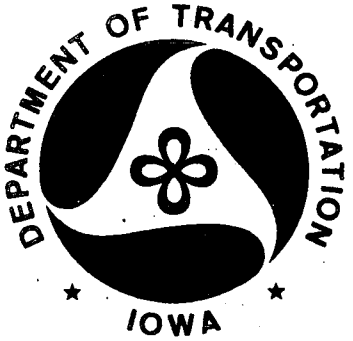
RECYCLING
of
ASPHALT CONCRETE
from
I-80 In Cass County



Highway Division
Office of Materials

December 1978

Final Report
Research Project HR-1011

DISCLAIMER

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FINAL REPORT
FOR
RESEARCH PROJECT HR-1011

RECYCLING OF ASPHALT CONCRETE

FROM I-80 IN CASS COUNTY

BY

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IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

DECEMBER 1978

TABLE OF CONTENTS

RECYCLING OF ASPHALT CONCRETE FROM I-80 IN CASS COUNTY

ABSTRACT

Approximately 40,000 tons of deteriorated asphalt concrete has been removed from Interstate 80 in Cass County and stockpiled. Laboratory tests indicate that this material has considerable value when upgraded with new aggregate and asphalt cement. This report documents the procedures used and results obtained on an experimental recycling project. It was demonstrated that present drum mixing-recycling equipment and procedures can be used to utilize this material with satisfactory results. Laboratory analyses of material components and mixtures were performed; these analyses indicate mixture can be produced that is uniform, stable, and very closely resembles mixture produced with all virgin material.

A 1700 foot long test section was constructed on US 169 in Kossuth County wherein salvaged asphalt concrete from I-80 in Cass County was utilized. The salvaged mix was blended with virgin aggregate and recycled through a modified drum mixing plant, the reprocessed mixture was satisfactorily placed 1½ inches thick as a resurfacing course on an old PCC pavement.

An inspection of the test section was made in December of 1978 to evaluate the performance after one full year of service. There was no evidence of rutting or shoving from traffic. The

surface does, however, have a very dry and somewhat ravelled appearance. This can be related to a low asphalt content in the mix and some temperature control problems which were difficult to get fully corrected on such a short project and with a short supply of readily available materials.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are justified in light of test results and one year of experience.

1. It is feasible to recycle the salvaged asphalt concrete stockpiled in Cass County.
2. The laboratory tests indicate that a satisfactory and uniform mixture can be produced by this recycling procedures.
3. The poor performance of the test section is related to laboratory work which indicated use of a combination of aggregates and recycled material which would become unstable with asphalt contents at or above 4.75%.
4. The mix design for future use of this salvaged material must provide for the addition of a combination of virgin materials which will permit the use of enough asphalt cement to provide for a final mix which will have a minimum film thickness of 6.5 microns. A minimum void percentage of 3.5 will also be required.

5. The salvaged material should be crushed to a maximum of one inch in size to provide a more uniform blend of new and recycled materials.
6. Where gravel was used for the additive, poor performance resulted because of the low AC content and high voids.
7. The material stockpiled in Cass County should be integrated into a resurfacing project in 1979.

INTRODUCTION

Approximately 40,000 tons of asphalt concrete have been removed from I-80 in Cass County. The material is being stored on leased property located approximately 3 miles north of the I-80, US 71 interchange. The lease requires the material be removed by December 30, 1979.

This material has been damaged somewhat by moisture, temperature and traffic. As presently constituted, it lacks the stability that is required for heavy interstate traffic. Even though this material has been damaged, laboratory tests indicate this material has considerable value when upgraded with approximately 35 percent virgin material and a small percentage of new asphalt cement.

The large quantity of salvageable material in Cass County and

the success of the recycling project in Kossuth County (HR-188) indicated that steps be taken to verify the laboratory findings referred to above. Therefore, an experimental section was established on US 169 in Kossuth County three and one half (3½) miles north of the Humboldt County Line. Although the test section was located a considerable distance from the stockpile and future usage areas, it was convenient to the contractors plant site. The expense associated with transporting the salvaged material was considerably less than that resulting from moving the large drum mixing plant for a small quantity of production.

The 1700 foot test section (Appendix A) was constructed under Staff Action authorization No. S-78-154, approved August 10, 1977 (Appendix B). Approximately 304 tons of recycled asphalt concrete were placed on a 20 foot wide PCC pavement originally constructed in 1936. A portion of the test section pavement was originally constructed with sloping curb; this required extra overlap by the paver at the centerline for a short distance. This highway carries an average of 2030 cars and trucks per day (ADT).

OBJECTIVES

The primary objectives for the project were established as follows:

1. Determine the feasibility of recycling the 40,000 ton stockpile located in Cass County

2. Determine recycled mixture characteristics using laboratory tests.
3. Determine roadway behavior of the recycled mixture.
4. Determine if this salvaged asphalt mixture could be blended with new aggregate and asphalt in an acceptable manner by the plant equipment available at this time.

