FINAL REPORT

ASPHALT EMULSIONS FOR HIGHWAY CONSTRUCTION (EMULSION SEAL COAT)

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Prepared Under Contract With the U.S. Department of Transportation Federal Highway Administration Region 15 Demonstration Projects Division Work Order No. DTFH71-80-55-IA-01

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INTRODUCTION

For the past several years Kossuth County has had a scheduled maintenance program of bituminous seal coating. This program has been used to maintain the 467 miles of asphaltic concrete surfaced roads in Kossuth County.

Since most of the experience that Kossuth County had in seal coating was with cutback asphalt, it was decided to include the use of emulsified asphalt in Kossuth County's 1980 seal coat program.

Federal Demonstration Project Funds were requested from the Federal Highway Administration to study the use of emulsified asphalt and funding was granted under Demonstration Project No. 55, Asphalt Emulsions for Highway Construction. Items studied were design and construction procedure, cost of alternate material, energy consumption and environmental considerations.

A construction contract was awarded to Everds Brothers, Inc. of Algona, Iowa, on July 1, 1980. There were four bidders on the 54.5 miles of seal coating that was let.

A map showing the location of the seal coating projects is shown in Appendix A, and a copy of the contract is shown in Appendix B.

The contractor started the project on July 11, 1980 and completed the project on August 1, 1980.

Construction inspection and follow-up inspections of the project were conducted by personnel of the Kossuth County Engineer's Office and testing of the materials, friction testing and road rater testing were conducted by the Material's Department of the Iowa Deaprtment of Transportation.

PRELIMINARY INVESTIGATION

Typical cross sections of all the projects are shown in Appendix C. The typical cross sections show the year the road was graded, the subbase and base course data as well as resurfacing data. It should be noted that, in addition

to the surface shown on the typical cross section, projects MSC-1, MSC-2, MSC-3 and MSC-8 all had a seal coat surface that-had-been applied at least five years prior to 1980.

Also shown in the typical cross section is the traffic count and the description of the location of the road.

Preliminary investigation also included friction testing and road rater deflection testing of the existing road surface. Since it was apparent that there would be duplication on the testing of the projects due to the 54 miles of road to be seal coated, the friction testing and road rater testing were MSG-Srun only on projects MSC-2 and MSC-7. By choosing these projects, we felt that we could acquire the data wanted for the different types of aggregates used.

DESIGN CRITERIA/PROCEDURES

The main objective of the bituminous seal coat was to provide a more waterproof type surface on existing thin lift asphaltic concrete bases to prevent moisture from penetrating through the asphaltic concrete to the subgrade. It has been the experience of Kossuth County that, by seal coating our thin-lift surfaces, we can maintain the road in serviceable condition until major resurfacing or reconstruction can be scheduled.

The second objective of the bituminous seal coat was to improve the surface integrity of the asphaltic concrete bases of adequate thickness. Since the gravel aggregate used in construction of base courses in Kossuth County contains upwards to seven percent shale, we experience roadway surface deterioration that is corrected by the application of seal coat.

A single surface treatment seal coat was used on all the demonstration projects. Single surface treatment seal coat is defined as a single application

of binder bitumen followed by a single application of cover aggregate. Three different types of binder bitumen were used on the nine different projects. They were as follows:

		TYPE		PROJECTS
	CRS-2	Cationic Emulsified	Asphalt	MSC-1, $MSC-2$, $MSC-7$
MINIONIS	HFMS-2			MSC-3, MSC-4, MSC-5, MSC-6
/////	MC-800	Cutback Asphalt	٠	MSC-8, MSC-9

Two different types of aggregates were used on the projects. One-half inch crushed limestone was used on eight of the projects and three-eighths inch pea gravel was used on project MSC-2.

Due to the haul distance for the cover aggregate, the one-half inch crushed limestone was hauled from two different quarries. Since the gradation was different, separate designs were required for the one-half inch crushed limestone.

The actual design for the projects was done using computation sheets from the Iowa Department of Transportation. The Iowa D.O.T. has used the modified Kearby design method which is based on the work of Jerome P. Kearby. Appendix D shows the design computations.

Appendix E shows the project number, type of binder bitumen, type of cover aggregate and target spread rate for the binder bitumen and cover aggregate. You will note that the target rates vary somewhat with the design computation sheets. This was influenced by past experience with the local aggregates and procedures established over the years. The target rates were set as a starting point for the various binder bitumen and cover aggregates, realizing that application rates would be adjusted during construction.

Iowa Department of Transportation Standard Specifications and Current Special Provisions applied to all of the projects and were incorporated in the bidding proposals and contract documents.

CONSTRUCTION CRITERIA/PROCEDURES

Before the contract work was started, the County maintenance crews patched the existing road surface with cold mix asphaltic concrete where it was required. County forces also mowed all of the shoulders to remove any vegetation on the edge of existing pavement. Sweeping of the roadway was included in the contract specifications and was done by the contractor.

The distributor used was manufactured by Etnyre Co. The distributor was 41 + 47 + 47capable of shooting 24-foot width with proper extensions, but was set up for any 17 - 47eleven foot application. It was equipped with S-36 1/8" nozzles set at a 30° angle to the spray bar which gave a triple spray pattern. At application setting the nozzles were 11¹/₂ inches from the road surface. The tank size was 2070 gallons and was calibrated by the U.S.H.C. No. 418. The distributor was checked against the manufacturer's operating manual and was in full compliance.

