EVALUATION OF RECYCLED RUBBER IN ASPHALT CONCRETE BLACK HAWK COUNTY

CONSTRUCTION REPORT
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-330B

DECEMBER 1992

Highway Division

Iowa Department of Transportation

Construction Report
for
Iowa Highway Research Board
Project HR-330B

Evaluation of Recycled Rubber in Asphalt Concrete Black Hawk County FN-21-6(6)--21-07

By

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7. ACKNOWLEDGEMENT OF COOPERATING ORGANIZATIONS

8. ABSTRACT

This project, located on IA 21 in Black Hawk County, is the fifth project in Iowa in 1991 to 1992 to use ground recycled crumb rubber from discarded tires in asphalt rubber cement (ARC).

This project was slightly different from four previous projects. The reacted rubber supplier was a different company and the supplier submitted their own mix design.

There were three research sections completed. One section used ARC in both the binder and surface courses in the northbound and southbound lanes, one section used the ARC in both courses in the northbound lane only, and there was a control section with conventional asphalt in both lanes.

9. KEY WORDS	10. NO. OF PAGES
Asphalt rubber cement Recycled tires Ground crumb rubber Crumb rubber modifier	40

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DISCLAIMER

INTRODUCTION

Starting in 1991, Iowa has been researching the use of discarded vehicle tires in asphalt rubber cement (ARC). The stockpile and disposal problems of discarded tires has prompted this research. The Iowa DOT has now completed six projects using recycled tires in a reacted rubber asphalt binder referred to as ARC.

This project on IA 21 in Black Hawk County was constructed in June 1992. The project has two ARC sections using the reacted rubber asphalt in both the binder and surface courses and a control section using a conventional mix.

OBJECTIVE

The objective of this research project was to evaluate the use of finely ground recycled tire rubber as ARC.

Hopefully, a conclusion can be made to determine if using ARC will:

1. Improve performance
2. Extend the life of the roadway
3. Be of enough value from an environmental standpoint to compensate for its higher cost.

CONTRACTOR

Aspro, Inc. of Waterloo, Iowa was the contractor on this project. The rubber reactor was furnished by International Surfacing of

Chandler, Arizona. Both the ARC and conventional mixes were produced at the Aspro plant at Waterloo, Iowa.

PROJECT LOCATION

The location of this project was on IA 21 from the Tama County line northerly 10.267 miles to 1.71 miles inside the south city limits of Waterloo, Iowa in Black Hawk County. The test sections are listed in Table I.

Table I

Test Section	Sta. to Sta.	Lane	Type of Mix
1	2135+00 to 2186+00	NB & SB	ARC in binder and surface
2	2186+00 to 2238+00	NB	ARC in binder and surface
3	2238+00 to 2270+00	NB & SB	Conventional control

PRECONSTRUCTION SURVEY

The existing surface was a 24 ft. wide full depth AC pavement constructed in 1968 and 1969. The daily traffic volume is 1750 vehicles per day (V.P.D.) with 9% trucks.

There was so much alligator cracking on the road that conducting a crack survey would have been extremely difficult. The photovan was used to document the original condition of the road. The road appeared very distressed.

A strengthening course was placed on portions of the project prior to resurfacing but no patching was done.

The Road Rater, measuring pavement deflections, was run prior to construction to provide structural data.

MATERIALS

The ARC was produced by International Surfacing Inc. from Chandler, Arizona. They purchased the rubber from Baker Rubber, South Bend, Indiana. Two types of rubbers were used in this project. 17% IGR 10-20 and 2% TBS 20 were the rubbers used. The IGR is a tire rubber but the TBS 20 was a tennis ball rubber. Special Provision 1028.03, the project specification, states that the ground rubber shall be produced from processing automobile and/or truck tires by ambient grinding methods. This makes the tennis ball rubber used in noncompliance. The Special Provisions and gradation limits are located in Appendix A. The gradations ran during construction appear in Appendix B.

The coarse aggregate was purchased from Waterloo South, Waterloo, Iowa and the fine aggregate from Aspro Pits in Waterloo. The AC was purchased from Koch, Inc of Dubuque, Iowa.

MIX DESIGN

International Surfacing Inc. provided their own mix design on the project with the only stipulation being they had to meet our mix design criteria as shown in Special Provision SP-1028.

This criteria was not met on the aggregate or rubber gradations. Also, the use of tennis ball rubber was contrary to specification. All the material noncompliances are shown in Appendix A. No decision on penalties or adjustments had been made at the time this report was written.

The ARC binder mixture consisted of 84% 3/4" limestone and 16% sand. The mixture had an intended ARC content of 6½%. The ARC consisted of 81% AC-5 and 19% rubber. The ARC surface mixture was 83% 1/2" limestone and 17% sand. The intended ARC content was 7.0% with 81% AC-5 and 19% rubber.

Aspro had some problems with low lab voids in the conventional mixture, therefore, the conventional mix design was altered slightly and the AC content lowered on both the binder and surface courses. The binder ended up having an AC content of 5.1% and the surface 5.1%. The ARC mix also had low lab voids but no changes were made. Lab densities and voids are shown on the plant reports in Appendix B.

PLANT OPERATION

The ARC and conventional mixes were produced at Aspro's South Plant in Waterloo, Iowa. It was a Barber Greene batch plant.

The ARC was produced at a site a few blocks from Aspro's plant and then hauled to the plant site in tankers. The International Surfacing system had a tank that the AC-5 was pumped into and held at 400°F until it went into the blender-reactor. The AC-5 was then placed in the blender-reactor and the rubber granules were augered in and the reaction process began. It was reacted at 350°F for 60-90 minutes in the reactor-blender chamber. It was then pumped into the tanker which hauled it to Aspro's plant.

Viscosity was determined at the reaction site by International Surfacing. The results ranged from 2100 cps to 2600 cps which are within specifications.

The plant produced approximately 210 ton/hr of the ARC mixture and approximately 300 ton/hr of the conventional mixture.

There was a problem with the ARC coating of the aggregates on both the binder and surface courses. This occurred the first day when producing the binder course so the mixing time was increased 10 seconds to 55 seconds. This seemed to improve coverage. The next day on the surface course the coating problem was again apparent. This time the ARC content was increased slightly which helped. Aspro had a little of the same aggregate coating problem with the conventional mixture but not to the degree it was with the ARC mix.

PAVING OPERATION

Paving of the ARC binder was on June 25, 1992 and the ARC surface on June 26, 1992. The conventional binder was placed prior to this and the conventional surface after the ARC was completed. Aspro was using a Blaw-Knox PF-500 paver.

The mix was very sticky compared to the 1991 ARC mixes. This made it more difficult to work with. There was no shoving or cracking of the mat during placement.

The roller operator had to stay back from the paver somewhat because of warmer temperatures. The ambient temperature was around 80°F.

There was some segregation in both the binder and surface courses of both the conventional and ARC mixes.

The inspectors mentioned a concern about the binder and surface courses of the ARC mixes binding. Such a coarse mix was used that by visual observation the tack coat seemed to be absorbed into the binder.

There is a definite difference in appearance between the ARC sections and the conventional sections. The ARC appears more open due to the coarse mix and is much darker.

CONSTRUCTION TESTING

Samples were obtained during construction for laboratory testing of aggregates, rubber, AC-5 and cores for creep and resilient modulus testing. The rubber gradation and aggregate gradation were not within specifications.

The Road Rater testing was conducted prior to and shortly after construction. Friction testing was completed after construction using an ASTM E274 trailer. The results of all field tests are in Appendix C and all lab results in Appendix B.

The creep and resilient modulus tests will be completed later.

COST COMPARISON

A drawback of using any ARC mixtures over convention mixtures is the higher cost. The conventional asphalt cement was bid at $99.95/ton while the ARC was bid at $513.00/ton. The calculated prices of the different mixes are summarized in Table II. The ARC binder mixture is 159% higher and the ARC surface mixture is 169% higher than the conventional mixtures.

Table II
Mixture Prices Calculated From Contract Bid

Conventional Binder		Conventional Surface	
	$12.68		$13.08
A.C. 10	5.10	A.C. 10	5.10
(5.1%)	$17.78/Ton	(5.1%)	$18.18/Ton

ARC Binder		ARC Surface	
	$12.68		$13.08
ARC	33.35	ARC	35.91
(6.5%)	$46.03/Ton	(7.0%)	$48.99/Ton

EVALUATION

Since construction, Road Rater and friction testing have been completed. There has not been sufficient time since construction to make any conclusions as to performance.

Friction testing, Road Rater testing, crack surveys and rut depth checks will be conducted annually.

Creep and resilient modulus testing should be completed this fall.

CONCLUSIONS

From the project the following conclusions can be made:

1. ARC mix can be constructed with little difference from that of a conventional mix.

2. ARC pavement appears to be in as good a condition as the conventional.

#082704

Iowa Department of Transportation
Highway Division
Ames, Iowa

Date of Letting: August 27, 1991
Date of Addendum: July 30, 1991

Black Hawk County
FN-21-6(6)--21-07

A. C. C. Resurfacing
Bid Order 41

In the proposal form on page 1 of the "Special Provisions Text" delete SP-1024, Special Provisions for Asphalt Rubber Cement (ARC) Concrete and replace it with SP-1028, Special Provisions for Asphalt Rubber Cement (ARC) Concrete (attached).

NOTICE: Only the prime contractor receives this addendum and responsibility for notifying any potential subcontractors or suppliers remains with the prime contractor.

SP-1028
(Replaces SP-1024)

Iowa Department of Transportation

SPECIAL PROVISIONS
for
ASPHALT RUBBER CEMENT (ARC) CONCRETE

FN-21-6(6)—21-07, Black Hawk County

August 27, 1991

THE STANDARD SPECIFICATIONS, SERIES OF 1984, ARE AMENDED BY THE FOLLOWING MODIFICATIONS. THESE ARE SPECIAL PROVISIONS, WHICH SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

1028.01 DESCRIPTION.

The asphalt rubber cement (ARC) concrete mix composition will include the incorporation of ARC in the mixture, using the aggregates selected by the Contractor.

