Final Report
for
Iowa DOT Project HR-507
Included in
Iowa DOT Construction Project - Clarke I-IR-35-2(157)33--14-20

Federal Highway Administration
Experimental Project IA-79-03

SPRINKLE TREATMENTS FOR ASPHALT CONCRETE

by
Vernon J. Marks
Research Engineer
515-239-1447

Iowa Department of Transportation
Office of Materials
Ames, Iowa 50010

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DISCLAIMER

INTRODUCTION

In recent years, the Iowa Department of Transportation has put greater emphasis on improving highway safety. This effort has been relatively successful with a reduction in traffic-related fatalities to levels experienced prior to 1950. The nationwide speed limit of 55 mph was probably the greatest contributor to the decline in traffic fatalities, but there have been many other efforts that have also contributed to this decline. The Iowa DOT has been testing all paved roadways periodically for friction coefficient since 1969. New techniques have been used to obtain a greater depth of surface texture on paved roadways. Transverse tined grooving has been used on portland cement concrete to provide increased texture depth.

The frictional values of asphalt concrete pavements are highly dependent on the characteristics of the aggregates incorporated into the mixture. The predominant aggregates available in Iowa for highway construction are crushed limestone or dolomite. Even the gravel deposits contain substantial quantities of carbonate aggregate. Unfortunately, many of these crushed limestones or dolomites are relatively soft and prone to polishing under traffic.

The Iowa Department of Transportation has established a frictional classification for aggregates.(1) This classification is divided into five types with Type 1 being the hardest and the coarsest grained aggregates and Type 5 being the softest and finest grained aggregates. There are no naturally occurring Type 1 or Type 2 ag-

gregates within the state of Iowa. Crushed quartzites and granites, which are in Type 2, may be obtained from adjoining states. The crushed limestone and dolomites in Iowa range from Type 3 which include the coarse grain dolomitic ledges to Type 5 which contains the fine grained, soft limestones.

With the energy crisis, it is very expensive to transport aggregates for long distances and, therefore, in many cases is not economically feasible to import hard, sharp, durable aggregates to provide more desirable or increased frictional qualities. Economically, it is more desirable to use locally available aggregate. Iowa began experimental investigation of improving frictional quality on asphalt concrete pavement by sprinkling a hard, durable aggregate on the surface of the fresh mat in 1974. There were problems in obtaining a uniform coverage with the hard, durable aggregate. This problem was alleviated with the use of the Bristowes spreader, which became available in 1977. Since that time, there have been numerous applications of sprinkle treatment on asphalt concrete surfaces to provide improved frictional qualities.

The most extensive investigation of sprinkle treatment of asphalt surfaces to improve frictional qualities was conducted as Iowa DOT project HR-199 (2), also known as U.S. Department of Transportation contract DOT-FH-15-295. This research evaluated the use of six sprinkle aggregates on three standard asphalt concrete mixtures. The research concluded that sprinkle treatments increase not only

the surface macrotexture significantly, but also improve the friction numbers of asphalt pavements.

PROJECT LOCATION AND PRECONSTRUCTION CONDITION

This project is located on I-35 from the Jct. of US 34, north approximately 9.8 miles to the Warren County line. In 1978, prior to the asphalt resurfacing of this project, the roadway was carrying an average daily traffic of 5,800 with 27.4% trucks. The 1978 friction numbers were 43 northbound, and 37 southbound. The asphalt concrete surface exhibited a substantial amount of cracking and openness that was requiring an increased degree of maintenance.

CONTRACTUAL ARRANGEMENTS

The successful bidder on this project, let March 27, 1979, was Des Moines Asphalt and Paving. The project included both surface recycling and an asphalt concrete surface course. The surface recycling included heating and reworking of the top 1" of the asphalt concrete. A 1" thick, Type A, 1/2" surface mix was placed on all driving surfaces after placement of a Type B, Class II variable thickness leveling course.

MATERIALS

All asphalt concrete mixtures were produced at the Des Moines Asphalt batch plant at West Des Moines. The mix designs are included as Appendix A-1 and A-2. The crushed limestone for the mixes was produced at the Martin-Marietta Ferguson plant and the sand was from Martin-Marietta at West Des Moines. The asphalt cement was an

AC-20 from Bituminous Materials & Supply of Algona, Iowa. The sprinkle treatment aggregate was a 3/4" top size gravel from the Martin-Marietta plant at West Des Moines (Appendix B-1).