The chip spreader was standard self-propelled dual belt Etnyre spreader. The maximum spread width was 13 feet. Two rollers were used. One was an 18-ton rubber-tired articulating Hyster roller and the second was a nine-ton standard rubber-tired roller.

The actual spread rates for the cover aggregates, spread rates for the binder bitumen, temperature of the binder bitumen, and surface air temperature are shown in Appendix F. It should be noted that these are average figures for each project.

By comparing Appendix E and Appendix F it is noted that the amount of cover aggregate actually used was considerably less than the target rate and was in fact closer to the design rate on the design computation sheets. The spread rates of the cover aggregate were lowered gradually on the first project until we experienced complete coverage of the binder bitumen with only a small quantity of loose aggregate that did not adhere to the binder bitumen.

The lowa D.O.T. test reports for the binder bitumen are shown in Appendix Comparison of the standard specifications.

The actual construction of the seal coat projects went quite well. The construction was normal in-every-sense of comparison and there-were not any special procedures needed for usage of the emulsified asphalt.

It was found that adhesion was excellent for both the pea gravel and limestone. It was also found that there was not any noticeable difference in the exists (on this per) adhesion qualities of anionic or cationic binder bitumen. This is not always with the cover aggregate that we used.

2.

The workmanship of the contractor was excellent resulting in a good appearance of the seal coat with very few loose chips on the surface.

COST OF ALTERNATE MATERIALS

Since the seal coat projects were let and construction using both emulsified asphalt and cutback asphalt, we were able to get very accurate cost comparisons.

The price bid for the CRS-2 emulsified binder bitumen was bid-at \$0.807 per gallon. The price bid for the HFMS-2 emulsified bitumen was bid-at \$0.818

per gallon, and the MC-800 cutback was bid at \$0.921 per gallon.

It is interesting to compare this to a similar sized project done by Kossuth County in 1983. The price bid for CRS-2 was \$0.73 per gallon and $\frac{1}{\sqrt{1-2}}$ MC-800 was bid-at \$1.05 per gallon. This shows that the price of emulsified asphalt has decreased while the cost of cutback asphalt has increased

Based on the target spread rate for the binder bitumen as shown on Appendix C, the cost per square yard for the binder bitumen was:

COST OF BINDER BITUMEN

(Based	on using limescone	cnips)
	1980	1983
CRS-2	\$0.2825/sq.yd.	\$0.2555/sq.yd.
HFMS-2	\$0.2618/sq.yd.	
MC-800	\$0.2947/sq.yd.	\$0.336/sq.yd.

Even though the application rate is higher for the emulsifed asphalt, the cost per square yard is less and based on our experience, the cost saving has increased over the past three years.

During the design stages of the project, it was anticipated that, by using the emulsified binder bitumen, the amount of cover aggregate required would be less than required when using the cutback binder bitumen. In the actual construction of the project and in subsequent seal coat projects we have found that we do use less cover aggregate when using emulsified asphalt. Based on our experience we have found that we use from 10 to 15 tons per mile less cover aggregate when using emulsion.

ENERGY CONSUMPTION

The energy required to manufacture the emulsified asphalt as compared to the cutback asphalt was not available from the supplier of the binder bitumen. However, information was available from the Asphalt Institute publication, IS-173, entitled "Energy Requirements for Roadway Pavements."

The energy required to produce the three different types of binder bitumen that were used is as shown:

Type of	Total	Cals. of	% Distil-	Energy req.	Total Energy
Binder	Callons	Petro. Distil-	lates	to produce	for 1 gallon
Bitumen	Used	lates Used	Saved ¹	l gal.(BTU) ²	(BTU)3
CRS-2	70,479	0	· 18	2,715	2,715
HFMS-2	98,574	9,857	8	2,715	16,215
MC-800	64,303	11,574	0	2,500	26,800

1 - Based on 18% Distillate in the MC-800

2 - From publication IS-173

3 - Includes energy of the cutback distillate @ 135,000 BTU/gallon

The energy consumption used during construction was the same for the emulsified asphalt as for the cutback asphalt. This was due to the fact that the supplier of the binder bitumen was located in Kossuth County and the binder bitumen was hauled direct from the producer to the job site and was used immediately. Therefore, it was not necessary to heat any of the binder bitumen before using, and the energy that might be saved due to the lower application temperatures of the emulsion was not a factor in this project.

ENVIRONMENTAL CONSIDERATIONS

At the time of project as well as the present time there are no local or state regulations concerning the use of asphalt emulsions. Also, there are no local or state regulations concerning HC emissions in Kossuth County.

POST CONSTRUCTION PERFORMANCE

Since construction, Kossuth County has been monitoring the performance of the seal coat projects, checking for any major distress or failures.

To date the project has performed as expected and we have not experienced any bleeding, streaking, raveling or loss of aggregate on any of the projects.

On a visual inspection of the projects it is impossible to identify any difference in the appearance or performance of either the emulsified asphalts used or of the cutback asphalt used.

The results of both the preliminary and final friction testing are shown in Appendix H. The results show that we have nearly the same friction coefficients now as we had prior to the seal coating. This is as expected as the previous surface was also a seal coat and the use of an emulsified asphalt as a binder for the cover aggregate would not affect the friction values.

