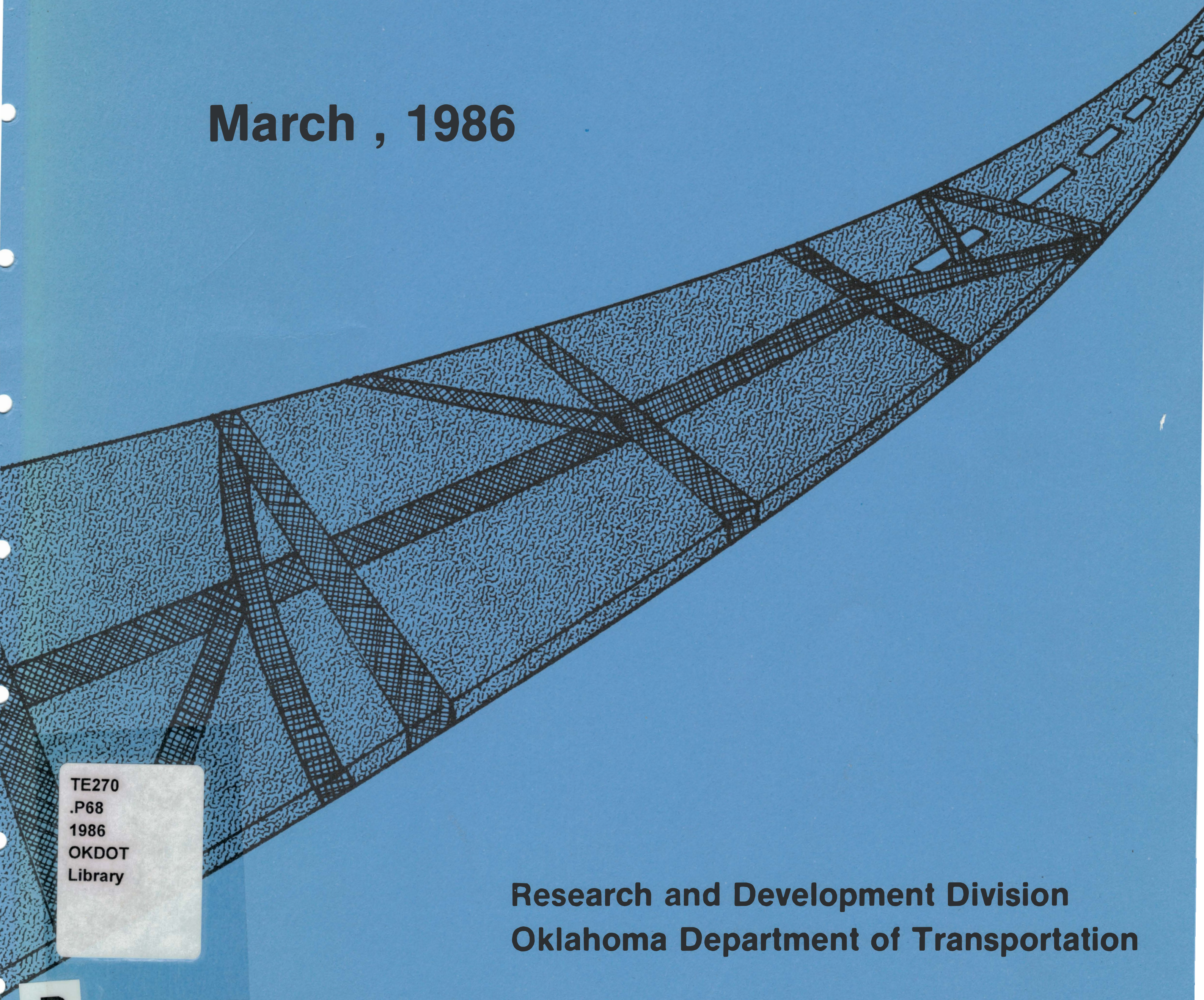
PRECOATED MEMBRANES

March , 1986



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16. ABSTRACT

This report describes the installation and performance evaluations of precoated membranes in Oklahoma. The report is presented in four separate sections and describes the performance of Bituthene, Polyguard, Protecto Wrap and Petrotac.

Each part was considered as a separate project for the evaluation and was compared to the standard overlay design for each project. The precoated membranes were installed in 1978, 1980, and 1982. The width of the membranes over the joints and cracks ranged from 12 in (300 mm) to 36 in (914 mm). The average overlay thickness over the membranes ranged from 1.5 in (38 mm) to 3.75 in (95 mm). All the precoated membranes appeared to be performing well in sealing and diminishing the reflective cracking in a cost effective manner.

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PRECOATED MEMBRANES

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EXECUTIVE SUMMARY

This report contains installation and performance evaluations of four precoated membranes in Oklahoma. The report is presented in four separate sections and describes the performance of Bituthene on I-35 near Ardmore which was installed in 1978. The second part describes Polyguard on US 270 near Arpelar which was installed in 1978. The third part relates the comparative performance of three membranes; namely, Bituthene, Polyguard, and Protecto Wrap. They were placed on US 183 south of Rocky in 1980. The fourth part includes the performance of Petrotac on I-35 near Edmond, placed in 1982.

The width of the membranes over the joints and cracks ranged from 12 to 36 in (0.3 to 0.9 m). The average overlay thickness over the membranes ranged from 1.5 to 3.75 in (38 to 95 mm). Each part was considered as a separate project for the evaluation and was compared to the standard overlay design for each project.

All the precoated membranes appeared to be performing well in sealing and diminishing the reflective cracking in a cost effective manner.

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BITUTHENE PRECOATED FABRIC MEMBRANE

INTRODUCTION

Background

The experimental Bituthene membrane was applied in July, 1978, to two sites on project IR-35-1(70)025. Bituthene is a trade name of a precoated fabric membrane manufactured by the W.R. Grace Company. The installation is located on the northbound and southbound lanes of I 35 about four miles south of Ardmore in Carter County. The existing jointed Portland cement concrete (PCC) slab is 12 ft (3.6 m) wide and 9 in (230 mm) thick on a 4 in (100 mm) base with 15 ft (4.6 m) joint spacings. The 1983 average daily traffic count was 12,000. The resurfacing project used a 3 in (76 mm) layer of Type C asphalt concrete (AC) and 3/4 in (19 mm) of open graded friction course. This was done by South Prairie Construction Company.

The alignment passes over primarily CL and CH (Unified classification) soils. These are formed from the rock units of the Dornick Hills formation. Here, the rock strata are predominantly shale with minor amounts of conglomerate, limestone, and shale. The rock strata in this area are steeply tilted.

The test section is located in a low fill of 3 to 6 ft (1 to 2 m). The slab faulting was very minor, about 1/8 in (3 mm) or less.

Purpose and Scope

The objectives of the experimental project were:

1. To retard and reduce reflective cracking at joints and cracks.
2. To stop the infiltration of water through joints and cracks into the underlying PCC pavement.

A precoated waterproofing strip membrane, "Heavy Duty Bituthene", was selected for this study.

The northbound lanes contain one treated section 435 ft (132.6 m) long, with two adjacent untreated sections as controls. The control sections are 200 ft (61.0 m) and 500 ft (152.4 m) long. See Figure 1.

The southbound lanes also contain one treated section 435 ft (132.6 m) long with two adjacent untreated control sections, each 200 ft (61.0 m) long. See Figure 1.

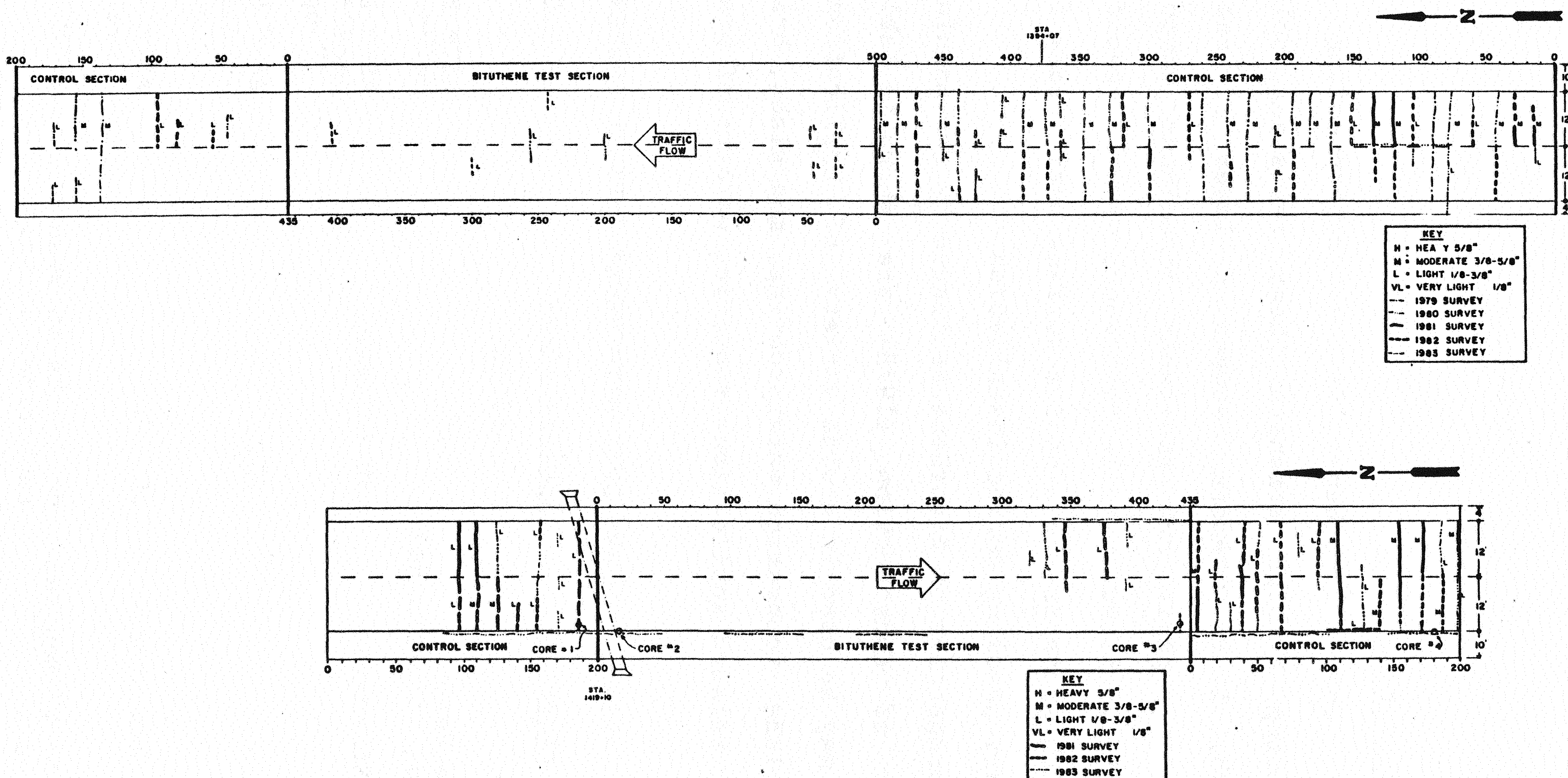

Figure 1. Crack reflection in Bituthene and control sections on I 35 southbound and northbound lanes at Ardmore.

MATERIALS

Fabric Properties

Heavy Duty Bituthene is a waterproofing membrane incorporating a high strength, heat resistant, polypropylene woven mesh. It is embedded between a layer of self-adhesive rubberized asphalt and non-tacky bituminous compound. The material is supplied in rolls interwound with a special release paper which protects the adhesive surface until ready for use and allows easy handling during installation.

The properties of Bituthene as listed by the manufacturer at the time of construction (1978) are shown in Table 1. This membrane may be used in a wide variety of applications. These uses include foundation waterproofing, mud slabs, bridge decks, and other related applications requiring waterproof protection.

Table 1. HEAVY DUTY BITUTHENE*-TYPICAL PROPERTIES

Property	Typical Value	Test Method
Thickness	.065 in	--
Permeance-Perms (grains/sq ft/hr/in Hg)	.10	ASTM E 96 Method B
Tensile Strength	50 lb/inch	ASTM D 882 (modified for 1" opening)
Elongation	75%	ASTM D 882 (modified for 1" opening)
Puncture Resistance	200 lb	ASTM E 154 (mesh)
Pliability ¼" mandrel 180° bend at 15°F.	no cracks in mesh or rubberized asphalt	ASTM D 146

*The current name for the fabric is Bituthene 5000 (1983).

INSTALLATION

The fabric was installed in July, 1978. The installation of the fabric was done by Research Division employees of the Oklahoma Department of Transportation (ODOT).

Bituthene primer was applied to the pavement at the rate of 0.03 gal/yd² (0.14 l/m²) to coat the joint area and random cracks prior to applying fabric. It took approximately 40 minutes for the primer to dry tack free. The fabric was centered over the joints by hand. A 3/4 ton pickup truck was driven over the membrane and pressed it to the existing pavement.

On the southbound lanes, all the transverse joints were covered with 1.5 ft (0.5 m) wide Bituthene. The longitudinal joints on the outside shoulder, the centerline joint and 180 ft (54.9 m) of joint on the inside shoulder also were covered with 1.5 ft (0.5 m) wide Bituthene. See Figures 2 and 3. Two random cracks within the test section were covered with 3 ft (0.9 m) wide Bituthene and the remaining cracks were covered with 1.5 ft (0.5 m) wide Bituthene. See Figure 4.

On the northbound lanes all the transverse, centerline and outside longitudinal joints were covered with 1.5 ft (0.5 m) wide Bituthene. There were no random cracks in this area. See Figures 5 and 6.

The traffic was allowed on the Bituthene membrane for 10 days. Then the road received a 3 in (76 mm) layer of Type C AC, and 3/4 in (19 mm) of open graded friction course. This was done by the contractor.

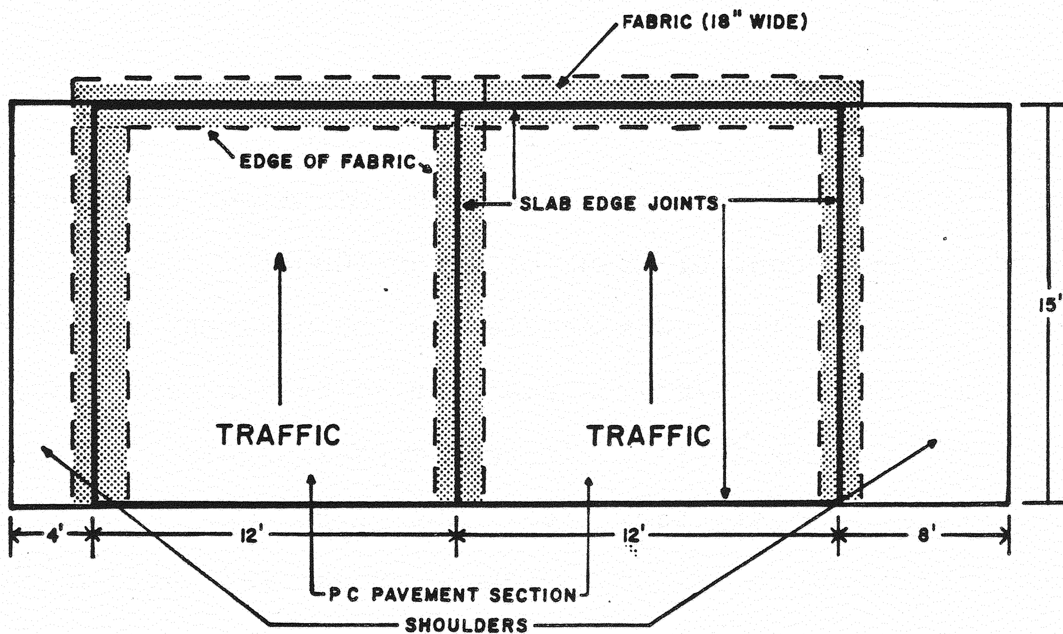

Figure 2. Plan view of Bituthene installation over the PCC joints.

