HR-1028

FINAL REPORT

ASPHALT EMULSIONS FOR HIGHWAY CONSTRUCTION

(EMULSION SEAL COAT)

By

Richard O. Schiek, P.E.

Kossuth County Engineer
Algona, Iowa

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 Materials Department of the Iowa Department 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 run 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 sub-grade. 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
HFMS-2	Emulsified Asphalt	MSC-3, MSC-4, MSC-5, MSC-6
MC-800	Cutback Asphalt	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, 1977 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 capable of shooting 24-foot width with proper extensions, but was set up for eleven 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 11½ 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 construction method used in applying the seal coat was of conventional practice. The distributor would apply the binder bitumen at 11-foot width (one-half of the roadway) at the proper application rate and the chip spreader would follow as close as practical with the cover aggregate. The length of the spread was governed by the number of trucks that were on the project with the cover aggregate. The rolling operation followed immediately behind the chip spreader and each roller would average three completed passes (forward and backward) on each section. Traffic control was under Standard I.D.O.T. Specifications and local traffic was allowed on the seal coat as soon as the rolling operation was complete.

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 Iowa D.O.T. test reports for the binder bitumen are shown in Appendix G. All materials were found to comply with 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 adhesion qualities of anionic or cationic binder bitumen. This is not always true but it was with the cover aggregate that we used.

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 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 limestone chips)

	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 requried 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 Binder Bitumen	Total Gallons Used	Gals. of Petro. Distillates Used	% Distillates Saved[1]	Energy req. to produce 1 gal. (BTU)[2]	Total Energy for 1 gallon (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

APPENDIX A

PROJECT LOCATION MAP

1980 SEAL COATING

GENERAL HIGHWAY AND TRANSPORTATION MAP

KOSSUTH COUNTY

IOWA

PREPARED BY THE

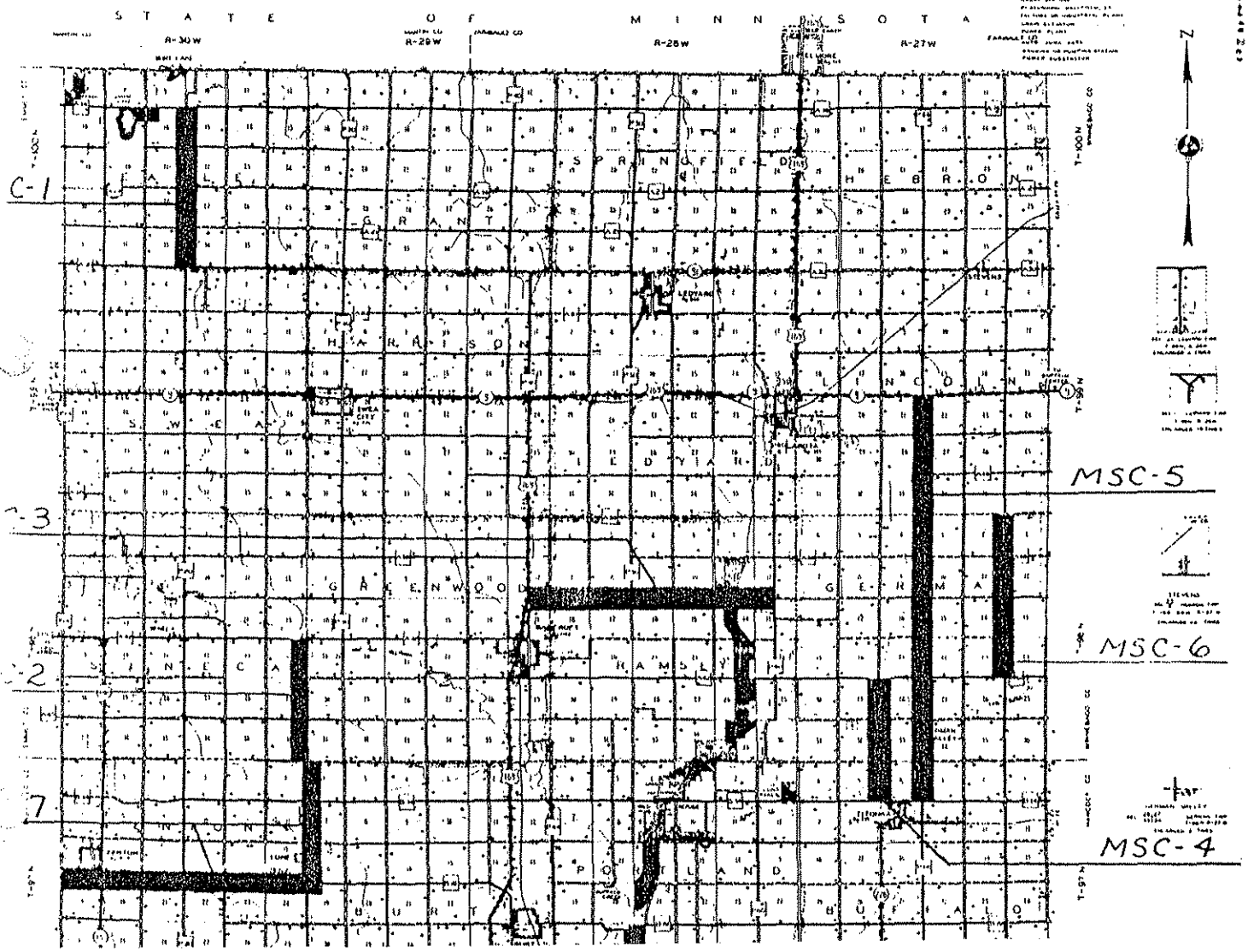
IOWA DEPARTMENT OF TRANSPORTATION
DIVISION OF PLANNING AND RESEARCH
OFFICE OF TRANSPORTATION INVENTORY