The Contractor shall have a representative of the rubber supplier available on the project site during production of the asphalt rubber cement concrete mixture.

1028.02 GENERAL REQUIREMENTS.

The ARC concrete mixes shall conform to the requirements of the standard specifications for the standard asphalt cement concrete mixes as specified in the plans. The Standard Specifications are modified as follows:

A. Mineral Aggregate for the ARC Concrete Mixes.

Mineral aggregate requirements shall be in accordance with the plans and the standard specifications except the gradations for the concrete mixtures shall meet the following:

Sieve size	Percent passing 1/2" Type A ARC Concrete Mixture	Percent passing 3/4" Type B ARC Concrete Mixture
1"		100
3/4"	100	90-100
1/2"	90-100	70-90
3/8"	75-95	60-80
#4	50-70	40-60
#8	35-50	30-45
#30	15-25	12-22
#50	6-16	5-14
#200	2-8	2-6

B. Asphalt Rubber Cement.

The asphalt rubber cement shall be a uniform reacted blend of compatible paving grade asphalt cement, ground reclaimed vulcanized rubber, extender oil if required, and liquid anti-stripping agent when indicated by standard moisture susceptibility tests. The asphalt rubber cement shall meet the physical parameters listed below.

Apparent Viscosity, 347°F., Spindle 3, 12 RPM cps (ASTM D2669 Brookfield)	Min Max	1,000 4,000
Penetration, 77°F., 100 g, 5 sec.: 1/10 mm. (ASTM D5)	Min Max	50 100
Penetration, 39.2°F., 200 g, 60 sec.: 1/10 mm. (ASTM D5)	Min	25
Softening Point: °F., (ASTM D36)	Min	120
Resilience, 77° F.,: % (ASTM D3407)	Min	10
Ductility, 39.2° F., 1 cpm: cm. (ASTM D113)	Min	10
TFOT Residue, (ASTM D1754) Penetration Retention, 39.2° F.: %	Min	75
Ductility Retention, 39.2° F.: %	Min	50

C. Asphalt Extender Oil.

An asphalt extender oil may be added, if necessary, to meet the requirements of asphalt rubber cement. Extender oil shall be a resinous, high flash point, aromatic hydrocarbon meeting the following test requirements.

Viscosity, SSU, at 100 degrees F (ASTM D88)	2500 min.
Flash Point, COC, degrees F (ASTM D92)	390 min.
Molecular Analysis (ASTM D 2007):	
Asphaltenes, Wt. %	0.1 min.
Aromatics, Wt. %	55.0 min.

D. Equipment.

All equipment shall conform to the standard specifications unless noted otherwise in this Special Provision.

1028.03 GROUND RECLAIMED VULCANIZED RUBBER.

A. General.

The ground rubber shall be produced from the processing automobile and/or truck tires by ambient grinding methods. The rubber shall be substantially free from contaminants including fabric, metal, mineral, and the non-rubber substances. The rubber shall be sufficiently dry to be free flowing and not produce a foaming problem when added to hot asphalt cement. Up to 4% by weight of talc or other appropriate blocking agent can be added to reduce agglomeration of the rubber particles.

A.1 Physical Requirements.

Gradation and Particle Length: When tested in accordance with ASTM C-136 using a 50 gram sample, the resulting rubber gradation shall meet the following gradation limits.

Sieve Size	Percent Passing Type II
#10	100
#16	75-100
#30	26-60
#50	0-20
#200	0-5
Max. Particle Length	3/16"

A.2 Fiber Content.

The ground rubber shall be designated Grade A or Grade B. For Grade A rubber, the fiber content shall be less than 0.1% by weight. For Grade B rubber the fiber content shall be less than 0.5% by weight. The fiber content shall be determined by weighing fiber agglomerations which are formed during the gradation test procedure. Rubber particles shall be removed from the fiber agglomerations before weighing.

A.3 Moisture Content.

The moisture content of the ground rubber shall be less than 0.75% by weight.

A.4 Mineral Contaminants

The mineral contaminant amount of the ground rubber shall not be greater than 0.25% by weight as determined after water separating a 50 gram rubber sample in a 1 liter glass beaker filled with water.

A.5 Metal Contaminants

The rubber shall contain no visible metal particles as indicated by thorough stirring of a 50 gm. sample with a magnet.

B. Packaging

The ground rubber shall be supplied in moisture resistant packaging such as either disposable bags or other appropriate containers. Bags shall be palletized into units for shipment and glue shall be placed between layers of bags to increase the unit stability during shipment. Palletized units containing bags shall be wrapped with ultra-violet resistant stretch wrap. The maximum allowable tolerance per bag will be $\pm$ 2 lbs. for bags weighing 100 lbs or less.

C. Labeling

Each container or bag of ground rubber shall be labeled with the manufacturer designation for the rubber and the specific type in accordance with this specification, the nominal rubber weight designation with tolerance, and the manufacturer lot designation. Palletized units shall contain a label which indicates

the manufacturer and production lot number designations, rubber type, and net pallet weight.

D. Certification

The supplier shall ship with the rubber, certificates of compliance which certify that all requirements of these specifications are complied with for each production lot number of shipment.

E. Anti-Stripping Agent

If required by the job mix formula to produce appropriate water resistance, an anti-stripping agent that is heat stable and approved for use by the specifying agency shall be incorporated into the asphalt rubber cement at the percentage required by the job mix formula. It shall be added to the asphalt cement prior to blending with the ground rubber.

1024.06 ASPHALT RUBBER CEMENT BLEND DESIGN

The asphalt cement shall be grade AC-5 unless otherwise recommended by the asphalt rubber supplier and approved by the Engineer. The asphalt rubber cement design shall be performed by the asphalt rubber supplier. The proportion of ground rubber shall be between 15 and 20 percent by weight of the total mixture of the asphalt rubber cement.

The Contractor shall supply to the Engineer a mix formulation at least 10 days before pavement construction is scheduled to begin. The mix formula shall consist of the following information.

A. Design Mix.

The design mix shall meet the requirements of the Standard Specifications, Series of 1984, and as amended herein.

B. Asphalt Cement.

The Source of Asphalt Cement.
The Grade of Asphalt Cement.
The Source and Grade of Extender Oil.
The Percentage of Asphalt Cement and Extender Oil by total weight of the Asphalt Rubber Cement.

C. Ground Reclaimed Rubber.

The Source of Reclaimed Rubber.
The Grade of Reclaimed Rubber.
The Percentage of Ground Rubber by total weight of the Asphalt Rubber Cement.

If ground rubber from more than one source is utilized, the above information will be required for each source of ground rubber used.

D. Anti-Strip Agent.

The Source of Anti-Strip.
The Percentage of Anti-Strip by weight of asphalt.

E. Physical Properties.

The physical properties of the blend in accordance with Section 1028.02B. The weight per gallon of the blend at 350°.

F. Asphalt Rubber Cement Content.

The design asphalt rubber cement content based on the dry weight of the aggregate.

G. Mix Temperature Range.

The mix temperature range for the aggregate and asphalt rubber cement.

H. Density Requirements.

The mixture design will be based on the 50 blow Marshall test.

1028.05 ASPHALT RUBBER CEMENT AND PRODUCTION EQUIPMENT

All equipment utilized in production and proportioning of the asphalt rubber cement shall be described as follows:

A. Asphalt Heating Tank.

An asphalt heating tank with a hot oil heat transfer system or retort heating system capable of heating asphalt cement to the necessary temperature for blending with the ground rubber. This unit shall be capable of heating a minimum of 3,000 gallons of asphalt cement.

B. Blender.

An asphalt rubber mechanical blender with a two stage continuous mixing process capable of producing a homogeneous mixture of asphalt cement and ground rubber, at the mix design specified ratios, as directed by the engineer. This unit shall be equipped with a ground rubber feed system capable of supplying the asphalt cement feed system, as not to interrupt the continuity of the blending process. A separate asphalt cement feed pump and finished product pump are required. This unit shall have both an asphalt cement totalizing meter in gallons and a flow rate meter in gallons per minute.

C. Storage Tank.

An asphalt rubber storage tank equipped with a heating system to maintain the proper temperature for pumping and adding of the asphalt rubber to the aggregate and an internal mixing unit within the storage vessel capable of maintaining a proper mixture of asphalt cement and ground rubber.

D. Supply System.

An asphalt rubber supply system equipped with a pump and metering device capable of adding the asphalt rubber by volume to the aggregate at the percentage required by the job-mix formula.

E. Temperature Gauge.

An armored thermometer of adequate range in temperature reading shall be fixed in the asphalt rubber feed line at a suitable location near the mixing unit.

1028.06 ASPHALT RUBBER CEMENT MIXING, REACTION AND TRANSFER PROCEDURE.

A. Asphalt Cement Temperature.

The temperature of the asphalt cement shall be between 375° and 425° F. at the addition of the ground rubber.

B. Blending and Reacting.

The asphalt cement and ground rubber shall be combined and mixed together in a blender unit, pumped into the agitated storage tank, and then reacted for a minimum of 45 minutes from the time the ground rubber is added to the asphalt cement. Temperature of the asphalt rubber cement shall be maintained between 325° and 375° F. during the reaction period.

C. Transfer.

After the material has reacted for at least 45 minutes, the asphalt rubber cement shall be metered into the mixing chamber of the hot mix plant at the percentage required by the job mix formula.

