FIELD EVALUATION OF EXPERIMENTAL FABRICS TO PREVENT REFLECTIVE CRACKING IN BITUMINOUS RESURFACING
Final Report

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A category 2 project conducted in cooperation
with the U.S. Department of Transportation,
Federal Highway Administration

Research Laboratory Section
Materials and Technology Division
Research Project 80 NM-617
Research Report No. R-1300

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SUMMARY

This study involved the installation of six different types of commercially available fabric strips as reinforcement over conventionally repaired joints and cracks on a 0.9-mile section of concrete pavement (I 94 BL in the City of Kalamazoo) being prepared for asphalt resurfacing. The purpose of the study was to compare the performance of fabric-treated and untreated repaired joints and cracks in the overlay.

Following the project completion in 1982, detailed crack surveys were made annually through 1986, during cold weather, to determine the effectiveness of the fabrics in preventing reflective cracking in the asphalt overlay. The surveys were stopped after the 1986 survey as there was little or no increase in reflective cracking from the 1985 survey. Cores were taken through the reflective cracks, to determine whether the fabrics had remained intact even though the joints and cracks in the existing pavement had reflected through the overlay.

The question of the cost effectiveness of using fabrics as reinforcement to reduce reflective cracking in the overlay was addressed by determining the cost of the fabric treatment and the cost that would have been required to rout and seal the reflective cracking in the year that it occurred.

Two other experimental fabric installations have also been evaluated by the Department.

Results

1) While there is some evidence that the fabrics will perform as a crack reducing material none of these have met the manufacturer's claim that they will greatly reduce or completely prevent reflective cracking. The evidence available to date suggests that further use of fabrics for the specific purpose of crack reduction is not warranted; while there may be some long-term benefits, they cannot be determined at the present time.

2) In the I 94 study, except for one fabric (Protecto Wrap), all of the fabrics have performed basically the same in reducing reflective cracking. However, since this project was started there have been improvements or changes in several of the fabrics.

3) There is a difference in the percentages of reflective cracking between the longitudinal and transverse cracking. After four years of service the average percentage of reflective cracking for longitudinal and transverse cracking are 36.2 and 42.5, respectively.

4) The fabrics remained intact even though the reflective cracking had appeared in the overlay, and have thus prevented surface water from penetrating the crack.

5) With the use of an assumed maintenance plan of routing and sealing the cracks in the year that they occur as a basis for cost comparison, the use of fabrics was found to be cost effective. It should be noted, however, that such maintenance is not a Departmental practice.

6) The rate of reflective cracking on the other two projects is similar to that on the project on I 94 BL in the City of Kalamazoo.

7) There does not appear to be any direct correlation between the physical properties listed in Table 6 and the reflective cracking results. However, this project was not designed to evaluate the physical properties of fabrics but to compare several fabrics for performance in reducing reflective cracking and for cost-effectiveness. The physical properties are useful in the design process for fabric selection and assuring uniformity of the fabric.

8) The field results indicate that the use of the fabrics as overlay reinforcement to reduce reflective cracking did to some extent retard the time for the reflective cracking to appear in the overlay

9) It is recommended that if the Department is going to continue to use the fabrics to reduce reflective cracking in bituminous overlays that a proposed supplemental specification for Waterproofing Joints and Cracks, setting requirements for fabrics, should be adopted by the Department. The proposed supplemental specification is included as an Appendix.

INTRODUCTION

In recent years, considerable experimental work with fabrics as reinforcement for asphalt overlay has been conducted across the nation in an attempt to provide a practical solution to the problem of reflective cracking in bituminous resurfacing. Reflective cracks are cracks in the new surface that "reflect" through from joints and cracks in old surfaces below, and are caused by horizontal and vertical movements due to traffic, or temperature and moisture variations in the existing pavement beneath the asphaltic overlay. Because of these movements, the working joints and cracks in the underlying pavement "reflect" through the overlay generally after one or two years of service, but on occasion show up right behind the paver. Prevention or reduction of reflective cracking is critical to the service life of the rehabilitated pavement.

The primary study, approved February 29, 1980 by the FHWA as a Category 2 Construction Project, involved six different types of commercially available fabric strips (Table 1) as reinforcement over conventionally repaired joints and cracks in a 43 year old reinforced concrete pavement (I 94 BL in the City of Kalamazoo) being prepared for asphalt resurfacing. Its purpose was to compare the performance of fabric-treated and untreated conventionally repaired joints (used as controls for comparison) in the asphalt overlay and to see if there were differences

TABLE 1
EXPERIMENTAL FABRICS

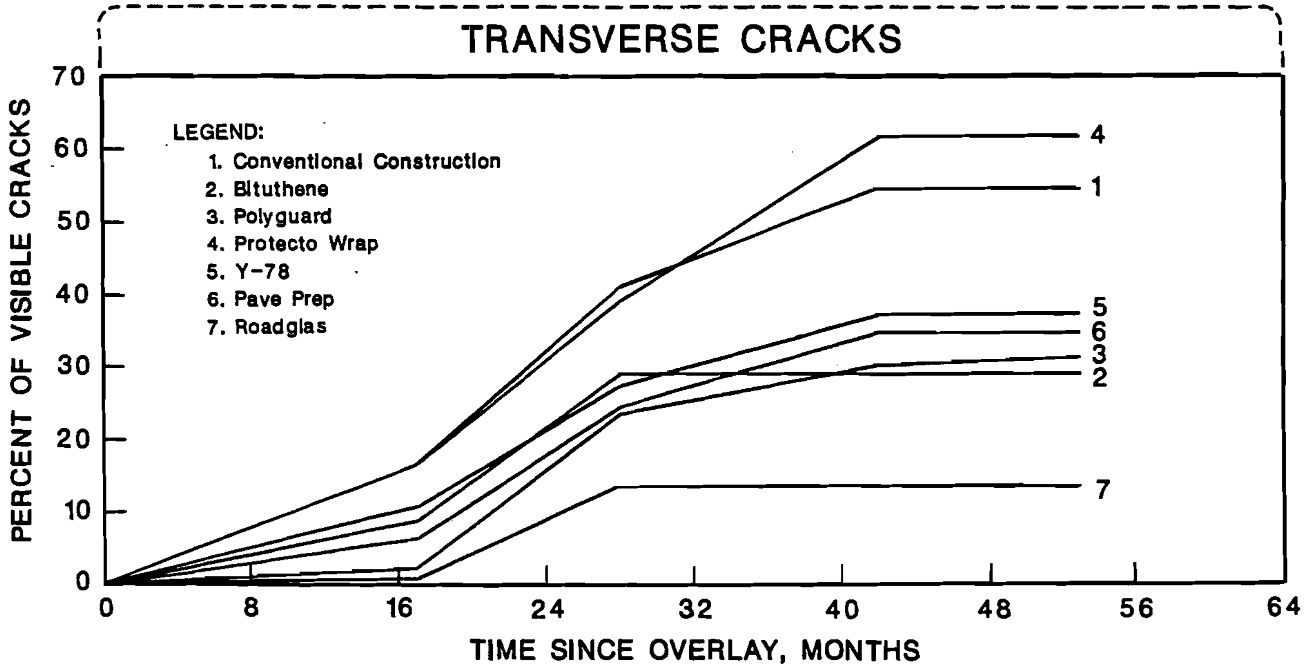
Fabric Type	Project Description	Research Project No.
Bituthene	Eastbound and center lanes on I 94 BL in Kalamazoo between Howard Ave and Michigan Ave	72 NM-323
Polyguard	Eastbound and center lanes on I 94 BL in Kalamazoo between Howard Ave and Michigan Ave	78 NM-566
Protecto Wrap	Eastbound and center lanes on I 94 BL in Kalamazoo between Howard Ave and Michigan Ave	74 NM-414
Y-78	Eastbound and center lanes on I 94 BL in Kalamazoo between Howard Ave and Michigan Ave	71 NM-286
Pave Prep	Eastbound and center lanes on I 94 BL in Kalamazoo between Howard Ave and Michigan Ave	74 NM-552
Roadglas	Eastbound and center lanes on I 94 BL in Kalamazoo between Howard Ave and Michigan Ave	80 NM-617
Bituthene	Northbound lanes on M 97 (Groesbeck Hwy) from north end of bridge over Clinton River south of Mount Clemens	72 NM-323
Mirafi 140	Southbound lanes on I 75 north and south of Sturgeon Valley Rd north of Gaylord	77 TI-398