PHONE (515) 296-1200

IN COOPERATION WITH

UNITED STATES DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

1977



APPENDIX B

CONTRACT COPY

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CONTRACT

d of Work Maintenance Seal Coating Miles 54.5

oject No. MSC-1-80 through MSC-9-80 County Kossuth

THIS AGREEMENT made and entered by and between Kossuth County, Iowa, by its Board of Supervisors
nsisting of the following members: William Larson, Chairman; Stanley Muckey; Marvin Eischen;
mes Koons; H. P. Mertz, party of the first part, and
Everds Bros., Inc. of Algona, Iowa, party of the second part.

WITNESSETH: That the party of the second part, for and in consideration of Two Hundred Twenty Thousand One Hundre
ty-two and 48/100---------- Dollars ($220,162.48)
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:

Item No.	Item	Quantity	Unit Price	Amount
	See Attached Description of Work			
	Note: Contractor agrees to comply with the Davis-Bacon Equal Employment Opportunity Ac			

Said specifications and plans are hereby made a part of and the basis of this agreement, and a true copy of said plans and specifications are now on file in
office of the County Auditor under date of July 1, 19 80.

That in consideration of the foregoing, the party of the first part hereby agrees to pay to the party of the second part, promptly and according to the
uirements of the specifications the amounts set forth, subject to the conditions as set forth in the specifications.

That it is mutually understood and agreed by the parties hereto that the notice to bidders, proposal, the specifications for Maintenance Seal Coat
oject No. MSC-1-80 through MSC-9-80 Kossuth County, Iowa, the within contract, the contractor's bond, and the
neral and detailed plans are and constitute the basis of contract between the parties hereto.

That it is further understood and agreed by the parties of this contract that the above work shall be commenced on or before, and shall be completed on or
fore:

Approx. or Specified Starting Date or Number of Working Days	Specified Completion Date or Number of Working Days
30 Working Days	August 30, 1980

t time is the essence of this contract and that said contract contains all of the terms and conditions agreed upon by the parties hereto.

It is further understood that the second party consents to the jurisdiction of the courts of Iowa to hear, determine and render judgement as to any controversy
ing hereunder.

IN WITNESS WHEREOF the parties hereto have set their hands for the purposes herein expressed to this and three other instruments of like tenor, as of the
1st day of July, 19 80.

proved:
WA STATE HIGHWAY COMMISSION

Contracts Engineer

Kossuth County, Iowa
Party of the first part

By Stanley Muckey
Pro Tem Chairman Stanley Muckey

Everds Bros., Inc.