MATERIALS

The salvaged asphalt binder and surface course mixture was removed from the Cass County section of I-80 between US 71 and the Adair County line during the 1977 construction season. Some of the material had been heater-planed and some has been resurfaced with a thin layer of Hot Sand Surface Course. No attempt was made to separate the salvaged material during removal and stockpiling operations.

The salvaged 1½" thick binder course was originally produced and placed in 1973 and 1974. It was a Type A 3/4 inch asphalt concrete mixture composed of 65 percent crushed limestone produced from the Argentine geologic formation, 35 percent locally produced sand, and 5.25 percent 85-100 penetration asphalt cement. The salvaged 1½" thick surface course was originally produced and placed in 1973 and 1974. It was a Type A ½ inch asphalt concrete mixture composed of 65 percent crushed gravel produced

from a glacial deposit near Auburn, 35 percent locally produced sand, and 5.25 percent 85-100 penetration asphalt cement.

Adverse interactions between material characteristics, traffic, and environmental conditions developed during the summer of 1974 resulting in severe ruts and corrugations. This behavior reduced the serviceability and presented hazards to the highway users. A project was scheduled for the 1977 construction season to remove and replace this material. Project details can be obtained from the plans, specifications, and project records for Cass County Project I-IR-80-2(64)63--14-15.

Samples of the salvaged material were characterized; the test data is summarized in Appendix C, Table I. Sample No. 7-263 is a composite sample of I-80 binder and surface course mixture. This material was used to develop the job mix formula for the test section. Samples 6-21, 6-22 and 6-23 are core samples of crushed gravel aggregate-surface course and samples 6-24, 6-25 and 6-26 are core samples of limestone aggregate-binder course obtained from I-80 prior to removal.

The original asphalt cement exhibited penetrations in the middle of the 85-100 range; the original absolute viscosity tests were in the 650-700 poise range. With the exception of sample 6-21, the recovery tests indicate that little hardening

occured during production and the 2 to 3 year service period. The low absolute viscosity and temperature susceptibility of the asphalt cement has been considered factors in the resulting poor performance of the resurfacing. These characteristics, together with the weather, heavy traffic, and moisture, resulted in aggregate stripping, rutting and corrugation of the binder and surface courses.

A job mix formula, refer to Appendix C, Table II, was developed for the test section utilizing 65 percent salvaged material and 35 percent virgin crushed limestone produced from the Kampen Quarry in Humboldt. The crushed stone source was selected because it could produce acceptable Type A quality aggregate and was located near the plant site. The design objective was to develop a recycled mix which would comply with requirements of Materials I.M. 511, Table A for standard Type A asphalt concrete. This was accomplished with the 35 percent virgin limestone and 1 percent new 85-100 penetration asphalt cement.

CONSTRUCTION

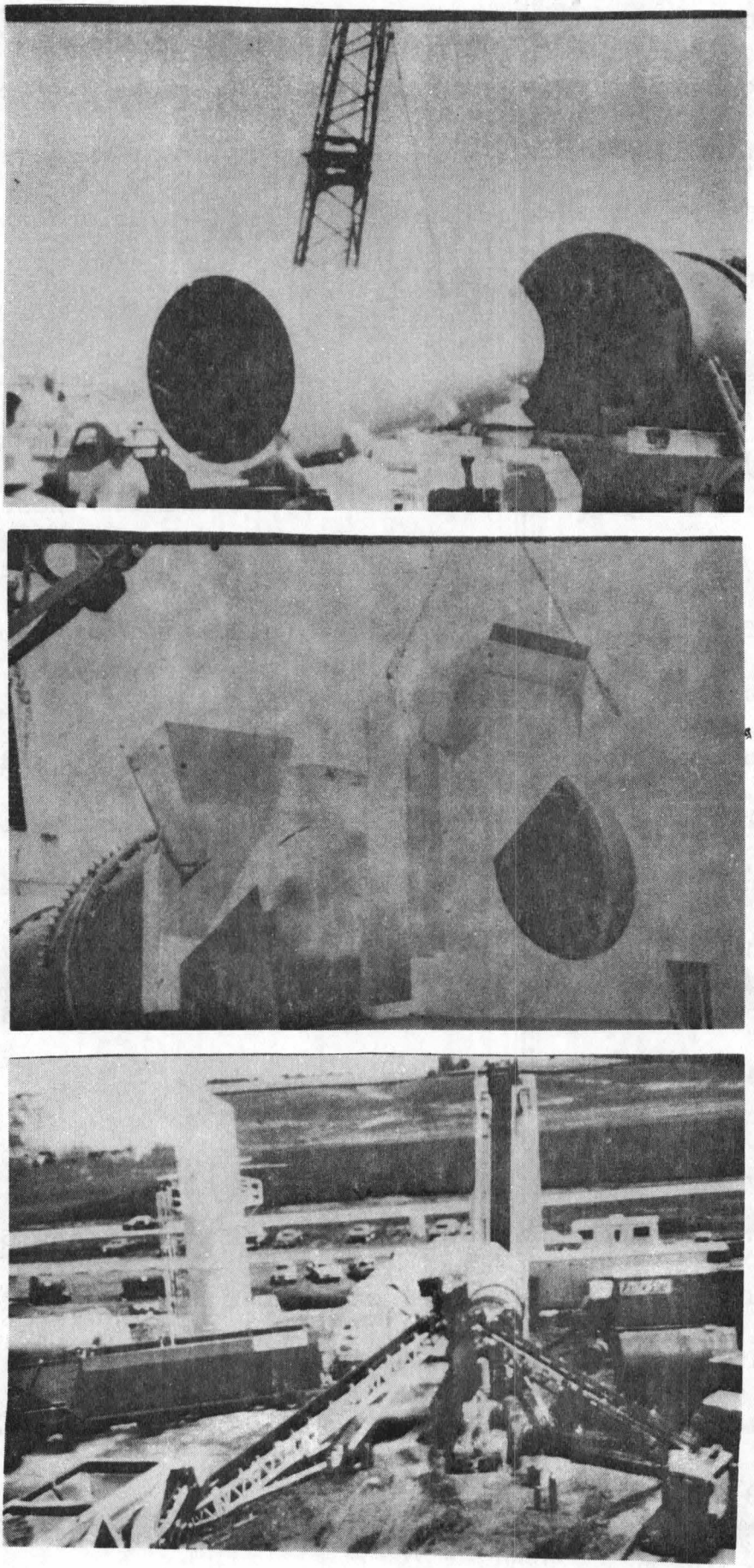
Production and placement of the recycled asphalt concrete mixture was completed by the Rohlin Construction Company of Estherville, Iowa on August 18, 1977. Salvaged mixture from Cass County and virgin limestone were delivered to the plant site by truck during non-operating periods.