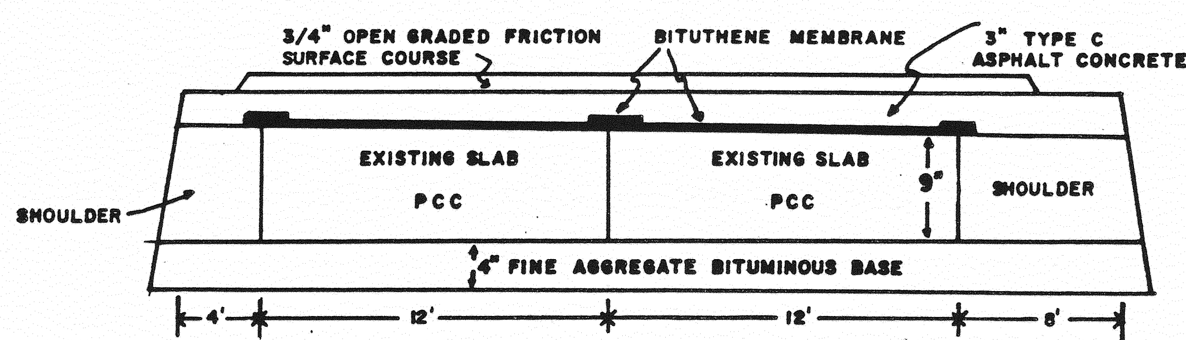

Figure 3. Cross section view of Bituthene installation over the PCC joints.

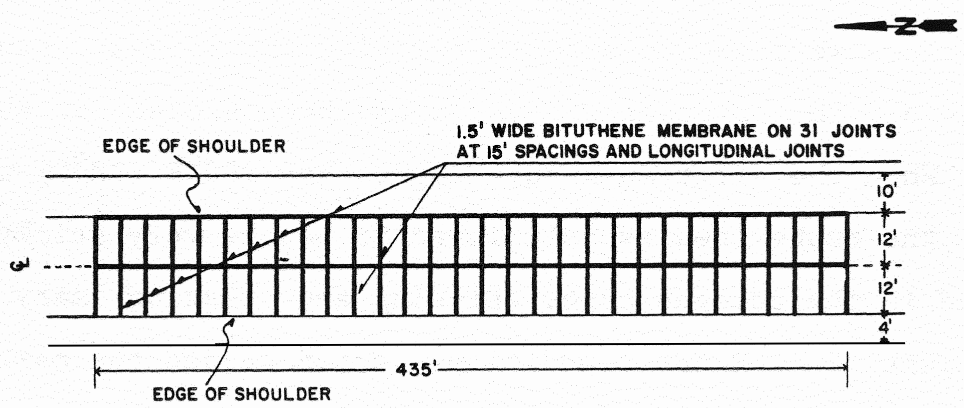

Figure 4. Bituthene treated section - northbound lanes.

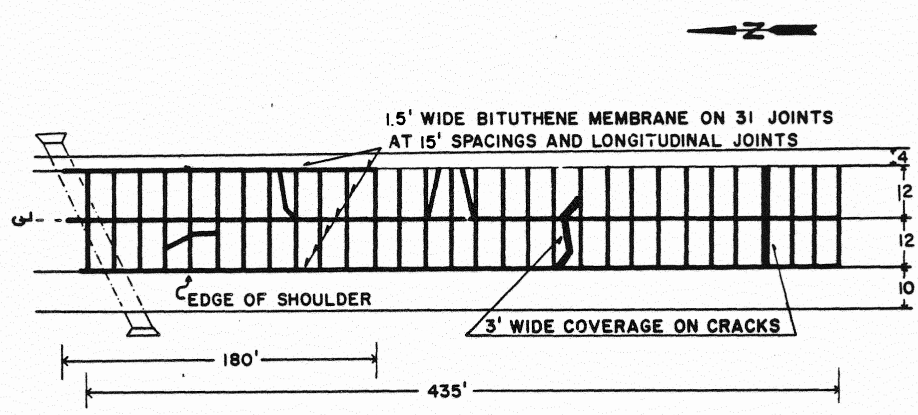

Figure 5. Bituthene treated section - southbound lanes.

Problems

Problems were encountered in removing the release paper. A portion of the precoated fabric had been stored for about two years. When the air temperature approached 100°F (38°C) the heat caused the rubberized asphalt layer to become very sticky. This resulted in the release paper sticking and tearing many times. See Figure 7. Windy conditions often caused the material to flutter and stick to itself. See Figure 8. It was noted that the Bituthene stored for about one year was much more difficult to separate from the release paper than the recently delivered material.

Figure 6. All the transverse, centerline and outside longitudinal joints were covered with 1.5 ft wide Bituthene on the northbound lanes.

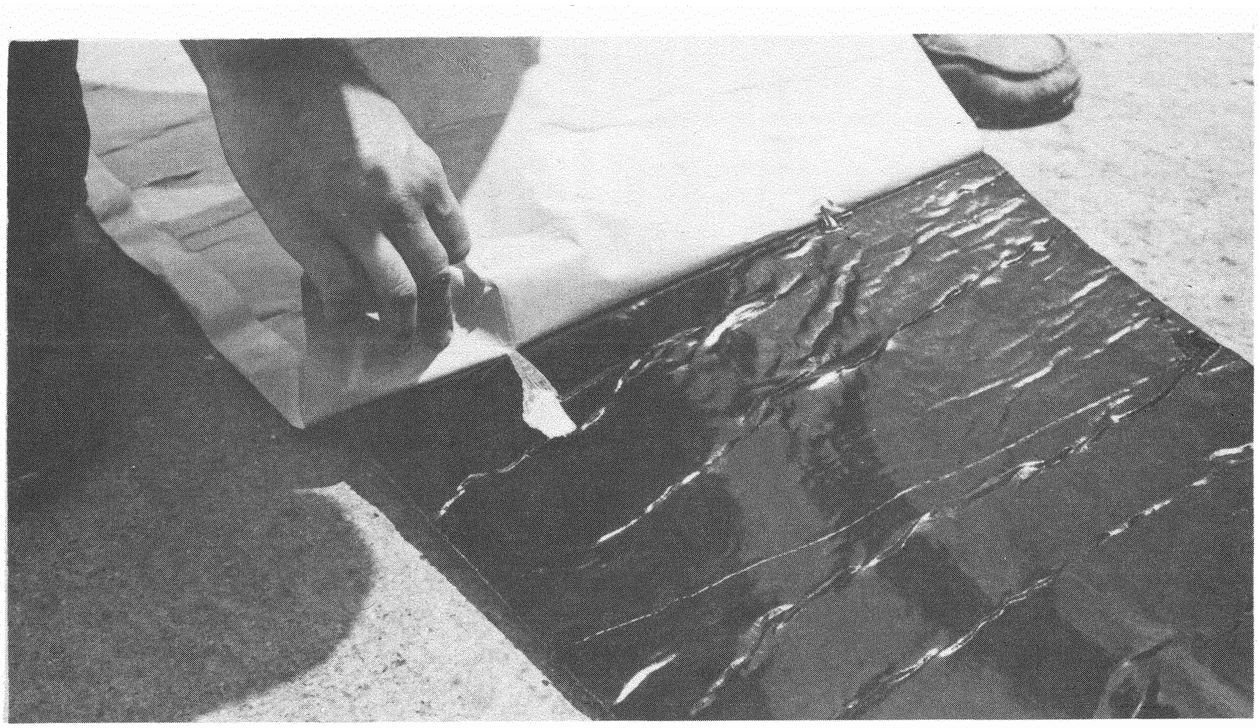

Figure 7. Hot weather combined with a long storage time, allowed the rubberized asphalt layer to become very sticky, causing tearing of release paper.

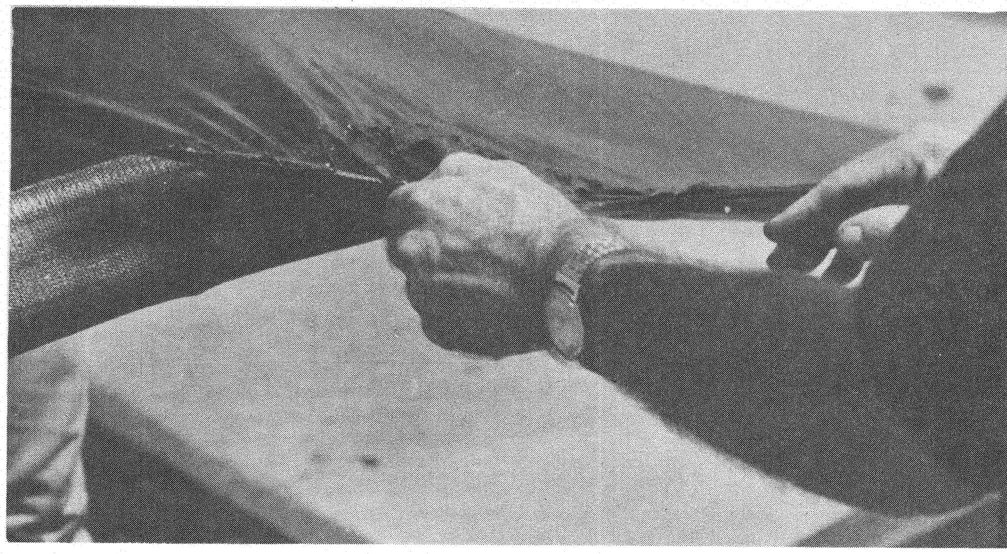

Figure 8. Windy condition often caused the material to flutter and stick to itself.

EVALUATION

The first evaluation was made in February, 1979 approximately six months after installation. There was no reflective cracking in the test sections and none in the control sections.

The one year evaluation was made in August, 1979. There was no reflective cracking in either of the Bituthene sections. Five transverse cracks were found in the south control section of the northbound lane. One transverse crack was found in the north control section of the northbound lanes. Also no cracks were found in the southbound control section. See Figure 1.

The two year evaluation was conducted in July, 1980. No reflective cracks were found in either of the Bituthene sections. Twenty transverse cracks were found in the northbound control sections. No cracks were found in either of the southbound control sections. See Figure 1.

The three year evaluation was made in May, 1981. The Bituthene was performing very well. No reflective cracks were found in either of the Bituthene sections. Twenty-four transverse cracks were observed in the northbound control sections. Seven transverse cracks also were found in the southbound control sections. One longitudinal crack, 30 ft long, was found at the edge of the shoulder in the southbound control section. See Figures 1 and 2.

The four year evaluation was conducted in March, 1982. The Bituthene sections showed some signs of distress. Four transverse cracks were found in the northbound Bituthene section. These cracks were about 3 ft (0.9 m) long and were located in the wheel path. Two transverse cracks also were observed in the southbound Bituthene section.

The number of transverse cracks in the northbound and southbound control sections have been steadily increasing and some of the crack lengths had extended to full width. See Figures 1 and 2.

The five year evaluation was made in March, 1983, approximately five years after the Bituthene installation. The fabric is performing very well.

Northbound Summary

In the northbound lanes, only seven transverse cracks or 23 percent, have reflected through in the Bituthene section in five years. These cracks are in the wheel path and are about 3 to 4 ft (0.9 to 1.2 m) long. The remaining 23 transverse joints show no sign of any reflective crack. No longitudinal crack has developed in the treated section.

Ninety-seven percent of the transverse joints have reflected through in the south control section. The transverse cracks ranged from 3 to 24 ft (0.9 to 7.3 m) long. One longitudinal crack, 60 ft (18.3 m) long, also has reflected through in the centerline of the road.

The north control section showed 50 percent reflective transverse cracks. They ranged from 3 to 24 ft (0.9 to 7.3 m) long. The remaining eight transverse joints have not reflected through yet. No longitudinal crack was found in the north control section.

Figure 9 shows the percent crack reflection length after five years. This is the total length of longitudinal and transverse crack reflections and should not be confused with the percent of reflective transverse cracks which were described previously.

Southbound Summary

In the southbound lanes only 20 percent of the transverse cracks have reflected through in the treated section. The remaining transverse joints showed no cracking. One longitudinal crack, 100 ft (30 m) long, has reflected through at the edge of the inside shoulder. Also, two longitudinal cracks approximately 50 ft (15 m) long have reflected through at the edge of the outside shoulder.

All the transverse joints have reflected through, in the south control section. These cracks range from 3 to 24 ft (0.9 to 7.3 m) in length. One longitudinal crack, 200 ft (61 m) long, has reflected at the edge of the outside shoulder.

Approximately 50 percent of the transverse joints, have reflected in the north control section. These cracks range from 3 to 24 ft (0.9 to 7.3 m) in length. Also one 100 ft (30 m) long longitudinal crack has reflected at the edge of the outside shoulder.

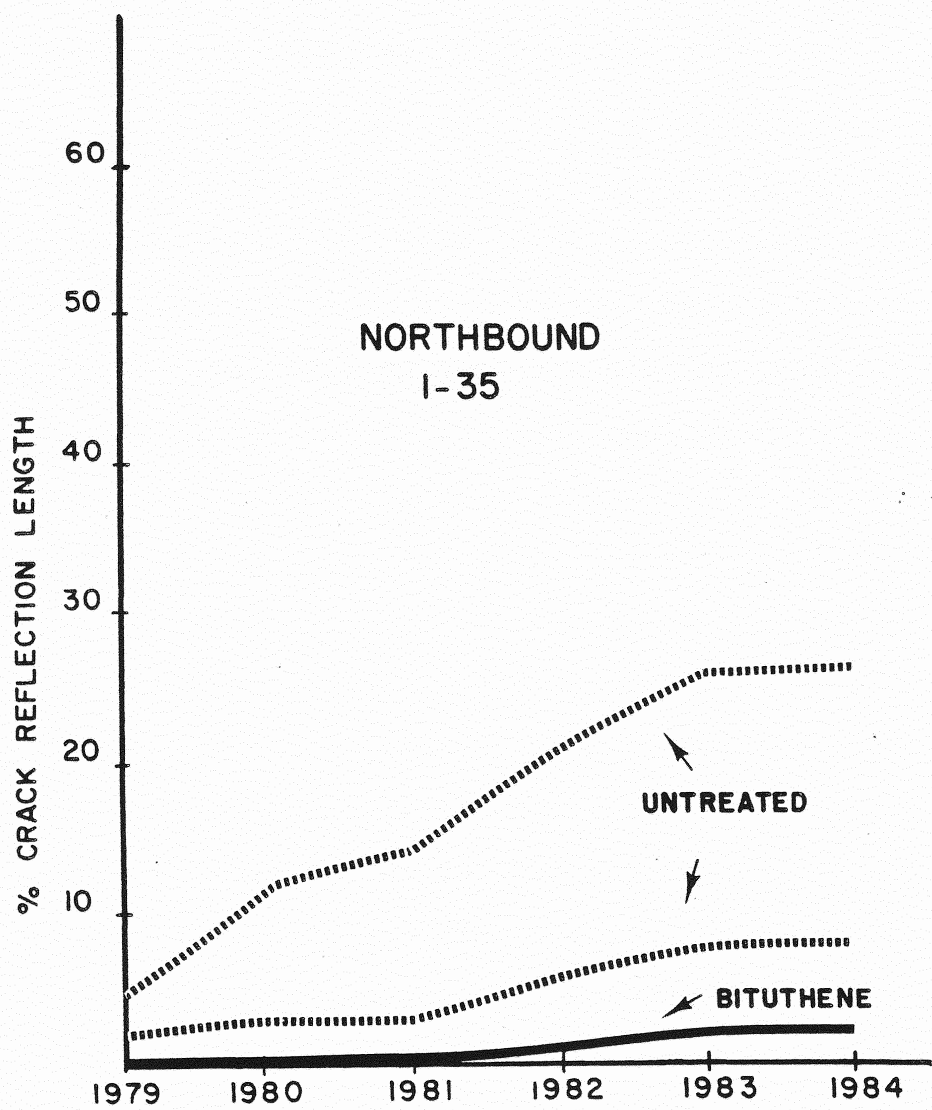

Figure 9. Amount of crack reflection - Northbound.