By

1980 MAINTENANCE SEAL COATING

MSC-1-80 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

MSC-2-80 3.0 miles of matinenance seal coating from the southwest corner of 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

MSC-3-80 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.

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

MSC-4-80 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

MSC-5-80 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.

Item #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

MSC-8-80 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.

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

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

TYPICAL CROSS SECTIONS

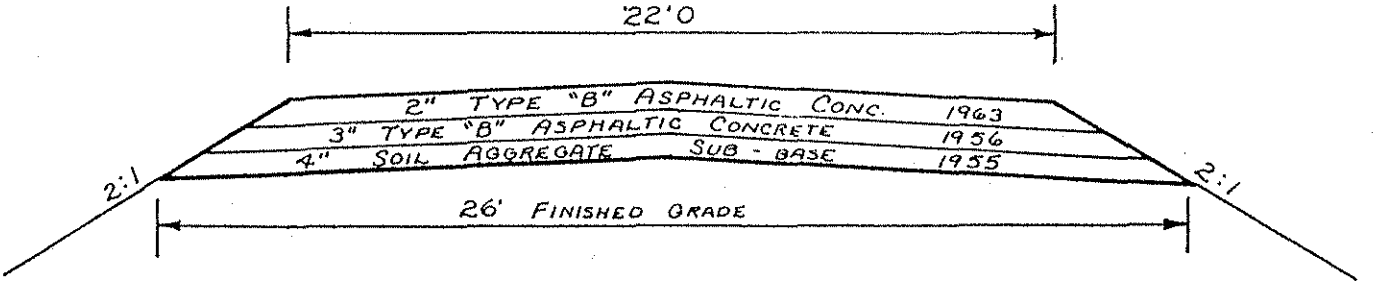
TYPICAL CROSS SECTION

PROJECT MSC-1-80

4.0 MILES

FROM S.W. COR. 34-100-30 TO S.W. COR. 10-100-30

A.D.T. = ~~75-150~~ 99-113 (1976) 123



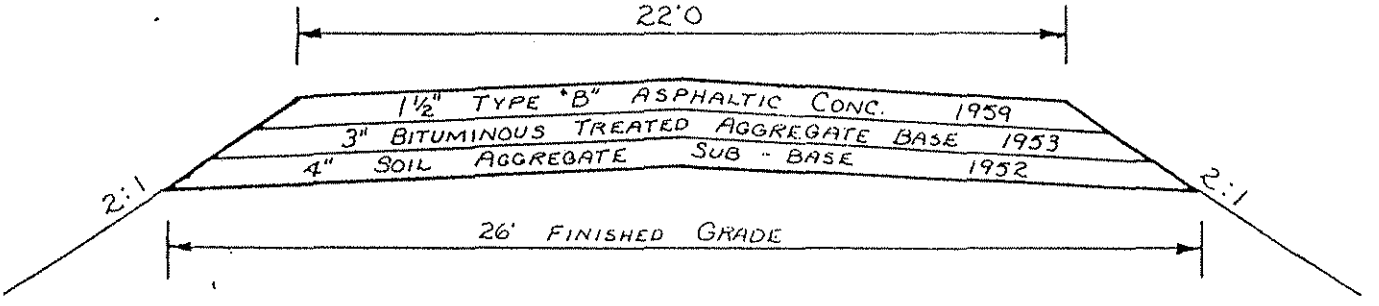
TYPICAL CROSS SECTION

PROJECT MSC-2-80

3.0 MILES

FROM S.W. COR. 31-98-29 TO S.W. COR. 18-98-29

A.D.T. = ~~203-216~~ 111-123 (1976) 133



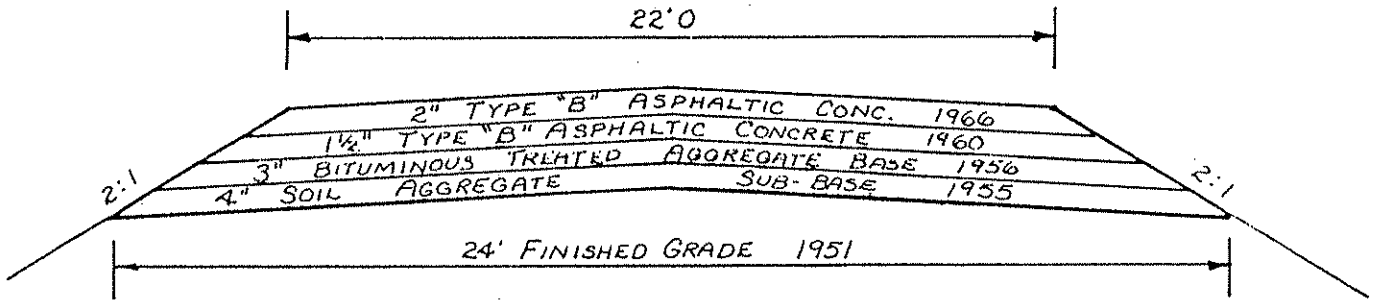
TYPICAL CROSS SECTION

PROJECT MSC-3-80

FROM S¼ COR. 12-98-29 TO S¼ COR. 12-98-28

6.0 MILES

A.D.T. = 112-~~194~~ 113-237 V.P.D. (1976) 1980



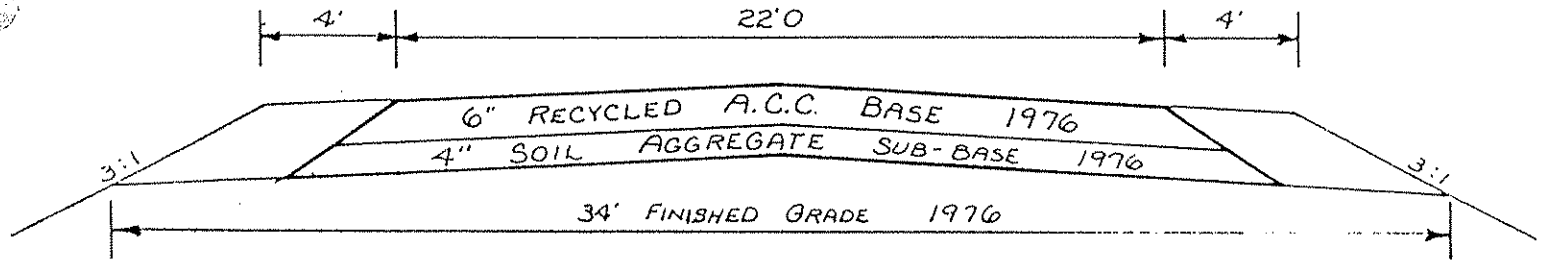
TYPICAL CROSS SECTION

PROJECT MSC-4-80

FROM S.W. COR. 4-97-27 TO S.W. COR. 21-98-27

3.0 MILES

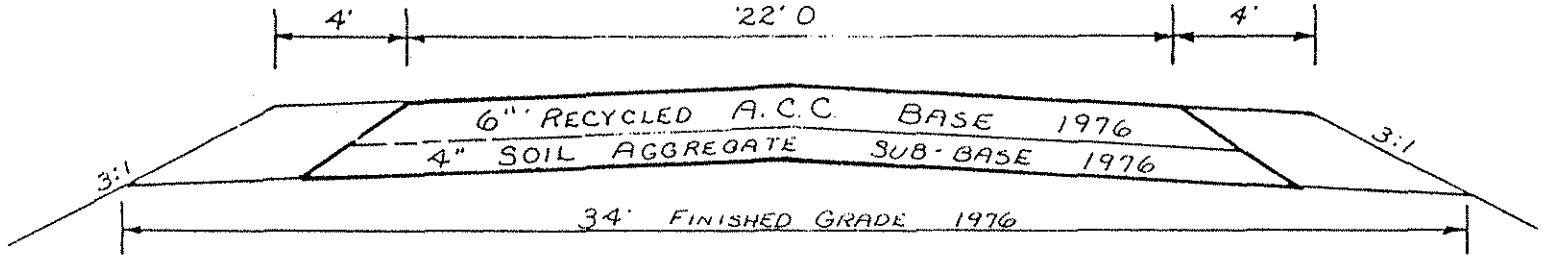
A.D.T. = 270-294 V.P.D. (1976)