The road rater information that we desired was incomplete in that we were not able to acquire information on all three sample projects as we originally anticipated. However, the information we did obtain was on a project which used emulsified asphalt and the results are shown in Appendix H. Even though we only have results on/one project it does show that the structural integrity of the pavement has been maintained over the past three years. This is as anticipated and it is reasonable to assume that the same would be true of all the projects.

All of the seal coat projects provided the water proofing qualities desired and have provided a safe driving surface for the public use.

SUMMARY

Based on the results of this demonstration project, Kossuth County found that emulsified asphalt was an acceptable material-when-used-as-a binder bitumen for seal coating.

We found that we did not have to significantly alter our design procedure or our construction procedures when using the emulsified asphalt.

We found that there is a very definite cost benefit when using emulsified asphalt as compared to a cutback asphalt. It has also been our experi-

ence on succeeding projects that the cost saving is ever greater as the price of emulsified asphalt has decreased slightly while the cost of cutback asphalt has increased.

The emulsified asphalt seal coat that we constructed has performed very well and we have not experienced any problems to date. The friction coefficients that we obtained compared favorably with the projects on which we used cutback asphalt. We did not experience any bleeding, streaking, raveling, or loss of the cover aggregate on any of the projects.

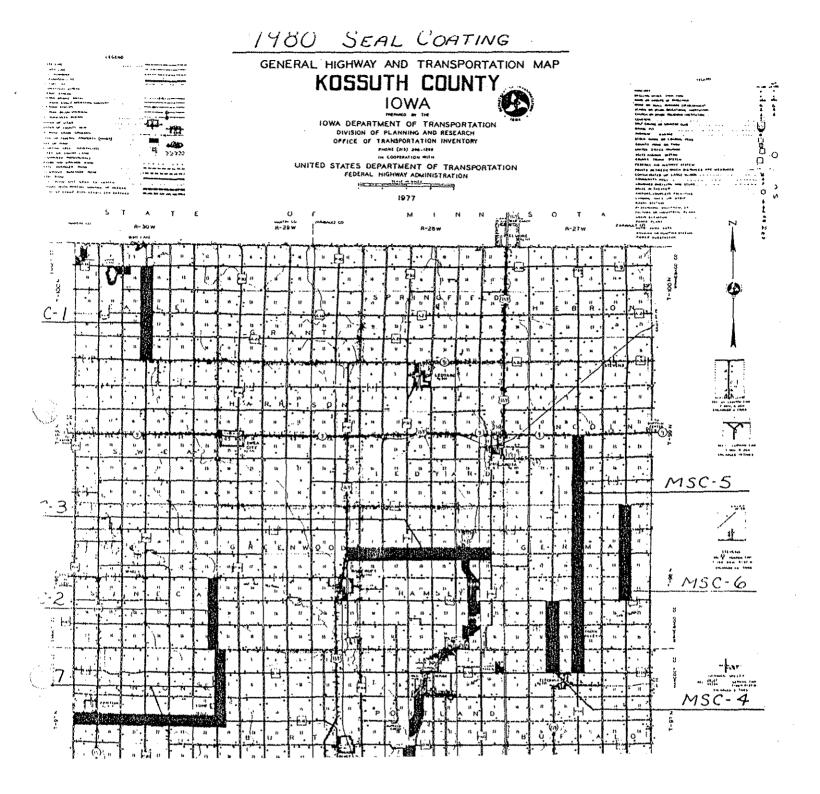
The emulsified asphalt that we used completely satisfied our main objective which was to provide a waterproof road surface as well as a safe driving surface for the public use.

APPENDICES

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APPENDIX A

PROJECT LOCATION MAP



APPENDIX B

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CONTRACT COPY

od of Work <u>Maintenance</u>		CONTRACT	Miles	54.5
ject No. MSC-1-80 three	ough MSC-9-80		County	Kossuth
THIS AGREEMENT made and usisting of the following me		Kossuth on, Chairman;		County, Iowa, by its Board of Supervisors y Muckey; Marvin Eischen;
asisting of the following me ames Koons; H. P. Mer	tz			, party of the first part, and
Everds Bros., Inc.		of Algona,	Iowa	, party of the second part.
WITNESSETH: That the part sty-two and 48/100	y of the second part, for a	nd in considerati	on of <u>Two</u>	Hundred Twenty Thousand One Hundre Dollars (\$ 220, 162.48)

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yable as set forth in the specifications constituting a part of this contract, hereby agrees to construct in accordance with the ans and specifications therefore, and in the locations designated in the notice to bidders, the various items of work as follows:

ltem No,	ltem	••••••••••••••••••••••••••••••••••••••	Quantity	Unit Price	Amount
	See Attached Description	on of Work			
	ł				
		*			
	Note: Contractor agree	s to comply with	the Davis-Bac	on Equal Emplo	yment Opportunity Ac
•					
·	· .			· · · · · · · · · · · · · · · · · · ·	
	lications and plans are hereby made a pa he County Auditor under date of <u>Ju</u>	rt of and the basis of this at $1y + 1$	preament, and a true c . 19-8(opy of said plans and :	spucifications are now on file in
That in cor wirements (isideration of the foregoing, the party of of the specifications the amounts set fort	the first part hereby agrees th, subject to the conditions	to pay to the party of as set forth in the st	the second part, promp ecilications.	tly and according to the
That it is r	nutually understood and agreed by the pa	rties hereto that the notice	to bidders, proposal,	the specifications for]	Maintenance Seal Cont act, the contractor's bond, and the
	MSC-1-80 through MSC-9-8 utailed plans are and constitute the basis further understood and agreed by the part		rtius hereto.		
:uro;		Approx. or Specified Starti or Number of Working D	ng Datu Jays	Specified Completion or Number of Working E	Date Days
	he assunce of this contract and that said	30 Working E	• •	August 30, 198	-
	in undurstood that the second party const				
IN WITNES	S WHEREOF the parties hereto have set t .st day of	heir hands for the purposes July	hordin expressed to 11	nis and three other inst 80	ruments of like tunor, as of the
wa STATE	HIGHWAY COMMISSION	,		Kossuth Rurry of the first part	County, towa
	Contracts Engineer		by <u>Van</u> Pro Tem	Wy man Sta	nley Muckey
·(0			Eyords	,	
		13	BV ALTCO	Alist!	Legen

1980 MAINTENANCE SEAL COATING

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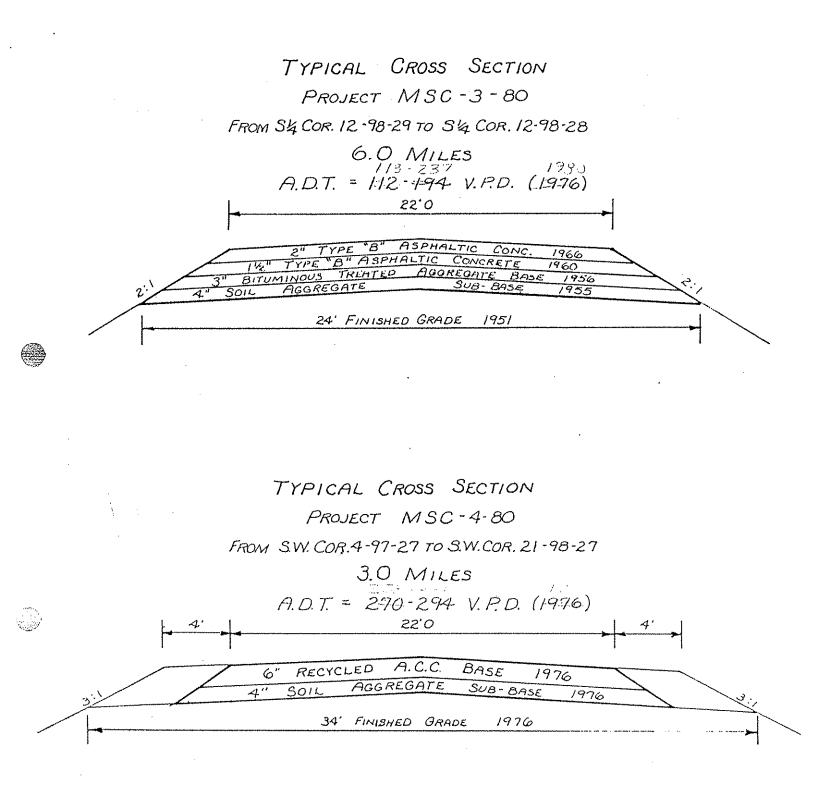
$\frac{MSC-1-80}{34-100-30}$ 4.0 miles of maintenance seal coating from the southwest corner of section 34-100-30 north 4.0 miles to the southwest corner section 10-100-30.
Item #1 - 696 tons of 1/2" cover aggregate @ \$4.80 = \$ 3,340.80 Item #2 - 15,488 gallons of CRS-2 binder bitumen @ \$0.807 = \$12,498.82
$\frac{MSC-2-80}{Section 31-98-29}$ north 3.0 miles to southwest corner section 18-98-29.
Item #1 - 483 tons of 3/8" cover aggregate @ \$4.20 = \$ 2,028.60 Item #2 - 9,681 gallons of CRS-2 binder bitumen @ \$0.807 = \$ 7,812.57
$\frac{MSC-3-80}{Section}$ 6.0 miles of maintenance seal coating from south quarter corner of section 12-98-29 east 6.0 miles to south quarter corner of section 12-98-28.
<pre>Item #1 - 1,044 tons of 1/2" cover aggregate @ \$4.20 = \$ 4,384.80 Item #2 - 23,232 gallons of HFMS-2 binder bitumen @ \$0.818 = \$19,003.78</pre>
<u>MSC-4-80</u> 3.0 miles of maintenance seal coating from the southwest corner of section $4-97-27$ north 3.0 miles to southwest corner section $21-98-27$.
Item #1 - 522 tons of 1/2" cover aggregate @ \$4.20 = \$ 2,192.40 Item #2 - 11,616 gallons of HFMS-2 binder bitumen @ \$0.818 = \$ 9,501.89
<u>MSC-5-80</u> 10.0 miles of maintenance seal coating from southwest corner of section $3-97-27$ north 10.0 miles to southwest corner of section $15-99-27$.
Item #1 - 1,740 tons of 1/2" cover aggregate @ \$4.20 = \$ 7,308.00 Item #2 - 38,720 gallons of HFMS-2 binder bitumen @ \$0.818 = \$31,672.96
MSC-6-80 4.0 miles of maintenance seal coating from southwest corner of section 24-98-27 north 4.0 miles to southwest corner of section 36-99-27.
Item #1 - 696 tons of 1/2" cover aggregate @ \$4.80 = \$ 3,340.80 Item #2 - 15,488 gallons of HFMS-2 binder bitumen @ \$0.818 = \$12,669.18
MSC-7-80 9.0 miles of maintenance seal coating from southwest corner of section 18-97-30 east 6.0 miles to southwest corner of section 18-97-29 then north 3.0 miles to southwest corner of section 31-98-29.
Ttem #1 -1,566tons of 1/2" cover aggregate @ \$4.20 = \$ 6,577.20 Item #2 - 34,848 gallons of CRS-2 binder bitumen @ \$0.807 = \$28,122.34
<u>MSC-8-80</u> 9.0 miles of maintenance seal coating from the southwest corner of section $31-96-28$ northeast 9.0 miles to southwest corner of section $21-97-28$.
<pre>Item #1 - 1,746 tons of 1/2" cover aggregate @ \$4.80 = \$ 8,380.80 Item #2 - 34,848 gallons of MC-800 Binder Bitumen @ \$0.921 = \$32,095.01</pre>
MSC-9-80 6.5 miles of maintenance seal coating from the southwest corner of section 1-95-29 east 6.5 miles to the southwest corner section 6-95-27.
Item #1 - 1,261 tons of 1/2" cover aggregate @ \$4.80 = \$ 6,052.80 Item #2 - 25,168 gallons of MC-800 binder bitumen @ \$0.921 = \$23,179.73