in the performance of the various fabrics. The trial project consisted of a 0.9-mile section of concrete pavement exhibiting substantial transverse joint failures and cracks where bituminous joint and crack repairs were required before resurfacing. Both longitudinal and transverse joints were treated with fabric for evaluation.

Procedures

In general, the fabric strip treatment over each test site required 1 to 2-ft wide strips for longitudinal joints and cracks; and 2 to 6-ft wide strips for repaired transverse joints and cracks. Transverse joints and cracks were fabric treated (reinforced) before the longitudinal joints according to the manufacturer's recommendations. The fabric strips covered the entire length of the longitudinal test joint throughout each test section and the entire width of the transverse test joints and cracks at each test section. The first portion of the overlay was placed in the fall of 1981 and the project was completed in the spring of 1982.

The I 94 BL project in the City of Kalamazoo consisted of two parts (two sections of roadway) with the same type of fabric to be placed on both parts. Table 2 shows the difference in percentage of reflective



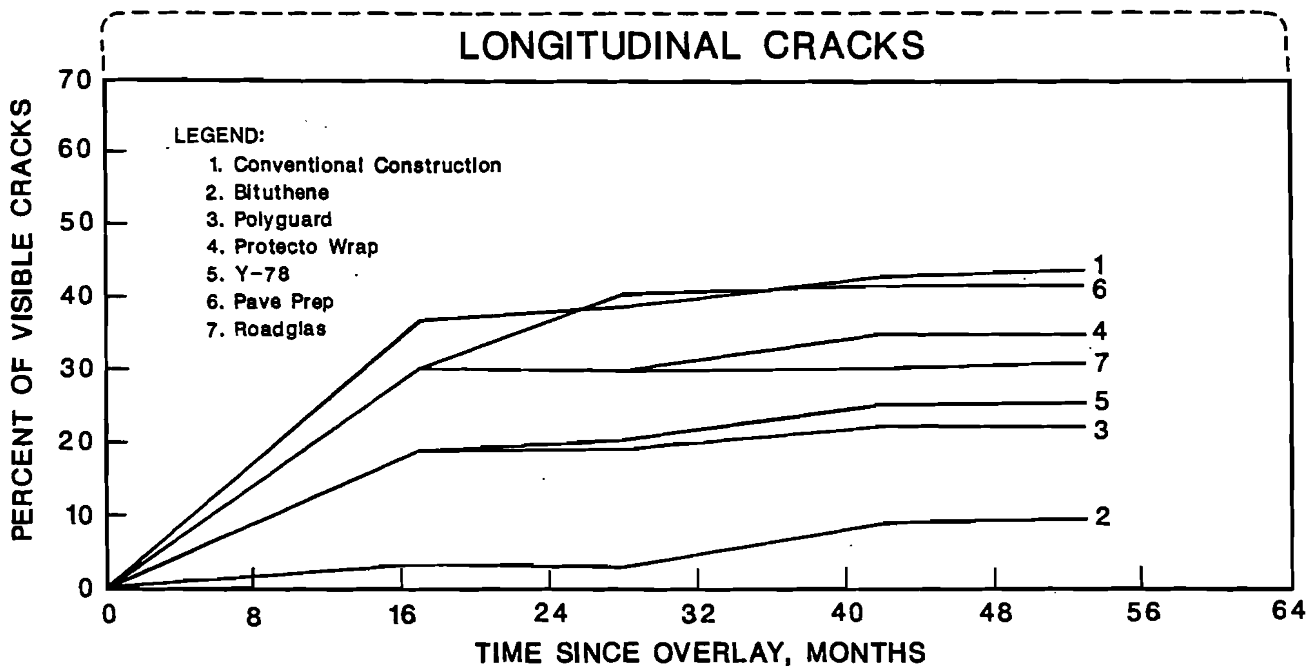


Figure 1. Increase in visible transverse and longitudinal cracks through asphaltic concrete resurfacing after the 1983-1986 winters (Research Projects 71 NM-286, 74 NM-414, 78 NM-552, 78 NM-566, 80 NM-617). Experimental Fabrics on I 94 BL, City of Kalamazoo.

cracking between parts I and II for the final survey. These differences could be caused by different amounts of traffic on parts I and II and also because part I was completed approximately seven months before part II.

TABLE 2
COMPARISON OF PERCENTAGE OF CRACKING FOR FINAL SURVEY FOR PARTS I AND II FOR PROJECT ON I 94 BL IN KALAMAZOO

	Fabric Type	Part I Percent Cracking 1986	Part II Percent Cracking 1986	Percent Difference Between Parts I and II
Transverse Cracking	Bituthene	29.3	29.2	+0.1
	Polyguard	52.6	25.1	+27.5
	Protecto Wrap	87.6	53.0	+34.6
	Y-78	23.1	43.0	-19.9
	Pave Prep	41.8	31.1	+10.7
	Roadglas	13.8	---	---
	Conventional	35.7	87.5	-51.8
Longitudinal Cracking	Bututhene	20.6	7.9	+12.7
	Polyguard	51.2	13.6	+37.6
	Protecto Wrap	93.3	20.3	+73.0
	Y-78	20.7	26.6	-5.9
	Pave Prep	69.6	28.7	+40.9
	Roadglas	31.1	---	---
	All Untreated Longitudinal Joints	42.4	45.0	-2.6

Since completion of this resurfacing project in May of 1982, annual detailed crack surveys have been made during cold weather when existing cracks and joints in the old pavement open up. Reflective cracks, visible under dry surface conditions and generally located directly over the underlying fabric treated joints and cracks, were expressed in terms of percentages of the total length of the test joints and cracks in the old pavement that have reflected through the new overlay. The performance after the first two winters is covered in Research Report No. R-1243. The performance after the third winter and preliminary cost effective comparison are covered in an October 11, 1985 Memorandum from C. J. Arnold to L. T. Oehler.