The width of the transverse cracks in both the Bituthene sections were classified as "light", 1/8 to 3/8 in, (3 to 9 mm). The width of the transverse and longitudinal cracks in the control sections ranged from light to medium, 1/8 to 5/8 in, (3 to 16 mm). In one case, the width of a longitudinal crack in the south control section of the southbound lane exceeded 3/4 in (19 mm). This longitudinal crack was at the edge of the outside lane.

Figure 10 shows the percent crack reflection length after five years. This is the total length of longitudinal and transverse crack reflections and should not be confused with the percent of reflective transverse cracks which were described previously.

Core Descriptions

Four cores were taken from the southbound lanes on April 4, 1983. Two cores were taken from the control sections and the other two were taken from the Bituthene section. See Figure 1, page 3 for the core locations.

A visual examination of the cores revealed that the Bituthene fabric had not ruptured after approximately five years of service. No tears, abrasions, or other defects were found.

The longitudinal cracks at the edge of the outside lane also were observed during the coring. These were in the southbound control and Bituthene sections. Faulting at the edge of the outside lanes was evident. It existed prior to the Bituthene application. The longitudinal joint under the Bituthene was more than 1 in (25 mm) wide. However, the fabric was still bonded well to the old surfaces over the longitudinal joint after five years of use.

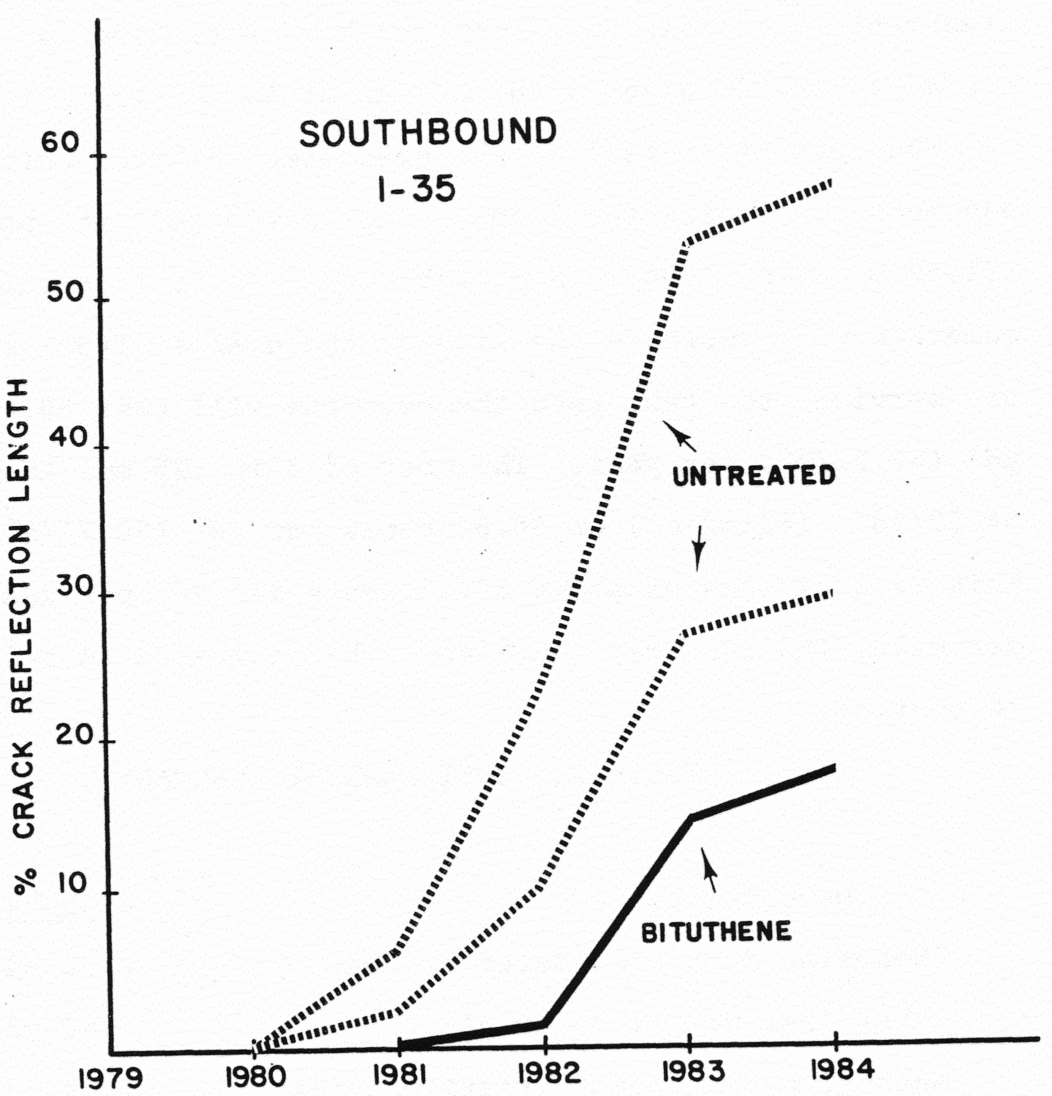

Figure 10. Amount of crack reflection - Southbound.

COST ANALYSIS

The quantity of fabric required to cover the joints, and cracks in the section shown in Figures 4 and 5 is about 14 yd^2 (11.6 m^2). This includes an estimated 2 yd^2 (1.7 m^2) for the treatment of occasional random cracks. A section is defined as two adjacent PCC slabs with an area of 40 yd^2 (33 m^2).

The cost of installing the precoated membrane onto an area of pavement, including the labor, was estimated to be $1.28/$yd^2$ ($1.50 m^2) in 1984. See Table 2. If it is assumed that the membrane will increase the life of the overlay from seven years of service to ten, then the membrane will cost $0.43 cents per yd^2 ($0.52/m^2) per year. The cost of 3 in (75 mm) AC overlay is $4.50/$yd^2$ ($5.42/$m^2$) or $0.64 cents per yd^2 ($0.77/m^2) per year. This is a savings of about $0.21 cents per yd^2 per year or $6,000 per mile, ($3,700/km) (four-lane) when compared to a 3 in (75 mm) AC overlay.

Table 2. COST ANALYSIS SUMMARY

Description	Costs
Precoated Membranes Material Cost	$ 2.70 yd^2*
Labor (per yd^2 of material)	.90 yd^2
Approximate Pavement Treatment Cost	1.28 yd^2
As compared to:	
3 in AC	4.50 yd^2

* To convert yd^2 to m^2, multiply by 0.8361

CONCLUSIONS AND RECOMMENDATION

The Bituthene strip precoated fabric membrane performed very well in diminishing and retarding reflective cracking. Considerably less transverse cracking was observed in the Bituthene test sections as compared to the control sections.

Twenty to twenty-three percent (21 percent average) of the transverse joints had reflected in the Bituthene test sections. Fifty to one hundred percent (74 percent average) of the transverse joints had reflected in the control sections.

It is recommended that ODOT's use of Bituthene or other precoated fabrics with similar properties be encouraged. The most appropriate use would be as a Portland cement pavement joint or random crack treatment when asphalt concrete overlays are to be applied. Such pavement should be properly evaluated to determine if the slabs are relatively stable with little or no faulting. If slabs are not stable then some method should be used to stabilize them.

The Ardmore Bituthene project will continue to be evaluated by the Research Division on an annual basis for the next five years or until a new overlay is placed.

A proposed Special Provision for Precoated Fabric Membrane, ODOT 414(1-b)SP, 7-16-83, is available from the Specification Engineer.

POLYGUARD PRECOATED MEMBRANE

INTRODUCTION

Background

The experimental Polyguard precoated fabric membrane project F-182(45) is located on US 270 west of the town of Arpelar in Pittsburg County, Oklahoma. The widening and resurfacing project is 7.28 mi (11.65 km) long and contains three Polyguard treated sections and two control sections. See Figure 1.

The existing Portland cement concrete (PCC) slab is 10 ft (3 m) wide and 8 in (200 mm) thick, with 30 ft (9.2 m) joint spacing. A fine aggregate bituminous base (FABB) 8 in (200 mm) thick, 10 ft (3 m) wide was utilized for the widening. The surfacing contains 2 in (50 mm) of Type C asphalt concrete (AC) as a leveling course and 1 1/2 in (38 mm) of Type C AC (ODOT 708.04) as a surface course. See Figure 2. This installation was done by Brooks & McConnell Construction Corp. of Oklahoma City in July, 1978.

The average daily traffic (ADT) count was 2,000 in 1983.

Purpose and Scope

The objectives of the experimental project were:

1. To prevent or retard reflective cracking of joints and cracks.

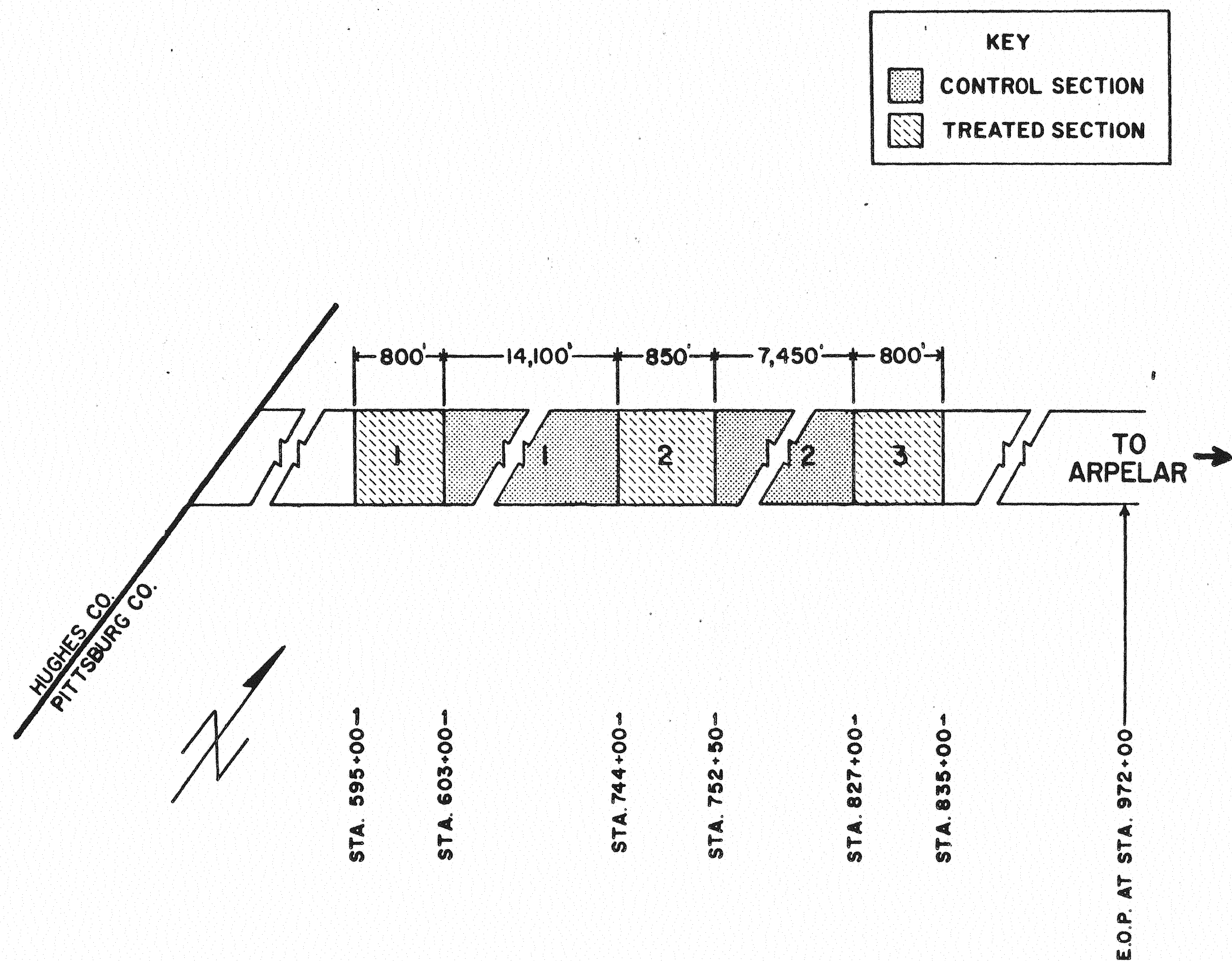

Figure 1. Polyguard and control sections layout, US 270, Pittsburg County.

2. To stop the infiltration of water through joints and cracks into the underlying PCC pavement.

Polyguard, was selected for this project. The test and control sections were selected randomly from the entire 7.28 mi (11.65 km) project. The project contains three Polyguard treated sections and two untreated sections as controls.

MATERIALS

The Polyguard membrane consists of a rubberized asphalt waterproofing element with a woven polypropylene mesh laminated to the outer surface. Polyguard is a registered trade name of Polyguard Products, Inc. It is wound on a disposable treated plastic strip sheet to prevent sticking together while in the rolls. The typical properties* are listed in Table 1.

Table 1. POLYGUARD PHYSICAL PROPERTIES

Thickness	65 mil
Width	15 in
Permeance-Perms (grains/sq ft/hr) ASTM E 96 (Method B)	0.1 in/Hg
Tensile Strength ASTM D 882 (Modified for 1 in Opening)	50 lb/in
Puncture Resistance (Mesh) ASTM E 154	200 lb
Pliability - 1/4 in Mandrel 180° bend at 15°F. ASTM D 146	No cracks in mesh or rubberized asphalt

* Average minimum values can generally be taken as 20 percent less than the typical properties.

INSTALLATION

Polyguard was applied over the longitudinal joints on July 25, 1978 using SS-1 emulsion as a prime coat. It was installed by a two-man contractor crew. The membrane was centered over the pavement edge joint between the existing PCC pavement and the FABB widening in the treated sections 1, 2 and 3. See Figure 3.

Five transverse joints in treated section Nos. 1 and 2 transverse joints in treated section No. 3 were covered with Polyguard. No membrane was installed over the transverse joints in section No. 2 where the longitudinal joint was treated.

The field representative for Polyguard, was on hand to aid in the placement of the membrane. See Appendix A at back of book for more information concerning the installation.