CONSTRUCTION

Placement of the asphalt concrete began with the Type B, Class II leveling and strengthening on June 12, 1979. The Type A, 1/2" surface was completed on September 11, 1979. The mix temperature was maintained at approximately 300°F and the mat temperature remained at about 280°F. The sprinkle treatment aggregate was placed using a Bristowes spreader following very closely behind the laydown machine in accordance with Supplemental Specification 842 (Appendix C1 and C2).

PERFORMANCE EVALUATION

The evaluation of the sprinkle treatment was primarily based on the friction number and the texture depth. A summary of those values are given below:

Friction and Texture Summary
I-35 MP 33.0 to 42.5 Clarke County

Date	Avg. Friction Number		Date	Texture Depth, Inches	
	NB	SB		NB	SB
11-2-79	43	42	11-16-79	.058	.061
5-12-80	46	46	8-8-80	.049	.052
5-14-81	49	49	11-9-81	.043	.041
6-2-82	50	49	10-5-82	.052	.030
7-6-83	37	37	---	---	---
7-9-84	43	43	11-6-84	.038	.023
7-10-85	47	48	11-19-85	.046	.053

It is noted from the summary that the friction had decreased from the 50 and 49 during June 1982. This decrease was attributed to the fog seal with dilute emulsion of June 1983. In July 1984 the friction values were again in the forties.

ECONOMICS

This project is not a good project to evaluate the economics of sprinkle treatment. The asphalt concrete mix was hauled approximately 40 miles to this project. If the asphalt mixture was produced at a site closer to the project site and the aggregates were locally available with a short haul distance the major difference in cost in providing the improved friction would be the increased special aggregate transportation cost which would probably be approximately 10¢ per ton mile. The sprinkle treatment requirement at 7 1/2 lbs. per sq. yd. for a roadway 24' wide would be 52.8 tons per mile of roadway. If the frictional qualities were obtained by utilizing 30% of the same hard, durable aggregate in a 2" thick, 24' wide roadway, it would require 1,531 tons per mile. This would require the long distance transportation of approximately 1,480 tons of special aggregate. If this special aggregate had to be transported for 100 miles at 10¢ per ton mile this would amount to $14,784 per mile of 24' wide roadway for the additional transportation.

DISCUSSION

It would appear that the sprinkle treatment was successful in providing desirable, improved, and durable friction qualities. The

asphalt concrete prior to the AC resurfacing with the sprinkle treatment produced an average friction number of 40. Since that time, the sprinkle treated surface has remained above 40 with the exception of a short period of time after a fog seal.

CONCLUSION

It can be concluded from this experimental evaluation of the use of sprinkle treatment that a sprinkle treatment application does provide improved, durable friction qualities to an asphalt concrete roadway even though soft aggregate is used in the asphalt mixture.

REFERENCES

1. I.M. T-203, General Aggregate Source Information 1986, Iowa Department of Transportation, January 1985

2. Shelquist, Robert A., "Sprinkle Treatment of Asphalt Surfaces", Final Report, Iowa Department of Transportation, January 1984

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE A SURFACE LAB NO. ABD9-41

INTENDED USE:

SIZE 1/2" SPEC. NO. 841 DATE REPORTED 5/29/79

COUNTY CLARKE PROJECT I-IR-35-2(157)33--14-20

CONTRACTOR DES MOINES ASPHALT

PROJ. LOCATION FROM WARREN CO. LINE SOUTH 9.8 MILES

AGG. SOURCES 1/2" CR. LST. - FERGUSON QR. - MARSHALL CO., 1/2" LST. CHIPS - FERGUSON QR. - MARSHALL CO., SAND - WEST DES MOINES PIT- POLK CO.
JOB MIX FORMULA AGGREGATE PROPORTIONS: 45% AAT9-125, 20% AAT9-126, 35% AAT9-128

JOB MIX FORMULA - COMBINED GRADATION

1-1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.8	NO.16	NO.30	NO.50	NO.100	NO.200
			100	90	65	46	35	24	12	7.2	5.4
TOLERANCE:			98/100	7	7	5		4			2

