EVALUATION OF MDOT MAINTENANCE
DIVISION SEAL COAT PROJECTS
Final Report

MICHIGAN DEPARTMENT OF TRANSPORTATION

MATERIALS and TECHNOLOGY DIVISION

EVALUATION OF MDOT MAINTENANCE DIVISION SEAL COAT PROJECTS
Final Report

V. T. Barnhart

Research Laboratory Section
Materials and Technology Division
Research Project 87 TI-1252
Research Report No. R-1306

Lansing, June 1990

ACTION PLAN

1. District

   A. The Maintenance Supervisor will submit a list of bituminous pavements to be considered for either crack sealing, seal patching, or full-width seal coat to the Operations Engineer with a recommendation as to which option should be used on each project.

   B. The Operations Engineer will review the PMS data, traffic data, and Bituminous Advisory Committee's criteria for Full-Width Seal Coat Treatment to determine if the project is a candidate for a full-width seal coat.

   C. The Project Development Engineer will review the list of projects to see that the projects selected for full-width seal coat are not scheduled for major rehabilitation within the next two years.

   D. The Operations Engineer will submit a prioritized list of projects for full-width seal coat to the Engineer of Maintenance for funding.

2. Maintenance Division

   A. The Engineer of Maintenance will review the proposed list of projects for full-width seal coat and approve the projects based on their meeting the Bituminous Advisory Committee's criteria for Full-Width Seal Coat Treatment. Then, based on the number of projects submitted by the Districts and the priority that each District has assigned to their projects, approve projects for funding.

   B. He will return a list of projects approved for funding to the Districts for construction.

3. District

   Assign personnel to oversee and check the quality of materials used and the construction of projects.

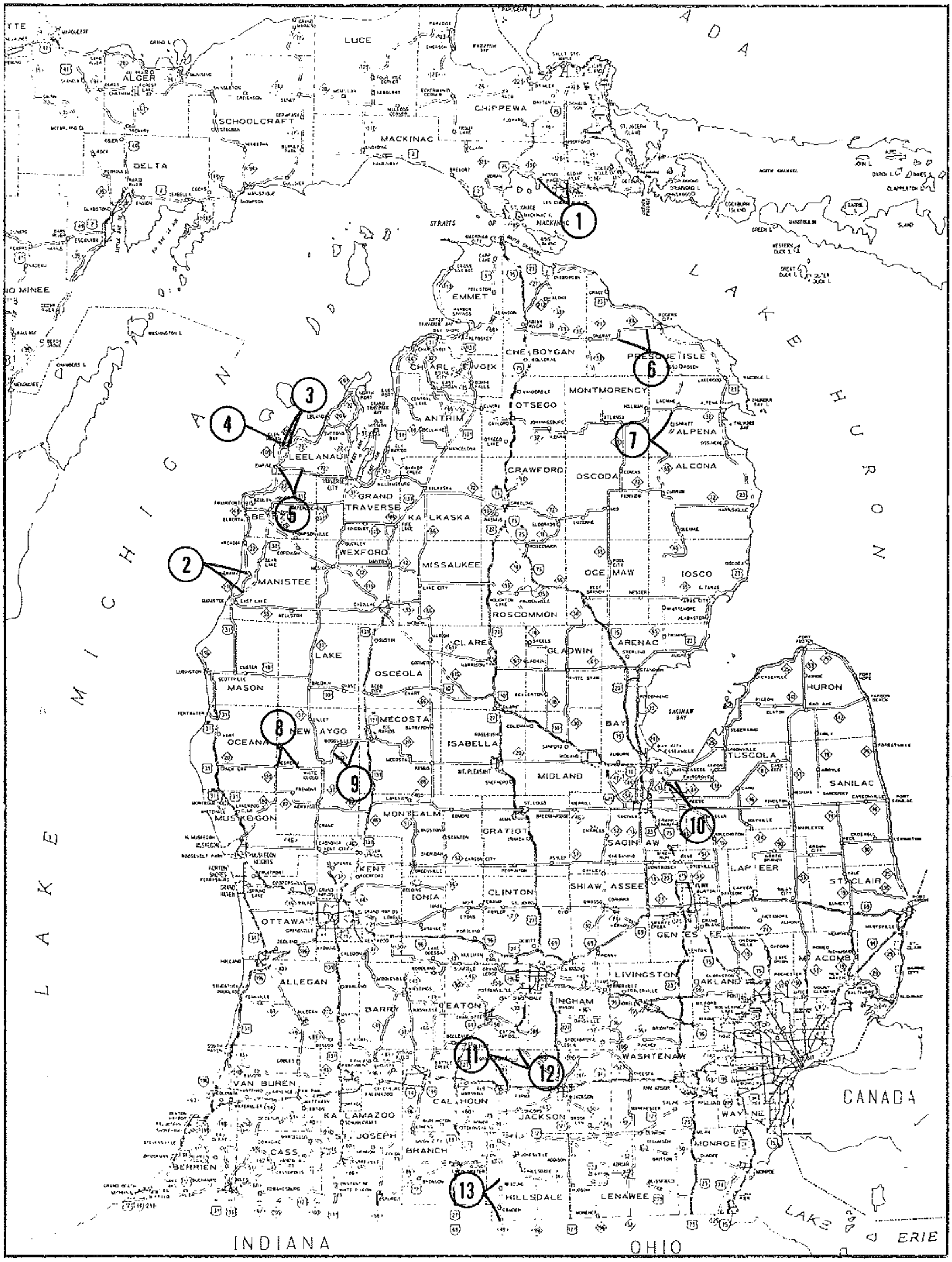


Figure 1. Maintenance seal coat projects.

Prior to 1986, the Michigan Department of Transportation restricted the use of bituminous seal coat treatments on State trunk lines to spot and strip applications. In May of 1986, the Department's Maintenance Division received approval to try full-width seal coat applications on a limited basis.

During the 1986 construction season 13 seal coat projects were completed on approximately 155 lane miles of low-volume state highways (M routes) using contract county forces (Table 1, Fig. 1). Both slag and natural aggregates were used with a high-float anionic asphalt emulsion blended with a polymer. Two different products were used, one was a proprietary product called 'Styrelf,' the other was a similar material, custom blended for these jobs, by the Koch Materials Co.