After the Polyguard was installed, the road received a 2 in (50 mm) layer of Type C AC as a leveling course and a 1 1/2 in (38 mm) layer of Type C AC as a surface course. See Figure 2.

Problems

Minor problems were encountered in removing the release sheet. The release sheet was sticking to the rubberized asphalt layer and was torn many times, slowing the installation.

Asphalt tack sticking to the AC haul truck tires pulled the membrane up about 2 in (50 mm) from the surface in some instances. This problem occurred when the trucks backed over the

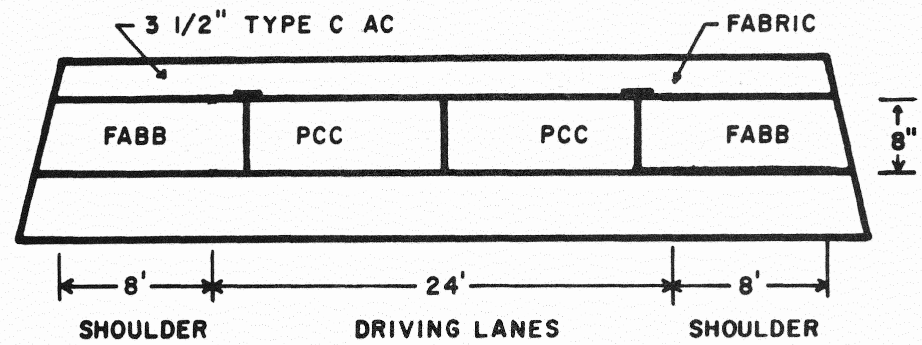

Figure 2. Crossection of pavement system using Polyguard.

Figure 3. Polyguard strip membrane installed over the longitudinal edge joint between the PCC slab and AC widening section.

membrane. See Figure 4. The problem was corrected by sprinkling loose AC mix over the membrane prior to the AC overlay. See Figure 5.

EVALUATION

The six month evaluation was conducted by Research Division personnel on February 28, 1979. Only one longitudinal crack at the edge of the pavement had reflected through. This crack was 35 ft (10.7 m) long and was in the control section.

One out of five treated joints had produced transverse reflected cracks completely across the lane in the treated section No. 1. No transverse cracks were observed in the two treated joints in section No. 2 and No. 3. Every third joint had reflected across the entire lane in both the non treated control sections.

The one year evaluation was made on July 8, 1979. The road condition was not significantly different from that of the six month evaluation.

The three year evaluation was made on June 19, 1981. Additional longitudinal cracks had reflected through in both the treated and the control sections. See Figure 6 for typical longitudinal crack configuration. These cracks were along the pavement edge of the widened section and were located in the right wheel path.

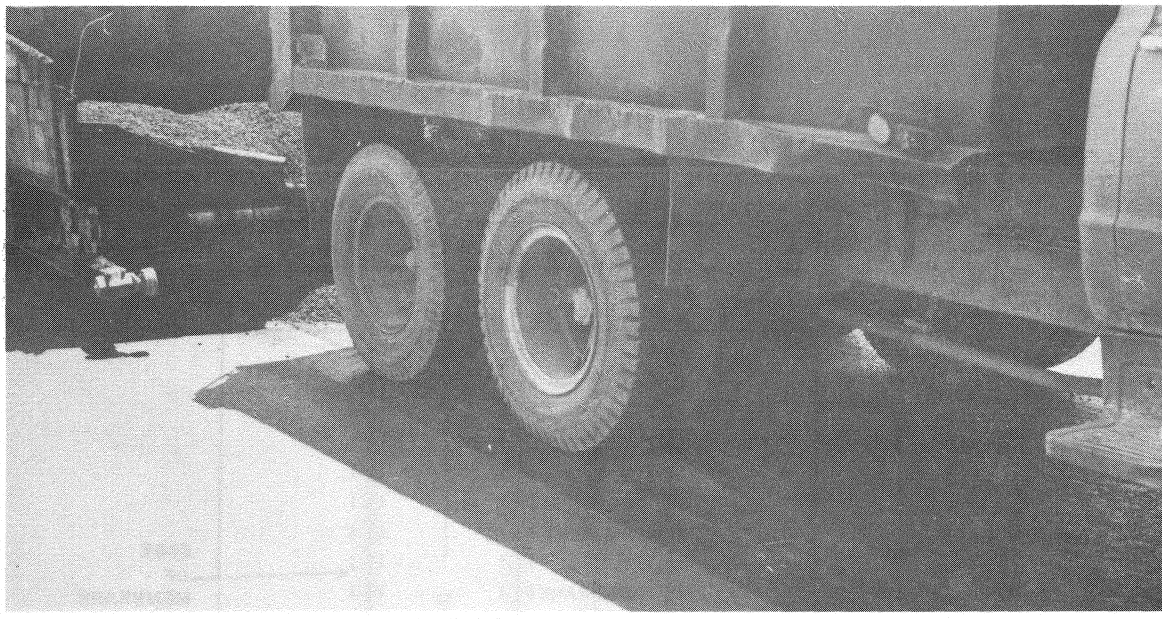

Figure 4. The tack on the truck tires pulled the fabric loose from the surface in some instances.

Figure 5. The asphalt concrete mix is sprinkled over the Polyguard to eliminate the fabric dislocation caused by the sticky tires.

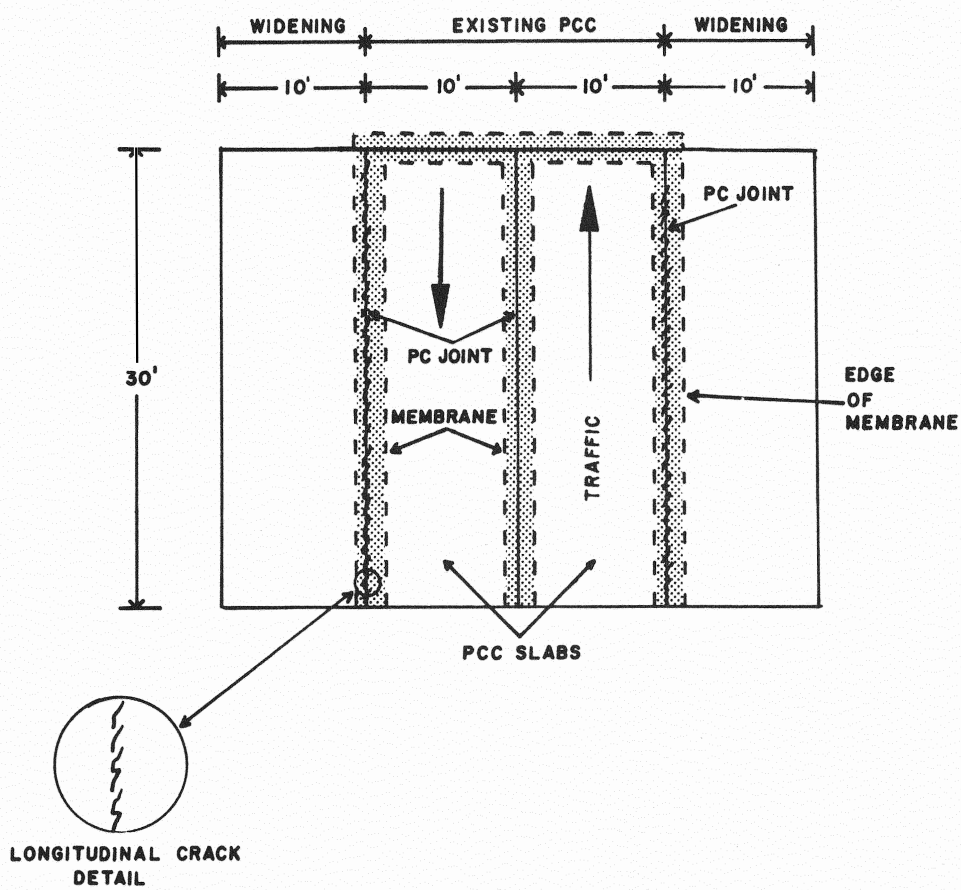

Figure 6. Typical longitudinal crack reflection.

Only one transverse crack was found in treated section No. 1. It was the same crack that was observed in the six month evaluation. More transverse cracks were found in the control sections when compared to the one year observations.

The four year evaluation was made on May 26, 1982. No significant changes were observed.

The five year evaluation was conducted on April 25, 1983. Again, the same transverse crack, as mentioned above, was the only one to have reflected through in treated Section No. 1. This crack had developed parallel secondary cracking and a spalled area. Neither of the two transverse treated joints in treated section No. 3 showed any sign of reflection cracking. Approximately every other transverse crack in the control sections had reflected.

The longitudinal cracks had reflected in both treated and control sections. See Figure 6 for a typical configuration of longitudinal cracks.

Core Descriptions

Eleven cores were taken for visual evaluation. Five cores were taken on April 25, 1983 in treated section No. 1 and the other six cores were obtained on May 19, 1983 in treated section No. 3. The cores were taken from reflected and nonreflected crack areas.

A close visual examination revealed that the Polyguard fabric had not ruptured after approximately five years of service. No abrasion was found in the fabric. The Polyguard layer appeared to be effectively waterproofing cracks in all cases.

Discussion

The use of Polyguard over the PCC pavement joints prior to an AC overlay has nearly eliminated transverse reflective cracking after five years of service.

There were longitudinal cracks over the new shoulder joints in both the treated and the untreated sections. This kind of crack appears to be the result of a combination of the horizontal, thermally induced movement of the underlying PCC slab relative to the AC shoulder and the vertical differential movement from heavy loads on the rigid PCC slab. This difference in materials and the weight of heavy vehicles causes the longitudinal pavement-shoulder edge joints to result in shear displacement.

Vertical joint movement due to dynamic load factors also could cause a crack at the longitudinal joint in the AC overlay. Another possible contributing factor may be the flexible properties of the AC shoulder section as compared to the rigid properties of the PCC slab.

COST

Table 2 shows the cost of Polyguard as of May, 1978, according to the contractor. The quantity of membrane required to cover the joints and cracks in the section shown in Figure 6 is about 17 yd^2 (14.2 m^2). This includes an estimated 2 yd^2 (1.7 m^2) for the treatment of occasional random cracks. A section is defined as two adjacent PCC slabs and this area is 67 yd^2 (56 m^2).

The installation cost of the precoated membrane including the labor is estimated to be \$3.24/yd^2 (\$3.86 m^2) of pavement covered by the membrane. See Table 2.

Table 2. COST OF POLYGUARD

Polyguard 665 membrane	\$2.70/yd^2*
Labor	0.54/yd^2
Total	\$3.24/yd^2

* To convert yd^2 to m^2, multiply by 0.8361.

CONCLUSIONS AND RECOMMENDATIONS

The Polyguard strip precoated membrane performed very well in diminishing and retarding transverse reflective cracking. Only one out of seven treated joints had reflected through.

Polyguard did not perform as well in diminishing longitudinal reflective cracking in the pavement edge shoulder joints where movements are significant.

Polyguard should provide good protection against the intrusion of water and consequent pumping of base or subgrade soil material after cracking occurs. No tears or abrasions were found in the Polyguard fabric in the cracked areas after five years of service, even in the cracked pavement edge joints.

It is recommended that Polyguard or other precoated fabric membranes with similar properties be considered for use as a PCC joint or random crack treatment when AC overlays are to be applied.

PRECOATED MEMBRANES AT ROCKY, OKLAHOMA

INTRODUCTION

Background

This operation was a widening and resurfacing project located on US 183 south of the town of Rocky in Washita County. The experimental section contains three different precoated strip membranes, namely: Bituthene, Polyguard, and Protecto Wrap. The installation of the membranes was done by the Research Division of the Oklahoma Department of Transportation (ODOT) in March 1980.

The existing asphalt concrete (AC) pavement included 6 in (152 mm) of soil asphalt base and 1½ in (38 mm) of Type C AC. A fine aggregate bituminous base (FABB) 8 in (203 mm) thick, 8 ft (2.4 m) wide was used for the widening. The surfacing consists of 1½ in (38 mm) of Type B AC as a surface course. The surfacing was done by Cornell Construction Co., Inc. in March, 1980.

Purpose

The purpose of the experimental project was as follows:

1. To observe the rate of reflection cracking.
2. To observe the sealing effect of precoated membranes preventing the infiltration of water through cracks into the AC pavement.
3. To compare the pavement performance of the three different precoated strip membrane treatments.

Scope

This project is designed to observe the installation and performance of Bituthene, Polyguard, and Protecto Wrap on flexible pavement.

Seven sections, ranging in length from 460 to 1000 ft (140 to 350 m), were selected randomly for Bituthene evaluation. A 200 ft (61 m) long section was selected for Polyguard evaluation. Another 200 ft (61 m) long section was selected for Protecto Wrap evaluation. Also six sections, ranging from 158 to 540 ft (48 to 164 m) were selected as control sections. See Figure 1.

These areas will be evaluated for a total of five years, or enough time to estimate the life cycle of the treatment.

Strip Materials on U S 183
Rocky, Washita County

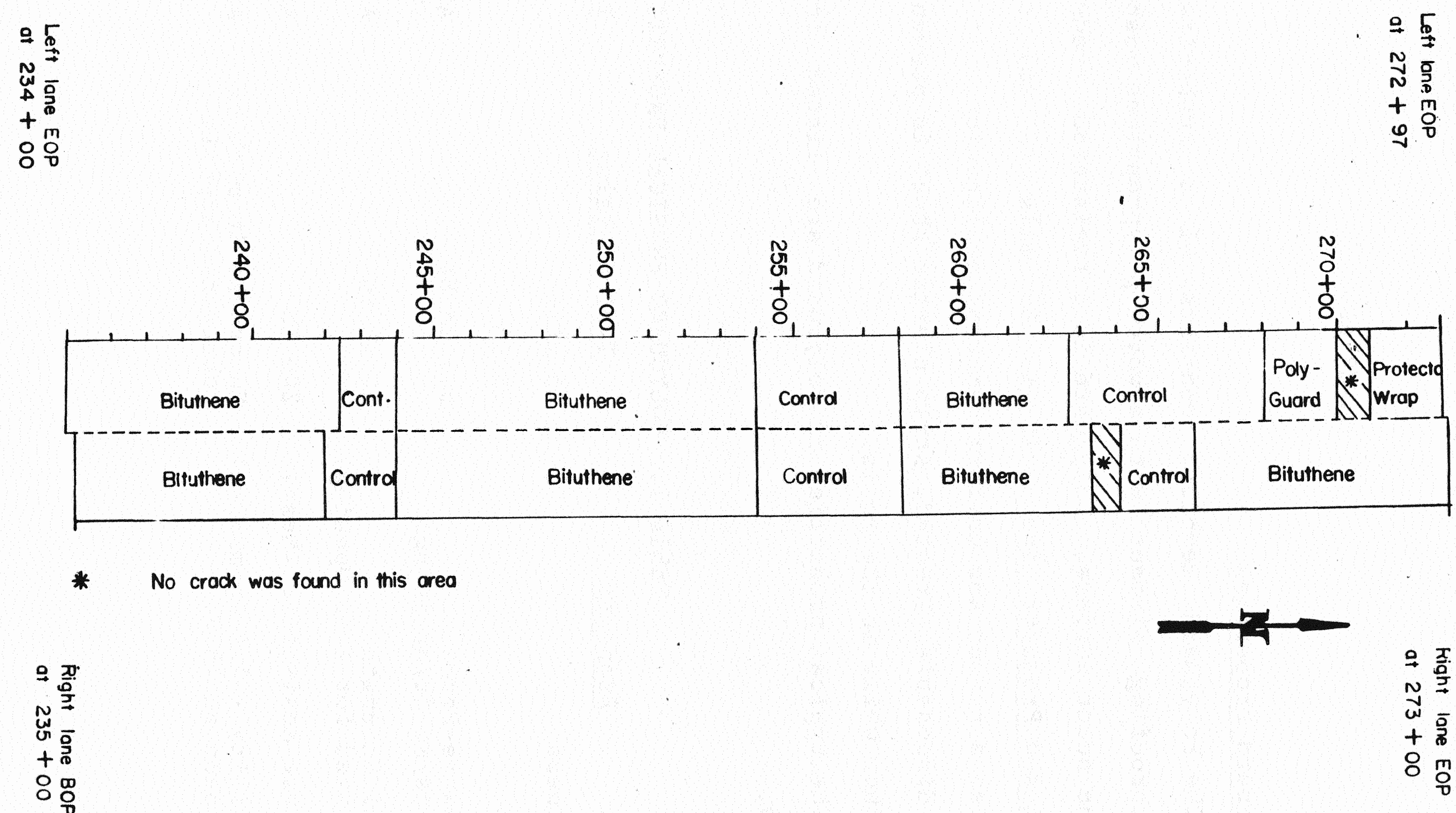

Figure 1. Treated and untreated sections, US 183, Rocky.