The contractor utilized a specially modified drum mixing plant manufactured by the Iowa Manufacturing Company of Cedar Rapids, Iowa. The modifications consisted of a second cold feed and weigh belt delivery unit, and a drum insert package which protected the salvaged asphalt mixture from the burner flame. Figure 1 shows how the drum insert package was constructed and mounted on the standard drum mixing unit. This equipment was designed and fabricated in response to the recycling work let by Kossuth County earlier in the year. This work was funded in part by the Iowa Highway Research Board through project HR-188; a formal report covering this research was developed by Kossuth County Engineer Richard P. Henely.

Work on the test section began on the morning of August 18, 1977; placement operations were completed and two-way traffic restored about noon the same day. Placement began on the north end of the test section on the northbound lane; the contractor reversed the laying sequence for the opposite lane.

Some difficulty was encountered during production with temperature control. The sensor located in the drum mixer discharge was found to be improperly located; this resulted in higher actual mixture temperatures than were displayed by the temperature monitor in the plant control room. Thermometer checks indicated some of the mixture was produced in the 325^{o}F to 350^{o}

Figure 1. Drum Mixing Plant Modifications

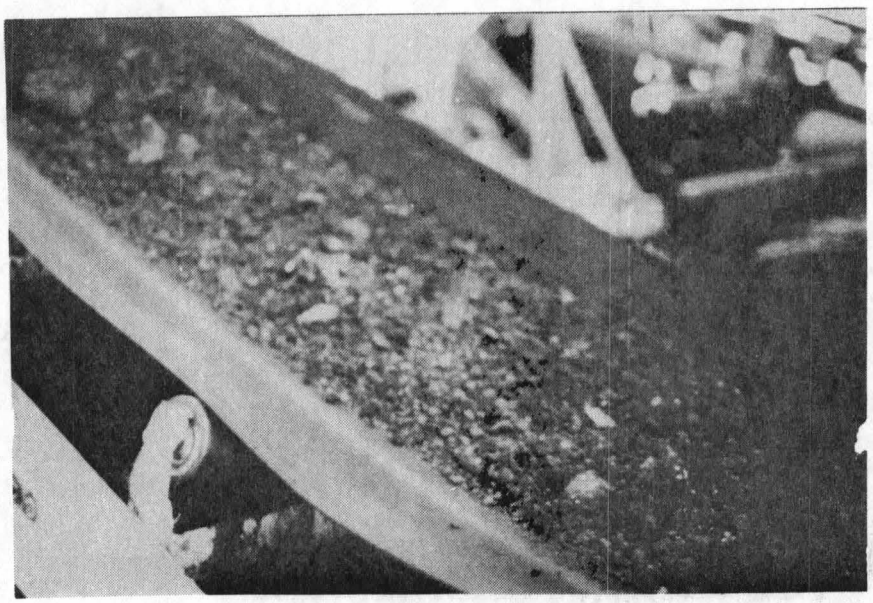


range. During this period, the exhaust stack exhibited abnormally high particulate emissions and blue smoke. After the equipment and operations were adjusted, normal mixture temperatures (250-300^{o}F) were obtained and stack emissions appeared satisfactory.