TYPICAL CROSS SECTION
PROJECT MSC-5-80
9.0 MILES

FROM S.W. COR. 3-97-27 TO S.W. COR. 15-99-27

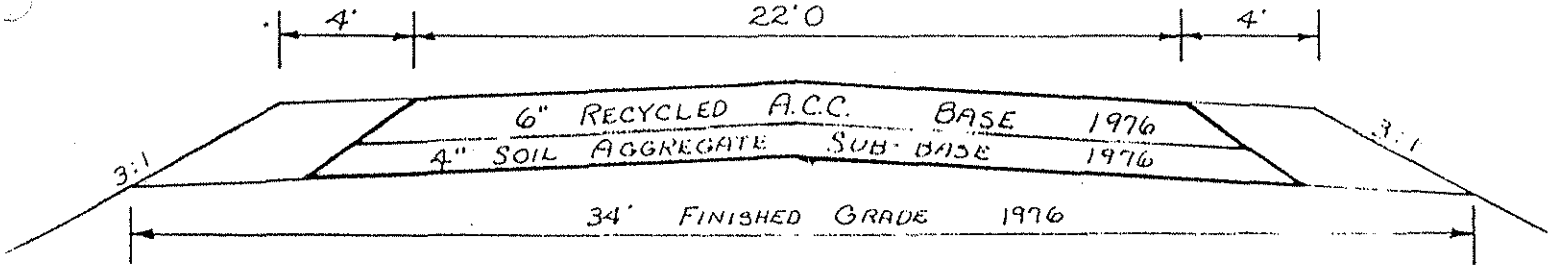
A.D.T. = 150-371 / 191-410 V.P.D. (1976) / 1990



TYPICAL CROSS SECTION
PROJECT MSC-6-80
4.0 MILES

FROM S.W. COR. 24-98-27 TO S.W. COR. 36-99-27

A.D.T. = 119-125-139 V.P.D. (1976) / 2000



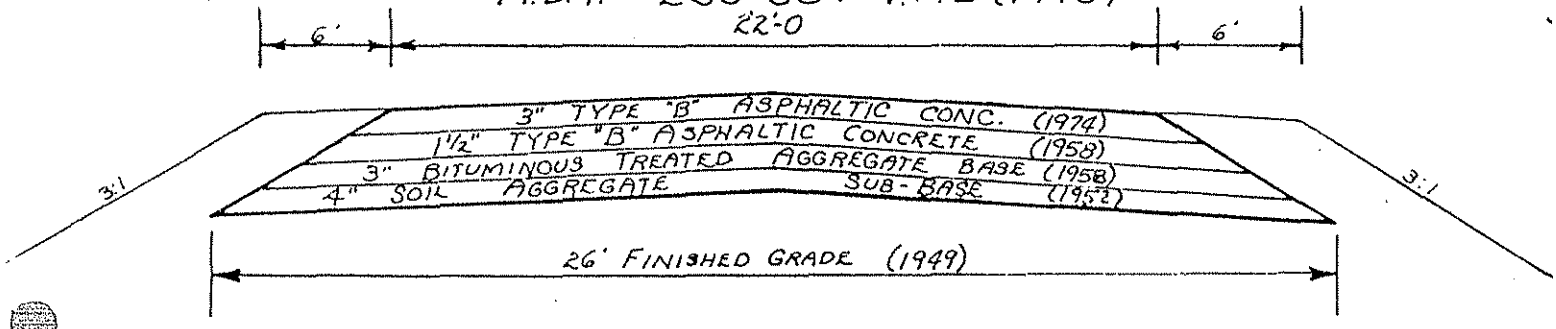
TYPICAL CROSS SECTION

PROJECT MSC-7-80

FROM SW COR. 16-97-30 TO SW COR. 31-98-29

9.0 MILES

A.D.T. = 255-589 V.P.D (1976)