D. Delays.

When a delay occurs in asphalt rubber cement use after its full reaction, the asphalt rubber shall be allowed to cool. The asphalt rubber cement shall be reheated slowly just prior to use to a temperature between 325° and 375° F., and shall also be thoroughly mixed before pumping and metering into the hot mix plant for combination with the aggregate. The viscosity of the asphalt rubber cement shall be checked by the asphalt rubber supplier. If the viscosity is out of the range specified in Section 1028.02B of this specification, the asphalt rubber cement shall be adjusted by the addition of either the asphalt cement or ground rubber as required to produce a material with the appropriate viscosity.

1028.07 COMPACTION REQUIREMENT.

The Asphalt Rubber Cement concrete shall be compacted to 95% of laboratory density.

1028.08 COMPACTION EQUIPMENT.

A minimum of two rollers meeting Article 2001.05 Paragraph B shall be furnished. Pneumatic tired rollers will not be allowed.

1028.09 METHOD OF MEASUREMENT AND BASIS OF PAYMENT OF ASPHALT RUBBER CEMENT (ARC) CONCRETE.

The Asphalt Rubber Cement Concrete Mix will be measured as per the standard specification, and be paid for in tons. Asphalt Rubber Cement for use in the Asphalt Rubber Cement Concrete Mix will be measured as per the standard specifications and be paid for in tons.

Listed below are the material noncompliances on project FN-21-6(6)--21-07, Black Hawk County. The contractor was Aspro Inc. of Waterloo, Iowa and the reacted rubber was finished by International Surfacing Inc., Chandler, Arizona. The special provisions according to SP-1028 are also listed.

Aggregate Gradations
1/2" Type A ARC

Sieve Size	SP-1028	Gradations Ran by Aspro			Gradation Ames Lab
3/4"	100	100	100	100	100
1/2"	90-100	99	98	98	99
3/8"	75-95	85	84	**74**	85
#4	50-70	55	55	**49**	55
#8	35-50	37	38	37	37
#30	15-25	20	21	20	19
#50	6-16	14	13	12	11.4
#200	2-8	**9.5**	**8.5**	7.2	7.5

3/4" Type B ARC

Sieve Size	SP-1028	Gradations Ran by Aspro			Gradation Ames Lab
1"	100	100	100	100	100
3/4"	90-100	99	99	99	100
1/2"	70-90	78	81	84	87
3/8"	60-80	60	61	70	71
#4	40-60	**38**	**36**	46	46
#8	30-45	**26**	**25**	32	31
#30	12-22	15	14	18	17
#50	5-14	9.3	8.9	11.9	10
#200	2-6	**6.5**	**6.1**	**8.3**	**7.1**

Rubber Gradations & Particle Length

Sieve Size	SP-1028	17% 1GR 10-20	2% TBS 20	Combined
#10	100	99	100	99
#16	75-100	44	100	50
#30	26-60	4.8	58	10
#50	0-20	1.0	18	2.8
#200	0-5	0.0	1.8	0.2
Max. Particle Length	3/16"	Many pieces ranged from 1/4" to 1/2".		

According to SP-1028.03

The ground rubber shall be produced from the processing automobile and/or truck tires by ambient grinding methods.

2% Tennis Ball Scrap was used in this project, lot #5470, which is in noncompliance.

Appendix B
Lab Results

Contractor's License No. 074806

HR-330

May 22, 1992

ISI Project No. R-9210

Aspro
P.O. Box 2620
Waterloo, Iowa 50704

Attention: Mr. Brad Blough, Estimator

Re: Iowa DOT Project FN-21-6(6)-21-07, Black Hawk County
Final Mix Design Report, Data and Recommendations for 1/2" and 3/4" Asphalt-Rubber Concrete (ARC) Mixes

Dear Brad:

We have completed the mix design testing for the above referenced project. This report outlines the procedures used and presents the final asphalt-rubber (A-R) binder and Marshall test data, required JMF information, and recommendations for each of the dense-graded ARC mixtures. Please submit this information as appropriate for approval.

Based on evaluation of the mix design data for the 3/4" leveling course mix, we recommend a design asphalt-rubber (A-R) binder content of 6.95% by weight of dry aggregate, equivalent to 6.5% by total mix weight. For the 1/2" surface mix, we recommend a design A-R binder content of 7.53% by weight of dry aggregate, equivalent to 7.0% by total mix weight. Based on the results of moisture resistance testing, we further recommend that the aggregates for both mixes be treated with 1% lime by dry aggregate weight to improve moisture resistance.

SAMPLE PREPARATION and TESTING

The asphalt-rubber binder was designed by ISI. Due to problems in achieving the specified minimum ductility at 39.2°F, four different asphalt cements were tried in a total of at least nine trial A-R reactions with varying percentages and types of ground rubber available for use. However, none of the blends could supply the required ductility. Since this physical property has not been correlated with performance of hot mix ARC pavements, and is primarily used for quality assurance, it is not critical. Mr. Keith Norris, Iowa DOT District 2 Materials Engineer, was contacted and indicated willingness to waive the ductility requirement upon ISI's written recommendation. The binder exhibits good flexibility at low temperatures.

Test data for the A-R binder, including specific gravity at 60°F and calculated weight per gallon at 350°F, are presented on the Asphalt-Rubber Blend Testing sheet, Figure 1. This binder will be used in both ARC mixes.

ISI received samples of three aggregates from Aspro, designated as follows:

3/4" Type A (for 3/4" leveling course)
1/2" Type A (for 1/2" surface course)
Washed Sand (for use in both mixtures)

The aggregate samples were artificially graded to match average stockpile grading data provided by Aspro. Aggregate blend proportions and composite gradings for each mixture are presented on Figures 3 and 5.

Prior to mixing batches for Marshall testing, the respective combined aggregates were heated to 300°F and the A-R binder was heated to 350°F. Testing was performed according to ASTM D1559 and the Asphalt Institute MS-2 Procedure. Compaction was performed at 280 +/- 5°F (275°F is the minimum laydown temperature for ARC mixes) using 50 blows per face.

Tests on the aggregate and the mixes were performed according to applicable ASTM and AASHTO procedures. Test data for the aggregates and respective ARC mixes are presented on Figures 6 and 8. Figures 7 and 9 present plots of the Marshall properties.

Moisture resistance testing, using the Root-Tunicliff Method was performed only on the 3/4" leveling course mixture. This procedure includes vacuum saturation of the wet specimens, followed by a 16-hour freeze cycle and a 24-hour soak in a 140°F waterbath. The tensile strength ratio (TSR) of moisture conditioned to dry control specimens is 61.7%. This is lower than the recommended minimum of 70%. Furthermore, visual inspection of the moisture conditioned specimens after testing indicated the presence of some plastic fines which did not retain coating. The final degree of saturation (average 138.3%, based on specimen volume increase) supports the observed presence of plastic fines. We therefore recommend addition of lime to both mixes, because of the similarity of the aggregates.

FURTHER RECOMMENDATIONS

Specific JMF recommendations are presented on the attached Job Mix Formula sheets: Figures 2 and 3 for the 3/4" ARC mix, and Figures 4 and 5 for the 1/2" ARC mix.

Based on laboratory air void content data for both mixes, we recommend a density requirement of 96% of laboratory Marshall density. If tests of either A-R mixture during placement indicate lower air void contents than the attached data, this recommendation may be modified as appropriate. However, we do not recommend that in-place air void content of the compacted mixes be less than 3% nor greater than 8%.

FURTHER RECOMMENDATIONS, continued

We recommend getting the ARC mixes to the grade at a temperature of about 300°F to facilitate compaction. As previously noted, the minimum laydown temperature for dense-graded ARC mixes is 275°F. We further recommend the use of the vibratory mode for at least the breakdown coverages, unless excessive aggregate fracturing is observed. It is our experience that this is the most effective method of compacting ARC mixes. Due to the distinctly different physical properties of the A-R binder, compaction must generally be achieved before the mat temperature drops below 250°F. Very little further compaction can be obtained at temperatures lower than this. Therefore, we recommend that the breakdown coverages follow the paver as closely as practicable. Finish rolling for appearance may be performed after the mat temperature drops below 250°F. If necessary to facilitate compaction, the lab data do not indicate any problem with increasing the binder content slightly (within Iowa DOT tolerances from the JMF).

The mix designs and recommendations are based on the aggregate materials and average grading data provided by Aspro and the attached laboratory data. Minor variations during production may occur due to normal plant or pit operations. However, if the aggregate sources change or gradation varies excessively from that used in these designs, these recommendations may no longer apply.

We are pleased to be of service to you on this project. If you have any questions, or if we can assist you further, please do not hesitate to contact us immediately.

Very truly yours,

Anne Stonex
Materials Systems Engineer and
Laboratory Director

Attachments

INTERNATIONAL SURFACING, INC.

Arizona Contractor's License No. 074806

May 19, 1992

ISI PRoject No. R-9210

Aspro
P.O. Box 2620
Waterloo, Iowa 50704

Attention: Mr. Brad Blough, Estimator

Re: Iowa DOT Project FN-21-6(6)-21-07, Black Hawk County
Preliminary Mix Design Data and Recommendations for 1/2" and 3/4" Asphalt-Rubber Concrete (ARC) Mixes

Dear Brad:

We have completed the initial mix design testing for both of the ARC mixes for the above referenced project. Moisture susceptibility testing on the 3/4" mix will be completed on Thursday, May 21. Due to limited time and materials, we are testing only the mix with the lowest binder content as the critical case. We have selected the AC-5 asphalt cement from Bituminous Materials as the base asphalt for the asphalt-rubber binder for both mixes. The same A-R binder was used for both mix designs. The laboratory test results for the A-R binder are attached, along with the gradation and Marshall data for both mixes. We will transmit a final report to you as soon as the rest of the testing is completed. This interim report is for your information and planning purposes, and is not the final submittal report for the Iowa DOT.

