE) test number T-2-48

TEST #	135-PM- 1		135-PM- 2		135-PM- 3		135-PM- 4		135-PM- 5	
STATION nearest 10m (25 ft.)	300+25		292+25		289+00		281+00		278+00	
Distance from edge	9	* Joint	15	* Joint	1	* Joint	6	* Joint	5	* Joint
Left or Right	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT
NUCLEAR 1	152.7	145.5	153.9	148.6	148.9	152.5	150.8	153.6	148.2	149.2
DENSITY 2	152.2	145.7	155.9	149.1	149.7	151.8	151.2	151.9	149.2	150.0
READINGS 3	153.3		154.2		149.7		152.6		149.8	
4	151.8		154.0		148.8		151.7		149.3	
Average Density	152.5	145.6	154.5	148.9	149.3	152.2	151.6	152.8	149.1	149.6
Corrected Density	152.5	145.6	154.5	148.9	149.3	152.2	151.6	152.8	149.1	149.6
% Relative Compaction	95	90	96	93	93	95	94	95	93	93

Correction Factor: 1.00

* Mean Test Section Density, Mg/m³ (pcf)= 151.4
* Mean Percent relative Compaction= 94
* Not Applicable to Partial Test Sections or Joint Densities

Special Provision spec
Single: 91-97
Mean: 93-96

Remarks: Test section meets required spec plus Special Provisions spec 402.03.06

Joint Test Specification	Min. 90		
Single Test Specification	Min. 90	Max.	97
Mean Test Section Specification	Min. 92	Max.	96

Accepted ✓ Rejected ☐

Resident Engineer Signature [signature]
DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-017
Rev. 5/05

Distribution: Headquarters Construction, Resident Engineer, District Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
NUCLEAR THIN LAYER COMPACTION REPORT
FOR PLANTMIX BITUMINOUS PAVEMENTS

Material Type	PBS Type 2C w/RAP	Contract Number	3716
Lift, Lane & Direction	1st Lift, Lane 3 Shoulder, EB	Date	6/28/19
Width and Depth	10' W x 3" D	Gauge Set Number	148
Lot/Sublot		Tested By	D. Butler

TEST SECTION

Sta. 259+65.9 | Sta. 253+15.3 | Sta. 251+79.3 | Sta. 244+96.1 | Sta. 236+76.9

265+85 | 259+31.2 | 252+77.4 | 246+23.6 | 239+69.8 | 233+16

Random Number Block: 18

Beginning Station: "LE" 265+85
Ending Station: "LE" 233+16

(A x length = longitudinal , B x width = transverse)

A	x		=		B	x		=	
653.8	x	0.947	=	619.1	10	x	0.169	=	1.7
653.8	x	0.942	=	615.9	10	x	0.985	=	9.9
653.8	x	0.150	=	98.1	10	x	0.962	=	9.6
653.8	x	0.195	=	127.5	10	x	0.313	=	3.1
653.8	x	0.448	=	292.9	10	x	0.215	=	2.2

TARGET DENSITY Mg/m³ (pcf) 160.7 From (RICE) test number T-1-49

TEST #	136-PM- 1		136-PM- 2		136-PM- 3		136-PM- 4		136-PM- 5	
STATION nearest 10m (25 ft.)	259+75		253+25		251+75		245+00		236+75	
Distance from edge	2	* Joint	10	* Joint	10	* Joint	3	* Joint	2	* Joint
Left or Right	LT		LT		LT		LT		LT	
NUCLEAR 1	153.9		149.0		149.4		157.6		154.2	
DENSITY 2	150.8		148.9		148.8		151.3		150.5	
READINGS 3	151.4		149.1		150.9		149.6		153.7	
4	150.8		151.3		149.3		150.2		151.3	
Average Density	151.7		149.6		149.6		150.9		152.4	
Corrected Density	151.7		149.6		149.6		150.9		152.4	
% Relative Compaction	94		93		93		94		95	

Correction Factor: 1.00

* Mean Test Section Density, Mg/m³ (pcf)= 150.8
* Mean Percent relative Compaction= 94
* Not Applicable to Partial Test Sections or Joint Densities

Special Provision spec.
Single: 92-97
Mean: 94-96

Remarks: Compaction on test section meets required spec plus special provisions 402.03.06

Joint Test Specification	Min.	90		
Single Test Specification	Min.	90	Max.	97
Mean Test Section Specification	Min.	92	Max.	96

Accepted ✓ Rejected ☐

Resident Engineer Signature [signature]
DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-017
Rev. 5/05

Distribution: Headquarters Construction, Resident Engineer, District Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
NUCLEAR THIN LAYER COMPACTION REPORT
FOR PLANTMIX BITUMINOUS PAVEMENTS

Material Type	PBS Type 2C w/ RAP	Contract Number	3716
Lift, Lane & Direction	1st Lift, Lane 2, EB	Date	6/28/19
Width and Depth	12' W x 3" D	Gauge Set Number	148
Lot/Sublot		Tested By	D. Butler

TEST SECTION

Sta. 266+28² Sta. 257+61³ Sta. 251+70⁴ Sta. 243+89³ Sta. 236+85⁸

269+07 | 262+55⁹ | 256+04² | 249+52⁸ | 243+01⁴ | 236+50

Random Number Block: 23

Beginning Station "LE" 269+07
Ending Station "LE" 236+50

(A x length = longitudinal , B x width = transverse)