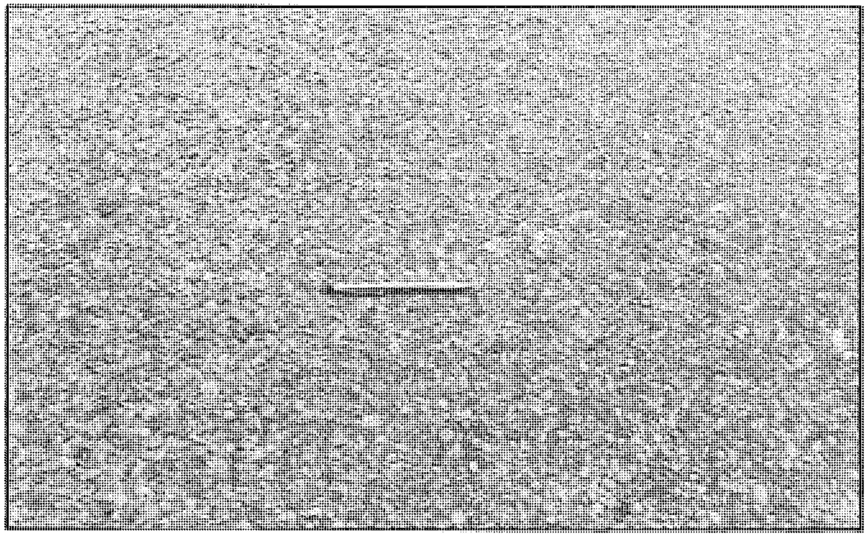
TABLE 1
LOCATIONS OF 1986 MAINTENANCE SEAL COAT PROJECTS

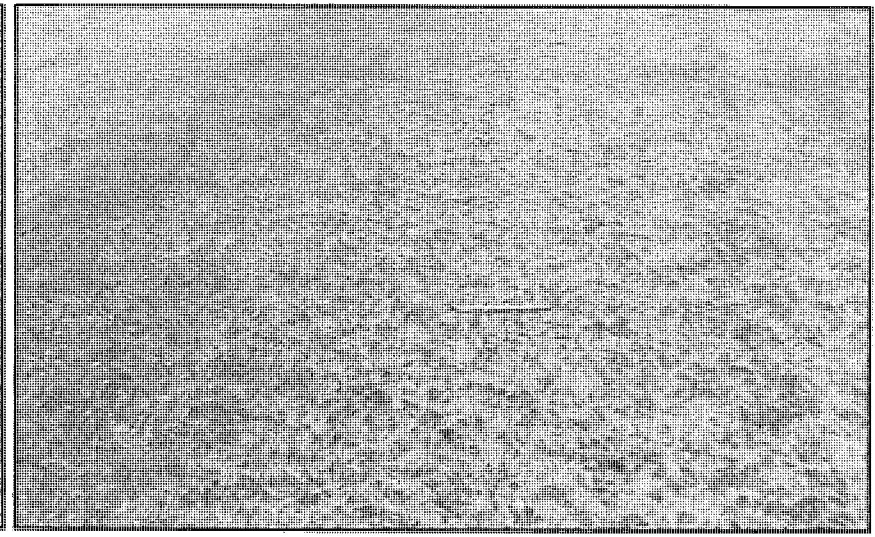
Project Number	Control Section	Route	District	Location	Asphalt Emulsion Binder	Aggregate Type	1985(1) (Comm) ADT	1987(1) (Comm) ADT	Length of Sealcoat, Miles	Work Completed
1	49041	M 134	2	Search Ban Rd E to W of Rudd Rd plus Ramps at M 134 and I 75	Koch	Gravel Aggregate	(110) 1300	(130) 1600	6.8	7/29/86
2	51031	M 22	3	US 31 N to Onekama	Styrelf	Gravel Aggregate	(80) 2000	(100) 1900	7.0	7/31/86
3	45031	M 109	3	Selected spots from M 22 to M 209	Styrelf	Gravel Aggregate	(90) 1050	(110) 1300	0.4	9/15/86
4	45051	M 209	3	Entire Route	Styrelf	Gravel Aggregate	(40) 700	(50) 900	0.4	9/15/86
5	45021	M 72	3	Selected spots from Co. Rd. #669 to Empire	Styrelf	Gravel Aggregate	(80) 1250	(90) 1400	1.2	9/15/86
6	04011	M 65	4	M 32 S to S Alpena Co. Ln.	Styrelf	Gravel Aggregate	(168) 1390	(194) 1680	15.5	8/29/86
7	71021	M 68	4	Millersburg Rd E to Curtis Rd	Styrelf	Dolomite	(120) 1400	(140) 1600	6.4	8/20/89
8	62014	M 20	5	Hesperia E to Croswell Rd	Koch	Slag Aggregate	(165) 3500	(165) 3800	7.0	8/01/86
9	62012	M 20	5	6.0 mi E of M 37 to E Co. Ln.	Koch	Slag Aggregate	(40) 800	(33) 767	12.0	7/17/86
10	09021	M 138	6	M 15 E to Munger and spot locations	Styrelf	Gravel Aggregate	(190) 2100	(210) 2300	2.0	7/01/86
11	38011	M 99	8	I 94 N to S city limits of Springport	Styrelf	Gravel Aggregate	(252) 2025	(272) 2225	7.6	9/09/86
12	38011	M 99	8	N city limits of Springport to M 50	Styrelf	Gravel Aggregate	(260) 2880	(284) 3020	5.3	9/12/86
13	30011	M 49	8	Ohio State Line to N of Bankers Rd N of Reading	Styrelf	Gravel Aggregate	(219) 2075	(222) 2108	11.2	8/12/86

NOTE: For detailed information regarding the aggregate type for each project except for Project No. 5 see Michigan Department of Transportation Testing Report No. 87 T-2. (Project No. 5 was added after the report was published.)

(1) Traffic counts revised from Testing Report No. 87 T-2.

Prior to the placement of the bituminous seal coat treatment a visual inspection of the condition of the thirteen projects was made using the Department's Photo Log of state trunk lines. That inspection showed one project in good condition (Project No. 4 on M 209) and the rest in fair to poor condition. This determination was based on the amount of cracking observed on the roadway and the amount of distress associated


No aggregate loss from the asphalt emulsion.


Medium loss of aggregate from the asphalt emulsion.


Low aggregate loss from the asphalt emulsion.

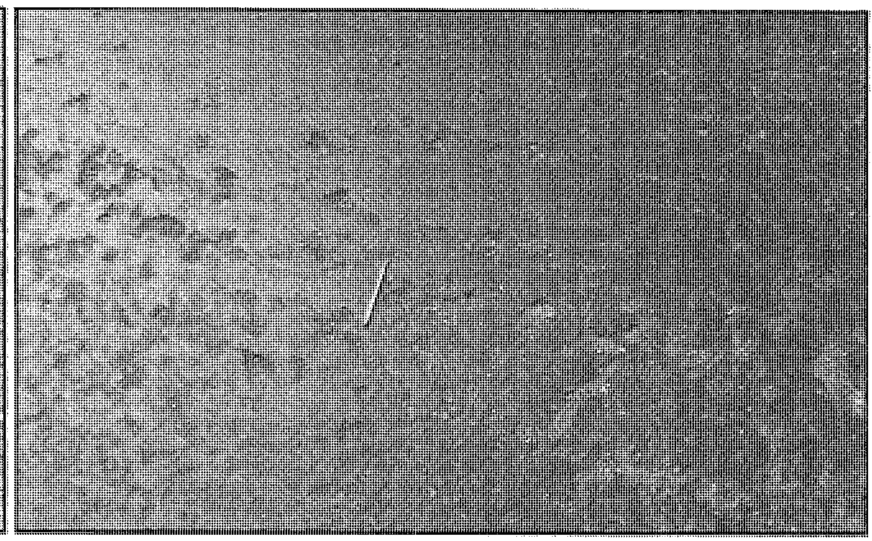

Heavy loss of aggregate from the asphalt emulsion and heavy flushing.

