

CONTROL OF REFLECTION CRACKING IN A FABRIC-REINFORCED OVERLAY
ON JOINTED PORTLAND CEMENT CONCRETE PAVEMENT

by

K. H. McGhee
Senior Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

A study of the installation and three-year performance evaluation of a fabric-reinforced bituminous concrete overlay of a jointed concrete pavement is reported. The fabric, a nonwoven polypropylene in an asphaltic mastic, was shown to act as a significant deterrent to the development of reflection cracks in an overlay exposed to over 30,000 vehicles per day for the evaluation period. A recommendation for further use of the fabric is included.

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INTRODUCTION

Transverse joints in rigid pavements typically reflect through relatively thick bituminous concrete overlays in a short period of time. Extensive efforts to prevent or retard such reflection cracking, which have been carried out over many years, have been only partially successful. Studies of several test sections installed in the early to mid-1970s have shown that the principal mechanism of such cracking relates to vertical movements of the joints under dynamic wheel loads.⁽¹⁾ Also, the studies have shown that fabric reinforcing layers and bond-breakers serve only to delay the cracking for a period of time dependent upon characteristics of the pavement and the volume of heavy traffic utilizing the roadway.⁽¹⁾ These same studies have shown that when the load transfer across joints approaches 100%, fabric may prevent reflection cracking. On the other hand, when differential deflection between two sides of a joint is as much as about 0.002 in. (51 μ m), the cracking is almost certain to occur very quickly with or without the fabric reinforcement.

A positive finding of these studies is that the reinforcing fabric is not torn by the formation of reflective cracking so that it likely acts as a waterproofing membrane.

In the summer of 1979 the Research Council, the Maintenance Division, and the Manassas Residency cooperated in the installation of an overlay reinforced with a heavyweight construction fabric composed of asphalt mastic and nonwoven polypropylene. This material, like many others, is purported to reduce or delay the incidence of reflection cracking and to aid in waterproofing the underlying concrete pavement through providing an effective seal at transverse and longitudinal joints.

EXPERIMENTAL FEATURES

Description of Pavement

The pavement selected for the test installation is on the northbound lane of Interstate 95 in Prince William County. The test section begins at an expansion joint between the pavement

and the bridge over Powell Creek just north of milepost 155. The section reaches northward for a distance of 0.24 mile (0.39 km) and includes twenty 61.5 ft. (18.8 m) long reinforced portland cement concrete slabs. An adjacent pavement section of similar length was established as a control section to be resurfaced without the use of a fabric. The test and control pavement consists of three 12 ft. (3.7 m) wide lanes.

The original pavement was constructed on a 6 in. (150 mm) crushed aggregate subbase. It was built in 1964 and has sustained over 10 million 18,000 lb. (8,160 kg) equivalent axle loads. Some of the transverse joints have been mildly to seriously damaged by pumping, blowups, and deterioration related to a metal-insert used to form the joints.⁽²⁾ Undermining caused by pumping had been corrected by undersealing with liquid asphalt a few months before the test section was installed. Nearly all joints in the outside or truck lane were damaged while those in the inner two lanes were in fairly good condition.

Deflection tests made at the joints in the truck lane immediately prior to installation of the test sections resulted in the distribution of differential joint deflections shown in Table 1, where zero differential deflection indicates that the joint load transfer is 100% efficient. Such high efficiency may also suggest nonworking joints.

Table 1
Differential Deflection of Transverse Joints
in Truck Lane

<u>Deflection (1/1000 in.)</u>	<u>Number of Joints</u>	
	<u>Test Section</u>	<u>Control Section</u>
0.0	8	7
0.002	8	5
0.004	1	8
0.006	1	0

Metric conversion: 1 in. = 25.4 mm

Material

The construction fabric used consists of unwoven polypropylene with 0.9 gal./yd.² (4 l/m²) of a patented asphalt mastic. Typical specifications for the material and its installation as furnished by the manufacturer are appended to this report.

APPLICATION

Fabric

Fabric was installed on the test section by state forces from the Dale City area headquarters on June 6-7, 1979.

The following method of application was used.

1. Large irregularities such as joint spalls were filled to approximate grade with asphaltic concrete type S-5. Many small spalls and cracks were ignored since the fabric suppliers claim the material will overcome small irregularities. Joints typical of both the test and control sections after this preparatory work are depicted in Figure 1. Surveys of the outside lane joints showed that 19 of the 20 on the test section were mildly to seriously spalled, as were 16 of the 20 in the control section.
2. Liquid asphalt type AC-20 was secured from a local asphalt plant and brought to the job site in a heated tar kettle. The asphalt was hand spread at a width of approximately 2 ft. (0.6 m) so as to span the joint to be treated.
3. After a few minutes of cooling to achieve tackiness of the liquid asphalt, the fabric was unrolled, aligned with the joint, and seated in the asphalt by brooming. The 20 in. (0.50 m) wide fabric applied in this manner formed a ribbon spanning approximately 10 in. (0.25 m) on either side of the treated joints as shown in Figure 2.
4. Excess asphalt on the edges of the fabric was blotted with a sand blanket to prevent wheel tracking and the pavement was reopened to traffic.