The salvaged asphalt concrete had been removed from the roadway by a CMI Roto Mill; this resulted in non-uniform sizing of material. The long haul (155 miles) and the tackiness of the salvaged material caused the milled material to congeal somewhat, refer to Figure 2. The large particles were apparently reprocessed satisfactorily because none were observed in the trucks, paver hopper, or finished surface. This would indicate that at least some large particles can be handled by this plant equipment. For the sake of uniformity and ease of feeding, sizing should be controlled quite carefully. Excessive quantities of oversize material would disrupt the feeding operations and cause non-uniform mix to be produced.

Placement and compaction operations were carried out in the usual manner. A standard Iowa Manufacturing Company paver (Figure 3) placed the material without difficulty. The compaction train consisted of a large vibratory roller and a pneumatic tired roller. The vibratory roller was used for breakdown and finish rolling.

Figure 2. Salvaged Asphalt Concrete



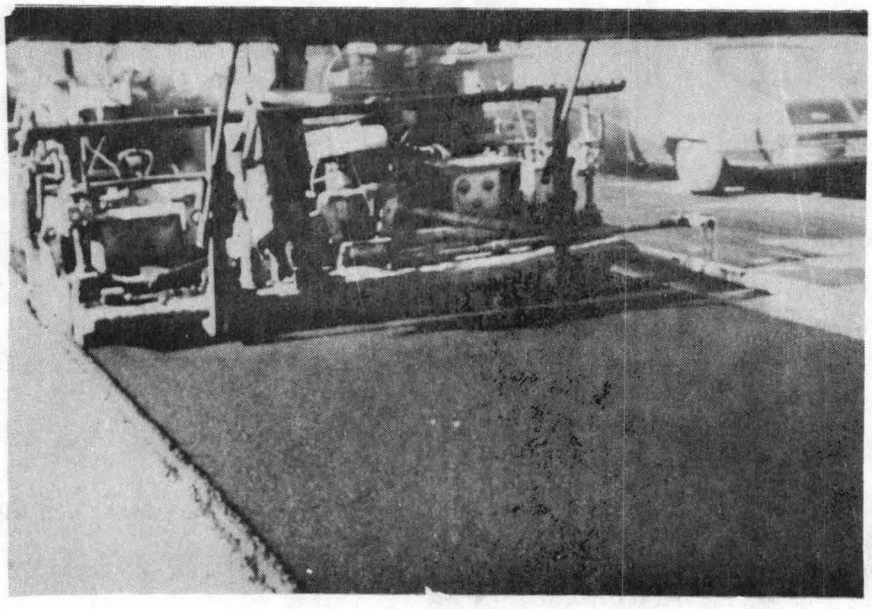
Due to stockpile loss and dry batching requirements, the contractor ran short of crushed limestone aggregate. Glacial gravel aggregate was taken from a county stockpile at the plant site to finish the test section, refer to layout of Appendix A.

TEST RESULTS

Four box samples of recycled mixture were obtained from the roadway just prior to compaction. Sealed samples were also obtained at the same time; these were kept in frozen storage until subjected to extraction and recovery tests. The test data are summarized in Appendix C, Table III and IV.

Box samples 1, 2, and 3 were obtained from the production formulation of 65 percent salvaged asphalt concrete, 35 percent virgin crushed limestone and an additional 1.26 percent 85-100 penetration asphalt cement. Box sample No. 4 was obtained from the last part of the run when 35 percent virgin glacial gravel was substituted for the limestone.

Figure 3. Iowa Manufacturing Company Paver



The extraction-gradation tests (Appendix C, Table III; samples 1, 2, and 3) indicate that some degradation took place. The percentages passing the No. 200 sieve increased from a preliminary estimate of 7.4 percent to an average of 9.8 percent. This can be remedied by more selective processing of the virgin aggregates.

The test section mixture composition exhibited above average density (2.43), Marshall stability (3869), and flow (13) values and below average laboratory void percentages (3.0). Reducing the percentage passing the No. 200 sieve will also tend to reduce the density, stability, and flow values and increase the void percentage. The mix characteristics will then be more comparable to mixture composed of all new material.

The test results for box samples 1, 2, and 3 indicate that a reasonably acceptable and uniform product can be obtained using this material and this process. Although it would be desirable to adjust the characteristics for some applications, the mixture as produced for the test section would be quite acceptable

for most primary and secondary uses.