The final crack survey for the project was conducted in March 1986. Figure 1 and Table 3 summarize the results of the March 1983, February 1984, April 1985, and March 1986 crack surveys. There was little or no increase in the longitudinal and transverse crack growth curves for reflective cracking in the bituminous overlay from the curves presented

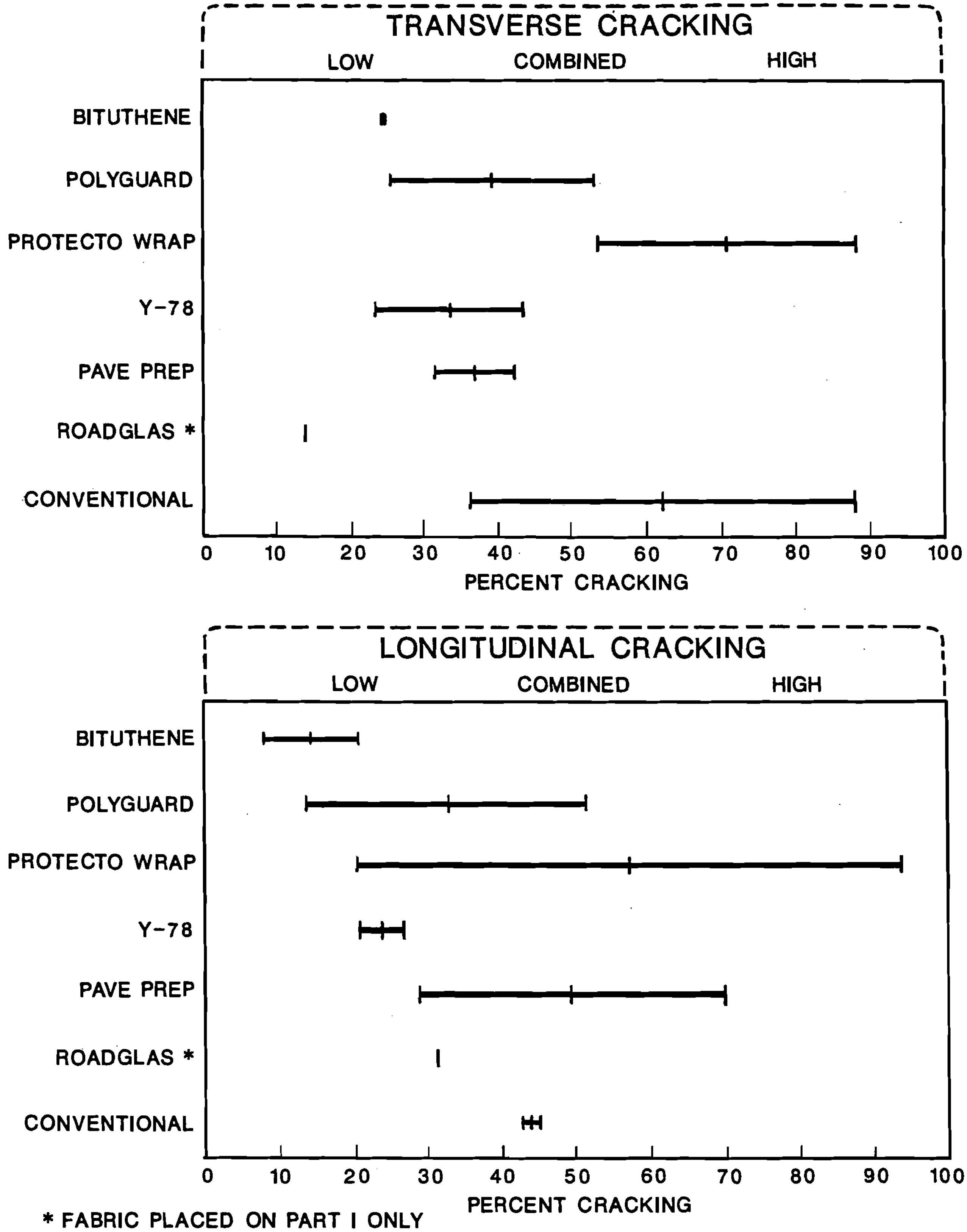


Figure 2. Comparison of high, low, and combined (average of Parts I and II) percentages of reflective cracking after four years of service for the project on I 94 BL, in the City of Kalamazoo.

TABLE 3
SUMMARIES OF FIELD SURVEYS OF KALAMAZOO FABRICS

	Fabric Type	Fabric Strip Length, lin ft	Fabric Strip Area Covered sq yd	1983 lin ft	1983 Percent	1984 lin ft	1984 Percent	1985 lin ft	1985 Percent	1986 lin ft	1986 Percent
Transverse Cracking	Bituthene	659	181.4	59	9.0	191	29.0	191	29.0	192.5	29.2
	Polyguard	756	111.2	16	2.1	180	23.8	230	30.4	238	31.5
	Protecto Wrap	541	152.0	90	16.6	210	38.8	334	61.7	334	61.7
	Y-78	650	153.4	70	10.8	180	27.7	242	37.2	242	37.2
	Pave Prep	588	143.1	38	6.5	144	24.5	204	34.7	204	34.7
	Roadglas	565	125.6	4	0.7	78	13.8	78	13.8	78	13.8
	Conventional	792	No Fabric	132	16.7	326	41.2	432	54.5	432	54.5
Longitudinal Cracking	Bituthene	1002	189.6	31	3.1	31	3.1	89	8.9	97	9.7
	Polyguard	1415	201.6	270	19.1	270	19.1	315	22.3	315	22.3
	Protecto Wrap	1038	176.0	313	30.1	313	30.1	363	34.9	363	34.9
	Y-78	1244	176.5	232	18.6	257	20.7	317	25.5	317	25.5
	Pave Prep	980	167.0	298	30.4	398	40.6	408	41.6	408	41.6
	Roadglas	1161	216.6	350	30.1	350	30.1	350	30.1	361	31.1
	All Untreated Longitudinal Jts	5573	No Fabric	2057	36.9	2182	39.1	2390	42.9	2434	43.7

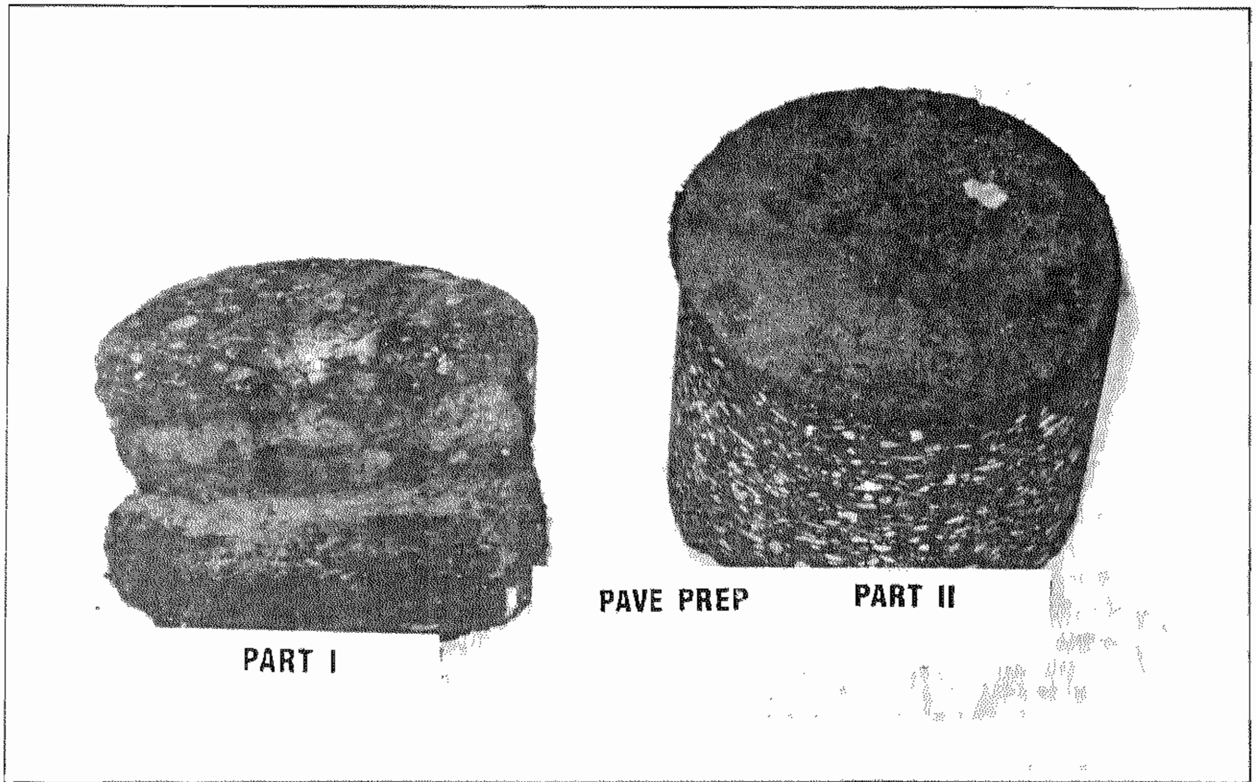
in the previously mentioned October 1985 Memorandum. Also, there was no appreciable change in the cost effective results presented in that report.