Figure 2. Showing the loss of aggregate.

with the cracks (small cracking around a transverse or longitudinal crack and bituminous material missing along the crack).

Since the completion of the projects, inspections were made in 1987, 1988, and 1989 to evaluate the performance of the seal coat treatments. Each inspection noted and recorded the following distress factors:

1) Amount of aggregate loss,

2) Amount of flushing or bleeding of the emulsion,

3) Streaking of the asphalt emulsion (as an indication of the uniformity in emulsion application),

4) Blackening of the wheelpath short of flushing or bleeding (as an indication of the densification by traffic of the aggregate in the wheelpath and as an indication that too much emulsion was applied), and

5) Reflective cracking was present or not and whether the cracks were open or closed.

Installation procedures and product description are covered in MDOT Testing Report No. 87 T-2. The performance after one winter is evaluated in a March 2, 1989 Memorandum from L. K. Heinig to C. J. Arnold (Appendix).

Inspection Results (1987-1989)

Aggregate loss ranged from no loss of aggregate to isolated spots where there was a high loss (Fig. 2). In general, the loss of aggregate from the asphalt emulsion was low on seven of the projects and medium on the remaining six (Table 2). Loss of aggregate could be due to traffic being allowed on the seal coat before the asphalt emulsion had time to set completely and by the normal wear from traffic on the roadway.

Flushing or bleeding of the asphalt emulsion ranged from low to high. Three projects had areas of very high flushing or bleeding and ranged from 3 percent in the 1987 survey to 5 percent in the 1989 survey. There were several projects which had intermittent flushing or bleeding that appeared to be asphalt-rich for the entire length of the project. No project was completely free of flushing or bleeding of asphalt emulsion.

Two of the projects had streaking of the asphalt emulsion that ranged from low to medium; however, it was in isolated areas. The streaking of the asphalt emulsion could have been caused by: 1) improper setting of the height of the spray bar on the asphalt distributor truck; 2) improper angle of the spray nozzle to the spray bar; or 3) improper pressure along the length of the spray bar that is used for dispensing the asphalt emulsion, or any combination of these three.

TABLE 2
CONDITION OF 1986 MAINTENANCE SEAL COAT PROJECTS

Project Number	Control Section	Route	District	Location	Aggregate Loss	Flushing or Bleeding	Asphalt Emulsion Streaking	Blackening of Wheelpath Short of Flushing or Bleeding	Cracking			
									Present	Not Present	Cracks Open	Cracks Closed
1	49041	M 134	2	Search Ban Rd E to W of Rudd Rd plus Ramps at M 134 and I 75	Low	Medium	Low	Medium	X	---	X	X
2	51031	M 22	3	US 31 N to Onekama	Medium	None	None	Medium	X	X	X	X
3	45031	M 109	3	Selected spots from M 22 to M 209	Medium	Medium	None	None	---	X	---	---
4	45051	M 209	3	Entire Route	Low	Medium	None	Low	---	X	---	---
5	45021	M 72	3	Selected spots from Co. Rd. #669 to Empire	Low	Heavy	None	Heavy	X	X	---	X
6	04011	M 65	4	M 32 S to S Alpena Co. Ln.	Low	Medium	Medium	Medium	X	---	X	X
7	71021	M 68	4	Millersburg Rd E to Curtis Rd	Medium	Low	None	None	X	---	X	X
8	62014	M 20	5	Hesperia E to Croswell Rd	Low	None	Medium	Low	X	X	X	X
9	62012	M 20	5	6.0 mi E of M 37 to E Co. Ln.	Low	Low	Low	Low	X	---	X	X
10	09021	M 138	6	M 15 E to Munger and spot locations	Medium	Low	None	None	X	---	X	X
11	38011	M 99	8	I 94 N to S city limits of Springport	Medium	Medium	None	Low	X	---	X	---
12	38011	M 99	8	N city limits of Springport to M 50	Medium	Medium	None	Medium	X	---	X	---
13	30011	M 49	8	Ohio State Line to N of Bankers Rd N of Reading	Low	Low	None	Medium	X	---	X	---

The blackening of the wheelpath short of flushing or bleeding ranged from none to medium. In general, blackening of the wheelpath short of flushing or bleeding could be categorized as low for all the projects.

Reflective cracking through the seal coat ranged from hairline cracks to cracks 1/2 in. or more in width. There was one project (Project No. 9 on M 20) where the cracks were sealed with a 4-ft wide seal coat patching prior to placement of the seal coat (generally these cracks were 1/2 in. or more in width). Reflective cracking did not open up as quickly on that project as on the other projects, and when it did open up it was generally hairline to 1/4 in. in width.

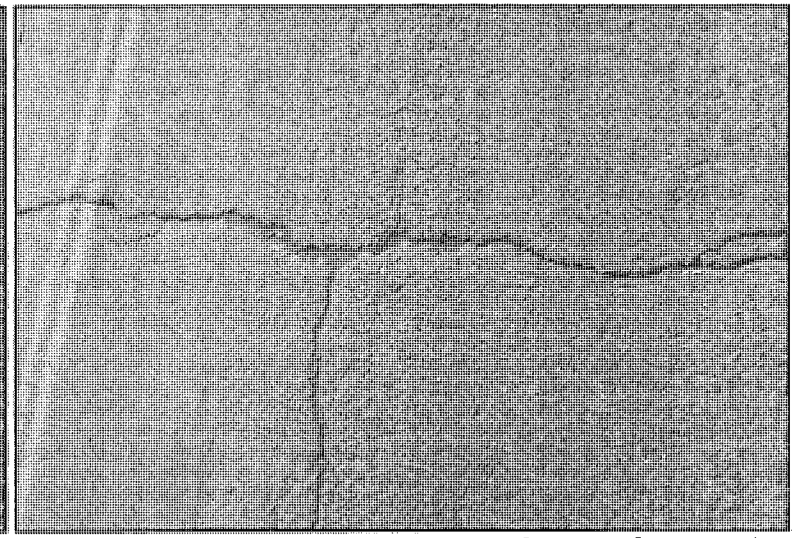
On seven of the projects (those in Districts 2, 3, 4, and 8) there were open cracks which were filled with seal coat during placement. The 1987 survey found that in 95 percent of these cracks the seal coat had not deteriorated (Fig. 3) and in the 1988 survey in 90 to 93 percent of these cracks, the seal coat was still intact. However, by 1989 cracks with undeteriorated seal coat had reduced to 40 percent for projects in District 8 and to 80 percent for projects in Districts 2, 3, and 4. This difference could possibly be due to: 1) lower traffic counts in Districts 2, 3, and 4 than in District 8 (Table 3); 2) lower numbers of freeze-thaw cycles in Districts 2, 3, and 4 than in District 8.