Preliminary tests on the selected A-R binder indicated a ductility at 39.2°F of 9.5. Although this value did not repeat in subsequent tests, it is our opinion that the proposed binder provides the best overall physical properties with respect to compatibility, viscosity, resilience, and softening point, of the nine trial A-R blends we tested. Since the referenced properties are those most directly related to performance, we are satisfied that the proposed binder is appropriate. The A-R specific gravity determination, along with tests on the aged A-R residue, will be completed Wednesday.

Because we used an assumed value of A-R specific gravity in the Marshall calculations, some of these calculations may be affected by the specific gravity test results. If so, we will transmit corrected Marshall data sheets and plots as soon as possible.

Based on evaluation of the preliminary mix design data for the 3/4" leveling course mix, we recommend a design asphalt-rubber (A-R) binder content of 6.95% by weight of dry aggregate, equivalent to 6.5% by total mix weight. For the 1/2" surface mix, we recommend a design A-R binder content of 7.53% by weight of dry aggregate, equivalent to 7.0% by total mix weight.

We are pleased to be of service to you in this matter. We plan to transmit additional data and final recommendations Thursday afternoon unless we advise you otherwise. We will include recommended density requirements and any other required data with the final submittals for these mix designs. As requested, we are faxing a copy of this transmittal to Mr. Keith Norris, Iowa DOT District 2 Materials Engineer. If you have any questions, please do not hesitate to contact us immediately.

Sincerely,

Anne Stonex
Materials Systems Engineer and
Laboratory Director

cc: Mr. Keith Norris, District 2 Materials Engineer

Attachments

ASPHALT–RUBBER BLEND TESTING

INTERNATIONAL SURFACING INCORPORATED ENGINEERING DEPT.	PROJECT: IOWA BLACK HAWK COUNTY
	PROJECT NO.: R–9210
	DATE: 5/15/92
	MATERIAL: A–R BINDER
	TESTED BY: A.J.G., K.L.B., T.R.K.

REMARKS:

BLEND COMPONENTS	% OF BLEND	WT. USED
ASPHALT CEMENT: BITUMINOUS MATERIAL AC–5	81	1693.1
RUBBER #1: BAKER WTP–20	17	355.3
RUBBER #2: TBS–20	2	41.8
ADMIXTURE:		
EXTENDER:		
DILUENT:		
TOTALS:	100	2090.2

TEST RESULTS

REACTION TIME (min)	30	60	90	135	360	1440
BROOKFIELD VISC. (cPs/temp) *(spindle#3, 20rpm)*	2560 354 F	3040 356 F	3110 355 F	2970 358 F	2850 359 F	2560 351 F
HAAKE VISC. (cPs/temp) *(rotor#2)*	2300 354 F	2500 356 F	2550 355 F	2650 358 F	2750 359 F	N/T
PEN., NEEDLE (dmm) *(77F, 100g, 5sec.)*		65		66	67	71
PEN., NEEDLE (dmm) *(39.2F, 200g, 60sec.)*		33		36	41	N/T
PEN., CONE (dmm) *(77F, 150g, 5sec.)*		56		61	63	76
DUCTILITY (cm) *(39.2F, 1cm/min.)*		7.5		9	9.5	9
RESILIENCE (%)	22	28		29	26	21
SOFTENING POINT (F)	131	133	134	138	136	135
FRACTURE TEMP. (F) *(Bend test)*						

NOTES: Hold–over temperature (360 to 1440 minutes) = 275 F

Project: Iowa DOT Project FN-21-6(6)-21-07, Black Hawk County 05/19/92
1/2" Surface By: KRH/AS

Agg. 1	3/4" Type A
Agg. 2	1/2" Type A
Agg. 3	Sand
Agg. 4	
Agg. 5	

Bin/Stockpile Proportions

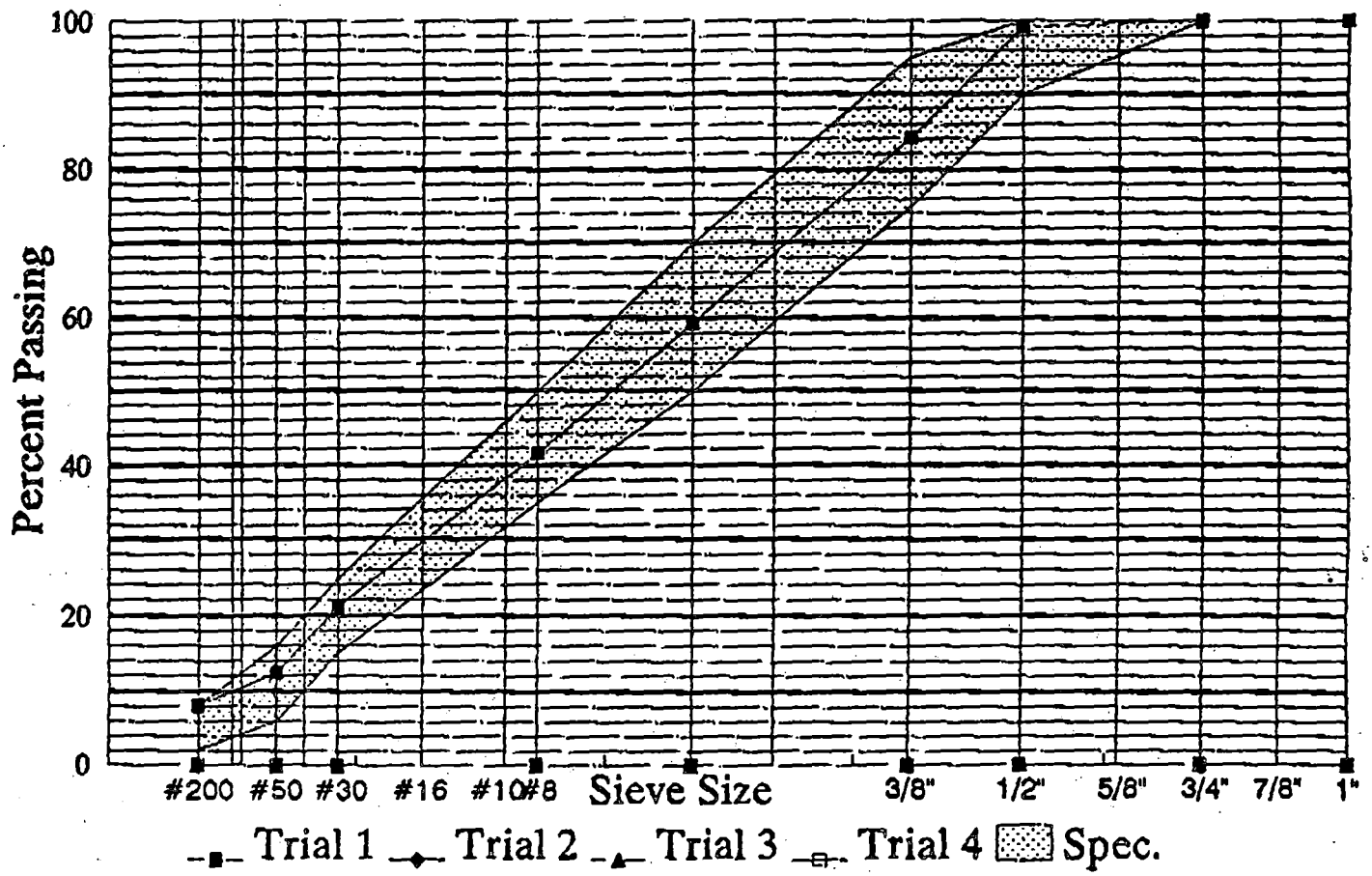
	Agg. 1	Agg. 2	Agg. 3	Agg. 4	Agg. 5	Total
Trial 1		83%	17%			100%
Trial 2						0%
Trial 3						0%
Trial 4						0%

Sieve Analysis

Sieve Size	Percent Passing				
	Agg. 1	Agg. 2	Agg. 3	Agg. 4	Agg. 5
1"	100	100	100		
3/4"	99	100	100		
1/2"	80	99	100		
3/8"	60	81	100		
#4	34	51	100		
#8	22	32	88		
#30	12	16	47		
#50	10	13	10		
#200	7.1	9.5	0.5		

Computed Composite Gradations

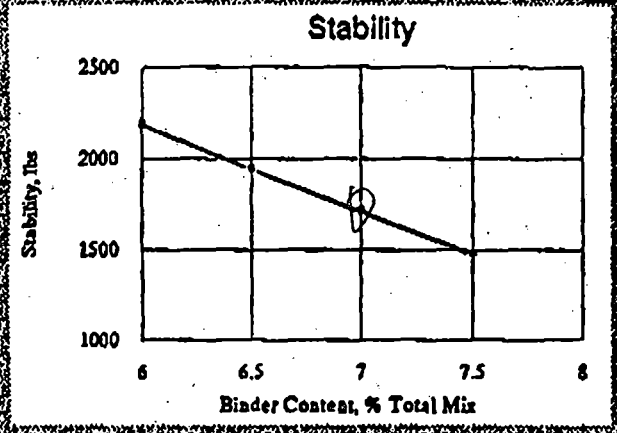
Sieve Size	Percent Passing					
	Trial 1	Trial 2	Trial 3	Trial 4	Spec. Min	Spec. Max
1"	100	0	0	0	100	100
3/4"	100	0	0	0	100	100
1/2"	99	0	0	0	90	100
3/8"	84	0	0	0	75	95
#4	59	0	0	0	50	70
#8	42	0	0	0	35	50
#30	21	0	0	0	15	25
#50	12	0	0	0	6	16
#200	8.0	0.0	0.0	0.0	2	8