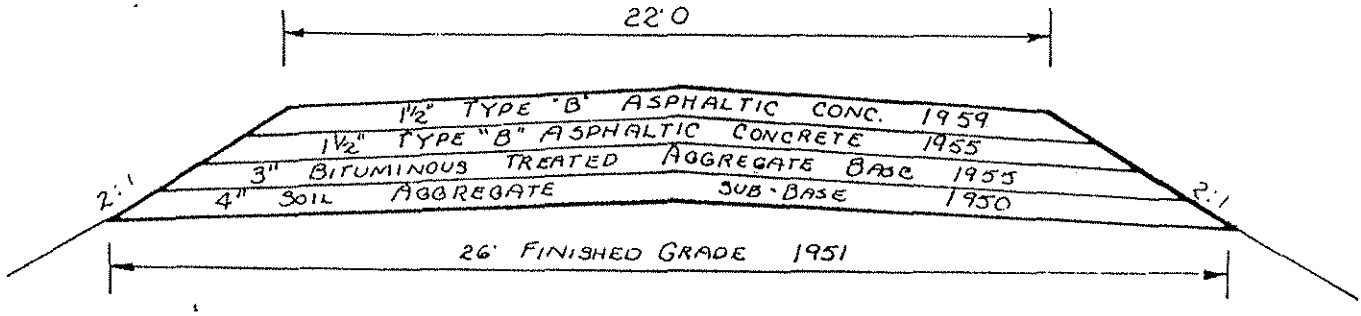
TYPICAL CROSS SECTION

PROJECT MSC-8-80

FROM S.W. COR. 31-96-28 TO S.W. COR. 21-97-28

9.0 MILES

A.D.T. = 188-309 V.P.D. (1976)



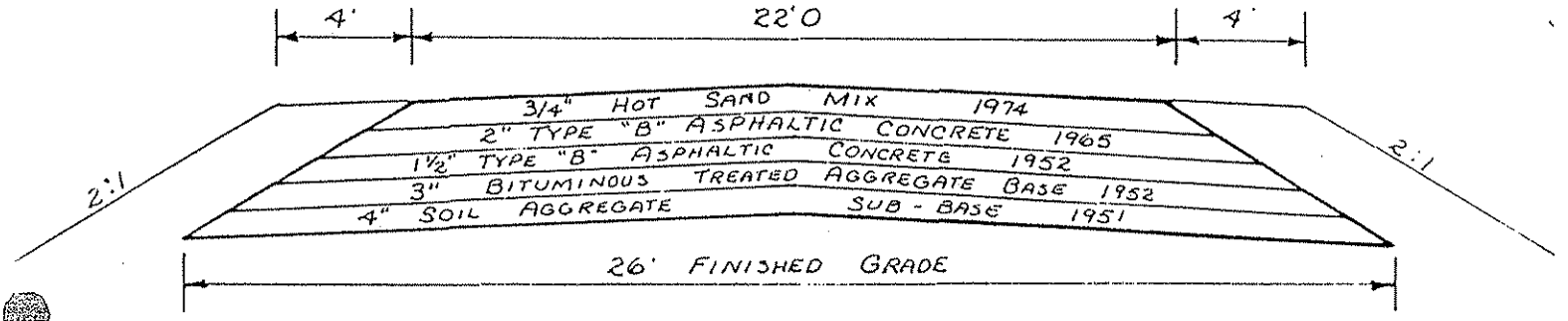
TYPICAL CROSS SECTION

PROJECT MSC - 9 - 80

FROM 3¼ COR. 1-95-29 TO S.W. COR. 6-95-28

6.5 MILES

A.D.T. = 517 - 740 V.P.D. (1976)



APPENDIX D

MODIFIED KEARBY DESIGN METHOD

1/2" Chips from Weaver Construction Co., Humboldt, Iowa

COMPUTATION SHEET for BITUMINOUS SEALING

Aggregate Characteristics

Sieve Size	3/4"	5/8"	1/2"	3/8"	4	8	16	30
% Retained		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. (W) 90 Lbs/Cu/Ft. Voids (V) .451594 %.

Absolute Volume (AV) = $\frac{W}{Sp.G \times 62.4} = \frac{90}{2.63 \times 62.4}$ = .548406 %. V=1.00-AV.