TABLE 3
TRAFFIC COUNTS FOR PROJECTS WITH
CRACKS OPEN AND FILLED WITH
SEAL COAT DURING PLACEMENT

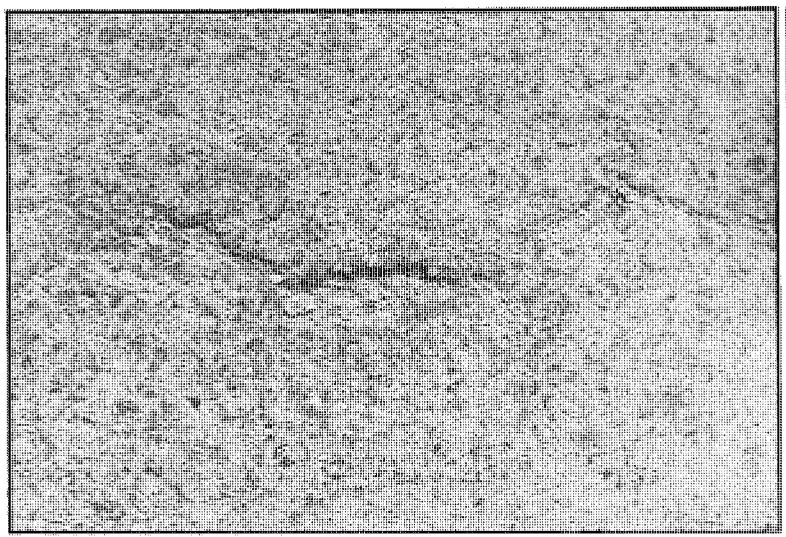
	Project Number	Route	1985 ADT*	1987 ADT*	1985 ADT* Comm	1987 ADT* Comm
Districts 2, 3, & 4	1	M 134	1300	1600	110	130
	2	M 22	2000	1900	80	100
	6	M 65	1390	1680	168	194
	7	M 68	1400	1600	120	140
	Total		6090	6780	478	564
	Avg.		1523	1695	120	141
District 8	11	M 99	2025	2225	252	272
	12	M 99	2880	3020	260	284
	13	M 49	2075	2108	219	222
	Total		6980	7353	731	778
	Avg.		2327	2451	244	259

*Traffic counts revised from Testing Report No. 87 T-2.

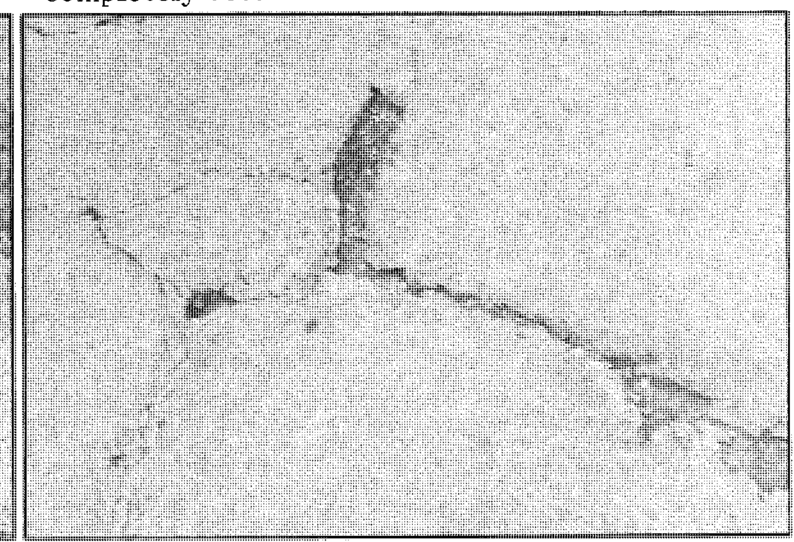
Crack that was open prior to seal coat placement with seal coat still intact in 1987.



Crack that was open prior to seal coat placement that was filled with seal coat but seal coat has completely deteriorated in 1987.



Crack that was open prior to seal coat being placed with seal coat still intact in 1989.



Crack that was open prior to seal coat placement that was filled with seal coat but seal coat has completely deteriorated in 1988.

Figure 3. Cracks open before seal coat placement with seal coat intact and seal coat deteriorated.

On six of the projects there were isolated spots where the seal coat had been completely removed due to acceleration and/or deceleration of traffic (Fig. 4). In 1987 and 1988 this type of deterioration comprised approximately 5 to 10 percent of the length of each project. By 1989 the deterioration had increased to 7 to 15 percent of the length of each project. These areas generally occurred at intersections, driveways, on curves, or on hills.

On four of the projects there were areas where the seal coat had been completely removed by maintenance and/or snow removal equipment (Fig. 5). The amount of removal ranged from just small areas (where a small circle or oval area at the center of the lane or the wheelpath had been removed) to the complete loss of the seal coat over the entire lane for several feet in the direction of traffic. For each project these areas comprised approximately 1 percent in the 1987 survey and increased to 3 to 5 percent by the 1989 survey.

On all but one project (Project No. 4 on M 209) there were indications of scraping along the centerline of the roadway and the center of the lane by snow removal equipment. The severity of this scraping ranged from the loss of some of the aggregate to the complete loss of aggregate and emulsion where there appeared to have been frost heave around open cracks (Figs. 6 and 7).