MATERIALS

Polyguard Properties

The Polyguard membrane consists of a rubberized asphalt waterproofing element with a woven polypropylene mesh laminated to the outer surface. Polyguard is a registered trade name of Polyguard Products, Inc. It is 65 mils (2 mm) thick which assures a strong and uniform membrane application. It is wound on a disposable, treated, strip plastic sheet to prevent sticking together while in the rolls.

The typical properties of Polyguard are listed in Table 1 below.

Table 1. POLYGUARD PHYSICAL PROPERTIES

Property	Typical Value	Test Method
Thickness	65 mils	--
Width	15 in	--
Permeance-Perms (grains/sq ft/hr in Hg)	0.1 in Hg	ASTM E 96 (Method B)
Tensil Strength (Modified for 1 in Opening)	50 lb/in	ASTM D 882
Puncture Resistance (Mesh)	200 lb	ASTM E 154
Pliability - 1/4 in mandrel 180° bend at 15°F.	No cracks in mesh or rubberized asphalt	ASTM D 146

Bituthene Properties

Heavy Duty Bituthene is a waterproofing membrane incorporating a high strength, heat resistant, polypropylene woven mesh. It is embedded between a layer of self-adhesive rubberized asphalt and non-tacky bituminous compound. The material is supplied in rolls interwound with a special release paper which protects the adhesive surface until ready for use and allows easy handling during installation.

The typical properties of Bituthene as listed by the manufacturer at the time of construction (1978) are shown in Table 2.

Table 2. HEAVY DUTY BITUTHENE*-TYPICAL PROPERTIES

Property	Typical Value	Test Method
Thickness	.065 in	--
Permeance-Perms (grains/sq ft/hr/in Hg)	.10	ASTM E 96 Method B
Tensile Strength	50 lb/inch	ASTM D 882 (modified for 1" opening)
Elongation	75%	ASTM D 882 (modified for 1" opening)
Puncture Resistance	200 lb	ASTM E 154 (mesh)
Pliability ¼" mandrel 180° bend at 15°F.	no cracks in mesh or rubberized asphalt	ASTM D 146

*The current name for the fabric is Bituthene 5000. (1983)

Protecto Wrap Properties

The Protecto Wrap M-400A membrane is manufactured from a formulation of bituminous resins modified with synthetic resins. This formulation is then reinforced with a spun bonded polypropylene fabric to withstand puncture and severe stress. The polypropylene reinforcement was changed to spun bonded polyester in 1982. The preformed membrane is claimed to provide effective waterproofing. The membrane is tacky on both sides to provide good bonding characteristics to the primed surface. It also binds to itself on overlap areas and to the protection sheet. M-400A is provided in rolls interwound with a release film to prevent self-adhesion of the material and to protect the surface of the membrane until overlaid.

The properties of Protecto Wrap as listed by the manufacturer as of May, 1984 are shown in Table 3.

Table 3. Protecto Wrap Typical Properties

Property	Typical Values	Test Method
Thickness	70 mil ± 5	
Tensile Strength (Avg. PSI)	730	ASTM D882-A
Elongation	80%	ASTM D882-A
Permeance-Perms (grains/sq ft/hr/in Hg)	0.1 max.	
Puncture Resistance (lbs)	180	ASTM E-96-B
Pliability	passes	ASTM E-154 ASTM D-146

INSTALLATION

The installation of the membranes was done by the Research Division of the ODOT in March 1980.

Bituthene was applied over the longitudinal and transverse cracks. See Figure 2. The widths of this membrane used on this project were 12 in (305 mm), 18 in (457 mm), and 24 in (610 mm). No systematic procedure was used for Bituthene installation; thus different widths were used randomly. Bituthene primer was applied to the pavement at a rate of 0.03 gal/yd^2 (0.14 l/m^2) to coat the area adjacent to the cracks prior to applying the membrane. See Figure 3. The membrane was centered over the cracks by hand. For more information regarding the Bituthene installation, see Appendix A.

Polyguard was applied over the block and longitudinal cracks. The width of this membrane was 23 in (580 mm). There were no transverse cracks in the Polyguard section.

Polyguard primer was applied to the pavement at a rate of 0.03 gal/yd^2 (0.14 l/m^2) prior to applying the membrane. For more information concerning the installation of Polyguard, see Appendix A.

Protecto Wrap was applied over the longitudinal and transverse cracks. The widths of the membrane used on this project were 15 in (380 mm) and 20 in (510 mm).

Protecto Wrap primer was applied to the pavement at a rate of 0.03 gal/yd^2 (0.14 l/m^2) prior to applying the membrane. See Appendix A for more information on the Protecto Wrap installation.

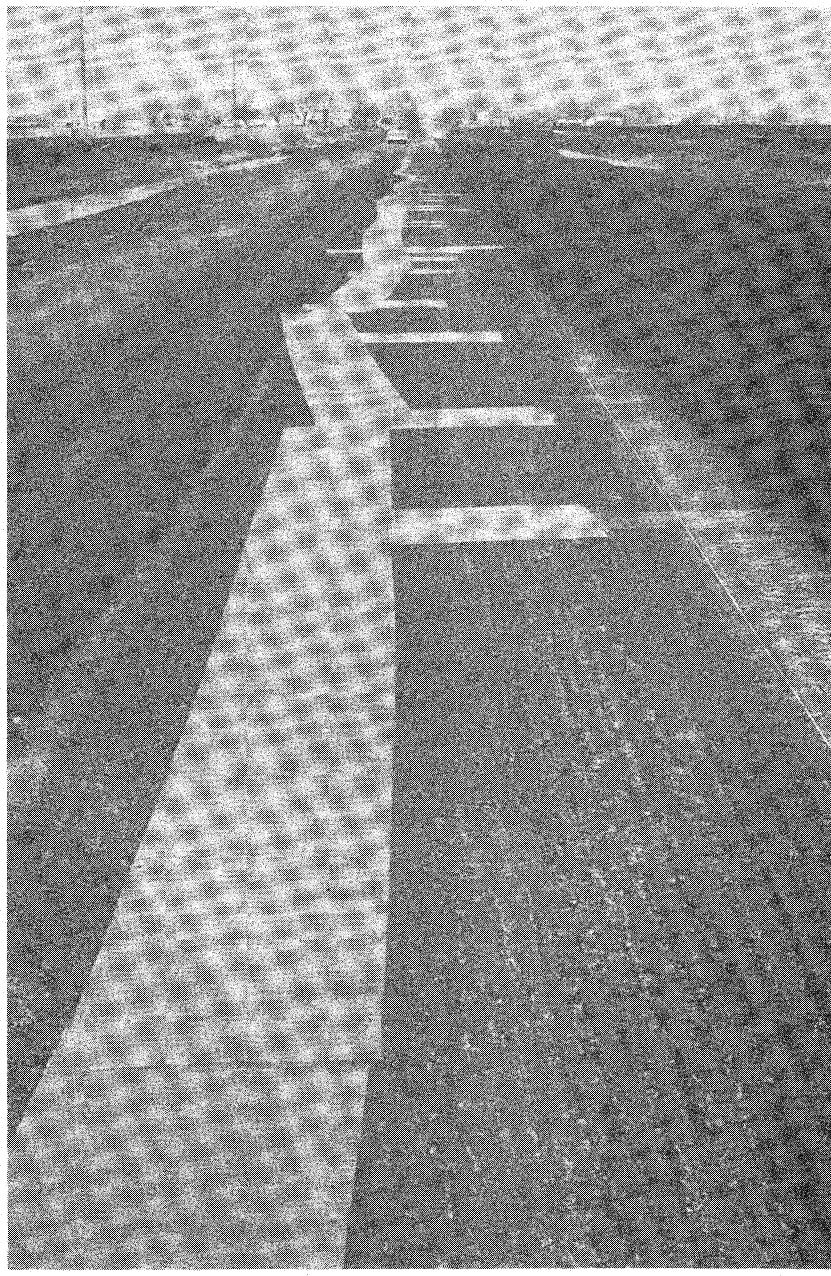

Figure 2. Bituthene was applied over the longitudinal and transverse cracks.

Figure 3. Primer was applied to the pavement to coat the cracks prior to applying the fabric.

EVALUATION

Crack Survey

The first year evaluation was conducted in February, 1981. No cracks were found in the test sections or control sections.

The second year evaluation was made in March, 1982. One longitudinal and five transverse cracks were found in the control sections. The length of the longitudinal crack was about 20 ft (6 m). The transverse crack lengths ranged from 3 to 15 ft (0.9 to 4.6 m). One longitudinal crack, 15 ft (4.6 m) long, was found on the shoulder in one of the seven Bituthene test sections. Coring revealed that the longitudinal crack was outside the membrane.

The third year evaluation was conducted in February, 1983. In the Bituthene test section, one longitudinal crack 30 ft (9.1 m) long, at the center line and one transverse crack, 6 ft (1.8 m) long, were observed. In the Polyguard section one diagonal reflective crack, 2 ft (0.6 m) long was found. In the Protecto Wrap section one longitudinal crack, 30 ft (9.1 m) long, was found.

Control sections showed more reflective cracks than in the previous years evaluation. Three new transverse cracks were found in five of the six control sections. However, no cracks were found in the sixth control section, and no additional longitudinal cracks were found in any of the control sections.

The fourth year evaluation was conducted in February, 1984. Three more transverse cracks had reflected in the Bituthene sections. Each of these was 12 ft (3.6 m) long. No more longitudinal cracks had developed since the 1983 evaluation.

One more transverse crack, 3 ft (0.9 m) long, was found in the Polyguard test section.

The Protecto Wrap test section showed a new transverse crack in the wheel path. It was 2 ft (0.6 m) long.

Control sections revealed eleven more transverse cracks. The lengths of the new transverse cracks ranged from 3 to 12 ft (0.9 to 3.6 m).

Coring

Cores were taken for visual evaluation. The first corings were conducted in March, 1982, approximately two years after the membrane installation. Three cores were obtained in one of the Bituthene test sections. Two of these were taken over the longitudinal cracks which were on the shoulder. No membrane was found at these crack sites. The third core was taken at a site where there was no surface crack. It should be noted that the third core was taken over a pre-existing longitudinal crack that had not reflected. The Bituthene membrane was bonded very well to the old and new AC layers, and there were no signs of construction stress, such as tears or abrasion.

One core was taken over a diagonal crack in the Polyguard test section. The coring revealed that the Polyguard had adhered to both old and new AC layers very well.

One core was taken over the longitudinal crack in the Protecto Wrap test section. There was poor bonding between the bottom of the membrane and underlying FABB layers. It had separated from the top layer of FABB. The Protecto Wrap, however, was bonded very well to the upper AC layer.

The second corings were conducted in June, 1984. Two cores, both over transverse cracks, were taken in the Bituthene test sections. One core contained no membrane. The other core was taken in a membrane area. No tear or abrasion was noted. Both of the above transverse cracks were of hairline width.

No cores were taken in the Polyguard test section. Three cores were taken in the Protecto Wrap test section. Two of them were over the longitudinal crack and one over the transverse crack. Again, the membrane had separated from the lower layer. Evidently the coring machine caused it to shear from the rough surface of FABB. The third core obtained from the Protecto Wrap test section was over the transverse crack. This showed that there was a good bond between the membrane and both AC layers. No abrasion or tears were found.

COSTS

The costs of the precoated membranes, as of May, 1984, including their installation are estimated to be \$3.87/yd^2 for Bituthene, \$3.24/yd^2 for Polyguard, and \$3.96/yd^2 for Protecto Wrap. See Table 4.

Table 4. COST OF PRECOATED MEMBRANES*

Membrane	Material	Installation	Total
Bituthene	\$3.33/yd^2	\$0.54/yd^2	\$3.87/yd^2**
Polyguard	2.70	0.54	3.24
Protecto Wrap	3.42	0.54	3.96

*These are costs for application of unit areas of the precoated membrane itself and not cost per unit area of a roadway.
**To convert yd^2 to m^2 multiply by 0.8361.

For example; assume a two lane AC paved highway with 50 percent longitudinal reflective cracks of various lengths, with transverse cracks, 24 ft (7.3 m) long, at 20 ft (6.3 m) intervals. See Figure 4. The cost, for one mile (1.61 km) of the membrane treatment for the road, is \$5,132. One foot (0.3 m) wide Polyguard membrane was used for the estimate. The cost of the membrane treatment per yd^2 of roadway surface is \$0.36 cents. See Table 5.

Table 5. COST OF PRECOATED MEMBRANE FOR ONE MILE SECTION - TWO LANE HIGHWAY

Membrane quantity to cover longitudinal cracks per mile.
5280 ft x 1 ft wide x 3 longitudinal cracks x 50% = 7920 ft^2

Cost of membrane to cover longitudinal cracks, per mile.
7920 ft^2 x \$ 3.24/yd^2 ÷ 9 ft^2/yd^2 = \$2,851

Membrane quantity to cover transverse cracks, per mile.
5280 ft x 1 ft wide x 24 ft ÷ 20 ft = 6,336 ft^2

Cost of membrane for transverse cracks per mile.
6336 ft^2 x \$ 3.24/yd^2 ÷ 9 ft^2/yd^2 = 2,281

Total cost of treatment, per mile.
\$2851 for longitudinal cracks + \$2281 for transverse cracks = \$5,132

Cost of one mile treatment - two lane highway \$0.36/yd^2

For comparison, 1 inch thick AC costs approximately \$1.50/yd^2

All the precoated membranes are similar in total cost to the Polyguard example shown above.

CONCLUSION AND RECOMMENDATION

The precoated membranes applied in 1980 on US 183 at Rocky performed very well in diminishing and retarding reflective cracking. Bituthene and Polyguard adhered very well to the AC layers. Protecto Wrap membrane was disbonded from the FABB surface during the coring. Protecto Wrap, however was bonded very well to the AC layers.

No abrasion or tears were found in any of the three precoated membranes. Bituthene, Polyguard, and Protecto Wrap should provide good protection against the intrusion of water and consequent pumping of base or subgrade soil material.

It is recommended that Bituthene, Polyguard, Protect Wrap, or other precoated fabric with similar properties, be considered for use as a PCC joint or AC pavement reflective crack treatment when AC overlays are to be applied.