Box Sample No. 4 exhibits slightly different characteristics due to the nature of the virgin glacial gravel that was added. Although the Marshall stability (3865 lbs) remained above average, the flow value dropped to 10 which is more normal for this type of asphalt-aggregate combination. The laboratory void level increased approximately 3½ percent to 6.4 percent. This occurred because the laboratory density decreased from 2.43 to 2.34 while maximum specific gravity (Rice) remained constant at 2.50. The changes as indicated above are attributed to the differences in aggregate characteristics; the most significant are gradation and composition. The gravel was quite fine through the intermediate sizes, e.g. No's. 8, 16, and 30, and contained unsound shale and limestone.

Four (4) sealed samples (Appendix C, Table IV),two from each lane, were also taken to determine the characteristics of the recovered asphalt cement.

The extracted aggregate gradations for sealed samples 1 and 2 agreed quite well with the results obtained from box samples 1, 2 and 3. No explanation can be provided for the gradation differences noted in sealed samples 3 and 4 versus box sample 4. These samples were all taken during the last part of the

production run. This part of the run was when the transition was made from limestone to gravel aggregate.

The recovered asphalt exhibited variable characterisitics (Appendix C, Table IV). The penetrations (@ 77°F) ranged from 39 to 55, while the absolute viscosity (@ 140°F) ranged from 1740 to 4270 poise. The low penetration and high viscosity results (sample 4) can be associated with mix produced with low quality gravel aggregate additive. This aggregate, because of its absorptive nature, has long been associated with rapid asphalt hardening.

The recovery data, although somewhat limited and variable, indicates no significant damage occurs in the recycling process. This data together with the other mixture characterization tests indicate that this process can produce reasonably acceptable and uniform recycled asphalt concrete.

Core samples were also obtained from the compacted recycled asphalt concrete. Thickness and density measurements were made; the data is summarized in Appendix C, Table V. The results indicate the northbound lane, which was placed first, was compacted to a higher more uniform level of density than the southbound lane. This is attributed to the fact that only one aggregate additive (limestone) was used on the northbound lane. There

was also some delay in changing directions; this resulted in some hot mix being held in trucks until placement resumed. The southbound lane was also laid slightly thinner because materials were in short supply. The results generally indicate that satisfactory density can be achieved if operations and materials are properly controlled.

ENVIRONMENTAL ASPECTS

This project was too small to allow for a complete emission testing program. Visual observations indicated that plant operations during start up did not yield acceptable stack opacity and particulate discharge; this was improved when plant adjustments were made. During the latter part of the run the plant appeared to produce an emission level visually comparable to that obtained earlier on the Kossuth County project. Research Project HR-188 conducted by Kossuth County Engineer, Richard P. Henely, focused on this aspect of asphalt recycling; complete emission testing was conducted on that project. The data can be obtained from that source. The HR-188 recycling project was unique in that for the first time in the United States all Federal and State emission testing was conducted and results met all standards.

PERFORMANCE EVALUATION

On December 18, 1978, an inspection of the test section was made to evaluate the effects of a full year of exposure to traffic and the environment. Several observations were made which

emphasize the fact that even though recycling is feasible, the selection of the virgin aggregate is critical., A review of the mix design data and incidents of temperature control problems during the placement process adds much support to a suggestion that the mix may not have been expected to perform too well.

The first observation made was that the surface had a very dry appearance with considerable surface spalling, a condition which can be associated with mixes of low asphalt content, and mixes which contain asphalt possibly damaged by overheating.

A review of mix design data (Appendix C, Table II) shows an asphalt content of only 4.25% could be recommended without reducing the void content too much. This also placed the film thickness at a minimum, a condition which prohibits degradation of the aggregate without causing a deficiency in the coating of the aggregate. Test reports (Appendix C, Table III) of the mix produced shows there was an increase in fines.

Earlier in this report, we have discussed a problem with a heat sensor which resulted in considerable mix being produced at a higher than normal temperature. This could also be a factor in the surface deterioration. There is also a discussion of some mix being held in trucks longer than normally acceptable. This resulted in some lower densities, another element which can contribute to early surface deterioration.

Another observation made was that there were a few full depth "pop-outs" of about 2 to 3 inches in diameter. These may be the result of some of the larger particles of the roto milled materials not softening sufficiently to blend into the mix or perhaps some mudballs became incorporated into the recycled material.

The section which utilized the locally available gravel as the virgin aggregate (Appendix A) has deteriorated considerably more than the sections which had limestone added., The known absorptive characteristics of this aggregate have contributed to this more rapid deterioration.