75 BLOW MARSHALL DENSITY		2.38	
ASPHALT SOURCE AND APPROXIMATE VISCOSITY	KOCH - 1140 POISES		
PLASTICITY INDEX			
% ASPH. IN MIX	4.25	5.25	6.25
NUMBER OF MARSHALL BLOWS	50	50	50
MARSHALL STABILITY - LBS.	2213	1850	1915
FLOW - 0.01 IN.	7	7	8
SP.GR. BY DISPLACEMENT(LAB DENS.)	2.32	2.34	2.36
BULK SP. GR. COMB. DRY AGG.	2.670	2.670	2.670
SP. GR. ASPH. @ 77 F.	1.029	1.029	1.029
CALC. SOLID SP.GR.	2.53	2.49	2.46
% VOIDS - CALC.	8.4	6.2	4.0
RICE SP. GR.	2.52	2.48	2.44
% VOIDS - RICE	7.8	5.5	3.4
% WATER ABSORPTION - AGGREGATE	1.07	1.07	1.07
% VOIDS IN THE MINERAL AGGREGATE	16.8	17.0	17.1
% V.M.A. FILLED WITH ASPHALT	50.2	63.6	76.9
CALCULATED ASPH.FILM THICKNESS(MICRONS)	6.8	8.7	10.7

A CONTENT OF 5.50% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:
ASPH. MIX DESIGN
I-IR-35-2(157)33--14-20, CLARKE
D. ANDERSON
R. PERCIVAL
R. D. CHAPMAN
R. SHELQUIST
D. JORDISON
L. ZEARLEY
DES MOINES ASPHALT
C. JONES
D. HINES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE A SURFACE LAB NO. ABD9-131

INTENDED USE:

SIZE 1/2" SPEC. NO. 841 DATE REPORTED 8/2/79

COUNTY CLARKE PROJECT I-IR-35-2(157)33--14-20

CONTRACTOR DES MOINES ASPHALT

PROJ. LOCATION FROM WARREN CO. LINE SOUTH 9.8 MILES

AGG. SOURCES 1/2" CR. LST. - FERGUSON QR. - MARSHALL CO.; 1/2" CR. LST. CHIPS - FERGUSON QR. - MARSHALL CO.; SAND - WEST DES MOINES PIT - POLK CO.
JOB MIX FORMULA AGGREGATE PROPORTIONS: 30% AAT9-428, 35% AAT9-429, 35% AAT9-430

JOB MIX FORMULA - COMBINED GRADATION

1-1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.8	NO.16	NO.30	NO.50	NO.100	NO.200
			100	89	59	44	35	24	12	6.6	5.4
TOLERANCE:			98/100	7	7	5		4			2

75 BLOW MARSHALL DENSITY		2.40	
ASPHALT SOURCE AND APPROXIMATE VISCOSITY	KOCH - 2250 POISES		
PLASTICITY INDEX			
% ASPH. IN MIX	4.25	5.25	6.25
NUMBER OF MARSHALL BLOWS	50	50	50
MARSHALL STABILITY - LBS.	2742	2292	2153
FLOW - 0.01 IN.	7	8	10
SP.GR. BY DISPLACEMENT(LAB DENS.)	2.34	2.38	2.39
BULK SP. GR. COMB. DRY AGG.	2.639	2.639	2.639
SP. GR. ASPH. @ 77 F.	1.032	1.032	1.032
CALC. SOLID SP.GR.	2.52	2.48	2.44
% VOIDS - CALC.	7.0	4.0	2.2
RICE SP. GR.	2.51	2.47	2.44
% VOIDS - RICE	6.8	4.7	2.0
% WATER ABSORPTION - AGGREGATE	1.43	1.43	1.43
% VOIDS IN THE MINERAL AGGREGATE	15.1	14.6	15.1
% V.M.A. FILLED WITH ASPHALT	53.5	72.5	85.6
CALCULATED ASPH.FILM THICKNESS(MICRONS)	6.6	8.5	10.5

THIS IS A VERIFICATION TRIAL MIX BECAUSE OF THE PROPORTION CHANGES OF THE AGGREGATES.