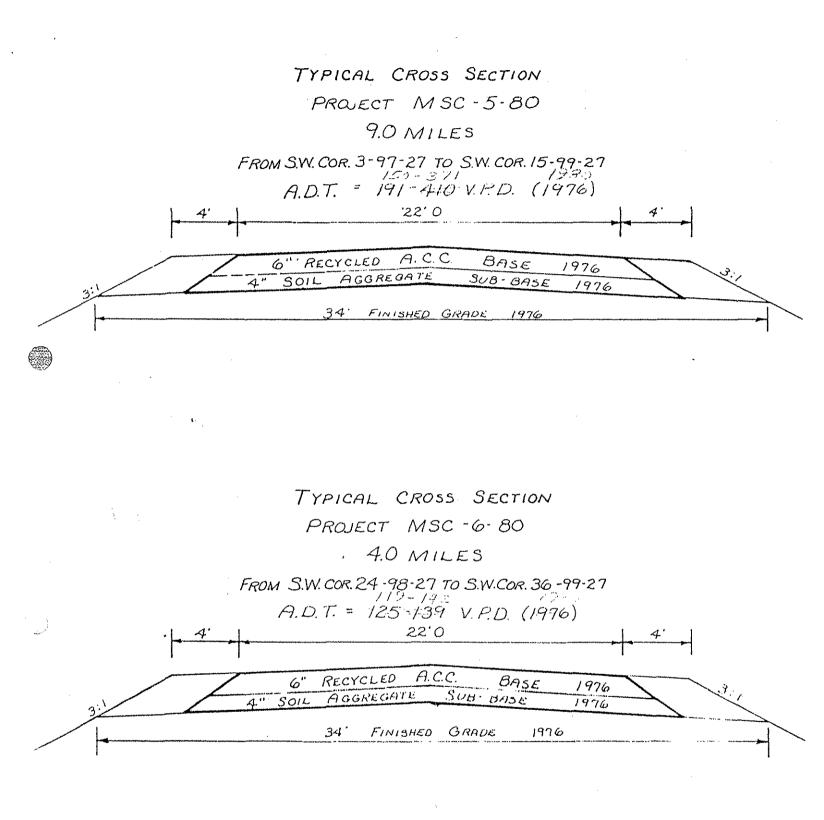
APPENDIX C

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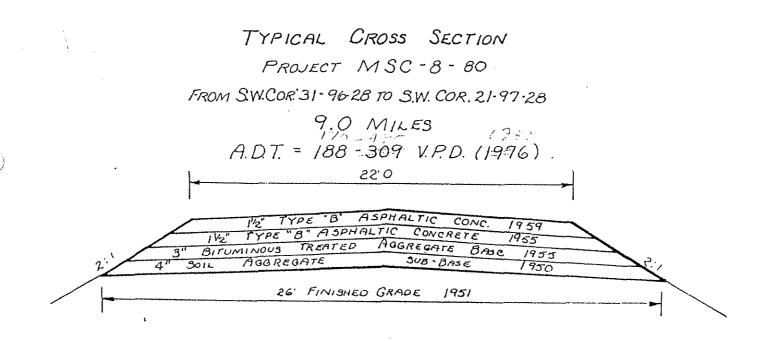
TYPICAL CROSS SECTIONS

TYPICAL CROSS SECTION PROJECT MSC-1-80 4.0 MILES FROM SW. COR. 34-100:30 TO S.W. COR. 10-100-30 39-113 1230 A.D.T. ■ 75=150 V.P.D. (1976) 22'0 TYPE "B" ASPHALTIC CONC. 2" 1963 TYPE "B" ASPHALTIC CONCRETE 1956 AGGREGATE UB - BASE SOIL 1956 26' FINISHED GRADE TYPICAL CROSS SECTION PROJECT MSC-2-80 , 3.0 MILES FROM SW. COR. 31-98-29 TO S.W. COR. 18-98-29 A.D.T. = 203 -246 V.P.D. (1976) 22.0 TYPE 'B" ASPHALTIC CONC. 12 TYPE D BITUMINOUS TREATED AGGREGATE BASE BITUMINOUS TREATED SUB BASE 1959 3" 1953 1952 SOIL 4" 26' FINISHED GRADE