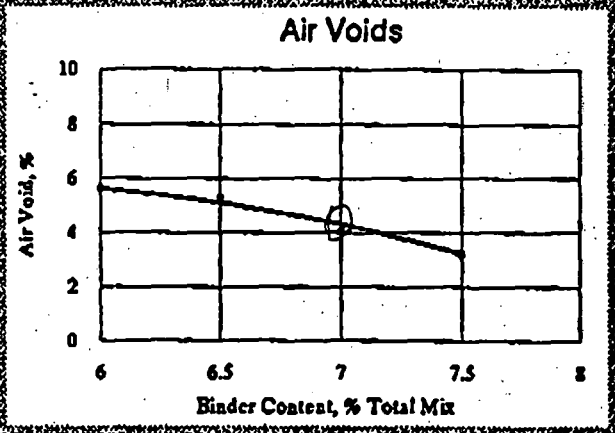


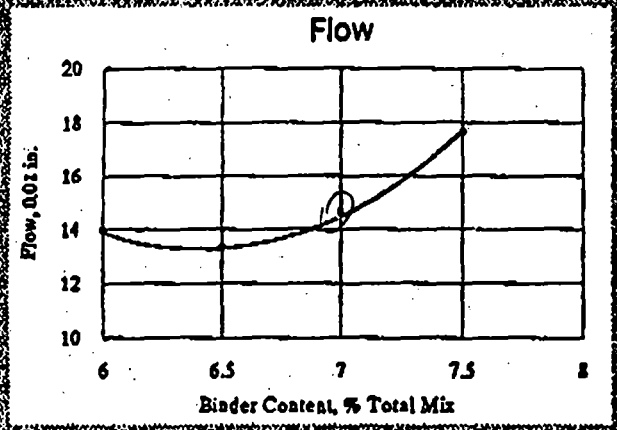
Summary of Marshall Mix Design

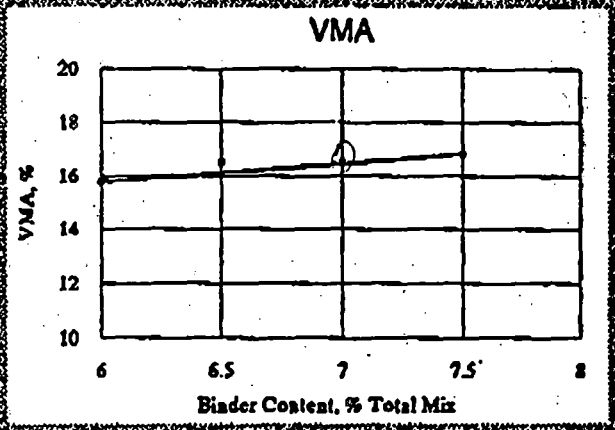
Project Name: Iowa DOT, Project No. FN-21-6(6)-07, Black Hawk County
Mix Description: 1/2" Surface

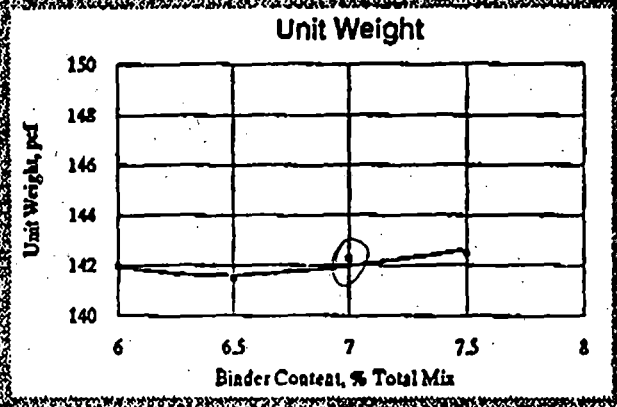
Date: 5/18/92
ISI Job No. R-9210

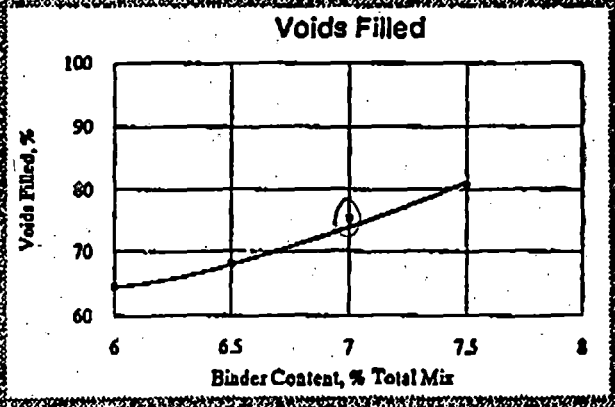


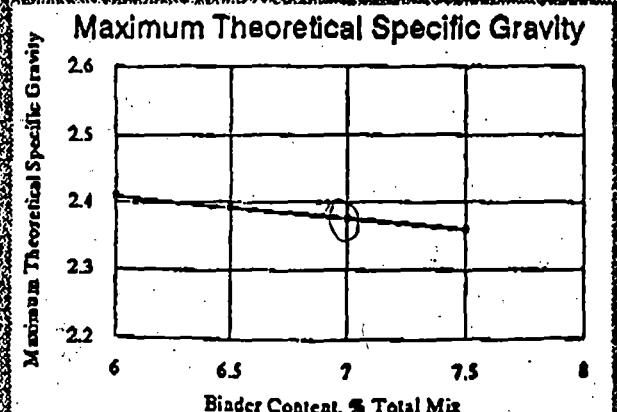












Recommended Binder Content 7.0%

Stability, lbs.	1720
Air Voids Total Mix, %	4.1
Unit Weight, pcf	142.3
Flow, 0.001 in.	15
VMA, %	16.5
Voids Filled, %	75
Maximum Theo. Sp. Grav.	2.377

Remarks:
Mix Compacted @ 280 +/- 5 F, 50 blows per side

Summary of Marshall Mix Testing

Project: Iowa DOT Project No. 21--6(6)--7, Black Hawk County
Mix: 1/2" Surface Mix

Date: 5/18/92

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
6.0%	1223	685.3	1217.7	2.265	141.3	2.410	6.05%	16.18%	62.6%		
6.0%	1236.4	701.4	1232.2	2.303	143.7	2.410	4.45%	14.75%	69.8%	2502	13
6.0%	1216.4	679	1212.8	2.257	140.8	2.410	6.38%	16.47%	61.3%	1891	15
6.0%	AVERAGE			2.275	142.0	2.410	5.63%	15.80%	64.6%	2197	14

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
6.5%	1227.5	687.4	1224.4	2.267	141.5	2.394	5.29%	16.54%	68.0%	1936	13
6.5%	1239.7	693.8	1235.3	2.263	141.2	2.394	5.46%	16.69%	67.3%	1936	14
6.5%	1216.6	683.4	1212.1	2.273	141.9	2.394	5.03%	16.31%	69.2%	1979	13
6.5%	AVERAGE			2.268	141.5	2.394	5.26%	16.51%	68.2%	1950	13

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
7.0%	1212.5	682	1209.8	2.280	142.3	2.377	4.06%	16.49%	75.4%	1767	14
7.0%	1214.7	685.5	1212.5	2.291	143.0	2.377	3.61%	16.10%	77.6%	1860	14
7.0%	1212.1	679	1209	2.268	141.5	2.377	4.59%	16.95%	72.9%	1541	16
7.0%	AVERAGE			2.280	142.3	2.377	4.08%	16.51%	75.3%	1723	15

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
7.5%	1267.5	711.8	1265	2.276	142.0	2.360	3.56%	17.09%	79.2%	1339	19
7.5%	1247.3	702.7	1245	2.286	142.7	2.360	3.15%	16.74%	81.2%	1584	18
7.5%	1203.6	678.5	1201.9	2.289	142.8	2.360	3.03%	16.63%	81.8%	1535	16
7.5%	AVERAGE			2.284	142.5	2.360	3.25%	16.82%	80.7%	1486	18

Project: Iowa DOT Project FN-21-6(6)-21-07, Black Hawk County 05/19/92
3/4" Leveling By: KRH/AS