COPIES:
ASPH. MIX DESIGN
I-IR-35-2(157)33--14-20, CLARKE
R. PERCIVAL
D. ANDERSON
R. CHAPMAN
R. SHELQUIST
D. JORDISON
L. ZEARLEY
DES MOINES ASPHALT
C. JONES
D. HINES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

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

* CORRECTED REPORT

MATERIAL 3/4 PLUS GRAVEL LAB NO. AAT9-5

INTENDED USE SPRINKLE COAT

COUNTY CLARKE PROJ NO. ~~I~~-IR-35-2(157)33--14-20

DESIGN CONTRACT NO.

PRODUCER MARTIN MARIETTA CONTRACTOR D.M. ASPHALT

SOURCE 15-22-78-25 POLK CO.

UNIT OF MATERIAL

SAMPLED BY HASSETT & SHORT SENDERS' NO. D79A-3

DATE SAMPLED 4/6/79 REC'D 4/12/79 REPORTED 5/11/79

*	% AGE
CHERT	6.5
QUARTZITE	2.7
SANDSTONE & SILTSTONE	4.1
TYPE 5 LIMESTONE	2.1
SHALE	0.2
CARBONACEOUS SHALE	0.5
IRON OXIDE	2.5
IGNEOUS	57.4
LIMESTONE	24.0
TOTAL	100.0

SKID RESISTANCE CLASSIFICATION: TYPE 3

COPIES:
BIT. AGG.
D. ANDERSON
DM LAB. - 3
GEOLOGY

DISPOSITION:

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

Specification 842
Supersedes 824

IOWA DEPARTMENT OF TRANSPORTATION
Ames, Iowa

Supplemental Specification
for

SPRINKLE TREATMENT OF ASPHALT CEMENT CONCRETE SURFACES

February 6, 1979

THE STANDARD SPECIFICATIONS, SERIES OF 1977, ARE AMENDED BY THE FOLLOWING ADDITIONS. THESE ARE SUPPLEMENTAL SPECIFICATIONS, AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

842.01 DESCRIPTION. Sprinkle treatment shall consist of properly graded aggregate, precoated with asphalt cement and applied to the surface of hot-mix asphalt cement concrete pavement as designated in these specifications and elsewhere in the contract documents.

842.02 MATERIALS. The materials used in sprinkle treatments of asphalt cement concrete surfaces shall meet the following requirements.

A. Aggregate shall be composed of a Type III crushed gravel or a Type II, III or IV crushed stone as classified in Materials Instructional Memorandum T-203 or lightweight aggregate (expanded shales).

Crushed gravel shall be produced as a separate operation by crushing gravel to the extent that 100 percent will pass the 3/4-inch sieve; the aggregate shall be prescreened prior to crushing on a screen at least 1/4 inch larger. The prescreen size shall be adjusted to compensate for screening efficiency, material variability, and carryover.

All limestone and gravel aggregates shall be washed products.

All aggregate sources and production procedures shall be subject to approval of the engineer, and the aggregate shall meet the following requirements.

1. Freezing-and-Thawing Test. The freezing-and-thawing loss, when tested according to Laboratory Test Method 211, Method A, shall not exceed 10 percent.
2. Abrasion Loss. The percentage of wear, as determined by AASHTO T 96, shall not exceed 35 for lightweight aggregate and 40 for all other aggregate.
3. Size of Particles. When tested by means of laboratory sieves, the aggregate shall meet the following limits. The percentage passing the No. 200 sieve shall be determined by washing, followed by dry sieving. Any mudballs present shall be completely broken up and dissolved.

Sieve Size	Percent Passing
3/4	100
3/8	0 - 15
No. 4	0 - 5
No. 200	- 1.5*

*The maximum percent passing the No. 200 sieve may be increased to 2.5 percent provided the documented production limit agreed to and maintained is 1.0 percent or less and any increase up to 2.5 percent is due to degradation of the parent material and not to contamination by other material.

B. Asphalt. The asphalt cement used to coat the aggregate shall be the grade used in the asphalt surface course.

C. Aggregate Coating. Samples of aggregates to be used for sprinkle treatment shall be submitted to the Central Laboratory for testing prior to precoating. The Laboratory will designate the proper coating, and this may be modified by the engineer. The designated coating will be between 0.75 percent and 2.0 percent, expressed as percent by weight of asphalt cement in the total mixture. The designated coating shall be considered a target value.