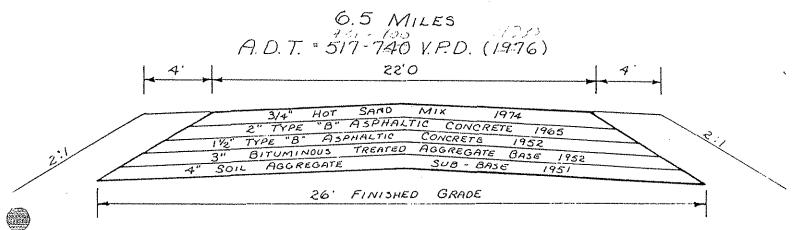
TYPICAL CROSS SECTION PROJECT MSC-7-80 FROM SWCOR. 16 -97-30 TO SWCOR. 31-98-29 9.0 MILES A.D.T. = 255-589 V.P.D(1976) 22:0 ASPHALTIC CONC (1974) ASPHALTIC CONCRETE TYPE 11/2 <u>(1958)</u> BITUMINOUS SOIL AGER TREATED AGGREGATE BASE (1958 SUB AGGREGATE 26' FINISHED GRADE (1949)



TYPICAL CROSS SECTION

PROJECT MSC-9-80

FROM S4 COR. 1-95-29 TO S.W. COR. 6-95-28



APPENDIX D

MODIFIED KEARBY DESIGN METHOD

1/2" Chips from Weaver Construction Co., Humboldt, Iowa CONFUTATION SHEET for SITURINCUS SEALING

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Aggregate Characteristics

Sieve Size	<u>3/4" : 5/8"</u>	1/2"	3/8" :	4 : 6	: :	: 16 :	30
<u> Retained</u> :	100	99	79	13 2.	2		.5
% Passing and Retained	÷ ÷	1 20	66	10.8	: 1.7	* *	.5
Sp.G. 2.63	D&R Wt.	(!') 90 .	Lbs/Cu/	'Et. Voids	(V) <u>.45</u>	1594	%.
Absolute Volu	= (VA) em	W .G x 62.4	90	= .54	8406_%.	V=1.00	AV.
	•						
	<u>CCMFUTATI</u>	ON of AVER	AGE PARTI	<u>CLE SIZE</u>		•	
Sieve Size	Av.Size Inches	Pass and	Ret. Su	mmation		•	
3/4"-5/8"	.6875 x						
5/8"-1/2"	.5625 x	.01		005625			
1/2"-3/8"	.4375 x	.20	·	087500			
3/8"-4	.2810 x	. 66.		185460			
4-8	.1404 x	.108	, 	015163			
ē-16	.0703 x	.017		001195		•	
16-30	.0351 x						
-30	.0175 x	.005		000088		•	
Av.Particle S (Effective M	at Thickness)	(T) = ·	295031 Ir) . .		
Spread Ratio ($SR) = \frac{36}{m} = -$	36 =	122.02	Sq.Yds/Cu	.Yd.	•	
Spread Ratio (Rate of Cover	• Mat'l.by Vo	(Rcv) = -	1 = 0.008	<u>195 </u> Sq.)	/ds/Cu.Y	đ.	
Rete of Cover	Mat'l.by Wt	S.(Rcw)=27	Rev W=27x	. 008195 _x 90	19.9	Lbs./S	Sq.Yd,
Embedment (E)	= _40	from tabl	e or as a	idjusted.			
Rate of Aspha	ilt (Ra) = V	*(5.61 T E	(2) = .45159	4_x <u>.662050</u>	_=299	Gal./S	Sq.Yd.
*fne value c	of (5.61 T E)	is obtair	ed from t	able			
	RECCHN	IENDED PREC	ENT EMBEI	DMENT (E)			
T 1/8" E 20%	1/4" 25%	3/8" 30%	1/2" 35%	5/8" 40%	3/4" 45%		·

These recommended embedment values are based on a glazed, impervious, impenetrable surface and should be adjusted to satisfy existing surface conditions.

1/2" Chips from Midwest Limestone Co., Inc., Cilmore City, Iowa CONFUTATION SHEET for BITUMINCUS SEALING

.