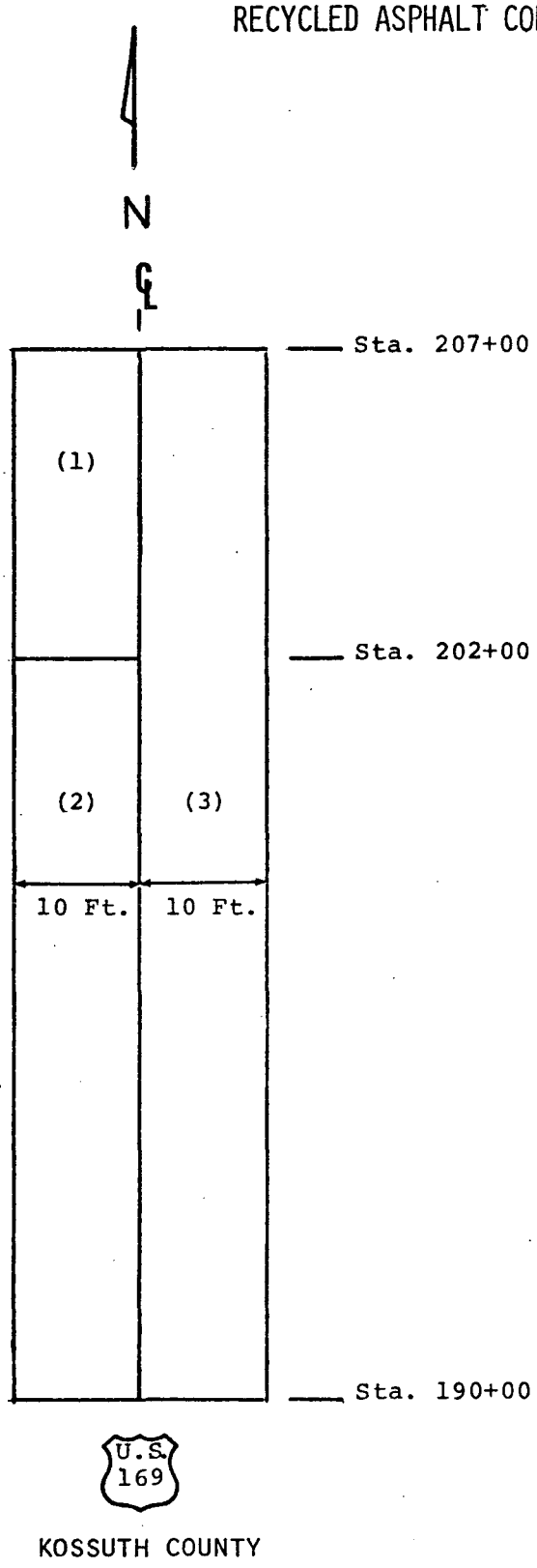
No rutting or shoving of the surface was noted indicating that the mix is standing up well under traffic.

ACKNOWLEDGEMENT

The study presented in this report was sponsored by the Highway Division of the Iowa Department of Transportation under Research Project HR-1011. The project was authorized by Staff Action Order No. S-78-154 as displayed in Appendix B.

The author wishes to extend sincere appreciation to Messrs. R. H. Given, George Calvert, C. L. Huisman, Lowell Zearley, R. I. Bortle, Phil Hassenstab, Vern Marks, Clif Schuldt, Richard Wing, Robert Hadacek and Marcus Lamoreux of the Iowa Department of Transportation, Highway Division; Messrs. Roy Rohlin, James Zeigler and Roger Soleberg of Rohlin Construction Company of Esterville, Iowa and Messrs. Vernon J. Schrimper, Ronald Dunmire, William Paxson, and Phillip J. Schlarmann of the Iowa Manufacturing Company of Cedar Rapids, Iowa. Their experience and expertise contributed greatly to this project. Special thanks to Kossuth County Engineer Richard P. Henely, and Mr. Rexford Walker and the Staff of the Iowa Department of Environmental Quality for their assitance and cooperation.

RESEARCH PROJECT HR-1011
RECYCLED ASPHALT CONCRETE OVERLAY



Recycled asphalt concrete overlay on U.S. 169 3-1/2 miles north of the Humboldt County Line.

Asphalt Layed over P.C. Paving.

Total asphalt concrete used:
304.26 Tons

Tack Coat used:
516 gallons

Section (1)
Asphalt mix:
65% Reclaimed material
35% County gravel

Sections (2) & (3)
Asphalt mix:
65% Reclaimed material
35% Limestone

A total of 126.40 tons of mix was placed on the southbound lane and a total of 177.86 tons was placed on the northbound lane.

Form 102.10
8-76

DEPARTMENT OF TRANSPORTATION

~~AGENDA ITEM / COMMISSION ORDER~~ / STAFF ACTION

~~Division/Bureau~~/Office Materials Item/Order No. S-78-154

Submitted by George Calvert Phone No. 6-1189 Meeting Date August 5, 1977

TITLE: HR-1011 "Recycling of Cass County I-80 Asphalt Concrete"

DISCUSSION/BACKGROUND:

Approximately 40,000 tons of asphalt concrete are currently being removed from I-80 in Cass County. The material is being stored on leased property located approximately 3 miles north of the I-80 - US 71 interchange. The lease requires the material be removed by December 30, 1979.