Results

From Figure 1, it would appear that the Roadglas fabric is slightly more effective in reducing the reflective transverse cracking than the other fabrics. The Roadglas, however, was only placed on part I and the rest of the fabrics were placed on both parts. This may account for the difference in performance between the Roadglas and the other fabrics as the percentages shown in Figure 1 are for the total amount of cracking for parts I and II. The cost of the Roadglas fabric treatment is three to four times the cost of any of the other fabric treatments, however, and thus may not be practical.

Figure 2 shows the high, low, and combined (average for parts I and II) percentages of reflective cracking for the fabrics on the primary project. It can be seen that except for one fabric (Protecto Wrap) all of the fabrics have performed about equally in the reduction of reflective cracking. Since this project was started there have been improvements in or changes made to several of the fabrics. However, a broad range of properties of the fabrics was covered in this project without major effects on results so it seems doubtful that changes in the fabrics would greatly alter the results.

Table 3 shows that there is a difference in the percentages of reflective cracking between longitudinal and transverse cracking. The



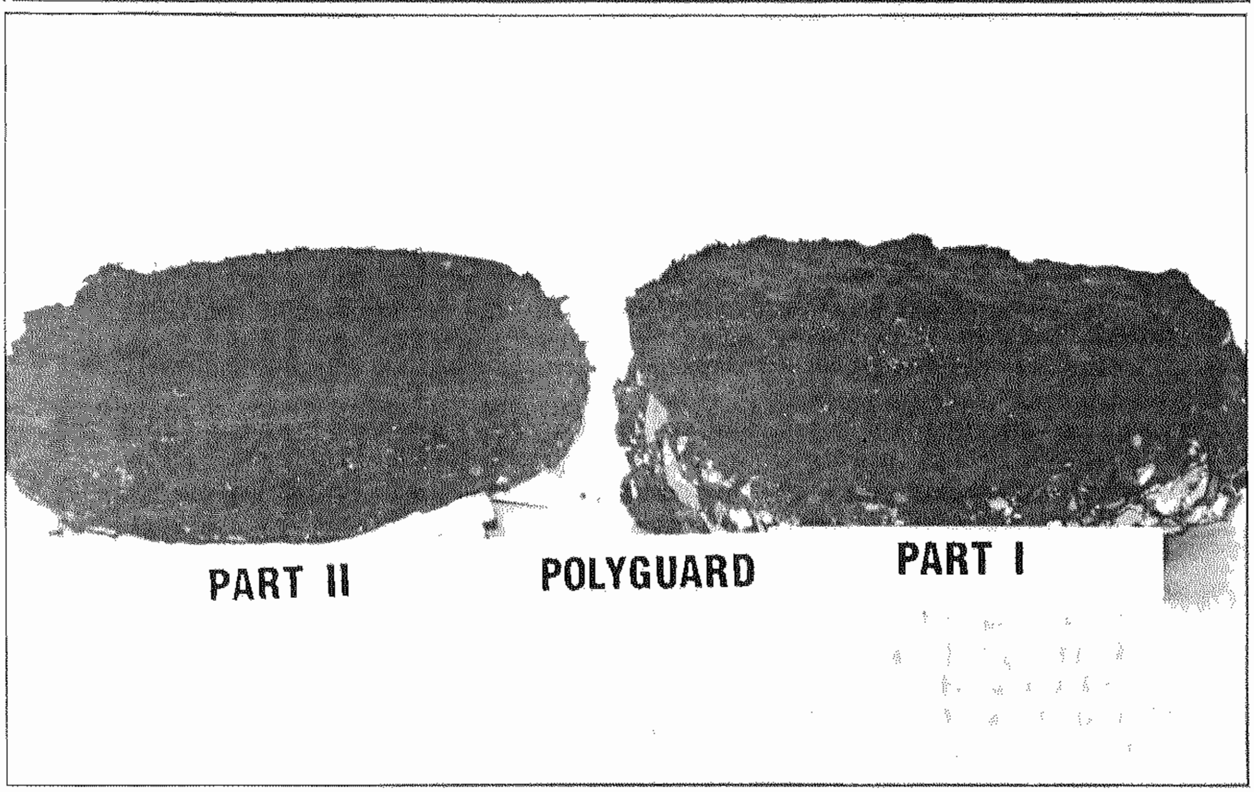


Figure 3. Typical condition of fabrics after four years of service for the project on I 94 BL, in the City of Kalamazoo.

possible reason for this difference could be because the longitudinal cracks (in most cases) are over a tied joint in the pavement that normally does not move as much as transverse cracks and joints do. This movement in the transverse cracks in the overlay is caused by temperature and moisture changes in the original pavement along with vertical movement at the cracks and joints caused by traffic.

On August 5, 1988 core samples were taken on the project for the purpose of determining the condition of the fabrics that were placed on parts I and II. The core samples were taken where reflective cracking had been observed over fabric that had been placed. Two samples were taken from each fabric at the locations indicated in Table 4.

TABLE 4
LOCATION OF CORES, I 94 BL

	Fabric Type	Station	Lane Location	Site Des.
Part II	Bituthene	220+29	Center Turn	A
Part II	Polyguard	224+32	Center Turn	B
Part II	Y-78	230+61	Center Turn	C
Part II	Protecto Wrap	234+22	Center Turn	D
Part II	Pave Prep	239+03	Center Turn	E
Part I	Pave Prep	251+05	E.B. Travel	F
Part I	Protecto Wrap	254+67	E.B. Travel	G
Part I	Y-78	257+10	E.B. Travel	H
Part I	Bituthene	259+45	E.B. Travel	I
Part I	Polyguard	262+15	E.B. Travel	K
Part I	Roadglas	266+37	E.B. Travel	L
Part I	Roadglas	267+28	E.B. Travel	M

It was found that even though the bituminous overlay had cracked, the fabrics had remained intact (Fig. 3) and prevented surface water from penetrating to the original crack in the concrete pavement. It was also observed that, in general, when there had been a bituminous joint or crack repair prior to the placement of the fabric, that the reflective cracking in the overlay occurred at the edge of the bituminous repair at the junction between the bituminous repair and the old concrete (Fig. 4). The crack did not go through the repair and then reflect through the overlay.