Aggregate Characteristics

Sieve Size : $3/4"$: $5/8"$: $1/2"$: $3/8"$: 4 : 8 : 16 : 30						
<u>« Retained</u> 100 98 67 10 1.1 .4						
% Fassing 2 31 57 8.9 .7 .4						
Sp.G. 2.65 D& R Wt. (!') 90. Lbs/Cu/Ft. Voids (V) .455733 %.						
Absolute Volume (AV) = $\frac{W}{\text{Sp.G x 62.4}} = \frac{90}{2.65 \text{ x 62.4}} = \frac{.544267}{\%} = \frac{.544267}{\%} = \frac{.544267}{\%}$						
CCMFUTATION of AVERAGE PARTICLE SIZE						
Av.Size % Sieve Size Inches Pass and Ret. Summation						
3/4"-5/8" .6875 x =						
5/8"-1/2" .5625 x .02 = .01125						
1/2"-3/8" .4375 x .31 = .135625						
3/8"-4 .2810 x .57. = .16017						
4-3 .1404 x .089012496						
5-16 .0703 x =						
16-30 .0351 x $.007$ = $.000246$						
-30 .0175 x $.004$ = $.00007$						
Av, Particle Size (Effective Mat Thickness) $(T) = .319857$ In.						
Spread Ratio (SR) = $\frac{36}{T}$ = $\frac{36}{.391857}$ = $\frac{112.55}{.59.Yds/Cu.Yd}$.						
Rate of Cover Mat'l.by Vol.(Rev) = $\frac{1}{SR}$ = .008885 Sq.Yds/Cu.Yd.						
SR Rate of Cover Mat'l.by Wt.(Rcw)=27 Rcv W=27x.008885x 90 =21.6 Lbs./Sq.Yd.						
Embedment (E) = 40 % from table or as adjusted.						
Rate of Asphalt (Ra) = V *(5.61 T E) = $\frac{455733}{x.717759} = \frac{.327}{.71759}$ Gal./Sq.Yd.						
*The value of (5.61 T E) is obtained from table						
RECOMMENDED PRECENT EMBEDMENT (E)						
T 1/8" 1/4" 3/8" 1/2" 5/8" 3/4" E 20% 25% 30% 35% 40% 45%						

These recommended embedment values are based on a glazed, impervious, impenetrable surface and should be adjusted to satisfy existing surface conditions.

3/8" Pea Gravel from Midwest Limestone Co., Boggess Pit, Emmetsburg, Iowa CONFUTATION SHEET for BITUMINCUS SEALING

Aggregate Characteristics

: Sieve Size :	; 3/4" : 5/8	: 1/2"	3/8":	4	3	16	30
: C_Retained:	÷	•	1	38.5	¢		.8
S Passing and Retained		·	61.5	37.7	*		:.8
Sp.G. 2.69	D & R Wt.	(!')94	Lbs/Cu/	'Ft. Void	s (V) <u>·4</u> 2	39996	_% .
Absolute Volu	$ame(AV) = \overline{S}$	W p.G x 62.4	<u>94</u> 2.69 x	= . <u>560</u> 62.4	004_%.	V=1.0	0-AV.
	CCMEUTAT	ICN of AVER	RAGE PARTI	CLE SIZE			
Sieve Size	Av.Size Inches	% Pass and	Ret. Su	mmatión			
0/4=-5/8=	.6875 x						
5/8"-1/2"	.5625 x			·			
1/2"-3/8"	.4375 x						
3/8=-4	.2810 x	.615		172815			
4-8	.1404 x	.377		052931			
ē−16	.0703 x						
16-30	.0351 x	£	·	······································			
-30 Av.Particie	.0175 x	.008	·	000140		•	
	Mat Thicknes	s)	(T) =	<u>225886</u> I	ń.	•	
Spread Ratio	(SR) = 36 =	36=	=	_Sq.Yds/C	a.Yd.		
Rate of Cove	r Mat'l.by V	.225886 /ol.(Rev) =	<u>1</u> = . <u>0062</u>	<u>75 </u> Sq.	Yds/Cu.)	۲ď.	
Rate of Cove	r Mat'l.by W	/t.(Rcw)=27	SR Rc∨ W=27:	x <u>.006275</u> x94	= 15.9	_Lbs.,	/Sq.Yd
Eabedment (E) =35	<u>%</u> from tab	le or as a	adjusted.			
Rate of Asph	alt (Ra) = N	/ *(5.61 T	E) =.439996	x.443527	1 95	Gal.	/Sq.Yu
	of (5.61 T F	•	1				-
	RECO	AMENDED PRE	CENT EMBLI	DMENE (E)			
T 1/8" E 20%	1/4" 25%				3/41		

impenetrable surface and should be adjusted to satisfy existing surface conditions.

APPENDIX E

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DESIGN SPREAD RATES

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DESIGN SPREAD RATES

Project #	Binder Mat'l.	Cover. Agg. *	Target Rate Binder Gal/yd ²	Target Rate Cov. Agg. #/yd2
MSC-1	CRS-2	1/2" Limestone ¹	0.35	27
MSC-2	CRS-2	3/8" Pea Gravel ²		25
MSC-3	HFMS-2	1/2" LIMESTONE ¹	0.35	27
MSC-4	HFMS-2	1/2" LIMESTONE ³	0.32	27
MSC-5	HFMS-2	1/2" LIMESTONE ³	0.32	27
MSC-6	HFMS-2	1/2" LIMESTONE ³		27
MSC-7	CRS-2	1/2" LIMESTONE ¹	0.35	27
MSC-3	MC-800	1/2" LIMESTONE ³	0.32	30
MSC-9	MC-800	1/2" LIMESTONE ³	0.32	30