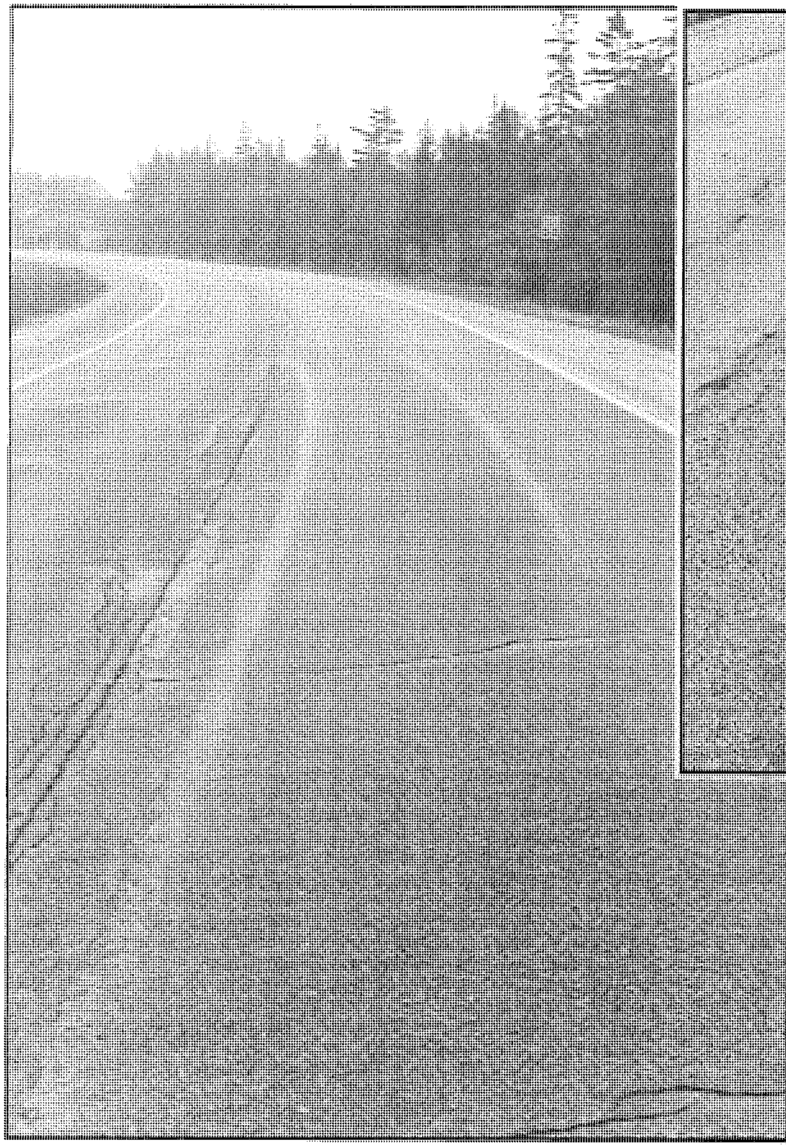
Friction measurements were made on all of the projects in the fall of 1986 and 1987 and biannually for 1988 and 1989. The friction measurements for the projects are presented in Table 4. The values recorded are in an acceptable range that would not require special attention.

Conclusions and Recommendations

Sealing of cracks open 1/2 in. or more prior to placement of the seal coat appears to reduce the amount of reflective cracking showing through the seal coat and also reduces the width of reflective cracks that occur later.

Some of the aggregate loss may be attributed to the lack of stone compaction into the emulsion when the seal coat is placed. However, this lack of compaction probably would have little effect on the amount of aggregate that is lost due to the scraping of the seal coat by snow removal equipment. This is because the scraper blade on snow removal equipment will pull the stones out of the asphalt emulsion regardless of how much the stone is compacted into the seal coat when it is placed.

There were several types of aggregates used on these seal coat projects (Table 1). In general, there appeared to be less loss of aggregate on the two projects where slag aggregate was used than from the other projects where natural aggregates were used. This might be due to better adhesion to the more porous slag aggregate surface.



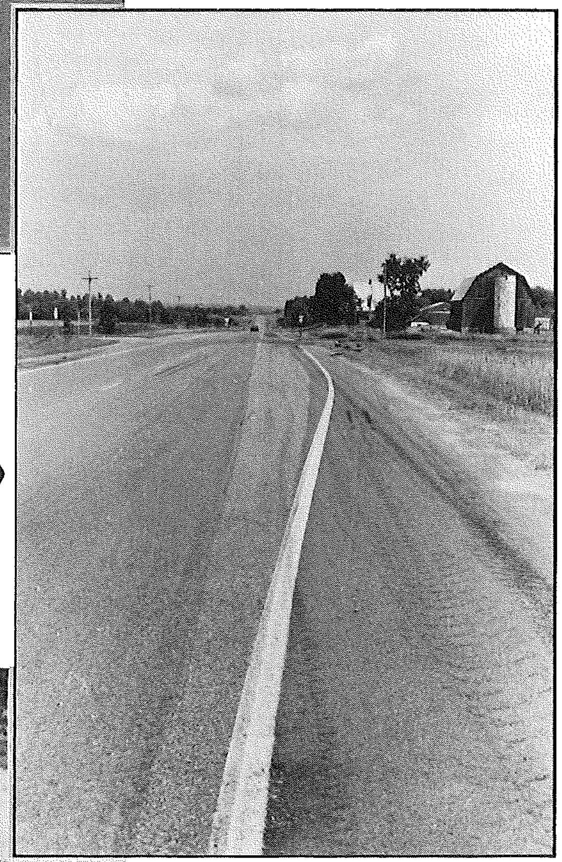
Loss of aggregate and emulsion due to acceleration or deceleration on level road.

Loss of aggregate and emulsion due to deceleration going into curve.

Figure 4

Loss of aggregate and emulsion at center line of road due to dragging of grader blade on high spots.

Loss of aggregate and emulsion from turn lane for Stone Road.



Loss of aggregate and emulsion for full lane width.

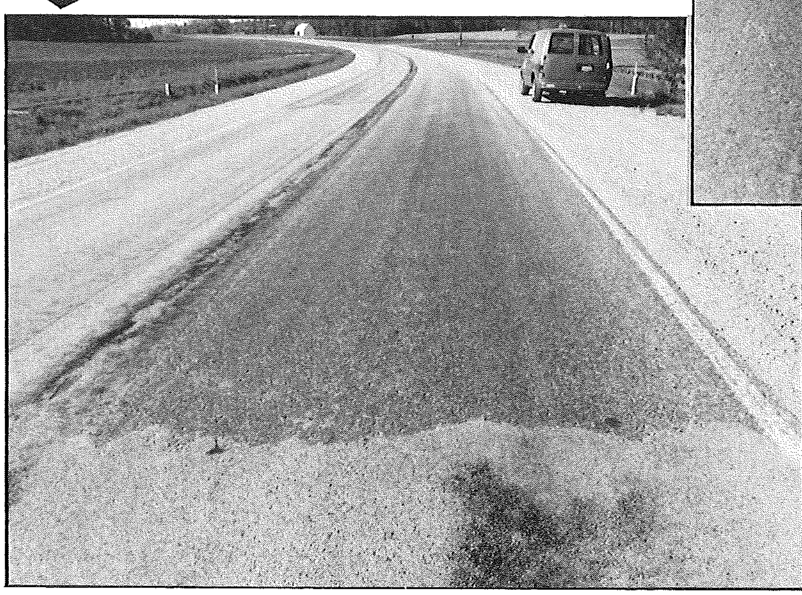


Figure 5.