To answer the question of whether the use of fabrics as reinforcement to effectively reduce reflective cracking in bituminous overlays is worth the cost, the cost of the fabric treatment and the cost that would have been required to rout and seal the reflective cracking in the year it occurred was determined (Table 5). The cost figures for this determination were obtained from the October 11, 1985 Memorandum from C. J. Arnold to L. T. Oehler. Figure 5 shows the cost of the fabric treatment plus the cost that would have been required to rout and seal the cracks in

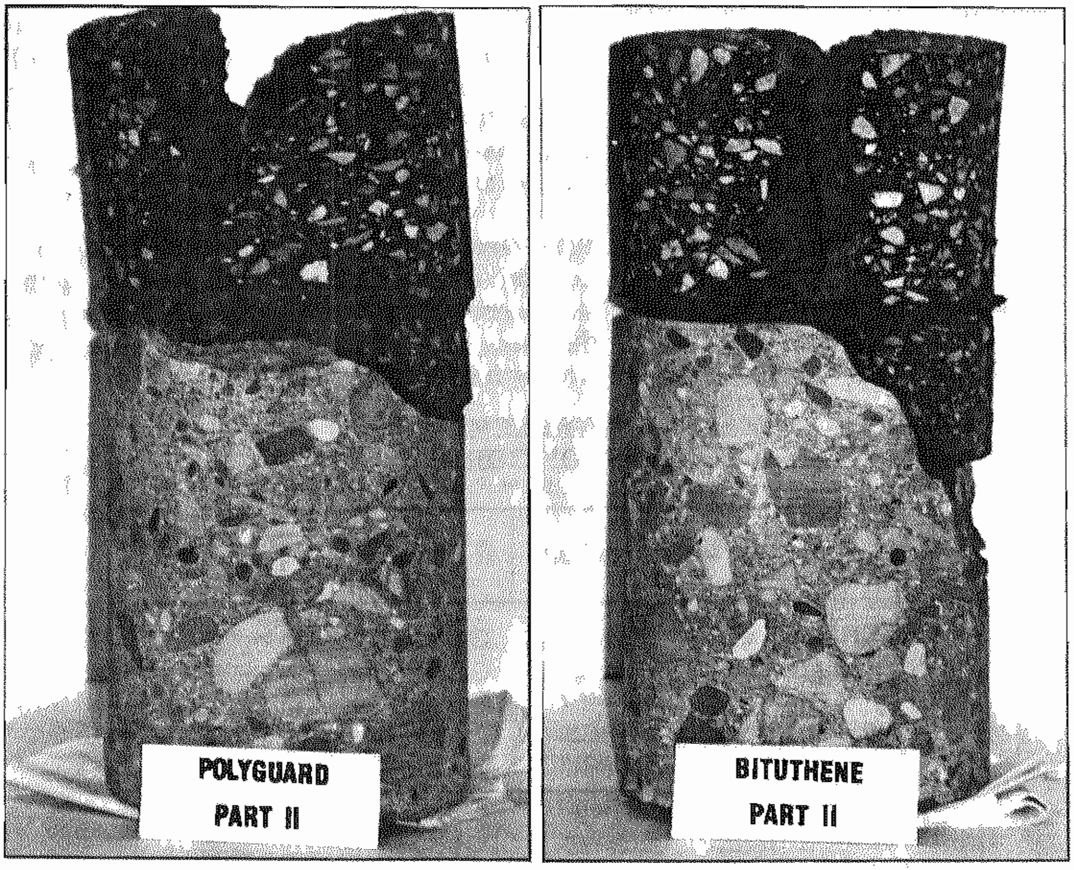


Figure 4. Reflective cracking in the asphalt concrete resurfacing at the edge of the bituminous joint/crack repair placed prior to the resurfacing on I 94 BL.

the year they occurred. It can be seen that all of the fabrics except for one (Roadglas) were cost effective in reducing reflective cracking in the bituminous overlay, based on the assumed analysis procedure. However, we have no method to quantify the effect of a crack that occurs and is left unsealed.

The percentages shown in the figures for the crack growth curves and the table for the summaries of the surveys of the fabrics in this and previous reports are percentages for the total amount of reflective cracking for both parts I and II.

Other expermental fabric installations evaluated by the Department are as follows:

Experimental Fabric on M 97, south of the City of Mount Clemens.

This project evaluated Bituthene (Table 1) as a waterproofing membrane applied to joints and cracks in concrete pavement to attempt to

TABLE 5
FABRIC COSTS COMBINING TRANSVERSE AND LONGITUDINAL CRACKING

Fabric Type	Total lin ft of Cracking	Total sq yds of Fabric	Total Reflective Cracking, lin ft				Cost to Seal Reflective Cracking (Total Ref. Cracking x $1.75/lin ft)				Cost of Fabric Treatment
			1983	1984	1985	1986	1983	1984	1985	1986	
Bituthene	1660	371.0	90	132	58	9.5	157.50	231.00	101.50	16.63	1313.34
Polyguard	2171	312.8	286	164	95	8	500.50	287.00	166.25	14.00	1119.83
Protecto Wrap	1579	328.0	403	120	174	0	705.25	210.00	304.50	0.00	1384.16
Y-78	1894	329.9	302	135	122	0	528.50	236.25	213.50	0.00	1088.67
Pave Prep	1568	310.1	336	206	70	0	588.00	360.50	122.50	0.00	1494.20
Roadglas	1726	342.2	354	74	0	11	619.50	129.50	0.00	19.25	4619.70
Conventional Bit. Overlay	6365	0.0	2189	319	314	44	3830.75	558.25	549.50	77.00	0.00

reduce reflective cracking in bituminous concrete overlays. The construction was completed in October 1979 and the installation data and product description are covered in an October 29 Memorandum. Performance after the first three winters is covered in a June 25, 1982 Memorandum. Both memoranda are from C. A. Zapata to R. A. Welke. The final crack survey was made in April 1987.

Experimental Fabric on I 75, North of the City of Gaylord.

This project was an FHWA experimental highway construction Category 2 project to evaluate the ability of Mirafi 140 (Table 1) to reduce reflective cracking when placed as a separation layer between the cracked surface of a flexible pavement and a bituminous concrete overlay. The construction was completed in September 1977 in accordance with Work Plan No. 52. The installation procedure, and product description are covered in Research Report No. R-1125 and the performance after five winters is covered in a June 30, 1982 Memorandum from C. A. Zapata to C. J. Arnold. The final crack survey was made in April 1987.

The rates of reflective cracking for the experimental fabric placed on the project on M 97, south of the City of Mount Clemens after eight winters and the fabric placed on the project on I 75, north of the City of Gaylord, after ten winters (even though the experimental fabric was placed on an existing bituminous pavement instead of an existing concrete pavement) are similar to the rate of reflective cracking for the Kalamazoo project as shown in Figure 6.