* LOCATION OF AGGREGATE QUARRIES

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1_{GILMORE} CITY

·2_{Emmetsburg}

3 Humboldt

APPENDIX F

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APPLICATION DATA

	PROJECT	Oil Avg. Rate Gal/yd2	OIL Avgutemp.	'≵" CHIPS Limestone Avg. Rate #/yd2	AVG. AIR TEMP. OF.	AVG. Road Temp. OF.
	MSC-1 crs-2	.3514	170 ⁰	21.4	84 ⁰	93 ⁰
	MSC-2 crs-2	.2999	159 ⁰	· 21.63 [*]	87 ⁰	96 ⁰
	MSC-3 hFms-2	، 3517	164 ⁰	23.97	71 ⁰	76 ⁰
	MSC-4 hfms-2	.3341	169 ⁰	24.99	78 ⁰	82 ⁰
	MSC-5 hfms-2	.3319	164 ⁰	23.32	79 ⁰	89 ⁰
	MSC-6 hfms-2	.3341	160 ⁰	23.17	73 ⁰	78 ⁰
	MSC-7 crs-2	.3573	164 ⁰	25.59	85 ⁰	90 ⁰
	MSC-8 мс-800	.321	237 ⁰	25.46	82 ⁰	89 ⁰
	MSC-9 мс-800	.3216	241 ⁰ .	26.53	740	790

* 3/8" PEA GRAVEL

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APPENDIX G

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BITUMINOUS MATERIALS - TEST DATA

10WA DEPARTMENT OF TRANSPORTATION OFFICE OF MATERIALS TEST REPORT - MISCELLANEOUS MATERIALS LAB LOCATION AMES

ATERIAL MC-800 LAB NO. AROO-40 NTENDED USE PROJ NO. RESEARCH OUNTY KOSSUTH . LSIGN CONTRACT NO. CONTRACTOR RODUCER BIT. MATLS. OURCE ALGONA WIT OF MATERIAL 2 GALS. AMPLED BY INGERTSON SENDER'S NO. 2RI0-30 REPORTED 7/10/80 E SAMPLED 6/23/80 REC'D 7/2/80 SP. GR. @ 60 F./ 60 F. 0.9746 FLASH POINT - OPEN CUP KINEMATIC VISCOSITY, CENTISTOKES, @ 140 F. 1575 DISTILLATION % BY VOL. TOTAL DISTILLATE TO 680 F. IH.P. 466 F. 374 F. 0.0% 437 F. 0.0% 500 F. 9.8% 600 F. 72.1% RESIDUE BY VOL. ABOVE 680 F. 84.7% RESIDUE BY WEIGHT ABOVE 680 F. 87.7% WATER RESIDUE FROM DISTILLATION PENETRATION @ 77 F. 100 GMS. 5 SEC. 136 DUCTILITY @ 77 F., CM. SOLUBLE IN TRICHLOROETHYLENE STRIFFING TEST USING AATO-290 AGG. (%) ABOVE 95 ABSOLUTE VISCOSITY AT 140 F. 300 MM HG, POISES 665 COPIES: ROAD OIL R. I. BORTLE R. P. HENELY R. INGERTSON L. ZEARLEY DISPOSITION: COMPLIES WITH AASHTO M-82 SIGNED: BERNARD C. BROWN 30

TESTING ENGINEER

IOWA DEPARTMENT OFFICE OF Test Report-Misco Laboratory Maso	MATERIALS ellaneous Mater	ials	R.L. Bortle P. Henely File
Material MSC-6	County	Kossuth	
Intended UseSealcoat	_ Project No	MSC-6	
Laboratory No@aroo-149	_ Design No		and the second
Date Reported	Contract No		
Producer Bituminous Materials & Supply			
Source Algona, IA			
Unit of Material			
Sampled By R. Chase		10Dat	e

Saybolt Furol Viscosity @ 77° F 203 Seconds
* % Residue @ 69.5%
Penetration @ 77°F, 100 Gms, 5 Sec 169

Signed W.J. Orozco

520258 15	IOWA DEPARTMENT OFFICE OF Test Report-Mise	R.I. Bortle R.I. Henely File	
	Laboratory Maso	n City	
faterial	CRS-2	County Kossuth	
	Sealcoat	_ Project NoMSC-2	
aboratory No.	2AROO-125	_ Design No	
ate Reported	7-18-80	Contract No	
oducer Bi	tuminous Materials & Supply	_ Contractor Everds Bros. In	26
-urce	Algona, IA		
nit of Material	·	Subcontractor	
• 2014 19 19 19 19 19 19 19 19 19 19 19 19 19			
miled By	R. Chase	_ Senders No Da	te <u>7-16-80</u>
	Saybolt Furol `% Re Penetration @	Viscosity @ 122°F 237 Sec sidue @ 71.6% 77°F, 100 Gms. 5 Sec 157 larity - Postive	

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Signed <u>W.J. Orozco 7-18-80</u>

APPENDIX H

FRICTION TEST-DATA FOR A

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ROAD RATER TEST DATA

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PRELIMINARY FRICTION TESTING DATA

Project	Date Tested	North or East Lane (Avg.)	South or West Lane (Avg.)
MSC-2	9-5-79	44	47
MSC-5	8-28-79	58	58
MSC-7	9-5-79	43	41

FINAL FRICTION TESTING

l·ISC-2	9-83	50	47 ->>.
MSC-5	9-83	52	59
MSC-7	9-83	43	44
]			

STRUCTURAL RATING FROM ROAD RATER DEFLECTION

STRUCTURAL RATING			
7/8/80	8/11/80	9/83	
1.65	1.65	2,55*	
2.10	2.10	**	
2.45	2.70	2,55	
	7/8/80 1.65 2.10	7/8/808/11/801.651.652.102.10	

*Road has been resurfaced **Not available