Agg. 1 3/4" Type A
Agg. 2 1/2" Type A
Agg. 3 Sand
Agg. 4
Agg. 5

Bin/Stockpile Proportions

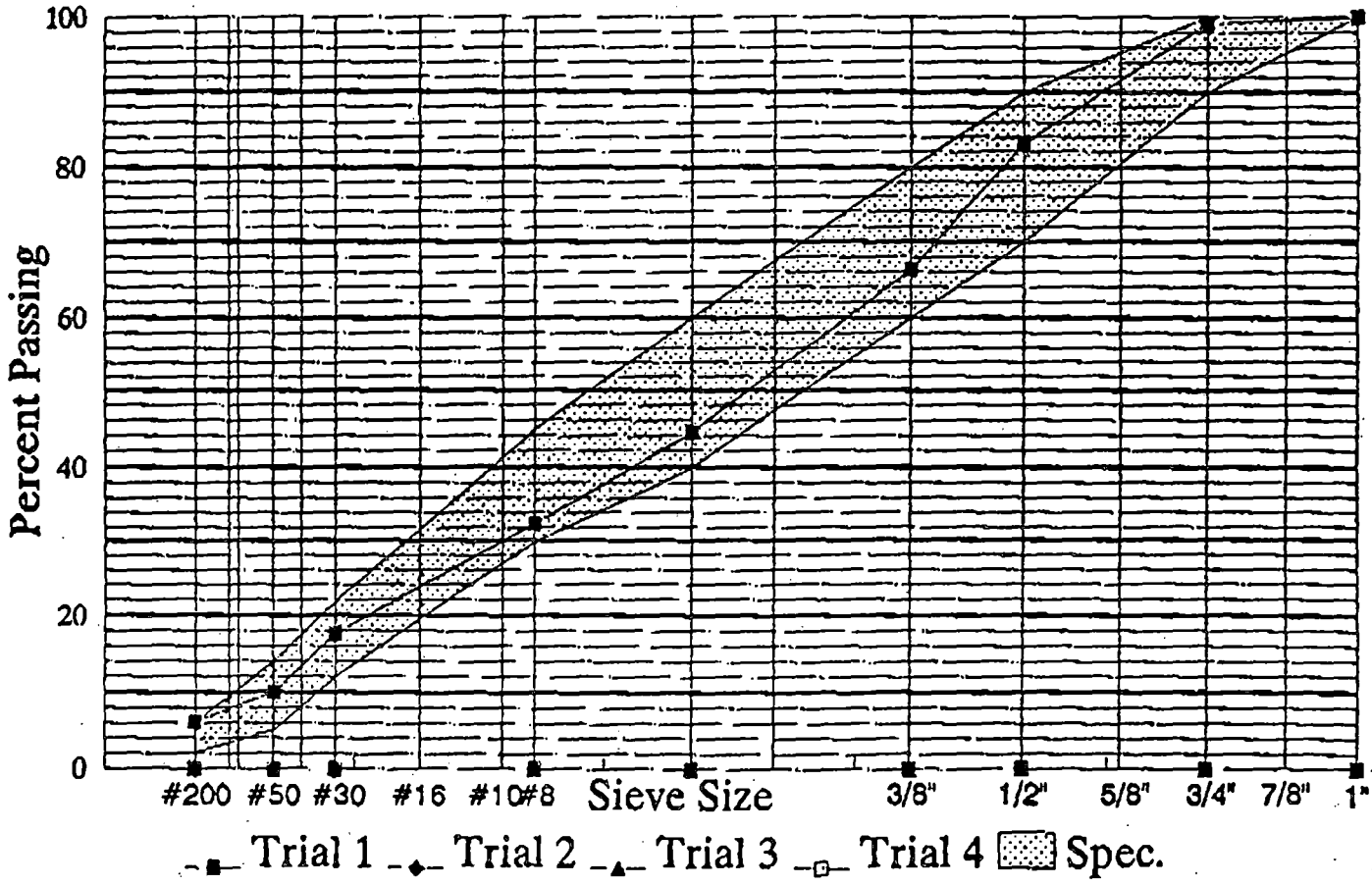
	Agg. 1	Agg. 2	Agg. 3	Agg. 4	Agg. 5	Total
Trial 1	84%		16%			100%
Trial 2						0%
Trial 3						0%
Trial 4						0%

Sieve Analysis

Sieve Size	Percent Passing				
	Agg. 1	Agg. 2	Agg. 3	Agg. 4	Agg. 5
1"	100	100	100		
3/4"	99	100	100		
1/2"	80	99	100		
3/8"	60	81	100		
#4	34	51	100		
#8	22	32	88		
#30	12	16	47		
#50	10	13	10		
#200	7.1	9.5	0.5		

Computed Composite Gradations

Sieve Size	Percent Passing					
	Trial 1	Trial 2	Trial 3	Trial 4	Spec. Min	Spec. Max
1"	100	0	0	0	100	100
3/4"	99	0	0	0	90	100
1/2"	83	0	0	0	70	90
3/8"	66	0	0	0	60	80
#4	45	0	0	0	40	60
#8	33	0	0	0	30	45
#30	18	0	0	0	12	22
#50	10	0	0	0	5	14
#200	6.0	0.0	0.0	0.0	2	6

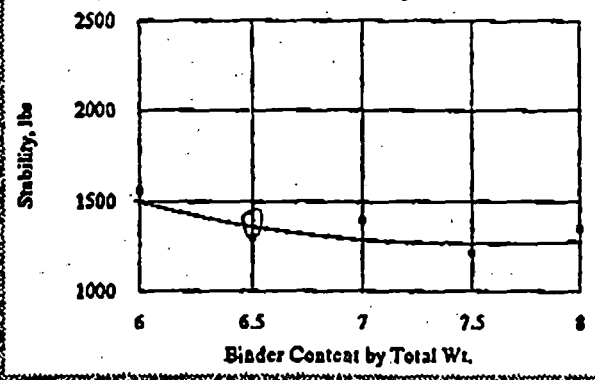


Summary of Marshall Mix Design

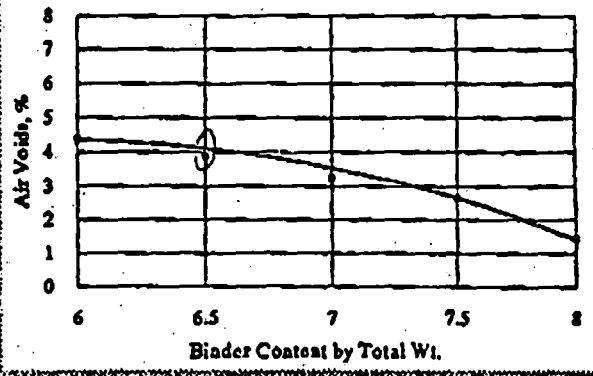
Project Name: Iowa DOT, Project No. FN-21-6(6)-07, Black Hawk County
Mix Description: 3/4" Leveling

Date: 5/18/92
ISI Job No. R-9210

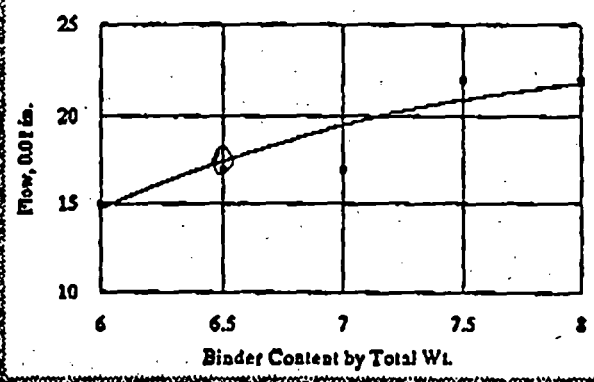
Stability



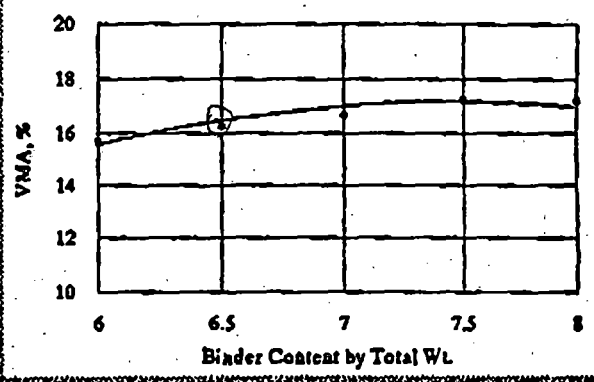
AIR VOIDS



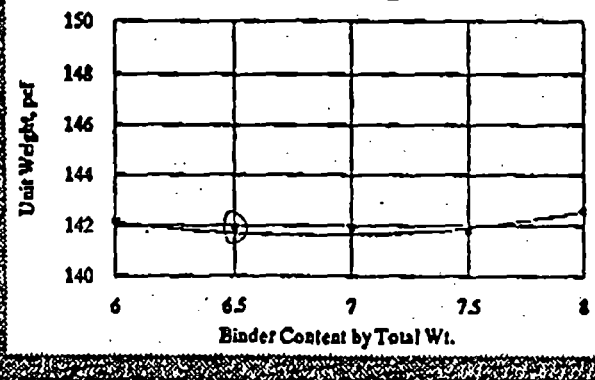
Flow



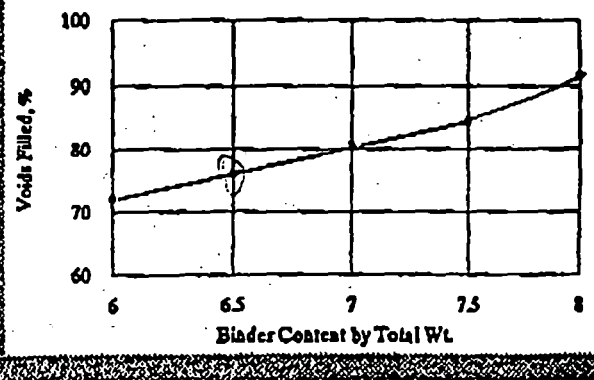
VMA



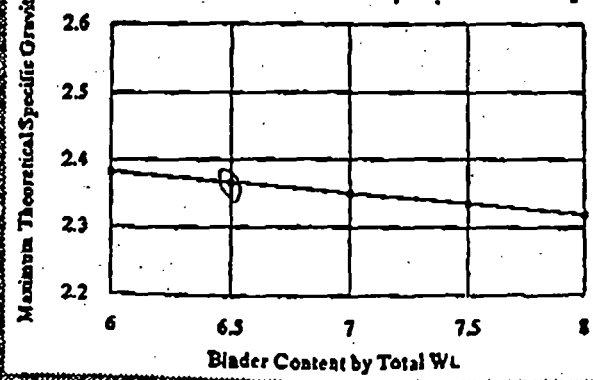
Unit Weight



Voids Filled



Maximum Theoretical Specific Gravity



Recommended Binder Content 6.5%

Stability, lbs.	1300
Air Voids Total Mix, %	3.9
Unit Weight, pcf	141.9
Flow, 0.001 in.	17
VMA, %	16.3
Voids Filled, %	76
Maximum Theo. Sp. Grav.	2.367

Remarks:
Mix Compacted @ 280 +/- 5 F, 50 blows per side

Summary of Marshall Mix Testing

Project: Iowa DOT Project No. 21–6(6)–7, Black Hawk County
Mix: 3/4" Leveling

Date: 5/18/92

Binder Content, %	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
6.0%	1227.8	694.7	1221.6	2.292	143.0	2.383	3.84%	15.18%	74.7%	16695	15
6.0%	1219.8	688.8	1212.1	2.283	142.4	2.383	4.21%	15.51%	72.9%	1620	14
6.0%	1158	647.8	1153.4	2.261	141.1	2.383	5.13%	16.33%	68.6%	1420	16
6.0%	AVERAGE			2.278	142.2	2.383	4.39%	15.67%	72.1%	6578	15