The physical properties for the fabrics, on the several projects, from the manufacturer's specifications are listed in Table 6 and there does not appear to be any direct correlation between these properties and the reflective cracking results. However, this project was not designed to evaluate the physical properties of the fabrics but to compare several fabrics for performance in reducing reflective cracking and determine if they are cost effective. Although there does not seem to be a strong relationship between reflective cracking and the physical properties,

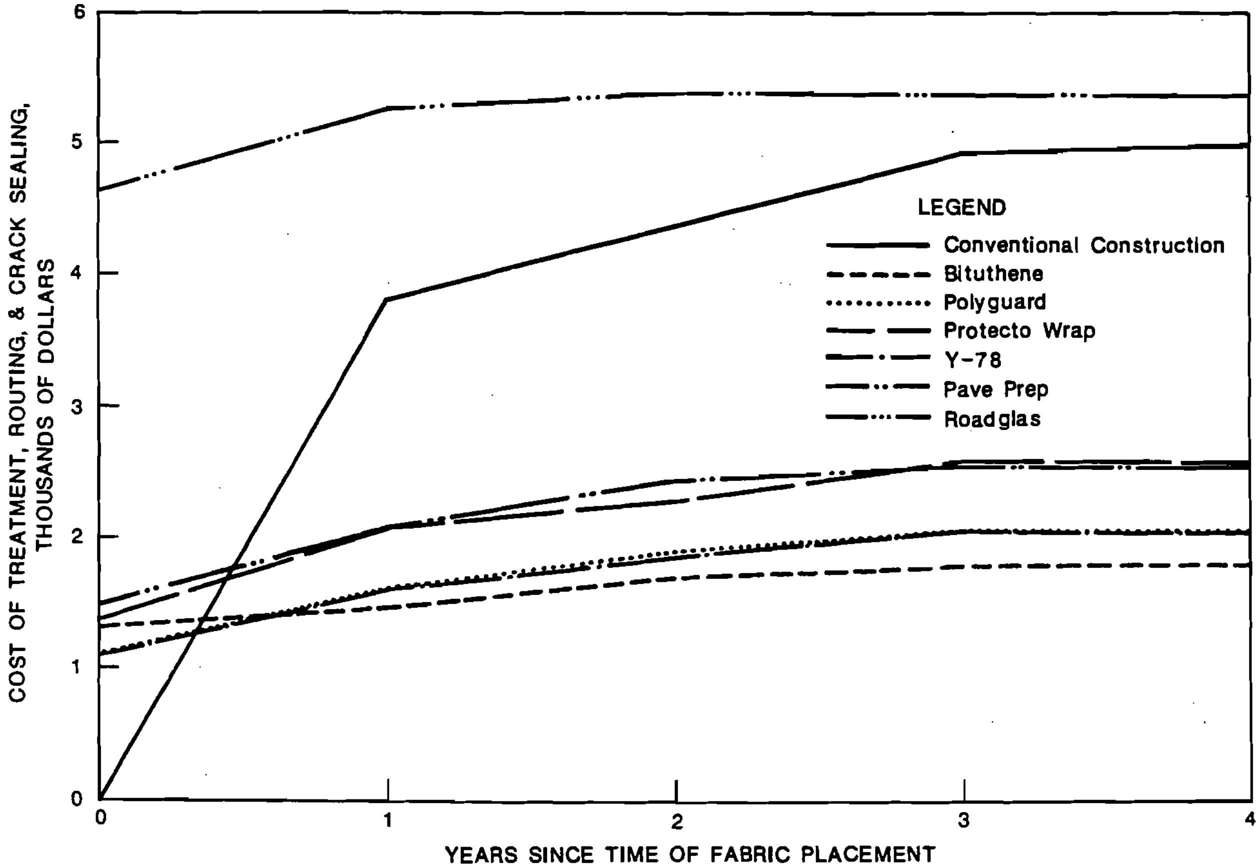


Figure 5. Fabric cost effectiveness for transverse and longitudinal cracking combined after four years of service for the project on I 94 BL.

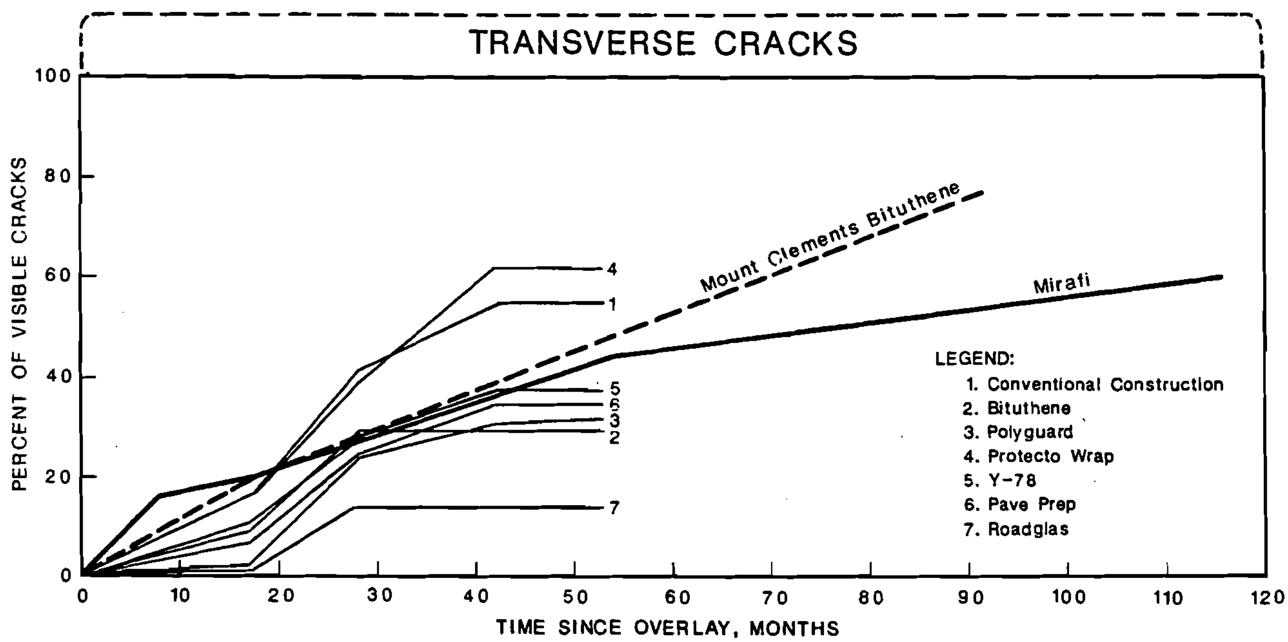


Figure 6. Comparison of the rate of reflective cracking between the experimental fabrics on M 97, Mount Clemens (Bituthene), I 75 south of Gaylord (Marifi) and project on I 94 BL, in the City of Kalamazoo.

TABLE 6
FABRIC PROPERTIES

Specifications	Fabric Type						
	Bituthene	Polyguard	Protecto Wrap M-400A	Y-78	Pave Prep	Roadglas	Mirafi 140
Weight	NA	NA	0.56 lb/ft² (0.99 oz/syd)	44 oz/syd	0.8 lb/ft² (1.42 oz/syd)	NA	4 oz/syd
Thickness	65 mils	65 mils	70 mils	75 mils	120 mils	50 mils	20 mils
Pliability	No cracking	No cracking	No cracking	No cracking	No cracking	NA	NA
Percent Elongation before breaking	75%	NA	25% - 40%*	85%	100%	NA	100%
Tensile Strength	50 lb/in.	50 lb/in.	1380 to 380 psi* (96.6 to 26.6 lb/in.)	60 lb/in.	900 lb/in.	1400 lb/in. width	52.5 lb/in.

*Varies with temperature (Temp Range 0 to 120 F)
NA = Not available

the use of the physical properties provides the designer with a guide as to the type of fabric to use and provides for quality checks on the fabric when it is received from the manufacturer.