842.03 EQUIPMENT. The equipment used for spreading the precoated aggregate shall be a Bristowes Chip Spreader. An equivalent spreader may be approved by the engineer.

Initial rolling shall be with a self-propelled, smooth, steel-tired roller meeting requirements of 2001.05B.

842.04 PRECOATED AGGREGATE. The equipment and procedures for precoating shall comply with the applicable requirements of 2001.22 and 2303.04.

The aggregate shall be precoated at a temperature between 240F and 275F and shall have a uniform, complete coating. The aggregate should be coated at the lowest temperature that insures complete coating. If coated aggregate is stockpiled, it shall be stockpiled on a clean, paved surface. Stockpiling methods which minimize segregation shall be used. Provisions should be made for manipulation or wetting of the coated aggregate if crusting of the aggregate occurs. No water shall be applied to the freshly coated aggregate until it has cooled sufficiently to

prevent the possibility of stripping. The engineer may require the stockpile to be covered.

At the option of the contractor, precoated aggregate remaining at the completion of the work will be purchased and paid for by the contracting authority. The precoated aggregate shall be hauled and stockpiled at a site designated by the engineer. The haul may be as far as the nearest maintenance garage of the contracting authority. The engineer may limit the quantity of aggregate to be precoated to assure this quantity is reasonable.

842.05 CONSTRUCTION. The precoated aggregate may be spread hot or cold. It shall be uniformly applied to the surface of the asphalt surface course as soon as possible after laydown and before initial rolling of the surface. The spreader shall span the lane to be spread. Provisions should be made for wetting the coated aggregate if crusting or unusual adherence of aggregate particles occurs.

The precoated aggregate shall be applied to the surface at a target rate of 7 1/2 pounds per square yard when crushed stone or gravel is used, and the contract quantities are based on this rate. When lightweight aggregate is used, the coated aggregate shall be applied at the rate of 5 pounds per square yard. These target rates may be adjusted by the engineer to insure proper coverage of the surface area.

Rolling shall commence immediately after the coated aggregate is applied unless otherwise directed by the engineer. The initial rolling shall be done with a steel roller. Compaction shall be in accordance with the requirements for the type of surface course being laid. Pneumatic-tired rollers, when used for intermediate compaction, shall not be used if tire pick up of sprinkle aggregate is encountered.

Any nonuniform distribution of coated aggregate shall be corrected with lutes or brooms before initial rolling.

Traffic will not be permitted on the finished surface until the pavement has cooled to such a level that the coated aggregate will not pick up under the tires. Sprinkling the pavement surface with water may be required, as directed by the engineer, to promote cooling of the pavement prior to opening the roadway to traffic.

842.06 LIMITATIONS. Sprinkle treatment of asphalt cement concrete surfaces shall not be placed after October 1 except by authorization of the Construction Engineer.

842.07 METHOD OF MEASUREMENT. The quantity of Aggregate for Sprinkle Treatment will be computed from weights of precoated aggregate that is applied to the asphalt surface course, in accordance with appropriate requirements of 2303.19A.

When payment is to be made for precoated aggregate remaining at the completion of the work, precoated aggregate will be measured separately in the same manner.

842.08 BASIS OF PAYMENT. For the number of tons of Aggregate for Sprinkle Treatment, satisfactorily applied to the asphalt surface course and measured as provided above, the contractor will be paid the contract price therefor.

For the number of tons of precoated aggregate remaining at the completion of the work and hauled and stockpiled according to 842.04, the contractor will be paid 25 percent of the contract price for Aggregate for Sprinkle Treatment.

These payments shall be full compensation for furnishing, precoating, and applying the precoated aggregate to the asphalt surface course and for furnishing, precoating, hauling, and stockpiling the precoated aggregate remaining at the completion of the work. Asphalt cement used for precoating will be considered incidental.

Water, when required, will be considered incidental.

Article 1109.03 shall not apply to Aggregate for Sprinkle Treatment when the change in quantities is due to use of lightweight aggregate.