COMPUTATION of AVERAGE PARTICLE SIZE

Sieve Size	Av.Size Inches		% Pass and Ret.		Summation
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
8-16	.0703	x	.017	=	.001195
16-30	.0351	x		=	
-30	.0175	x	.005	=	.000088

Av.Particle Size (Effective Mat Thickness) (T) = .295031 In.

Spread Ratio (SR) = $\frac{36}{T} = \frac{36}{.295031}$ = 122.02 Sq.Yds/Cu.Yd.

Rate of Cover Mat'l.by Vol.(Rcv) = $\frac{1}{SR}$ = 0.008195 Sq.Yds/Cu.Yd.

Rate of Cover Mat'l.by Wt.(Rcw)=27 Rcv W=27x.008195x 90 = 19.9 Lbs./Sq.Yd.

Embedment (E) = 40 % from table or as adjusted.

Rate of Asphalt (Ra) = V *(5.61 T E) = .451594 x.662050 = .299 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.

1/2" Chips from Midwest Limestone Co., Inc., Gilmore City, Iowa

COMPUTATION SHEET for BITUMINOUS SEALING

Aggregate Characteristics

Sieve Size	3/4"	5/8"	1/2"	3/8"	4	8	16	30
% Retained		100	98	67	10	1.1		.4
% Passing and Retained		2	31	57	8.9	.7		.4

Sp.G. 2.65 D & R Wt. (W) 90. Lbs/Cu/Ft. Voids (V) .455733 %.

Absolute Volume (AV) = $\frac{W}{Sp.G \times 62.4} = \frac{90}{2.65 \times 62.4}$ = .544267 %. V=1.00-AV.

COMPUTATION of AVERAGE PARTICLE SIZE

Sieve Size	Av.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
4-8	.1404	x	.089	=	.012496
8-16	.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) = $\frac{36}{T} = \frac{36}{.391857}$ = 112.55 Sq.Yds/Cu.Yd.

Rate of Cover Mat'l.by Vol.(Rcv) = $\frac{1}{SR}$ = .008885 Sq.Yds/Cu.Yd.

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) =.455733 x.717759 = .327 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

COMPUTATION SHEET for BITUMINOUS SEALING

Aggregate Characteristics

Sieve Size	3/4"	5/8"	1/2"	3/8"	4	8	16	30
% Retained				100	38.5			.8
% Passing and Retained				61.5	37.7			.8

Sp.G. 2.69 D & R Wt. (W) 94 Lbs/Cu/Ft. Voids (V) .439996 %.

Absolute Volume (AV) = $\frac{W}{Sp.G \times 62.4} = \frac{94}{2.69 \times 62.4}$ = .560004 %. V=1.00-AV.

COMPUTATION of AVERAGE PARTICLE SIZE

Sieve Size	Av.Size Inches		% Pass and Ret.		Summation
3/4"-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
8-16	.0703	x		=	
16-30	.0351	x		=	
-30	.0175	x	.008	=	.000140

Av.Particle Size (Effective Mat Thickness) (T) = .225886 In.

Spread Ratio (SR) = $\frac{36}{T} = \frac{36}{.225886}$ = 159.37 Sq.Yds/Cu.Yd.

Rate of Cover Mat'l.by Vol.(Rcv) = $\frac{1}{SR}$ = .006275 Sq.Yds/Cu.Yd.

Rate of Cover Mat'l.by Wt.(Rcw)=27 Rcv W=27x.006275x94 = 15.9 Lbs./Sq.Yd.

Embedment (E) = .35 % from table or as adjusted.

Rate of Asphalt (Ra) = V *(5.61 T E) =.439996 x.443527 = .195 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.