A			=		B			=	
651.4	x	0.428	=	278.8	12	x	0.117	=	1.4
651.4	x	0.759	=	494.4	12	x	0.239	=	2.9
651.4	x	0.666	=	433.8	12	x	0.491	=	5.9
651.4	x	0.865	=	563.5	12	x	0.333	=	4.0
651.4	x	0.945	=	615.6	12	x	0.364	=	4.4

TARGET DENSITY Mg/m³ (pcf) 160.7 From (RICE) test number T-1-49

TEST #		137-PM-1		137-PM-2		137-PM-3		137-PM-4		137-PM-5	
STATION nearest 10m (25 ft.)		266+25		257+50		251+75		244+00		237+00	
Distance from edge		1	* Joint	3	* Joint	6	* Joint	4	* Joint	4	* Joint
Left or Right		LT	LT	LT	LT	LT	LT	LT	LT	LT	LT
NUCLEAR	1	149.4	147.9	150.6	146.5	152.2	146.9	149.0	145.1	150.5	148.5
DENSITY	2	149.5	147.7	151.1	147.3	151.1	145.5	149.3	146.2	150.2	148.9
READINGS	3	149.9		149.1		151.2		149.9		150.7	
	4	150.8		150.4		151.4		149.4		150.9	
Average Density		149.9	147.8	150.3	146.9	151.5	146.2	149.4	145.7	150.6	148.7
Corrected Density		149.9	147.8	150.3	146.9	151.5	146.2	149.4	145.7	150.6	148.7
% Relative Compaction		93	92	94	91	94	91	93	91	94	93

Correction Factor 1.00

* Mean Test Section Density, Mg/m³ (pcf)= 150.3
* Mean Percent relative Compaction= 94
* Not Applicable to Partial Test Sections or Joint Densities

Special Provision spec.
Single: 92-97
Mean: 94-96

Remarks: Compaction on test section meets required spec plus special provisions 402.03.06

Joint Test Specification	Min.	90		
Single Test Specification	Min.	90	Max.	97
Mean Test Section Specification	Min.	92	Max.	96

Accepted ✓ Rejected ☐

Resident Engineer Signature [signature]
DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

NDOT
040-017
Rev. 5/05

Distribution: Headquarters Construction, Resident Engineer, District Engineer, Contractor

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
NUCLEAR THIN LAYER COMPACTION REPORT
FOR PLANTMIX BITUMINOUS PAVEMENTS

Material Type	PBS Type 2C w/RAP	Contract Number	3716
Lift, Lane & Direction	1st Lift, Lane 1, EB	Date	6/28/19
Width and Depth	16' w x 3" D	Gauge Set Number	148
Lot/Sublot		Tested By	D. Butler

TEST SECTION

Sta. 267+77⁹ Sta. 260+35² Sta. 256+61⁸ Sta. 249+78⁶ Sta. 240+72³

272+50 | 265+73⁹ | 258+97² | 252+20⁸ | 245+44⁴ | 238+68

Random Number Block: 15

Beginning Station: "LE" 272+50
Ending Station: "LE" 238+68

(A x length = longitudinal , B x width = transverse)

A					B				
676.9	x	0.698	=	472.1	16	x	0.683	=	10.9
676.4	x	0.796	=	538.4	16	x	0.996	=	15.9
676.4	x	0.348	=	235.4	16	x	0.743	=	11.9
676.4	x	0.358	=	242.2	16	x	0.595	=	9.5
676.4	x	0.698	=	472.1	16	x	0.539	=	8.6

TARGET DENSITY Mg/m³ (pcf) 160.6 From (RICE) test number T-2-49

TEST #	138-PM-1		138-PM-2		138-PM-3		138-PM-4		138-PM-5	
STATION nearest 10m (25 ft.)	267+75		260+25		256+50		249+75		240+75	
Distance from edge	11	* Joint	16	* Joint	12	* Joint	10	* Joint	9	* Joint
Left or Right	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT
NUCLEAR DENSITY READINGS 1	151.4	151.9	152.8	147.0	150.5	150.8	150.3	148.4	152.5	148.2
2	149.7	153.3	152.2	145.4	150.1	149.9	151.2	148.9	150.8	147.8
3	150.7		151.6		151.5		150.5		150.9	
4	149.9		151.8		151.1		151.2		152.2	
Average Density	150.5	152.6	152.1	146.2	150.8	150.4	150.8	148.7	151.6	148.0
Corrected Density	150.5	152.6	152.1	146.2	150.8	150.4	150.8	148.7	151.6	148.0
% Relative Compaction	94	95	95	91	94	94	94	93	94	92

Correction Factor: 1.00

* Mean Test Section Density, Mg/m³ (pcf)= 151.2
* Mean Percent relative Compaction= 94
* Not Applicable to Partial Test Sections or Joint Densities

Special Provision spec
Single: 92-97
Mean: 94-96

Remarks: Compaction on test section meets required spec. plus special provisions spec 402.03.06.

Joint Test Specification	Min.	90		
Single Test Specification	Min.	90	Max.	97
Mean Test Section Specification	Min.	92	Max.	96

Accepted ✓ Rejected ☐

Resident Engineer Signature [signature]
DON CHRISTIANSEN, P.E.
RESIDENT ENGINEER

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