PETROTAC PRECOATED FABRIC MEMBRANE/PETROMAT SANDWICH

INTRODUCTION

Background

The prevalence of cracking in bituminous concrete overlays is a major factor contributing to the premature failure of a pavement system. This cracking is caused by cyclic stresses induced in the overlay by movement, whether vertical or horizontal, in the underlying pavement. These cracks permit water to enter the pavement structure, promote raveling, and disbonding of the overlay, and thus, present a continuous maintenance problem. Damage induced by these cracks ultimately requires extensive repairs of localized areas even though most of the pavement surface has many remaining years of serviceable life. Thus, any method of preventing the formation or reducing the severity of reflective cracks becomes highly desirable.

Many methods have been used in the effort to solve this problem including crack filling, pavement breaking, recycling, asphalt additives, stress relieving layers, seal coating and rubberized asphalt membranes. One method developed to reduce reflective cracking is the addition of a geotextile in the pavement structure. This use of fabrics is rapidly increasing in the United States and has attracted many manufacturers to introduce fabrics for the paving industry. These fabrics differ significantly in polymeric composition, methods of construction, and fabric structure.

Projects done with the use of nonwoven polypropylene fabrics in Oklahoma have shown good success (2). The use of precoated fabric membranes such as Polyguard, Bituthene, and Protecto Wrap over cracks and joints in PCC pavement also has shown very good performance for five years after the installation.

The highway selected for this experimental project was a badly cracked section of I 35 north of the city of Edmond (Bradbury Corner) in Oklahoma County. The average daily traffic (ADT) was 23,100 in 1983. This section was built in 1958. The existing jointed PCC slab was 24 ft (7.3 m) wide and 8 in (200 mm) thick, with 15 ft (4.6 m) joint spacing. The pavement system also had 4 in (100 mm) of sand cushion over 8 in (200 mm) of subbase.

Purpose

The purposes of the experimental project were as follows:

1. To determine the rate of formation of reflective cracking of joints and cracks.
2. To determine the effect of fabrics on the infiltration of water through joints and cracks into the PCC pavement.
3. To compare the performance of a nonwoven full width mat fabric interlayer with a precoated fabric strip membrane.

Scope

Project IR-35-4(105)141 was a 4.6 mi (7.4 km) resurfacing project on I 35 north of Edmond in Oklahoma County. The construction started in September, 1982 and ended in May, 1983. It began at the intersection of US 66 and extended north to Waterloo Road. This project included the installation of two types of reinforcing fabrics: a precoated strip membrane fabric, Petrotac (formerly Y-78), and full width Petromat as a "sandwich" interlayer. Petromat and Petrotac are products of Phillips Fibers Corporation.

Four 300 ft (91 m) sections were selected randomly for evaluation from the one mile long section that was treated with Petrotac.

Six 300 ft (91 m) sections were selected randomly from the Petromat treatment for evaluation.

Three 300 ft (91 m) sections also were selected randomly as the control (untreated) sections for comparison.

Each of the selected sections contained crack conditions representative of the entire project.

During the construction, some changes were made by the Oklahoma Department of Transportation. It was decided to crack and seat the PCC slabs in selected areas. Any soft subgrade sections were removed and replaced with full depth asphalt concrete (AC). All the sections will be monitored for five years.

The overlay consisted of 1 in (25 mm) of Type D AC (ODOT 708.04 SP.), 2 in (51 mm) of Type C AC (ODOT 708.04) and 3/4 in (19 mm) of Open Graded Friction Surface Course (OGFSC) (ODOT 708.04).

MATERIALS

Petrotac Properties

Petrotac is a combination of nonwoven polypropylene fabric precoated with rubberized asphalt. It is protected by a release sheet to be removed at the time of installation. Petrotac was a new product and was used for the first time in Oklahoma on this highway project. The physical properties are listed by the manufacturer, Phillips Fibers Corporation, as shown in Table 1.

Petromat Properties

Petromat is a needle punched, nonwoven polypropylene fabric manufactured by Phillips Fibers Corporation. The fabric was originally made for carpet backing. It has been used by the highway industry as a waterproofing and stress relieving membrane beneath the road surface. The properties of Petromat as listed by the manufacturer are shown in Table 2.

Table 1. PETROTAC PHYSICAL PROPERTIES*

Properties	Typical Value (Except as noted)	Test Method
Thickness, mils	75	ASTM D1777
Grab Tensile, lbs (MD)	180	ASTM D1682
(XMD)	190	
Elongation, % (MD)	85	ASTM D1682
(XMD)	75	
Strip tensile, lbs/in	60	ASTM D882 (modified for 1 in spacing between grips)
Puncture resistance, lbs	200 325*	ASTM E154 (*modified for strain rate of 12 inch/min)
Puncture resistance, lbs	80	CW02215-Corps of Engineers
Permeance - Perms	0.10 (max)	ASTM E96 Method B
Pliability ¼ in mandrel 180° bend at -25°F	No cracks in fabric or rubberized asphalt	ASTM D146
Adhesion to concrete Shear strength, psi		
@ 140°F	4	PFC Test Method, shearing rate 1 in/min.
@72°F after 28 days in water	8	

* 1983

Table 2. PETROMAT PHYSICAL PROPERTIES

Properties	Typical	Minimum
Weight, oz/yd^2	4.3	3.8
Tensile Strength, lbs (1)	115	90
Elongation-at-Break, % (1)	65	55
Asphalt Retention, gals/yd^2 (2)	-	0.20
Color	Black	
Width, inches (3)	75 & 150	
Length/Roll, yds	100	

(1) ASTM Method D-1682-64
(2) Phillips Procedure
(3) Other widths available on special order

CONSTRUCTION

Petrotac Installation

A one mile section in the southbound lanes received Petrotac. See Figure 1. Petrotac was installed by the contractor's two-man crew. It was applied over the transverse joints, longitudinal joints, and diagonally cracked PCC surface. See Figure 2. Prior to installation, the longitudinal and transverse joints and cracks wider than 3/8 in (10 mm) were sealed with SS-1 emulsion.

Petrotac was centered over joints and cracks. No tack coat was required for the installation of Petrotac. Transverse joints and cracks were treated prior to treating the longitudinal joints. The transverse joints and selected cracks were covered by hand. For the installation of the longitudinal joints, the manufacturer furnished a special laydown machine. See Figure 3.

It took between 1 and 2 minutes to install a 25 ft (7.6 m) long Petrotac strip over the cracks and transverse joints. The longitudinal joint installation went four times faster. A 102 ft (31 m) roll of Petrotac was installed over one longitudinal joint in 1-2 minutes using the special laydown machine.

Petrotac was installed in two areas. The first was installed from Sta. 958+00 to Sta. 1004+70. The second area installed from Sta. 840+10 to Sta. 843+45.

Four 300 ft (91 m) sections were selected from the first Petrotac area and all the second Petrotac area was selected for evaluation. These sections are marked on the shoulder.

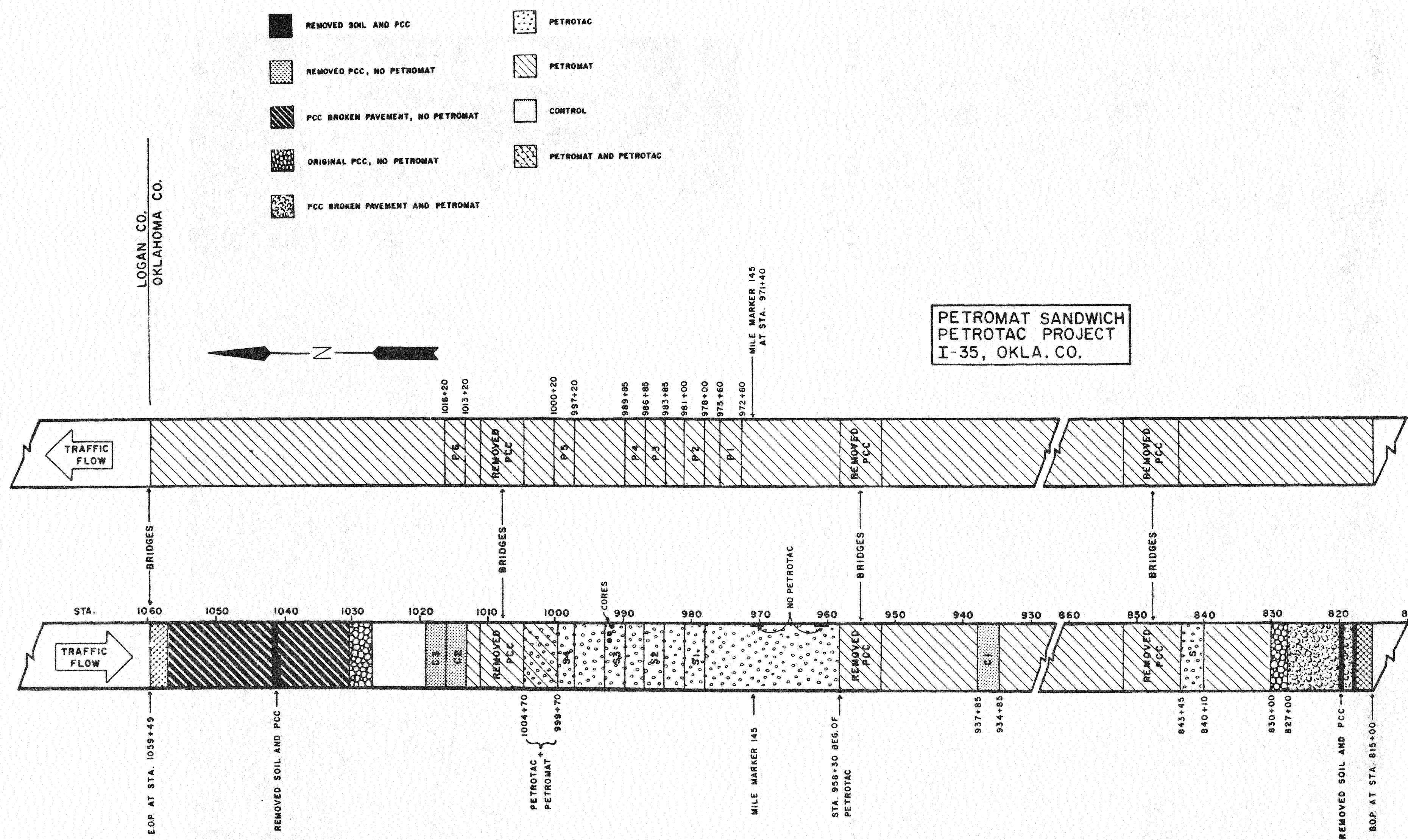

Figure 1. PCC Pavement treatment sections, I 35, Oklahoma County.

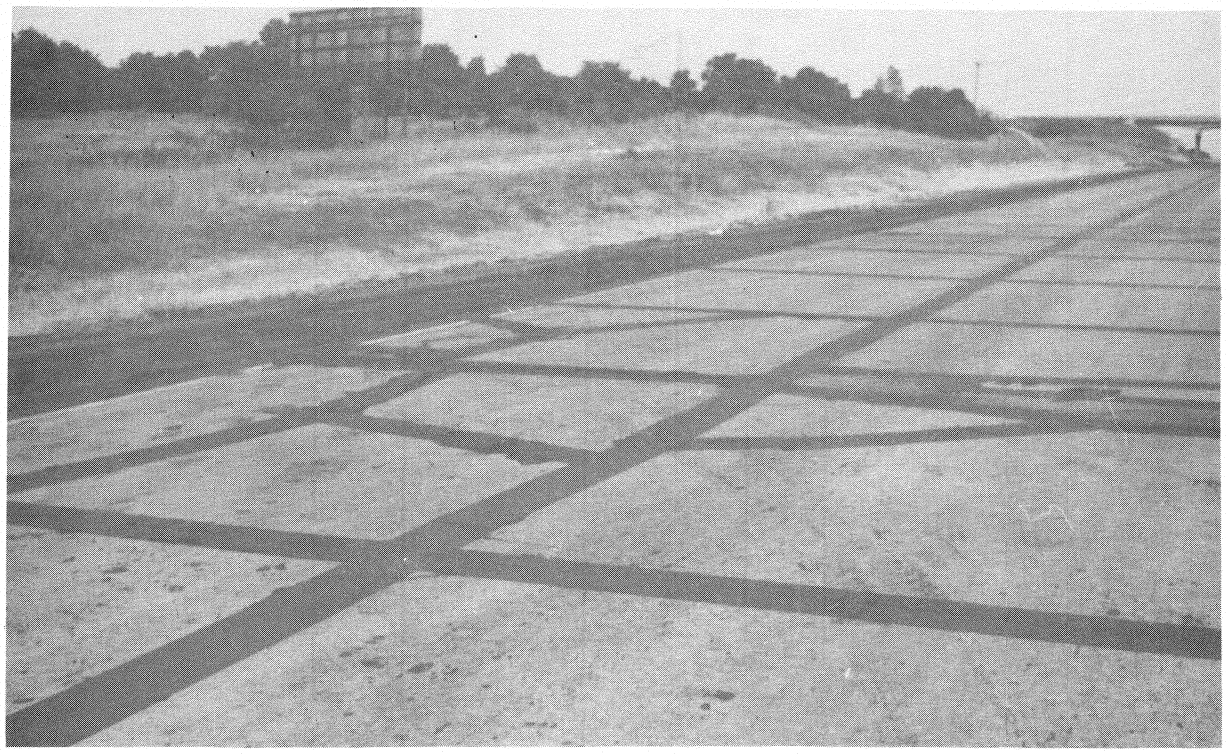

Figure 2. Petrotac installed over the transverse, and longitudinal joints, and diagonal cracks in PC concrete pavement.

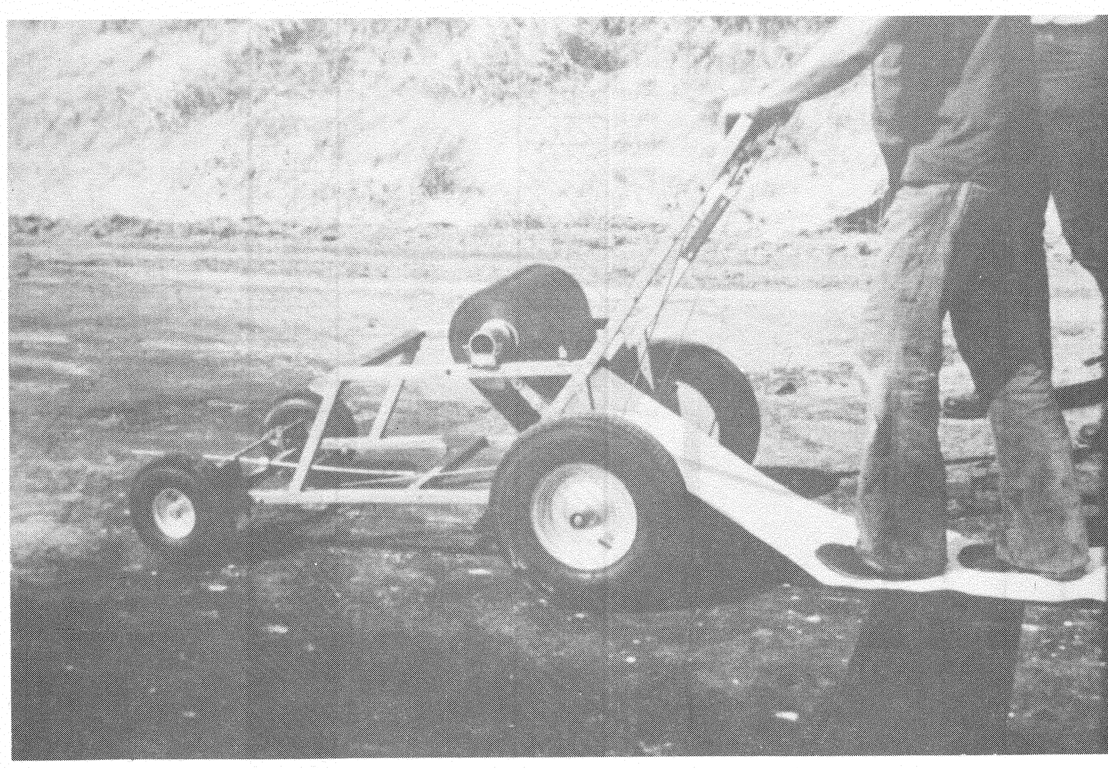

Figure 3. A special laydown machine was used to install the Petrotac over the longitudinal joints.