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
6.5%	1212.8	686.1	1203.3	2.285	142.6	2.367	3.46%	15.89%	78.2%	1188	14
6.5%	1214.6	681.3	1211.7	2.272	141.8	2.367	3.99%	16.35%	75.6%	1467	17
6.5%	1228.5	688.2	1224.2	2.266	141.4	2.367	4.26%	16.58%	74.3%	1253	19
6.5%	AVERAGE			2.274	141.9	2.367	3.90%	16.27%	76.1%	1303	17

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
7.0%	1210.3	683.7	1203.3	2.285	142.6	2.350	2.78%	16.32%	83.0%	1530	15
7.0%	1208.3	676.3	1204.5	2.264	141.3	2.350	3.67%	17.09%	78.5%	1374	19
7.0%	1200.1	674.1	1196.1	2.274	141.9	2.350	3.25%	16.73%	80.6%	1302	16
7.0%	AVERAGE			2.274	141.9	2.350	3.23%	16.71%	80.7%	1402	17

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
7.5%	1239.6	698.1	1236.1	2.283	142.4	2.334	2.21%	16.86%	86.9%	1188	21
7.5%	1202.2	675.8	1200	2.280	142.2	2.334	2.35%	16.97%	86.2%	1311	20
7.5%	1199.8	668.2	1198	2.254	140.6	2.334	3.46%	17.92%	80.7%	1152	24
7.5%	AVERAGE			2.272	141.8	2.334	2.67%	17.25%	84.6%	1217	22

Binder Content	SSD Wt. SSD	Wt. in H2O	Dry Wt. in Air	Specific Gravity	Unit Weight	Maximum Theoretical	Air Voids	VMA	Voids Filled	Corrected Stability	Flow
8.0%	1205.5	676.7	1204.3	2.277	142.1	2.319	1.78%	17.50%	89.8%	1376	24
8.0%	1237.7	696.6	1236.8	2.286	142.6	2.319	1.42%	17.20%	91.7%	1359	21
8.0%	1231.7	694.9	1230.6	2.292	143.1	2.319	1.13%	16.95%	93.3%	1329	22
8.0%	AVERAGE			2.285	142.6	2.319	1.44%	17.22%	91.6%	1355	22

ILLEGIBLE

Form 820007 10/91 H-1392

Iowa Department of Transportation

DAILY PLANT REPORT

BITUMINOUS TREATED BASE, ASPHALT CONCRETE

County BLACK HAWK
Project FN-21-6(6)--21-07
Contract No. 33786
Date 6-25-92
Report No. 17

Contractor ABPRO, INC. Plant Location SOUTH PLANT - WATERLOO
Plant Type BATCH Make BARBER GREENE Pollution Equipment BAG HOUSE Resident Engineer G.L. LUND
Mix Type A Class 1 Size 3/4" Crushed Aggr. Sources WATERLOO SOUTH - BMC Recycle Source
Asphalt Source & Grade KOCH AC-5 Sand Sources ABPRO PITS Plant Operated 7:00 A.M. to 5:15 P.M. Mix No. ARC-BINDER 6.5AC

BITUMINOUS MAT SIEVE ANALYSIS OF COMBINED AGGREGATES

SAMPLE			SIEVE NO. - % PASSING												
JOB MIX FORMULA - LIMITS					90-100	70-90	60-80	40-60	30-45		12-22			20-60	3/4" BINDER-ARC
Spl. ID	Time	Compl.	1½	1	¾	½	⅜	4	8	16	30	50	100	200	
1	AM	NO	[illegible]												
2	PM	NO	[illegible]												
3	AM	NO	[illegible]												
AVERAGE			[illegible]												

SAMPLES SUBMITTED		SAMPLES SUBMITTED	
Materials	Senders No.	Materials	Senders No.
	31	AC-5	12
ARC	32		
"	33		

Intended Added 6.5 % A.C. Tank Meas. [illegible] % A.C.
Intended Total 6.5 % A.C. Total [illegible] % A.C.

BATCH WEIGHT

LAB. DEN. 2.317 DENSITY RECORD SOLID DEN. 2.387

Course Laid	Station	℄ Refer	Date Laid	*(1)	Density	% Density	% Voids
A.R.C.-BINDER	2131+77	10' RT	6-25-92	2"	2.266	[illegible]	
	2145+11	6.6' LT		2¼	2.278		
	2154+81	10.2' LT		2⅛	2.219		
	2160+85	9.6' LT		2	2.273		
	2168+21	10.0' LT		2	2.250		
	2174+31	10.8' LT		1¾	2.249		
	2185+00	4.4' RT		2	2.306		
			AVERAGES		2.263	97.66	[illegible]

TEMPERATURE RECORD

Time	7	9	11	1	3	5
Air	~~70~~ / 70	70	75		80	82
A.C.	~~330~~	330	350		350	350
Aggr.	~~350~~	350	340		345	345
Mix	~~300~~	300	305		305	300
Mat.	400	310	275	280	270	275

$1.75 9:30 9:45 10:00 12:00 2:40 4:00

RECYCLED MIX ONLY
Total RAP Used Tons (Totalizer)
Total Aggr. Used Tons
RAP Used % (Target) (Actual)
Aggr. Used % (Target) (Actual)

ALL MATERIALS DELIVERIES

Type	Car or Ticket No.	Total Quantity
AC-5	2209	48140
"	2244	47100
"	2254	47520
RUBBER	3653	46000
AC-10	3223	50140

Avg. Field Density Lot #1
Avg. Field Density Lot #2
Advisory - Fines/Bitumen Ratio = 7.0 ÷ 6.51 = 1.075
Ave. % Field Voids = 5.2
Lab % Voids = [illegible]
Q.I. (Density) = ~~1.84~~ 2.26
(Show Calculation)

$S.D. = \sqrt{\frac{\Sigma(97.669 - X)^2}{(7-1)}} = 1.180$

$Q.I. = (97.669 - 95.000) \div 1.180 = 2.26$

PRODUCTION AND PLACEMENT RECORD

*(2)	Side	Course Laid	From Station to Station	Tons Today	Tons To Date
2"		ARC BINDER	2184+74 - 2186+16	1365.655	1365.655
	LEFT	" "	2134+74 - 2186+16	710.337	
	RIGHT	" "	2134+74 - 2186+00	655.318	

Acceptance Cold Feed (Certified Projects Only)	1	¾	½	⅜	4	8	16	30	50	100	200
	100	98	82	64	41	(28)	21	16	9.8	7.6	(6.8)

COMMENTS

ACCEPTANCE GRADATION IS AVERAGE OF 3 GRADATIONS, NONCOMPLIANCE NOTICE WRITTEN FOR LAB VOIDS. L Dahlin

Acceptance Fines/Bitumen Ratio = 6.8 ÷ 6.51 = 1.04

COMMENTS: Delays, Breakdowns, Corrective Action, etc.
*Thickness: (1) Actual, (2) Intended
Bituminous Treated Base: Enter % Moisture in % Voids Column

Signed [signature]

1.36C

32

Form 820007 08/90 H-1691

Iowa Department of Transportation

DAILY PLANT REPORT

BITUMINOUS TREATED BASE, ASPHALT TREATED BASE, ASPHALT CONCRETE

County BLACK HAWK
Project FN-21-6(6)--21-07
Contract No. 33786
Date 6-26-92
Report No. 18

Contractor ASPRO, INC. Plant Location SOUTH PLANT - WATERLOO
Plant Type BATCH Make BARBER GREENE Pollution Equipment BAG HOUSE Resident Engineer G.L. LUND
Mix Type A Class _____ Size 1/2" Crushed Aggr. Sources WATERLOO SOUTH BMC Recycle Source _____
Asphalt Source & Grade KOCH AC-5 Sand Sources ASPRO PITS Plant Operated 6:00 A.M. to 6:30 P.M. Mix No. 1/2" ARC 7% A/C

BITUMINOUS MAT

SIEVE ANALYSIS OF COMBINED AGGREGATES

SAMPLE			SIEVE NO. - % PASSING												
JOB MIX FORMULA - LIMITS						90-100	75-95	50-70	35-50		15-25			20-8.0	
Spl. ID	Time	Compl.	1½	1	¾	½	⅜	4	8	16	30	50	100	200	
1	AM	No				99	85	55	37	28	20	14	11	9.5	
2	AM	NO				98	84	55	38	28	21	13	10	8.5	
3	PM	NO				98	74	49	37	29	20	12	8.1	7.2	
AVERAGE						98	81	53	37	28	20	13	9.7	(8.4)	

SAMPLES SUBMITTED		SAMPLES SUBMITTED	
Materials	Senders No.	Materials	Senders No.
1/2" ARC SURFACE	34	AC-5	13
"	35		
"	36		

Intended Added 7.0 % A.C. BATCH WTS Tank Meas 6.98 % A.C.
Intended Total 7.0 % A.C. Total 6.98 % A.C.