Based upon the success of the Kossuth County research project, HR-188, this material is valuable for use in recycled asphalt concrete. It has been damaged somewhat by moisture, temperature, and traffic and lacks the stability that is required for heavy interstate traffic. Even though this material has been damaged, laboratory tests indicate this material has considerable value when upgraded with approximately 35 per cent virgin material. A field trial is needed to verify the laboratory findings.

The Rohlin Construction Company is operating a specially modified plant just south of Algona that is capable of producing recycled asphalt concrete. They have agreed to produce 300 tons to construct a reasonable sized test section on US 169.

The test section will provide the opportunity to: 1. test handling and processing procedures, 2. develop design criteria and 3. evaluate performance of the recycled material. The information and test data will be used to develop the necessary parameters for appropriate utilization of the 40,000 ton stockpile. Several resurfacing and rehabilitation projects can be developed within reasonable proximity of the stockpile site. It is anticipated that sizeable project cost savings can be realized through the recycling of this material.

PROPOSAL/ACTION/RECOMMENDATION

It is recommended that staff approval be granted to expend an amount not to exceed $12,000 from the Primary Road Research Fund for construction of this recycled asphalt research test section.

cc: Highway Dist. (2)
Accounting

~~COMMISSION~~ STAFF ACTION:

Moved by _____ Seconded by _____

Vote	Aye	Nay	Pass
Dunn			
Gardner			
Garst			
McGrath			
Rigler			
Schoelerman			
Thoms			

Division Director	Finance (if $ involved)	Legal (if liabilities)	State Director (if required)
			8/10/77

Appendix C - Test Data

Table I

Research Project HR-1011

Characteristics of Salvaged Asphalt Concrete

Sample No. 7-263*
Extr. Gradation

Sieve Size	% Passing
3/4"	100
1/2"	96
3/8"	84
No. 4	65
No. 8	52
No. 16	41
No. 30	30
No. 50	15
No. 100	8.3
No. 200	6.8
Extr. % A.C.	5.2

Rec. Pen. A.C. 65
Rec. Abs. Visc. 1020 P
Rec. Kin. Visc. 247 Cs

Recompacted Mix
Lab. Dens. 2.40
Marshall Stability 1898
Marshall Flow 9

Sample No. 6-21**
Rec. Pen. AC 32
Rec. Abs. Visc. 3089 P
Rec. Kin. Visc. 371 Cs

Sample No. 6-22**
Rec. Pen. AC 45
Rec. Abs. Visc. 1989 P
Rec. Kin. Visc. 320 Cs

Sample No. 6-23**
Rec. Pen. AC 47
Rec. Abs. Visc. 1678 P
Rec. Kin. Visc. 306 Cs

Sample No. 6-24***
Rec. Pen. AC 53
Rec. Abs. Visc. 1453 P
Rec. Kin. Visc. 289 Cs

Sample No. 6-25***
Rec. Pen. AC 76
Rec. Abs. Visc. 980 P
Rec. Kin. Visc. 252 Cs

Sample No. 6-26***
Rec. Pen. AC 64
Rec. Abs. Visc. 1147 P
Rec. Kin. Visc. 265 Cs

Key: Rec. Pen. A.C. - Recovered Penertation of A.C. @ 77°F.
Rec. Abs. Visc. - Recovered Absolute Viscosity of A.C. @ 140°F.
Rec. Kin. Visc. - Recovered Kinematic Viscosity of A.C. @ 275°F
P - Poise
Cs - Centistokes
* - Combined Binder and Surface Course.
** - Surface Course
*** - Binder Course

Table II

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

MIX, TYPE AND CLASS: RECYCLED ASPH. CONC. LAB NO. ABD7-179

INTENDED USE:

SIZE 3/4" SPEC. NO. DATE REPORTED 8-15-77

COUNTY KOSSUTH PROJECT DEPT. INFO.(IA. 169)

CONTRACTOR ROHLIN

PROJ. LOCATION

AGG. SOURCES RECYCLED MATL. FROM CASS I-80, CONTAINING 5.2% ASPHALT;
CRUSHED LIMESTONE-KAMPEN QR.-HUMBOLDT CO.
JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% ABC7-263(RECY) 35% AAT7-467(LMST)

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	96	87	58	46	35	26	15	9.5	7.4

TOLERANCE:				
75 BLOW MARSHALL DENSITY			2.44	
ASPHALT SOURCE AND APPROXIMATE VISCOSITY	KOCH - 1300 POISES			
PLASTICITY INDEX				
% ASPH. IN MIX	3.75	4.75	5.75	6.75
NUMBER OF MARSHALL BLOWS	50	50	50	50
MARSHALL STABILITY - LBS.	3068	2183	1990	1600
FLOW - 0.01 IN.	9	12	17	25
SP.GR. BY DISPLACEMENT(LAB DENS.)	2.37	2.42	2.42	2.40
BULK SP. GR. COMB. DRY AGG.	2.659	2.659	2.659	2.659
SP. GR. ASPH. @ 77 F.	1.029	1.029	1.029	1.029
CALC. SOLID SP.GR.	2.53	2.49	2.46	2.42
% VOIDS - CALC.	6.4	3.0	1.5	0.9
CE SP. GR.	2.53	2.49	2.44	2.41
% VOIDS - RICE	6.3	2.8	1.0	0.5
% WATER ABSORPTION - AGGREGATE	0.74	0.74	0.74	0.74
% VOIDS IN THE MINERAL AGGREGATE	14.2	13.3	14.2	15.8
% V.M.A. FILLED WITH ASPHALT	55.0	77.7	89.3	94.4
CALCULATED ASPH.FILM THICKNESS(MICRONS)	5.1	6.7	8.3	10.0