No Petrotac was installed over the longitudinal joints at the inside shoulder in two locations. These were from Sta. 960+00 to Sta. 962+00 and from Sta. 969+40 to 971+40. See Figure 1. These two control sections will be monitored and compared with the treated sections.

Petrotac was exposed to construction traffic for 14 days. Petrotac was covered with 1 in (25 mm) of Type D AC, then 2 in (50 mm) of Type C AC, and 3/4 in (19 mm) of OGFSC. Approximately 0.05 gal/yd^2 (0.23 l/m^2) of SS-1 emulsion was used as a tack coat for each layer.

Petromat Installation

Petromat was installed in the entire 4.6 miles (7.4 km) of the project except where Petrotac sections and control (untreated) sections are located. See Figure 1. All the joints and cracks were first sealed with one treatment of SS-1 emulsion. The existing PCC was overlaid with 1 in (25 mm) of Type D AC.

Petromat then was installed over the Type D AC using AC-3 (85-100 penetration) as a tack coat. See Figure 4. The tack coat application ranged from 0.22 gal/yd^2 (1.0 l/m^2) to 0.29 gal/yd^2 (1.3 l/m^2). The speed of the laydown machine was about 5 mi/hr (8 km/hr). Petromat was covered with 2 in (50 mm) of Type C AC and 3/4 in (19 mm) of OGFSC.

Six 300 ft (91 m) sections from the northbound lanes were selected at random for evaluation.

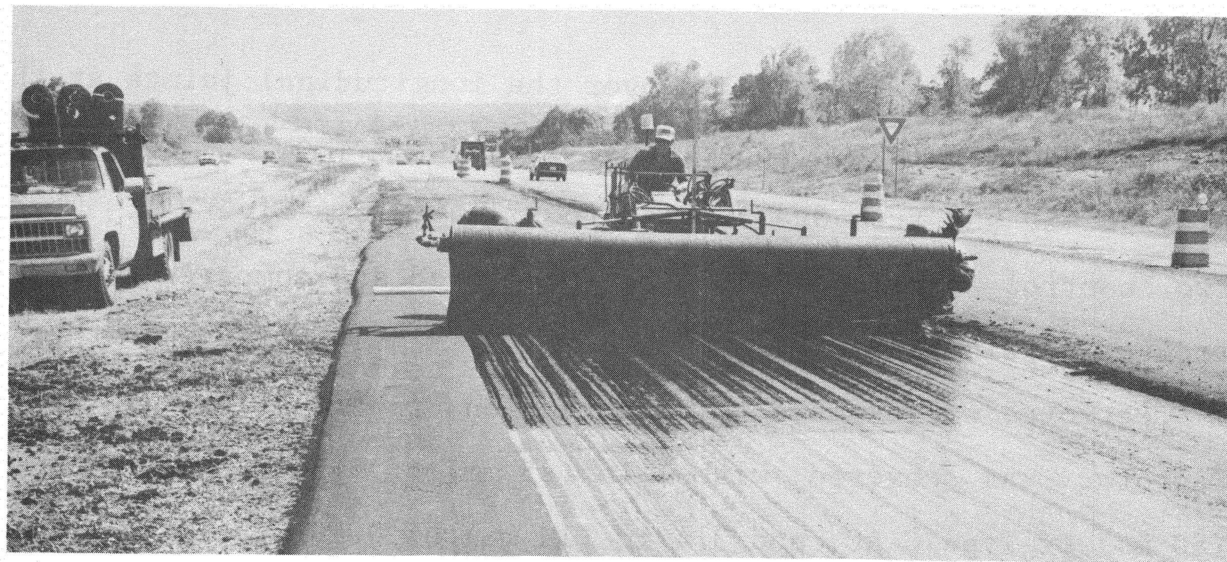

Figure 4. Petromat was applied over the Type D AC.

Figure 5. The existing slabs were cracked with a pile driver type pavement breaker where removal or seating was desired.

Pavement Breaking and Removing

During construction, some changes were made by the Oklahoma Department of Transportation. It was decided to "crack and seat" the PCC slabs in severely damaged areas in the southbound lanes. See Figure 1.

The existing PCC slabs were cracked with a pile driver type pavement breaker. See Figure 5. The cracked pavement was first rolled with a fifty ton steel wheeled roller to ensure that the pavement pieces were seated firmly against the subgrade. See Figure 6. Two or three passes were required to seat the cracked pavement. Also, a 10 ton single-drum vibratory roller was used where the cracked pavement overlaid a soft subgrade.

Any highly unstable subgrade sections were removed and patched with full depth Type A AC. See Figures 7 and 8. The locations of removed sections are shown in Figure 1. SS-1 emulsion was applied onto the broken pavement at the rate of 0.03 gal/yd^2 to 0.04 gal/yd^2 (0.14 l/m^2 to 0.18 l/m^2). The pavement was then overlaid with a leveling course of 1 in (25 mm) of Type D AC.

Petromat was placed on the leveling course and covered with an average of 2 in (50 mm) of Type C AC and 3/4 in (19 mm) of OGFSC.

Note: No Petromat was placed over the extents that were cracked and seated or those that were removed and replaced with AC pavement, from Sta. 815+00 to 817+50 and from Sta. 1030+00 to Sta. 1059+49. See Figure 1. This was done to allow a comparison among the above treatments with and without Petromat.

Figure 6. The cracked pavement was rolled with a steel wheeled roller to ensure seating.

Figure 7. Soft subgrade sections were removed and replaced with AC.

Problems

Petrotac. Minor problems were encountered in removing the release paper from the rubberized asphalt layer of Petrotac.

A wet surface in one case caused the Type D AC leveling course mix not to bond to the existing pavement. Therefore, the new overlay had to be removed with a front end loader. This caused the Petrotac to be disturbed and peeled back in a few areas. Total replacement of damaged Petrotac was not possible due to a well developed adhesion bond between the fabric and pavement surface. A new piece of Petrotac was installed directly over the damaged Petrotac to correct the problem.

Construction traffic disturbed the Petrotac in some areas. See Figure 9

Petromat. There were some difficulties with the spray bar on the asphalt distributor. Although an attempt was made to adjust the spread of the nozzles, the tack coat for the Petromat was applied twice in order to get even coverage. See Figures 10 and 11.

Heavy construction traffic also disturbed the Petromat. See Figure 12 and 13. The damaged Petromat sections were left in place and were not replaced.

Petromat was more susceptible to construction traffic damage than Petrotac.

Figure 8. A PCC pavement section. It was removed and patched with full depth Type A AC mix.

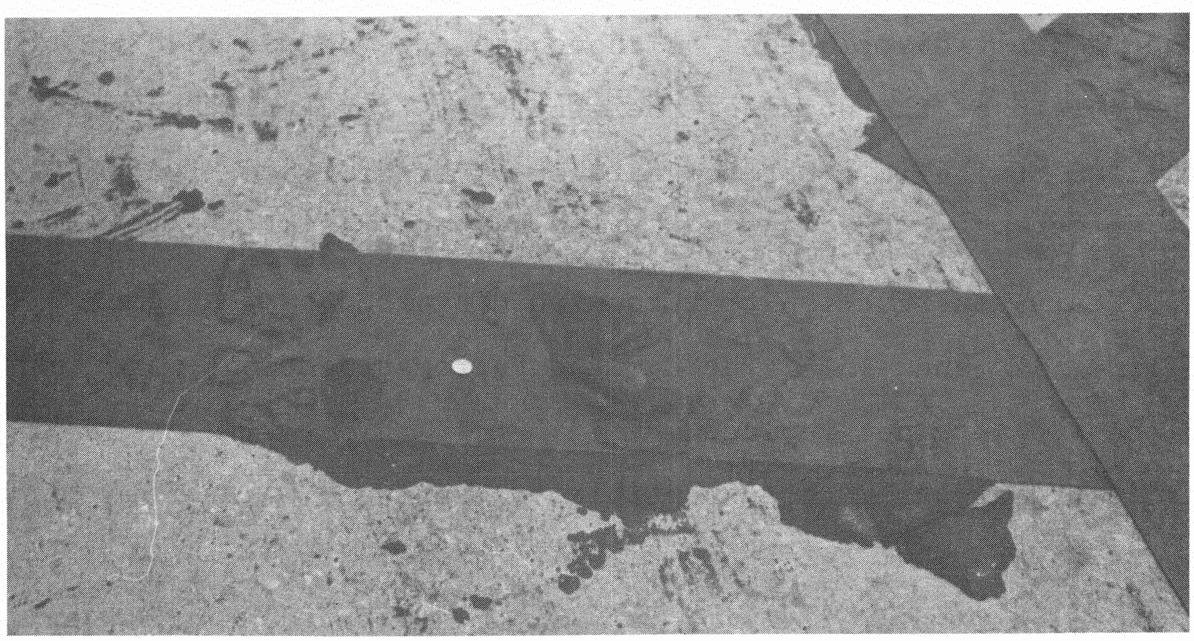

Figure 9. The disturbance of Petrotac was due to construction traffic.

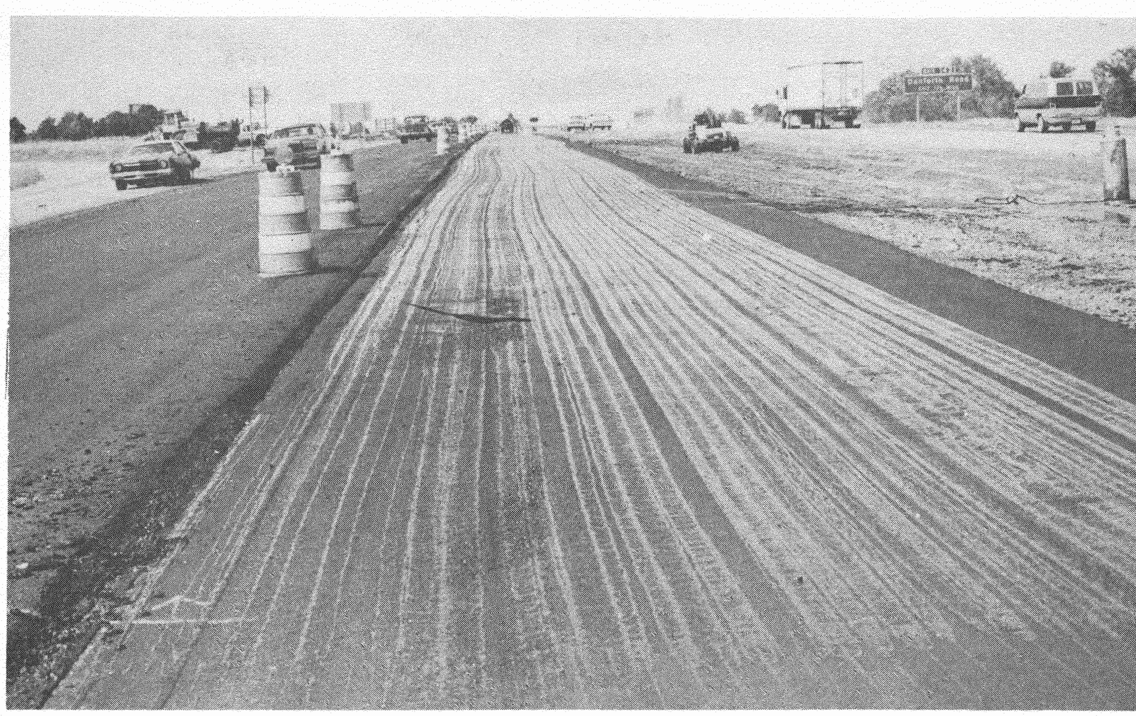

Figure 10. The tack coat was not spread uniformly due to a faulty asphalt distributor.

Figure 11. The tack coat for the Petromat was applied twice in order to get even coverage.

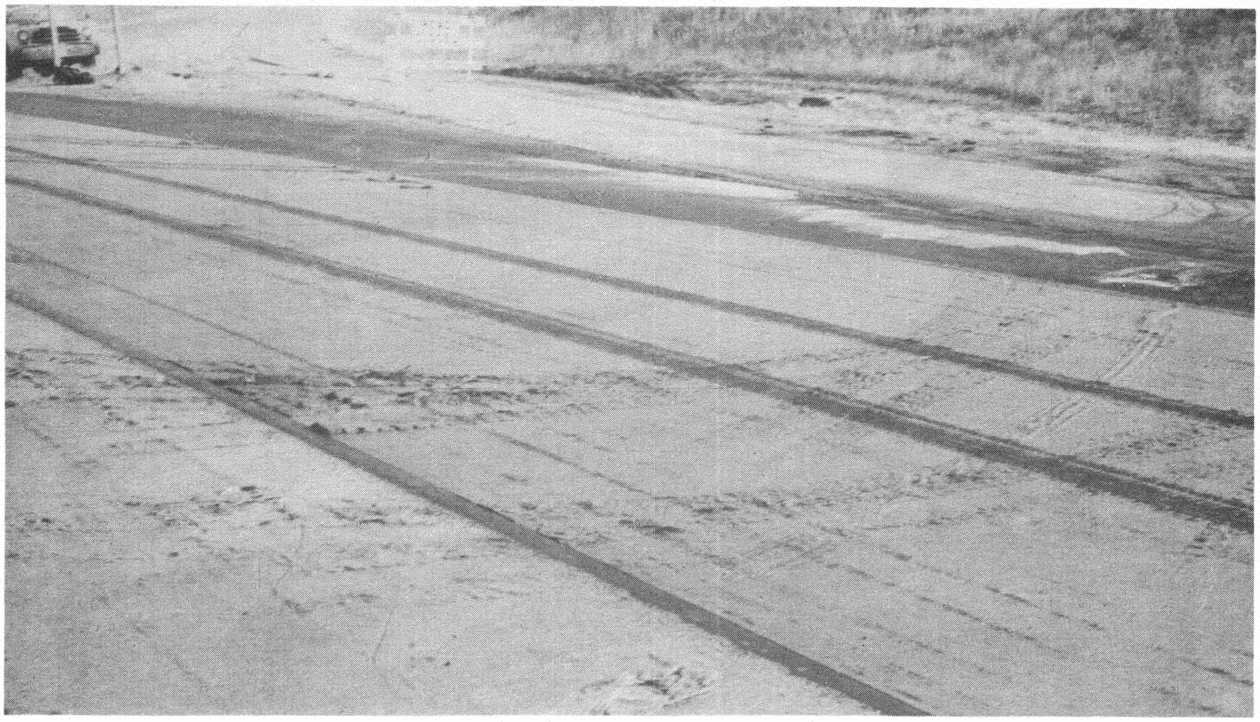

Figure 12. Petromat disturbance caused by heavy construction traffic turning on the treated surface.