APPENDIX E

DESIGN SPREAD RATES

DESIGN SPREAD RATES

PROJECT #	BINDER MAT'L.	COVER. AGG. *	TARGET RATE BINDER GAL/YD^2	TARGET RATE COV. AGG. #/YD^2
MSC-1	CRS-2	1/2" LIMESTONE[1]	0.35	27
MSC-2	CRS-2	3/8" PEA GRAVEL[2]	0.28	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]	0.32	27
MSC-7	CRS-2	1/2" LIMESTONE[1]	0.35	27
MSC-8	MC-800	1/2" LIMESTONE[3]	0.32	30
MSC-9	MC-800	1/2" LIMESTONE[3]	0.32	30

* LOCATION OF AGGREGATE QUARRIES

[1] GILMORE CITY

[2] EMMETSBURG

[3] HUMBOLDT

APPENDIX F

APPLICATION DATA

Project	Oil Avg. Rate Gal/yd2	Oil Avg. Temp. °F.	½" Chips Limestone Avg. Rate #/yd2	Avg. Air Temp. °F.	Avg. Road Temp. °F.
MSC-1 CRS-2	.3514	170°	21.4	84°	93°
MSC-2 CRS-2	.2999	159°	21.63*	87°	96°
MSC-3 HFMS-2	.3517	164°	23.97	71°	76°
MSC-4 HFMS-2	.3341	169°	24.99	78°	82°
MSC-5 HFMS-2	.3319	164°	23.32	79°	89°
MSC-6 HFMS-2	.3341	160°	23.17	73°	78°
MSC-7 CRS-2	.3573	164°	25.59	85°	90°
MSC-8 MC-800	.321	237°	25.46	82°	89°
MSC-9 MC-800	.3216	241°	26.53	74°	79°

* 3/8" Pea Gravel

APPENDIX G

BITUMINOUS MATERIALS - TEST DATA

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

ATERIAL MC-800 LAB NO. AR00-40

NTENDED USE

OUNTY KOSSUTH PROJ NO. RESEARCH

LSIGN CONTRACT NO.

RODUCER BIT. MATLS. CONTRACTOR

OURCE ALGONA

NIT OF MATERIAL 2 GALS.

AMPLED BY INGERTSON SENDER'S NO. 2RI0-30

E SAMPLED 6/23/80 REC'D 7/2/80 REPORTED 7/10/80

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.	
IB.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	
STRIPPING TEST USING AAT0-290 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
TESTING ENGINEER

Form 820358
12-76

IOWA DEPARTMENT OF TRANSPORTATION

OFFICE OF MATERIALS
Test Report-Miscellaneous Materials

R.L. Bortle
R.P. Henely
File

Laboratory Mason City

Material MSC-6 County Kossuth

Intended Use Sealcoat Project No. MSC-6

Laboratory No. @aroo-149 Design No.

Date Reported 7-24-80 Contract No.

Producer Bituminous Materials & Supply Contractor Everds Brothers

Source Algona, IA

Unit of Material Subcontractor

Sampled By R. Chase Senders No. 10 Date 7-23-80

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

DISPOSITION: Complies

Signed W.J. Orozco

Ames
R.I. Bortle
R. Henely
File

IOWA DEPARTMENT OF TRANSPORTATION

OFFICE OF MATERIALS
Test Report-Miscellaneous Materials

Laboratory Mason City

Material CRS-2 County Kossuth

Intended Use Sealcoat Project No. MSC-2

Laboratory No. 2AROO-125 Design No.

Date Reported 7-18-80 Contract No.

Producer Bituminous Materials & Supply Contractor Everds Bros. Inc.

Source Algona, IA

Unit of Material Subcontractor

Sampled By R. Chase Senders No. 4 Date 7-16-80

Saybolt Furol Viscosity @ 122°F 237 Seconds
% Residue @ 71.6%
Penetration @ 77°F, 100 Gms. 5 Sec 157
Determined Polarity - Postive

DISPOSITION: Complies

Signed W.J. Orozco 7-18-80

APPENDIX H

FRICTION TEST DATA

ROAD RATER TEST DATA

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

MSC-2	9-83	50	47
MSC-5	9-83	52	59
MSC-7	9-83	43	44

STRUCTURAL RATING FROM ROAD RATER DEFLECTION

PROJECT	STRUCTURAL RATING		
	7/8/80	8/11/80	9/83
MSC-2	1.65	1.65	2.55*
MSC-5	2.10	2.10	**
MSC-7	2.45	2.70	2.55

*ROAD HAS BEEN RESURFACED
**NOT AVAILABLE