TABLE 4
FRICTION MEASUREMENTS FOR MAINTENANCE SEAL COAT PROJECTS PLACED IN 1986
(Project 5 (45021, M 72) not tested)

Project Number	Control Section	Route	Location	Lane	1986 Friction Numbers				1987 Friction Numbers				1988 Friction Numbers				1988 Friction Numbers				1989 Friction Numbers				1989 Friction Numbers			
					Test Date	Low	High	Avg.	Test Date	Low	High	Avg.	Test Date	Low	High	Avg.	Test Date	Low	High	Avg.	Test Date	Low	High	Avg.	Test Date	Low	High	Avg.
1	49041	M 134	Search Ban Rd E to W of Rudd Rd plus Ramps at M 134 and I 75[1]	EB	09/23/86	47	49	48	09/23/87	52	59	56	05/24/88	47	59	54	10/26/88	53	62	58	06/20/89	45	60	54	10/24/89	51	55	51
				WB		46	50	48		52	57	55		53	57	55		57	62	59		51	58	54		51	55	53
2	51031	M 22	US 31 N to Onekama	NB	9/30/86	37	48	44	10/09/87	34	56	41	05/10/88	28	43	34	12/06/88*	33	50	44	06/19/89	32	43	37	10/31/89	32	44	37
				SB		40	50	45		32	42	38		26	38	33		34	51	43		28	40	36		33	41	36
3	45031	M 109	Selected spots from M 22 to M 209	EB	No test				10/22/87	39	47	44	05/26/88	38	43	40	12/06/88	58	60	59	06/20/89	31	54	44	11/08/89	40	44	42
				WB						45	48	47		43	47	46		53	55	54		28	54	46		45	49	47
4	45051	M 209	Entire Route	NB	No test				10/22/87	45	47	46	05/25/88	43	45	44	12/06/88	56	62	56	06/20/89	47	56	48	11/08/89	47	48	48
				SB						42	47	44		40	44	42		55	58	56		41	54	49		47	50	48
6	04011	M 65	M 32 S to S Alpena Co. Ln.	NB	09/22/86	48	55	52	10/22/87	38	49	44	05/25/88	35	56	43	10/27/88	40	57	48	06/21/89	38	56	48	10/25/89	34	56	43
				SB		50	57	52		42	52	46		37	51	44		40	59	51		43	57	50		39	55	48
7	71021	M 68	Millersburg Rd E to Curtis Rd	EB	09/22/86	50	54	52	10/20/87	44	49	47	05/25/88	46	53	49	10/26/88	50	61	54	06/21/89	46	53	49	10/25/89	47	52	50
				WB		52	54	53		43	51	47		42	55	49		51	59	55		44	58	50		44	54	48
8	62014	M 20	Hesperia E to Croswell Rd	EB	09/30/86	50	57	54	10/02/87	50	59	55	05/04/88	50	63	56	12/06/88	54	72	64	06/19/89	50	66	57	11/09/89	48	63	54
				WB		50	59	54		56	63	60		51	64	57		57	70	64		51	62	58		46	57	52
9	62012	M 20	6.0 mi E of M 37 to E Co. Ln.	EB	09/30/86	48	55	51	10/02/87	47	57	53	05/04/88	43	57	51	12/06/88	52	61	58	06/19/89	41	54	50	11/09/89	43	52	48
				WB		51	55	53		50	56	53		42	52	48		55	67	59		42	51	47		43	52	48
10	09021	M 138	M 15 E to Munger and spot locations	EB	10/08/86	29	33	31	09/28/87	26	29	27	05/05/88	21	28	24	11/01/88	32	36	33	06/23/89	25	29	28	No test[2]			
				WB		29	31	30		24	28	26		20	23	24		30	44	35		25	29	26				
11	38011	M 99	I 94 N to S city limits of Springport	NB	09/25/86	42	55	49	07/27/87	37	51	43	05/03/88	34	45	39	11/09/88	38	54	46	05/11/89	36	51	44	12/05/89	36	44	40
				SB		51	55	53		30	51	44		37	46	42		33	55	46		41	51	46		34	47	40
12	38011	M 99	N city limits of Springport to M 50	NB	09/25/86	46	54	51	07/27/87	45	49	47	05/03/88	32	47	41	11/09/88	42	55	48	05/11/89	40	51	45	12/06/89	30	46	39
				SB		40	57	48		46	54	49		35	47	41		39	56	49		34	53	45		42	49	45
13	30011	M 49	Ohio State Line to N of Bankers Rd N of Reading	NB	09/25/86	41	51	46	08/18/87	38	45	43	05/09/88	34	54	44	11/07/88	51	66	59	05/11/89	30	61	51	12/05/89	24	55	49
				SB		43	49	45		30	44	41		38	54	45		47	63	57		43	62	51		42	55	50

[1] Project #1 (49041 M 134) has been shortened due to resurfacing, new limits are Search Ban Rd E'ly to 3 Mi Rd in Hessel MP 14.5 to MP 18.8.

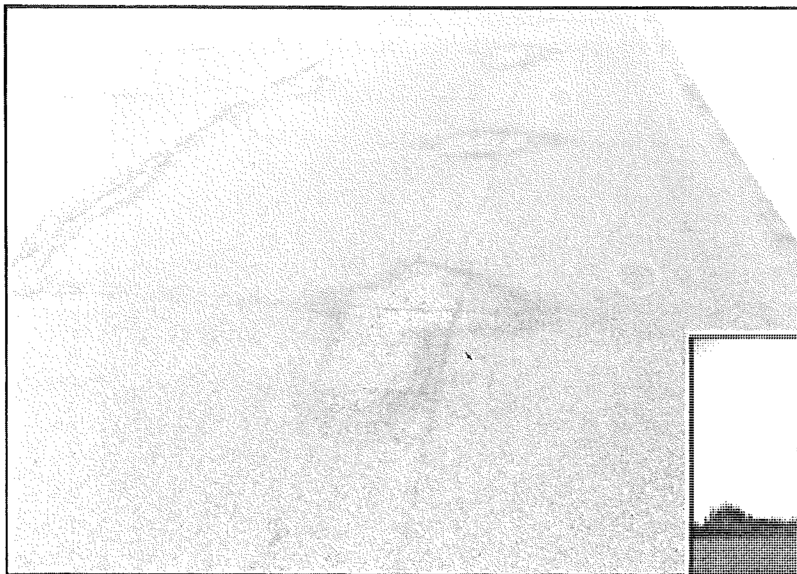
[2] Project #10 (09041 M 138) at Munger was not tested in the fall of 1989 due to cold weather.

Figure 6. Scraping of center line and center of wheel paths showing loss of aggregate only.

In general the seal coats appear to keep the pavement from breaking up and provide a waterproof seal for the roadway for two to three years. Also, the ability of the seal coat to fill in the larger cracks and remain intact and provide a waterproof seal appears to be good.