Figure 13. View of disturbed Petromat.

EVALUATION

Three days after the Type D AC was placed over the Petrotac, several transverse and longitudinal cracks were observed in the 1 mi (1.6 km) Petrotac section. See Figure 14. Three cores were taken for visual evaluation. One core was taken over the longitudinal crack at the edge of the inside shoulder. One core was taken over the transverse crack in the left lane (Figure 15) and the other over a transverse joint with no visible crack in the right lane.

The Type D leveling procedure produced a thin overlay with less than 1 in (25 mm) thickness in the inside lane. The rolling of the thin mat produced cracks over the PCC pavement joints. The coring revealed that an overlay of 1 in (25 mm) of Type D AC or less does not provide enough support to prevent cracking during compaction. The overlay thickness over the reflected transverse crack was 0.50 in (13 mm). The Type D AC layer over the reflected longitudinal crack had a 0.75 in (19 mm) thickness.

The overlay thickness over the transverse joint with no reflective crack was 1.40 in (35 mm).

No tears or disturbances were observed in the three Petrotac cores. See Figure 16. Petrotac was bonded well to the PCC slab in all cases.

Both Petrotac and Petromat performed well under construction traffic. Some disturbance from turning movements and tire skid marks across the fabric were noticed during construction.

Petromat was damaged more than the Petrotac. Allowing traffic on the unprotected fabric installation should be permitted only with caution. In the Petrotac areas reflective cracks were propagated over the joints where the overlay thickness was less than 1 in (25 mm).

The data from field studies by the Oklahoma Department of Transportation indicate a 1 1/2 in (38 mm) minimum AC thickness gives additional support to an existing pavement structure (1). Heavy traffic on a thin overlay should be kept to a minimum. This will help prevent cracks from reflecting through the thin lift.

Coring revealed that the SS-1 joint sealant did not fill the joints very well. A good job of filling joints would assist the fabrics in their function. This should be evaluated in future projects.

There are many advantages in using pavement cracking and seating as a means of developing stability and thus reducing reflection cracking in asphalt overlays. The technique uses readily available equipment. Compared with most other alternatives, pavement cracking and seating is energy efficient, as no materials are removed for disposal and no additional materials are required for reflection crack control.

The disadvantage of cracking the PCC pavement is that the structural strength of the PCC pavement is reduced. To what degree the strength of the pavement system is reduced should be investigated.

Figure 14. Close view of transverse crack over joint in Petrotac treated section - overlay less than 1 in. thick.

Figure 15. Core taken over the reflected transverse crack in the Petrotac section - overlay less than 1 inch thick. Note the "sealed" joint.

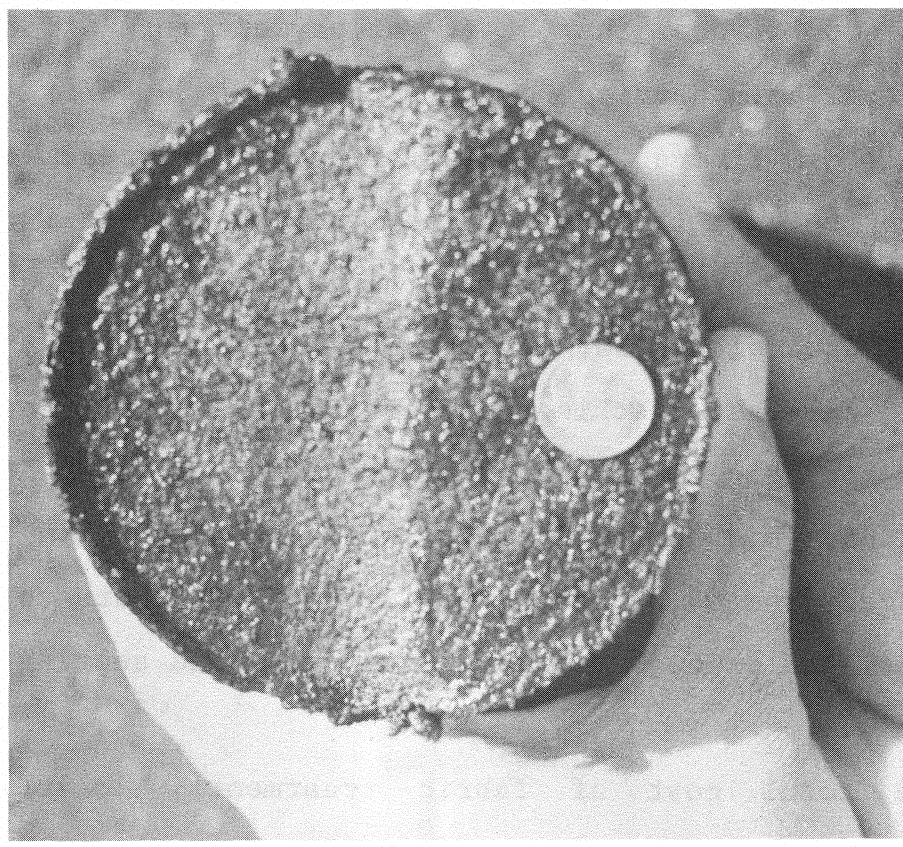

Figure 16. Four inch core taken over 1 inch joint, showing no damage to the Petrotac membrane.

COST ANALYSIS

Table 3 summarizes the materials and in-place 1982 costs for the project. Note the basis of payment for Petrotac was per linear ft. The bid price for Petrotac was \$0.45/ft (\$1.48/m). The Phillips Fibers Corporation price for Petrotac was \$0.36/ft including freight, laydown machine, and the operator. The costs for different treatments shown in the table were converted to obtain an equivalent cost per square yard. Note that the price for the pavement cracking and seating is a negotiated price and is not a bid price. According to the National Asphalt Pavement Association, bid prices for cracking and seating in the fall of 1982 ranged from \$0.20 cents to $\$1/yd^2$ (\$0.26 cents to $\$1.20/m^2$). The negotiated price for pavement cracking and seating was $\$4/yd^2$ ($\$4.80/m^2$).

The total cost of fabric treatments, including crack sealing, was $\$0.85$ cents/yd^2 ($\$1.59/m^2$) of pavement with Petromat and $\$0.95$ cents/yd^2 ($\$1.14/m^2$) with Petrotac. The price of pavement breaking and removing and then replacing it with 8 in (200 mm) of AC was $\$12.92/yd^2$ ($\$15.57/m^2$). Approximately $\$5.58/yd^2$ ($\$6.72m^2$), the price of a 3 3/4 in (95 mm) overlay, should be added to each treatment to arrive at the total cost of the pavement rehabilitation. See Table 4 for the itemized cost of treatments.

Table 3. COST ANALYSIS

Material	Equivalent Cost of Treatment per yd^2
Petromat fabric, Phillips Fibers Corporation price.	$0.41
Petromat fabric, bid price	.50
Bituminous binder, bid price	.18
Petrotac Precoated, Phillips Fibers Corporation price	.62
Petrotac Precoated, bid price	.72
Crack and joint sealing, bid price (SS-1 emulsion)	.17
Pavement breaking and removing of PCC, bid price	1.00
Pavement cracking and seating of PCC, negotiated price	4.00
Type C asphalt concrete 1 in thick, bid price	1.49
Type D asphalt concrete 1 in thick, bid price	1.49

Table 4. COST OF PAVEMENT TREATMENTS/yd^2

Operation	Standard Petromat Treatment	Petrotac Treatment	Pavement removal replace with AC	Crack & seat slabs	Pavement removal replace with AC+ Petromat	Crack & seat slabs +Petromat
Fabric	$0.68	$0.78	-	-	$0.68	$0.68
Crack Sealing	0.17	0.17	-	-	-	-
PCC Breaking & Seating	-	-	$1.00	-	1.00	-
PCC Cracking & Seating	-	-	-	4.00	-	4.00
Replacing PCC with 8 in AC	-	-	12.92	-	12.92	-
Overlay 3 3/4 in AC*	5.58	5.58	5.58	5.58	5.58	5.58
Total Cost of Treatment	$6.43	$6.53	$19.50	$9.58	$20.18	$10.26
Cost Comparisons	100%**	102%	303%	149%	314%	164%

* This lift thickness includes the Type D, C, and OGFSC

** Base percentage

CONCLUSION AND RECOMMENDATION

The performance of Petrotac and Petromat over the PCC slab remains to be determined. A visual examination of cores taken during construction showed no tears in either Petrotac or Petromat in the area of the joints. Petrotac and Petromat performed well under the construction traffic. Petromat was more susceptible to damage than Petrotac.

The Type D leveling course of less than 1 in (25 mm) showed reflective cracking three days after placement. Allowing traffic on thin AC overlays of less than 1.5 in (38 mm) will probably cause cracks to reflect almost immediately.

Coring revealed that the joints were not sealed properly. This should be evaluated in future projects.

Pavement cracking and seating as a means of reducing reflection cracking in asphalt overlays is promising. However, this technique will reduce the structural strength of pavement. To what degree this strength is reduced should be investigated.

The pavement treatment with Petromat was the least expensive at \$6.43/yd^2 (\$7.75/m^2) and pavement removing and replacement with AC was the most expensive at \$12.92/yd^2 (\$15.57/m^2). The total cost for pavement rehabilitation with Petrotac was \$6.53/yd^2 (\$7.87/m^2). The pavement cracking and seating was \$9.58/yd^2 (\$11.54/m^2).

The study areas have been marked on the shoulder. The test sites will be evaluated for performance on an annual basis for five years. The evaluation will include a condition survey and ride quality observations.

While the long-term performance of Petrotac and Petromat remains to be determined, their use is feasible. It is recommended that Petrotac and Petromat be used over the joints and cracks on PCC pavements prior to an asphalt concrete overlay.

REFERENCES

1. American Association of State Highway Officials, Interim Guide for Design of Pavement Structure, 1976.

2. Pourkhosrow, Ghasem, "The Evaluation of Nonwoven Fabrics: Petromat and Mirafi", Oklahoma Department of Transportation, May, 1982.

APPENDIX A

SPECIFICATION

OKLAHOMA DEPARTMENT OF TRANSPORTATION
PROPOSED SPECIAL PROVISIONS
FOR
PRECOATED FABRIC MEMBRANE

These Special Provisions revise, amend, and where in conflict, supercede applicable sections of the Standard Specifications for Highway Construction Edition of 1976.

414.01. DESCRIPTION. This work shall consist of the application of a precoated fabric membrane. This material is to be placed over cracks and joints in Portland cement concrete pavements in reasonably close conformity with the dimensions as shown on the plans or established by the Engineer.

414.02. MATERIALS. (a) Precoated Fabric. The fabric membrane shall be rubberized asphalt or plasticized coal tar or other modified asphalt impregnated woven or non-woven synthetic fabric attached to release paper which is removed at the time of installation.

The fabric shall meet the following test requirements.

Tests	Limit	Test Method
Weight	45-50 oz./yd.^{2}	ASTM D 2646 (wo/paper release)
Thickness	0.065 inches, min. (1.65 mm)	
Tensile strength, lbs. (MD and XMD)	150, min. (68 kg.)	ASTM D 1682
Strip tensile strength, lbs.	50, min. (23 kg.)	ASTM D 882
Puncture Resistance, lbs.	200, min. (91 kg.)	ASTM E 154
Pliability - 1/4 in. (6.4 mm) mandrel, 180° bend at 15°F (-9°C)	No cracks in mesh or pre-coat material	ASTM D 146
Permeance - Perms (grains/SF/hr./in. Hg)	0.10, max.	ASTM E 96 (Method B)

The membrane shall be furnished by the manufacturer in rolls suitable for handling and placement.

(b) Certification: The Contractor shall furnish a Type "A" Materials Certification for the precoated membrane in accordance with Section 106.12. A three square yard (2.7 sq. m) sample of the fabric shall also be furnished the Materials Engineer from each lot or shipment for testing.

414.03. (a) Equipment and tools necessary for performing all parts of the work shall be furnished by the Contractor in conformance with Section 108.06.

(b) Miscellaneous Equipment. Miscellaneous equipment shall include stiff bristle brooms to smooth the fabric and scissors (or blades) to cut the fabric.

414.04. CONSTRUCTION METHODS. (a) Surface Preparation. Pavement surface shall be free of dust, surface moisture, and vegetation. Cracks wider than 3/8 inch (10 mm) or wider than the D 90 of the bituminous overlay mix, whichever is wider, shall be filled with bituminous material and Portland cement concrete slabs shall be stabilized.

Any spall greater than three inches (75 mm) in diameter which will cause a failure of the material to bond to the pavement or will leave a cavity under the material shall be corrected prior to the placement of the membrane. Spalls shall be repaired using asphalt concrete such as cold patching material as approved by the Engineer.

(b) Application of Bituminous Binder. Bituminous binder, if required, shall be applied at a minimum rate of 300 square feet per gallon (7.4 square meters per liter) or in accordance with the Manufacturer's recommendations, prior to placement of the membrane. The binder will extend one inch (25 mm) wider than the membrane, and will be allowed to dry until tack-free before applying the membrane.

(c) Placement of Membrane. The membrane shall be centered over joints to be treated and then tamped or rolled. Transverse joints and cracks shall be treated before longitudinal joints. Should a crack require more than one strip, the strips shall be overlapped at least 2 1/2 inches (60 mm) in the direction of paving. Every effort shall be made to lay the membrane as smoothly as possible. The membrane shall be broomed to remove air bubbles and maximize membrane contact with the pavement surface. Wrinkles shall be cut and laid out flat.

If misalignment of the membrane occurs, it shall be cut, realigned, removed, replaced, and jointed as directed by the Engineer.

(d) Weather Limitation. The membrane shall not be applied when the air temperature is less than 50°F (10°).

(e) Width Limitation. The membrane shall be installed in widths of 11 3/8 inches (290 mm) minimum.

Traffic may be allowd on the membrane for a reasonable period of time prior to application of tack coat and overlay.

(f) Pavement Overlay. An asphalt emulsion tack coat shall be applied over pavement and membrane. It is very important that the emulsion be allowed to break completely. Cut back asphalts shall not be used. Paving mix should be applied as specified; however, an overlay thickness of less than 1 1/2 inches (38 mm) is not recommended. Any damage or disbonding of the membrane caused by traffic or wet weather conditions due to unnecessary delay or negligence of the Contractor shall be repaired at his own expense.

The temperature of the paving mix at time of placement on the membrane shall not exceed 325°F (163°C) to prevent damage to the membrane.

Should equipment tires pick up the membrane or the paver cause movement of the membrane during paving operations, the Contractor may broadcast asphalt paving mix ahead of trucks and paver to prevent damage. Any damage to the membrane shall be repaired by the Contractor at his expense.

414.05. METHOD OF MEASUREMENT. Precoated fabric membrane shall be measured by the linear foot in place.

414.06. BASIS OF PAYMENT. The accepted quantities of precoated fabric membrane measured as provided above will be paid for at the contract unit price for:

SP.	PRECOATED FABRIC MEMBRANE	LIN. FT.

which shall be full compensation for finishing all materials, equipment, labor and incidentals to complete the work as specified.