LAB. DEN. 2.318

DENSITY RECORD

SOLID DEN. 2.369

Course Laid	Station	℄ Refer	Date Laid	*(1)	Density	% Density	% Voids
SURFACE	2237+90	RT	6-26-92	2"	2.307	99.310	2.8
	2135+70			2¼	2.296	99.051	3.1
	2186+76			2	2.243	96.764	5.3
	TO	LT		2	2.289	98.749	3.4
	2135+70			2	2.290	98.792	3.3
				1¾	2.218	95.686	6.4
			V	1¾	2.234	96.326	5.7
					2.267	97.818	

TEMPERATURE RECORD

Time	6	8	10	12	3	5
Air	58	58	70	78	70	68
A.C.	350	350	350	350	350	350
Aggr.	370	370	375	365	365	370
Mix	315	310	315	310	310	315
Mat	310	300	310	320	300	300

6.37 @ 1330

RECYCLED MIX ONLY
Total RAP Used Tons _____
Total Aggr. Used Tons _____
RAP Used % _____
Aggr. Used % _____

MATERIALS DELIVERIES

Type	Ticket No.	Quantity
AC-5	2259	50340
"	2284	49600
AC-10	2722	50260
"	2750	50600
AC-5	2302	50180
"	2297	47340
"	2316	49540
AC-10	2776	50460
"	2799	50700

Avg. Field Density Lot #1 4.31
Avg. Field Density Lot #2

PRODUCTION AND PLACEMENT RECORD

*(2)	Side	Course Laid	From Station to Station	Tons Today	Tons To Date
2"	RT	ARC SURFACE	2237+90 to 2135+70 (125)	(733) ~~2326.457~~	~~2326.457~~
	LT	" "	2186+76 to 2135+70 (105)	(463) 2323.213	2323.213

Acceptance Cold Feed (Certified Projects Only)	1	¾	½	⅜	4	8	16	30	50	100	200
		100	98	80	53	38	29	20	12	8.9	(8.3)

Advisory - Fines/Bitumen Ratio = 8.4 ÷ 6.98 = 1.203 ✓
Ave. % Field Voids = 4.3
Lab % Voids = [redacted] 2.15
Q.I. (Density) = 1.89
(Show Calculation)

$$S.D. = \sqrt{\frac{\Sigma(97.818 - x)^2}{(7-1)}} = 1.49$$

$$QI = \frac{97.818 - 95.000}{1.489} = 1.89$$

Acceptance Fines/Bitumen Ratio = 8.3 ÷ 6.98 = 1.19

COMMENTS ACCEPTANCE GRADATION IS AVERAGE OF 3 GRADATIONS.

JT

COMMENTS: Delays, Breakdowns, Corrective Action, etc.
*Thickness: (1) Actual, (2) Intended
Bituminous Treated Base: Enter % Moisture in % Voids Column

Signed _____ Inspector 13.56 Cert. No.

MATERIALS OFFICE – RECORDS CENTER COPY

33

Asphalt
V. Marks
K. Younkin
C. Anderson

IOWA DEPARTMENT OF TRANSPORTATION
Office of Materials
Highway Division

TEST REPORT — MISCELLANEOUS MATERIALS

AMES LABORATORY

Material AC-5 & Rubber Blend **Laboratory No.** AB2-129

Intended Use A.R.C. Overlay

County Black Hawk **Proj. No.** FN-21-6(6)--21-07

Producer International Surfacers **Contractor** Aspro

Source Waterloo

Unit of Material Blend of AC-5, 2% TBS 20 rubber, and 17% 16R 10-20 rubber

Sampled by Anderson **Sender's No.** CA2-105

Date Sampled 6-25-92 **Date Rec'd** 7-7-92 **Date Reported** 7-10-92

SP-1028, Page 2

B. Asphalt Rubber Cement.

The asphalt rubber cement shall be a uniform reacted blend of compatible paving grade asphalt cement, ground reclaimed vulcanized rubber, extender oil if required, and liquid anti-stripping agent when indicated by standard moisture susceptibility tests. The asphalt rubber cement shall meet the physical parameters listed below.

	Lab Mix			Field Mi
Apparent Viscosity, 347°F., Spindle 3, 12 RPM cps (ASTM D2669 Brookfield)	1600	Min Max	1,000 4,000	1800
Penetration, 77°F., 100 g, 5 sec.: 1/10 mm. (ASTM D5)	59	Min Max	50 100	69
Penetration, 39.2°F., 200 g, 60 sec.: 1/10 mm. (ASTM D5)	47	Min	25	49
Softening Point: °F., (ASTM D36)	134.6	Min	120	132.8
Resilience, 77° F.,: % (ASTM D3407)	47	Min	10	27
Ductility, 39.2° F., 1 cpm: cm. (ASTM D113)	11	Min	10	16
TFOT Residue, (ASTM D1754) Penetration Retention, 39.2° F.: %	95.7	Min	75	85.7
Ductility Retention, 39.2° F.: %	72.7	Min	50	56.2

DISTRIBUTION For Information

AAT2-0270
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IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - BITUMINOUS AGGREGATES
LAB LOCATION - AMES

LAB NO....:AAT2-0270

MATERIAL........:1GR-10/20 TYPE 1-A RUBBER
INTENDED USE....:A.R.C. OVERLAY
PRODUCER........:INTERNATIONAL SURFACERS
PROJECT NO......:FN-21-6(6)--21-07
CONTRACTOR:ASPRO

SOURCE..........:WATERLOO
UNIT OF MATERIAL:LOT #4844
SAMPLED BY......:ANDERSON
SENDER NO.:CA2-106
DATE SAMPLED: 06/25/92   DATE RECEIVED: 06/29/92   DATE REPORTED: 07/01/92

SIEVE ANALYSIS:

#4	100
#10	99
#16	44
#30	4.8
#50	1.0
#200	0.0

MANY PIECES WERE MEASURED THAT RANGED FROM 1/4" TO 1/2". THIS EXCEDES THE LENGTH LIMIT OF 3/16".

COPIES TO:
CENTRAL LAB   C. ANDERSON   V. MARKS

DISPOSITION:

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

ooooo

AAT2-0271
A

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - BITUMINOUS AGGREGATES
LAB LOCATION - AMES

LAB NO....:AAT2-0271

MATERIAL........:TBS 20 RUBBER
INTENDED USE....:A.R.C. OVERLAY
PRODUCER........:INTERNATIONAL SURFACERS
PROJECT NO......:FN-21-6(6)--21-07
CONTRACTOR:ASPRO

SOURCE..........:WATERLOO
UNIT OF MATERIAL:LOT #5470
SAMPLED BY......:ANDERSON
SENDER NO.:CA2-107
DATE SAMPLED: 06/26/92 DATE RECEIVED: 06/29/92 DATE REPORTED: 07/01/92

SIEVE ANALYSIS: #10: 100, #16: 100, #30: 58, #50: 18,
#200: 1.8

LAB NUMBER AAT2-0271

COPIES TO:
~~CENTRAL LAB~~ B. MARKS C. ANDERSON

DISPOSITION:

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

ooooo

Appendix C
Field Tests

IOWA DEPARTMENT OF TRANSPORTATION

TO OFFICE: Materials - Research

DATE: August 18, 1992

ATTENTION: Vernon Marks

REF. NO.: ~~435.204~~ HR-330B

FROM: Mohammad Mujeeb

OFFICE: Materials - Special Investigations

SUBJECT: Friction Testing on IA 21 in Black Hawk County from Milepost 91.00 to Milepost 94.00

Friction testing was conducted on IA 21 on August 7, 1992. All testing was performed at 40 mph with standard tread (ASTM E-501) test tire. The results are as follows:

SECTION 1	Milepost	Northbound	Milepost	Southbound
	91.12	45	91.19	45
	91.20	49	91.34	45
	91.27	45	91.49	52
	91.44	52	91.61	47
	91.63	47	91.74	47
	91.80	41	91.84	43
		==	91.94	42
	Avg.	47		==
			Avg.	46

SECTION 2	Milepost	Northbound
	92.07	45
	92.14	40
	92.23	32
	92.35	45
	92.47	43
	92.62	43
	92.74	46
	92.85	36
		==
	Avg.	41

SECTION 3	Milepost	Northbound	Milepost	Southbound
	93.06	56	93.11	53
	93.14	50	93.26	51
	93.23	44	93.34	50
	93.44	50	93.42	53
	93.54	51	93.48	52
		==	93.54	53
	Avg.	50		==
			Avg.	52

MM:kmd

HR-330B
Rut Depth Measurements
July 31, 1992

Station	A.R.C. Northbound OWT	A.R.C. Northbound IWT	A.R.C. Southbound OWT	A.R.C. Southbound IWT
2135+00	.02	.01	.05	.03
2140+00	.02	.03	.06	.03
2145+00	.08	.09	.04	.05
2150+00	.07	.05	.02	.03
2155+00	.08	.09	.05	.05
2160+00	.05	.07	.06	.05
2165+00	.07	.10	.09	.05
2170+00	.04	.09	.09	.05
2175+00	.05	.08	.08	.08
2180+00	.05	.05	.09	.09
2185+00	.05	.03	.02	.02

Station	A.R.C. Northbound OWT	A.R.C. Northbound IWT	Conventional Southbound OWT	Conventional Southbound IWT
2190+00	.02	.10	.05	.02
2195+00	.05	.09	.05	.03
2200+00	.07	.04	.03	.02
2205+00	.04	.09	.05	.03
2210+00	.03	.09	.06	.02
2215+00	.03	.07	.05	.02
2220+00	.02	.05	.02	.03
2225+00	.03	.09	.06	.04
2230+00	.05	.05	.02	.03
2235+00	.02	.08	.02	.03

Station	Conventional Northbound OWT	Conventional Northbound IWT	Conventional Southbound OWT	Conventional Southbound IWT
2240+00	.05	.07	.02	.03
2245+00	.03	.07	.03	.04
2250+00	.02	.05	.02	.07
2255+00	.02	.08	.03	.05
2260+00	.03	.07	.06	.04
2265+00	.04	.07	.02	.05
2270+00	.02	.10	.06	.05

HR-330B
Road Rater

	Preconstruction 3-3-92	Post Construction 7-14-92
Section 1	3.91	5.90
Section 2	3.42	5.55
Section 3	3.52	5.22