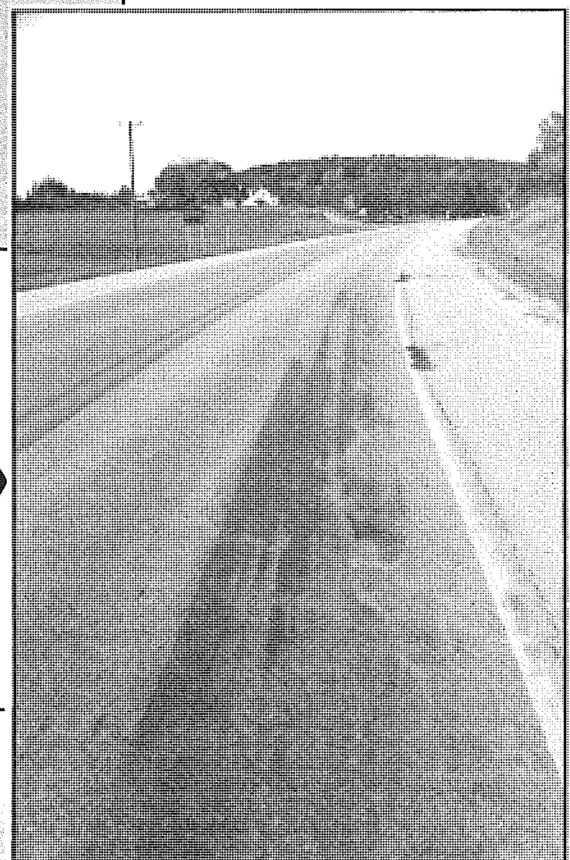
The amount of flushing or bleeding of the seal coat could be reduced by closer adherence to the recommended asphalt emulsion application rate. However, if there was an excess of asphalt used when the hot mix bituminous pavement was placed and there was flushing or bleeding of the hot mix prior to the seal coat placement this flushing or bleeding cannot be controlled or corrected by the seal coat.

Most of the damage to the seal coats resulting in the loss of aggregate or the complete loss of the aggregate and asphalt emulsion appears to have been caused by snow removal or road maintenance equipment. However, the damage caused by the snow removal equipment cannot be completely eliminated because of the need to keep the roads clear of snow and ice in the winter.



Loss of aggregate and emulsion from center of lane caused by snow removal equipment and possibly by frost heave.

Complete loss of aggregate and emulsion from low side of a curve caused by snow removal equipment.



Complete loss of aggregate and emulsion from center of lane from snow removal equipment.

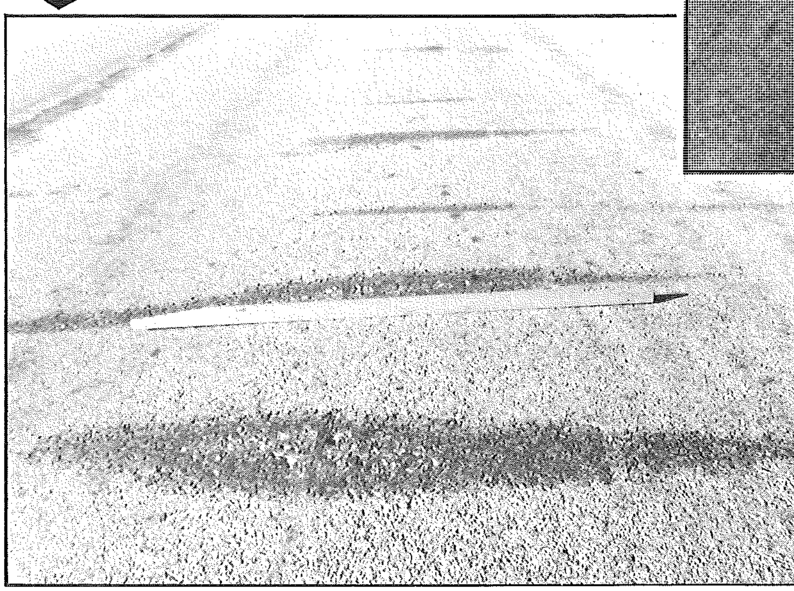


Figure 7.

The full-width seal coat treatments appear to perform well as a temporary measure to defer placement of bituminous overlays on low volume roads. Based on current data the average life of the seal coat treatment is 3.1 years and the average cost per year per lane mile of the seal coat treatment is $1,594.72. The use of full-width seal coat treatments should be continued using the guidelines established by the Bituminous Advisory Committee in a February 9, 1988 Memorandum from E. Winkler to W. J. MacCreery (Appendix) except that the current data (Tables 1 and 2, Project Nos. 8 and 12) indicate that the Average Daily Traffic (ADT) could be raised to 4,000 ADT or less instead of the 2,500 ADT or less as recommended by the Bituminous Advisory Committee. Also, it is recommended that all cracks open 1/2 in. or greater be sealed prior to the placement of the seal coat treatment. The sealing of cracks open less than 1/2 in. would not be necessary because of the seal coat treatment's ability to provide an adequate seal for these cracks.

APPENDIX

OFFICE MEMORANDUM

DATE: March 2, 1988

TO: C. J. Arnold
Engineer of Research

FROM: L. K. Heinig
Supervising Engineer
Soils, Bituminous & Pavement Performance Unit

SUBJECT: Maintenance Seal Coat Projects
Research Project 87 TI-1252

As of our last inspection 13 projects had received seal coat treatment involving more than 155 lane miles of low volume state highways (M routes). Both slag and natural aggregates were used with asphalt emulsion binders, all of which were modified with latex additives (Styrelf binders were used on 10 of the 13 projects). The seal coats range in age of from 12 to 14 months.

Most of the jobs are now holding up well despite some localized areas of aggregate loss, streaking, and flushing.

Cracks have reflected through the seal coats on all projects to some extent. Cracks ranged from hair line to 1/2 inch or more in width. Cracks which were sealed prior to the seal coat application (generally those 1/2 inch wide or more) usually reflected through as hair line cracks.

Performance observations will continue for another year or so. The jobs will also be monitored through the PMS system so that an estimate of cost effectiveness of the treatment can be assessed.

MATERIALS AND TECHNOLOGY DIVISION

L. K. Heinig

Supervising Engineer

LKH:JFD:cgc

cc: J. H. DeFoe
V. D. Barnhart

OFFICE MEMORANDUM

DATE: February 9, 1988

TO: W. J. MacCreery
Deputy Director - Highways

FROM: E. Winkler, Chairperson
Bituminous Advisory Committee

SUBJECT: Committee Recommendation for Seal Coat Program

The bituminous advisory committee recommends that maintenance be allowed to use seal coats as an additional tool to retard pavement distress.

The following selecting criteria are recommended:

1. Traffic of 2500 ADT or less.

2. Do not use on failed pavement or pavements with surface distress due to base failures.

3. Do not use in cities or villages.

4. Do not use at intersections where there are heavy turn movements and/or breaking actions.

5. Seal coats are to be placed by qualified contractors or contract counties. Counties must have necessary experience and have demonstrated good results.

7. State tested materials to be used.

The committee has observed the seal coats since 1986 and has determined this to be a good system.