CONCLUSIONS

The field results from these projects indicate that the use of the experimental fabrics as overlay reinforcement to reduce reflective cracking did to some extent extend the length of time for reflective cracking to show through the bituminous overlay.

While there is some evidence that the experimental fabrics do perform as crack resistant material, none of them have met the manufacturers' claims that they will either greatly reduce or completely prevent reflective cracking.

The use of fabrics in the prevention of reflective cracking in a bituminous overlay is cost effective if a maintenance program of routing and sealing the reflective cracks as they occur is performed in the years following the placement of the fabrics and overlay. If such a maintenance program is not followed the use of the fabrics would not be cost effective.

It is recommended that if the Department is going to continue to use fabrics to reduce reflective cracking in bituminous overlays, that a proposed Supplemental Specification for Waterproofing Joints and Cracks, setting the requirements for fabrics, be adopted by the Department. The supplemental specification will provide the requirements that the Department will need for quality checks on the fabrics. The proposed supplemental specification is included as an Appendix to this report. However, based on the results of this research we cannot recommend the continued use of the fabrics in an attempt to significantly reduce reflective cracking.

APPENDIX

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SUPPLEMENTAL SPECIFICATION
FOR
WATERPROOFING JOINTS AND CRACKS

1. Description.-This work shall consist of furnishing and placing a waterproofing membrane or engineering fabric with asphalt sealant, over joints/cracks in an existing paved surface that is being prepared for resurfacing. This work shall be done in accordance with the details shown on the plans or as directed by the Engineer and the requirements herein.

2. Materials.-The Contractor may use either a waterproofing membrane or an engineering fabric with asphalt sealant.

2-a. Waterproofing Membrane.-The membrane shall incorporate a high strength, heat resistant mesh embedded in a layer of self-adhesive rubberized asphalt with the following properties:

	Properties	Requirement	Test Method
2-a-1)	Thickness	20 mils minimum	
2-a-2)	Permeance-Perms, Grains/sq. ft./hr., In Hg.:	0.10 max	ASTM E 96 Method B
2-a-3)	Tensile Strength, lb./in. width:	50 min.	ASTM D 4595
2-a-4)	Elongation-at-brake, Percent:	50 minimum	ASTM D 4595
2-a-5)	Puncture Resistance (mesh), lbs.:	200 minimum	ASTM D 4833
2-a-6)	Pliability - 1/4 inch Mandrel 180 Deg. Bend @ 15 Deg. F	No cracks in mesh or Rubberized Asphalt	ASTM D 146

2-b. Engineering Fabric.-The woven or non-woven fabric shall be constructed of synthetic fibers; resistant to chemical attack, mildew, rot; satisfactory for use with asphalt cements and shall meet the following physical requirements:

	Original Physical Properties	Requirement Min	Max	Test Method
2-b-1)	Tensile Strength Lbs./in. width	80	--	ASTM D 4632 As Modified by paragraph 2-c Testing requirements of this specification

2-b-2)	Elongation-at-break, Percent:	50	150	ASTM D 4632 As modified by paragraph 2-c Testing requirements of this specification.
2-b-3)	Asphalt Retention, oz./sq. ft.	0.2	8.2	Paragraph 2-c Testing requirements of this specification.
2-b-4)	Change in area caused by asphalt retention test and subsequent asphalt removal. Reported as change in area of specimen measured after test as compared to area of specimen prior to test, percent:		±15	Paragraph 2-c Testing requirements of this specification.
2-b-5)	Melting Point, Degrees F:	300 or greater		ASTM D 276

2-b-6) Physical Properties After 275 F Asphalt Retention Test and Subsequent Asphalt Removal.-Fabric samples so treated shall, when tested in accordance with the methods prescribed for tensile and elongation tests, comply with the minimum and maximum strength requirements as set forth for "as-received' samples under "Original Physical Properties" with a 10 percent tolerance allowed.

2-c. Testing Requirements.-The determination of the "Tensile Strength" and "Elongation-at-break" for the engineering fabrics shall be made in accordance with ASTM D 4632 entitled "Standard Methods of Test for Breaking Load and Elongation of Geotextiles (Grab Method)" with the following exceptions:

The testing machine used shall be a constant-rate-of-extension tensile testing machine and shall be the type of testing machine described in ASTM D 76, 1.1.1.

The fabric shall be tested dry.

Ten individual specimens shall be chosen for determination of original physical properties, tensile and elongation testing in the wrap-wise direction and ten individual specimens shall be chosen for testing in the filling-wise direction. It is important that these specimens be chosen at random from each individual test sample of approximately three feet long by the full roll width selected at random in accordance with the prescribed sampling procedure. The sample may be taken from the end portion of a roll provided there is no evidence that it is distorted or different from other portions of the roll. In cases of dispute, take a sample that will exclude fabric from the outer wrap of the roll or the inner wrap around the core. Additional individual specimens shall be selected for those tests involving hot asphalt.

Asphalt retention and changes in area for the engineering fabrics shall be determined as follows:

Five wrap-wise specimens and five filling-wise specimens measuring four inches by eight inches shall be selected at random from the individual three foot by roll width test sample. The individual test samples will be conditioned in accordance with Subsection 9.1 of ASTM D 4632, and then individually weighed to the nearest 0.1 gram and then submerged for 30 minutes in the specified asphalt cement maintained at a temperature of 275 ± 4 F in a mechanical convection oven. After the required submersion the asphalt cement coated-saturated test specimens shall be removed and hung to drain (long axis vertical) in the oven for an addition 30 minutes at 275 ± 4 F. The asphalt cement coated-saturated specimens shall then be removed from the oven and hung to drain (long axis vertical) for one hour at a temperature of 76 ± 4 F.

The asphalt cement used for this test shall meet the detailed requirements for viscosity grade AC-10 in Table 8.04-1 of Subsection 8.04.03 of the Michigan Department of Transportation 1984 Standard Specifications for Construction with the additional requirement that the viscosity at 275 F shall be within the range of 2.3 to 2.8 stokes. After the one hour at 76 ± 4 F the asphalt cement coated-saturated specimens shall then be trimmed of any excess asphalt cement such as edge drippings. The asphalt cement coated-saturated specimens shall then be weighed to the nearest 0.1 gram and then placed in naphtha heated to 110 ± 5 F for 30 minutes. Fresh naphtha contained in trays at the specified temperature may be alternated as necessary during the 30 minute period to effect removal of the asphalt cement from the specimens. Specimens will be blotted with paper towels and allowed to air dry to effect naphtha removal. The area of the specimens will than be measured for the determination of percent change in area.

Calculate the average of the asphalt retention and the average of the change in area for all acceptable specimens. The asphalt retention and the change in area for individual specimens shall be calculated as follows:

$$\text{Asphalt retention, oz./sq. ft.} = \frac{\text{Weight in grams of asphalt cement retained} \times 0.0352739}{\text{area of specimen after test in sq. inches} \div 144}$$

$$\text{Change in area, } \% \pm = \left[\left(\frac{\text{Area of specimen after test in sq. inches}}{\text{Original area of specimen in sq. inches}}\right) - 100\right] \times 100$$

Where - % represents shrinkage of fabric upon asphalt cement submersion

\+ % represents swelling of fabric upon asphalt cement submersion

Load test specimens which have been previously subjected to the 275 F asphalt retention test and asphalt removal procedure shall be centered in the jaws of the tensile testing machine. The three inch jaw separation will be maintained. If the original 4 x 8 inch specimen has expanded or shrunk in size the required fabric spacing around the jaws will of necessity not be maintained. Specimens will be centered and the 3 inch jaw separation maintained.