A CONTENT OF 4.25% ASPHALT IS RECOMMENDED TO START THE JOB.
THIS IS AN ADDITION OF 1.0 % OF ASPHALT.

COPIES:
ASPH. MIX DESIGN
R. I. BORTLE
B. ORTGIES
C. HUISMAN
L. ZEARLEY
ROHLIN
D. HINES
C. JONES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER

Table III

RESEARCH PROJECT HR-1011

CHARACTERISTICS OF BOX SAMPLES OF RECYCLED MIXTURE

Sieve Size	Mix Sample No. 1 NB Rdwy.	Mix Sample No. 2 NB Rdwy.	Mix Sample No. 3 SB Rdwy.	Mix Sample No. 4 SB Rdwy.
		Percent Passing		
3/4"	100	100	100	100
1/2"	96.7	96.3	97.3	98.4
3/8"	85.9	85.6	83.7	89.2
No. 4	63.9	62.6	61.2	72.5
No. 8	50.6	49.3	49.0	58.8
No. 16	38.5	38.4	38.4	46.5
No. 30	28.3	29.3	29.3	34.3
No. 50	17.2	18.8	19.1	20.9
No. 100	10.8	12.5	12.7	12.9
No. 200	8.4	10.2	10.3	10.2
Lab Dens.	2.43	2.44	2.42	2.34
Rice Sp. Gr.	2.50	2.51	2.50	2.50
% Voids	2.9	2.8	3.2	6.4
Marshall Stab.	3820	3623	4163	3863
Marshall Flow	12	13	13	10
Extr. % A.C.	4.0	4.2	4.2	4.1
% Retained Stability	-	96.0	---	58.9

Mix Samples 1, 2, & 3 - 65% Recycled A.C. & 35% Virgin Limestone, + 1.26% A.C.
Mix Sample 4 - 65% Recycled A.C. & 35% Glacial Gravel + 1.26% A.C.
Lab Density - 50 Blow Marshall Compaction

Table IV

RESEARCH PROJECT HR-1011

CHARACTERISTICS OF SEALED SAMPLES

Sieve Size	Mix Sample No. 1 NB Rdwy.	Mix Sample No. 2 NB Rdwy.	Mix Sample No. 3 SB Rdwy.	Mix Sample No. 4 SB Rdwy.
3/4	100	100	100	100
1/2	98	98	98	97
3/8	84	86	88	78
No. 4	60	61	67	55
No. 8	47	48	52	42
No. 16	37	38	41	33
No. 30	29	29	32	25
No. 50	18	19	22	16
No. 100	12	13	14	11
No. 200	9.7	10.4	11.2	9.1
Rec. Pen.	45	52	55	39
Rec. Abs. Visc.	2380	2000	1740	4270
Rec. Kin. Visc.	392	363	341	526

Mix Samples 1, 2, & 3 - 65% Recycled A.C. & 35% Virgin Limestone +1.26% A.C.
Mix Sample 4 - 65% Recycled A.C. & 35% County Gravel + 1.26% A.C.
Rec. Pen. - Recovered Penetration @ 77°F. (25°C.)
Pen. Abs. Visc. - Recovered Absolute Viscosity @ 140°F. (60°C) poise.
Rec. Kin. Visc. - Recovered Kinematic Viscosity @ 275°F. (135°C.) Centistokes

Table V

RESEARCH PROJECT HR-1011

CORE SAMPLE DENSITY TEST RESULTS

Northbound Lane

Core No.	Station	Core Thickness	Core Density	Lab Density	% Density
1	195+65 R	1.6"	2.29	2.43	94.2
2	197+80 R	1.3"	2.32	2.43	95.5
4	201+30 R	1.7"	2.33	2.43	95.9
6	203+30 R	1.6"	2.30	2.43	94.6
7	205+00 R	1.6"	2.28	2.43	93.8
	Average		2.304		94.8

Southbound Lane

3	197+80 L	1.7"	2.38	2.43	97.9
5*	201+30 L	1.6"	2.18	2.43	89.7
8**	205+00 L	1.4"	2.19	2.34	93.6

*Transition area between limestone and gravel aggregate additive.

**Gravel aggregate used for additive.