Chairperson

EDW:tmw

cc: P. Miller
BAC File

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

MAINTENANCE DIVISION

MARCH 1, 1988

POLYMERIZED EMULSION - SPECIFICATIONS (HFST)

The asphalt must be polymerized prior to emulsification. The emulsion should be classified as a high-float, rapid-setting, anionic-type emulsion suitable for seal coat.

Test of Emulsion

	Minimum	Maximum
Viscosity @122 Degrees F, SSF	50+	300
Storage Stability, 1 day, 1% The material after setting undisturbed for 24 hours shall show no white, milky separation, but shall be smooth and homogeneous throughout.		2.0
Sieve Test, %		0.1
Demulsibility, 0.02 N $CaCl_2$, %	40	
Asphalt Content by Distillation @400 Degrees F, (1)%	65	
Oil in Distillate by Volume, %		2.0

Test on Residue from Distillation

	Minimum	Maximum
Penetration @77 Degrees F, 100 g., 5 sec. 1/10 mm.	100	200
Float Test @140 Degrees F, sec.	1,200	
Ductility @77 Degrees F, cm.	125	
Solubility in Trichloroethylene, %	97.5	
Tensile Stress @800% Elongation, 39.2 Degrees F, 50 cm/min. kg/cm^2 (2) (3)	2.0	
Elastic Recovery (4)	58	

(1) ASTM D244 with modifications to include a 400 Degrees F ± 10 Degrees F, maximum temperature to be held for 15 minutes.
(2) ASTM D412 "Tension Testing of Vulcanized Rubber"
(3) Tests are in progress to relate forced ductility to the tensile stress. If this can be done, a much less costly piece of equipment could be used in the testing for specifications.
(4) Procedure attached.

ELASTIC RECOVERY BY MEANS OF DUCTILOMETER

Ductilometer Temperature

Polymerized Asphalt Cement	10 Degrees C (50 Degrees F)
Polymerized Asphalt Emulsion Residue Less than 200 Penetration	10 Degrees C (50 Degrees F)
Polymerized Asphalt Emulsion Residue Greater than 200 Penetration	4 Degrees C (39.2 Degrees F)
Asphalt Cement	10 Degrees C (50 Degrees F)

Procedure

Condition the ductilometer and samples to be treated at the temperature prescribed for that material. Prepare the brass plate, mold, and briquet specimen in accordance with ASTM D113. "Ductility of Bituminous Materials". Keep the specimen at the specified test temperature for 85 - 95 minutes. Immediately after conditioning, place the specimen in the ductilometer and proceed to elongate the sample to 20 cm. The rate of pull shall be 5 cm/min, unless other wise stated. After the 20 cm elongation has been reached; stop the ductilometer and hold the sample in its elongated position for 5 minutes. At this time, clip the sample approximately in half by means of scissors or other suitable cutting devices. Let the sample remain in the ductilometer in an undisturbed condition for one (1) hour. At the end of this time period, retract the half sample specimen until the two broken ends touch. At this point note the elongation in cm.

Calculation

Calculate percent recovery by the following formula:

$$\% \text{ Recovery} = \frac{20 - X}{20} \times 100$$

X = Observed elongation after rejoining of sample, cm.s

S P E C I A L   P R O V I S I O N S

For Bituminous Seal Coat

DESCRIPTION

Bituminous seal coats shall be constructed in accordance with Section 4.06 of the 1984 MDOT Standard Specifications for Construction and as herein specified.

MATERIALS

Prior to the start of work, the bituminous material and cover aggregate shall be tested by department personnel and approved by the engineer.

Aggregate Cover Material

The aggregate shall be a natural aggregate or slag aggregate and meet the requirements specified for coarse aggregate in Section 8.02 of the 1984 standard specifications and the gradation for 31A modified as follows:

Sieve Size	Percent Passing by Weight
1/2"	100%
3/8"	95-100%
No. 4	35-65%
No. 8	0-15% *
No. 200	2% Maximum Loss by Wash *

* modified

Application Rate

25-28 lbs/syd - Natural Aggregate
20-22 lbs/syd - Slag Aggregate

For aggregates from carbonate quarries (limestone and or dolomite) and aggregates from natural gravel sources containing greater than 70 percent carbonate particles in the coarse aggregate (portion coarser than No. 4 sieve), an AWI number of 240 is required.

Bituminous Material

The bituminous binder material shall be a polymerized, high float, rapid-setting anionic type emulsion suitable for seal coats and as designated by Polymerized Emulsion - Specifications (HFST).

Application Rate between .33 - .37 Gal./s.yd.
Application Temperature between 150-170° F.

EQUIPMENT

The suitability and condition of all equipment shall meet the requirements of sub-section 4.06.03 of the standard specifications and be approved by the engineer before the work is started.

Rollers

Self-propelled pneumatic tired rollers shall be used for rolling the cover aggregate immediately after spreading. Pneumatic tired rollers shall have a total compacting width of not less than 60 inches and have minimum contact pressure of 40 pounds per square inch and weighing not less than 8 tons. A steel wheeled roller weighing between 6 and 8 tons may be substituted as a second finishing roller if approved by the engineer and if it does not crush the aggregate particles.

CONSTRUCTION METHODS

Crack Preparation

All cracks 1/2 inch or wider shall be cleaned with compressed air (minimum 95 psi) and sealed prior to the application of the seal coat using the same type materials as designated for the seal coat or materials compatible with the bituminous binder as approved by the engineer.

Surface Preparation

Immediately before application of the bituminous binder, the existing pavement surface shall be thoroughly cleaned with a power broom.

Preparation of Cover Material

Cover material shall be sufficiently dry when it comes in contact with the bituminous binder so that a satisfactory bond or coating is obtained. In any case, the moisture content shall not exceed 3 percent by weight, dry basis.

Application of Cover Material

Immediately following the application of the bituminous binder, the cover material shall be uniformly spread. At no time shall the distributor be more than 500 feet ahead of the chip spreader. Generally, no more binder should be applied than can be covered with aggregate within 90 seconds. Efforts should be made to control the speed of distributor so that the cover material can be placed in a continuous operation avoiding unnecessary stop and go operations. When required by the engineer, any excess cover material shall be removed by approved methods.

Rolling

Immediately following application of the cover material, sufficient rolling shall be done to embed the cover material before the bituminous binder has set and before opening to traffic. At no time shall there be more than 300 feet of unrolled cover material. Two approved type rollers should be used; the rollers should be operated at a speed not greater than 5 m.p.h.

Traffic Control

All necessary signing, traffic control and lane closures shall be in accordance with MMUTCD and Sections 1.04.04 and 6.31 of the standard specifications. Radio equipped flagmen or a pilot vehicle will be required if two-way traffic is to be maintained on one lane. Post reduced speed signs, 45 m.p.h. or lower, as directed by engineer for 24 hour period after job is completed. Temporary lane markers shall be provided until such time as the permanent pavement markings can be applied.