2-d. Packaging Requirements.-The waterproofing membrane (Wpf. Memb.) and the engineering fabric (Engr. Fab.) shall be packaged in standard width rolls of specified length. The Wpf. Memb. and the Engr. Fab. themselves shall be wound onto suitable cylindrical forms or cores to aid in handling and unrolling. Each roll of Engr. Fab. or Wpf. Memb. and the form or core upon which it is rolled shall be packaged individually in a suitable sheath, wrapper or container to help protect the Engr. Fab. or Wpf. Memb. from damage due to ultra-violet light, moisture, mud, dirt, and temperatures greater than 100 F during shipment, storage, and handling.

2-e. Identification Requirements.-Each roll shall be labeled or tagged in such a manner that the information for sample identification and other quality control purposes can be read from the label without opening the roll packaging. Each roll shall be identified by the manufacturer as to lot number or control numbers, date of manufacture, tare weight of core plus wrapper, width and length of Wpf. Memb. or Engr. Fab. on the roll plus the gross weight of the entire package which is to include Wpf. Memb. or Engr. Fab., core, wrapping sheath or container, tags, etc.

2-f. Sampling Requirements.-Each roll may be subject to a fabric-weight determination on a per-roll basis. In addition, individual test samples shall be cut from at least one roll selected at random from each 100 rolls or faction thereof representing each shipment. Individual samples shall be no less than three feet in length by full-roll width.

2-g. Basis for Rejection.-Should any individual roll fail to meet the fabric-weight requirement when the entire roll is weighed then that roll is subject to rejection. Should any individual sample selected at random from 100 rolls (or fraction thereof) fail to meet any specification requirement, then that roll shall be rejected and two additional samples shall be taken, one from each of two other additional rolls selected at random from the same 100-roll lot (or fraction thereof). If either of these two additional samples fail to comply with any portion of the specification, then the entire quantity of rolls represented by that sample will be rejected.

3. Weather Limitations.-No materials shall be applied when the air and/or pavement temperature is below 40 F. When weather is overcast or windy, air and/or pavement temperatures shall be above 50 F to allow waterproofing membrane and engineering fabric placement while binder material is still molten. No materials shall be applied while the paved surface is wet.

4. Equipment.

4-a. The equipment for installing the waterproofing membrane shall consist of suitable sweepers, hand brooms, air compressor, pouring buckets, rubber-edge squeegees, cutting knives, and heating tar kettle. All hand tools shall be in a clean condition. Tar kettles shall be equipped with a working thermometer and shall be capable of maintaining temperature of the binder material between 350 F and 400 F or according to the manufacturer's specifications.

4-b. The equipment for the engineering fabric shall consist of the following:

4-b-1 Asphalt Distributor: The distributor shall be capable of spraying the asphalt sealant at the prescribed uniform application rate. No streaking, skipping, or dripping will be permitted. The distributor shall also be equipped with a hand spray having a single nozzle and positive shut-off valve.

4-b-2 Fabric Handling Equipment: Mechanical or manual laydown equipment shall be capable of laying the fabric smoothly.

4-b-3 Miscellaneous Equipment: Stiff bristle brooms or squeegees to smooth the fabric, scissors or blades to cut the fabric, and brushes for applying asphalt sealant at fabric overlaps shall be provided. Pneumatic Tired rolling equipment to smooth the fabric into the sealant and sanding equipment may be required for certain jobs.

5. Conditioning Existing Surface.-Prior to the placement of the waterproofing membrane and the engineering fabric, the paved surface, joints, and cracks shall be made clean, smooth, dry, and free of fins, sharp edges, oil, grease, and loose or foreign materials.

6. Application of Material.

6-a. The application of the waterproofing membrane shall be as follows:

6-a-1 Binder Placement: The binder recommended by the manufacturer shall be spread over the area to be covered by the membrane and to at least four inches wider. The binder shall be applied at the rate as recommended by the manufacturer or as directed by the Engineer.

6-a-2 Membrane Placement: Immediately following the placement of the binder material, waterproofing membrane shall be placed on the binder material. Adjoining waterproofing membrane strips shall be overlapped a minimum of four inches. Wrinkles in the membrane should be avoided. Any tears, punctures, large wrinkles and air blisters in the membrane shall be repaired in accordance with the manufacturer's specifications prior to placement of the bituminous overlay. The edges of the waterproofing membrane shall be sealed after placement in accordance with the manufacturer's specifications. Removal and replacement of waterproofing membrane that is damaged will be the responsibility of the Contractor.

6-b. The application of the engineering fabric shall be as follows:

6-b-1 Application of Asphalt Sealant: The sealant recommended by the manufacturer shall be uniformly spray applied to the area to be covered by the fabric and to at least six inches wider. The sealant shall be applied at the rate as recommended by the manufacturer or as directed by the Engineer.

6-b-2 Fabric Placement: Immediately upon application of the asphalt, the fabric shall be aligned and carefully broomed and/or rolled to maximize fabric contact with the pavement surface. Wrinkles in the fabric should be avoided. Wrinkles or folds in the fabric shall be slit and laid flat. Adjoining fabric strips shall be overlapped sufficiently to ensure full closure of the joint, but should not exceed six inches. Transverse joints shall be overlapped in the directions of paving to prevent edge pickup by the paver. In lapping joints, the top fabric shall be folded back to allow application of a light coat of sealant to be placed. The top fabric is then folded back into the sealant and broomed or squeegeed out to remove any air bubbles. Removal and replacement of fabric that is damaged will be the responsibility of the Contractor.

6-b-3 Turning of equipment shall be gradual and kept to a minimum to avoid damage to the fabric. On typical sections not receiving a thin overlay such as an open-graded friction course, the surface of the engineering fabric shall be covered with a thin layer of clean sand or clean crusher screenings at a rate sufficient to absorb the excess asphalt. The sand and/or crusher screenings shall be approved by the Engineer. On typical sections to receive a thin overlay such as an open-graded friction course, only sufficient sand shall be spread ahead of the tires to prevent sticking.

6-b-4 All storage tanks, piping, retorts, booster tanks and distributors used in storing or handling asphalt material shall be kept clean and in good operating condition at all times, and they shall be operated in such a manner that there will be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the Contractor to provide and maintain, in good working order, a recording thermometer in the storage heating unit at all times.

Open to Traffic.-The areas where the waterproofing membrane or engineering fabric was placed may be opened to construction traffic in accordance with the manufacturer's specifications or as directed by the Engineer. No general traffic shall be allowed on the areas where the waterproofing membrane or engineering fabric was placed until the bituminous overlay is placed.

8. Measurement and Payment.-The completed work as measured for WATERPROOFING JOINTS AND CRACKS will be paid for at the contract unit price for the following contract items (pay items):

Pay Item	Pay Unit
Waterproofing Membrane	Square Yard
Engineering Fabric	Square Yard

The Waterproofing Joints and Cracks quantities will be determined by the actual number of square yards placed. Payment for the work of Waterproofing Joints and Cracks includes the cost of furnishing the material, labor, and equipment for preparing the pavement, furnishing and placing the membrane binder or fabric sealant and furnishing and placing the waterproofing membrane or engineering fabric.