The fabric was applied in the above manner to the previously selected 20 transverse joints and to the pavement shoulder joint on each edge of the concrete pavement. Since experience has shown little reflection cracking associated with longitudinal joints between lanes of concrete pavement, no fabric was used in those locations.

Bituminous Concrete Resurfacing

The fabric was exposed to traffic of some 25,000 vehicles per day from June 7, 1979, to July 10, 1979, when the pavement was resurfaced.

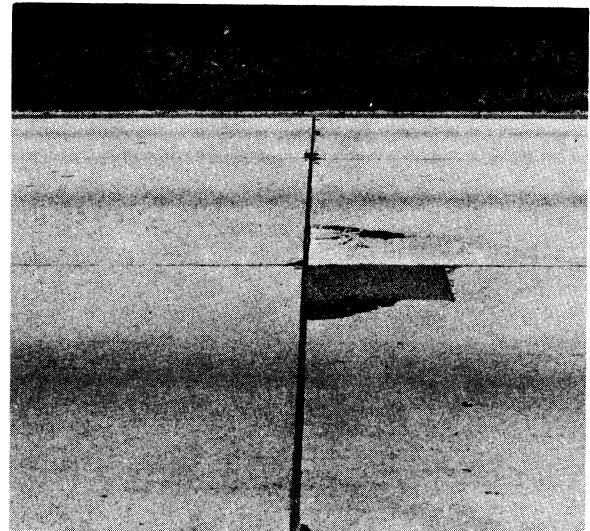
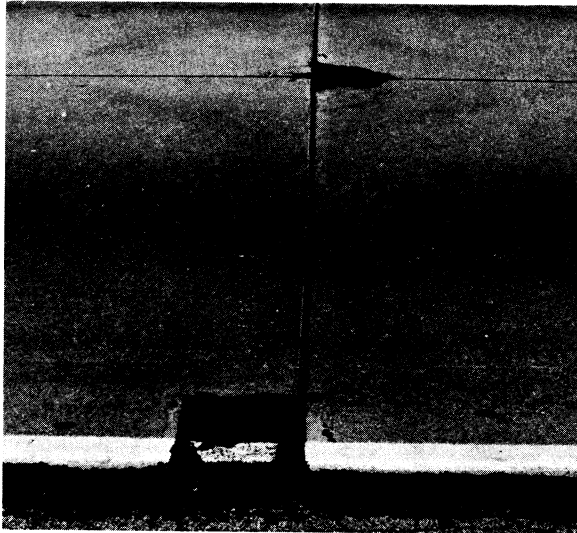


Figure 1. Typical joint on test section (left) and control section before treatment.

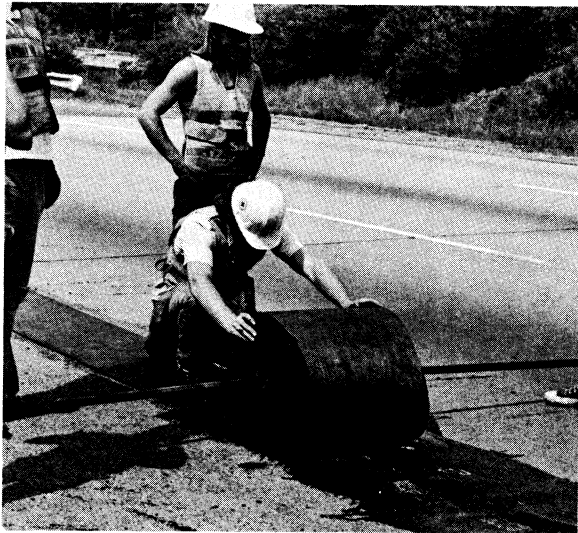


Figure 2. Installing fabric over pavement shoulder joint (left), and finished job.

Condition surveys immediately prior to the overlay showed the fabric to be in excellent condition. The only small defects noted were some wheel path locations where the fabric had been mildly frayed by traffic. Figure 3 shows the condition of the fabric at the time of the overlay.



Figure 3. Fabric after four weeks under traffic.

Resurfacing consisted of the application of 300 lb./yd.² (160 kg/m²) of bituminous concrete type I-2 and 1 1/2 in. (38 mm) of type S-5. The resurfacing was applied by two pavers operating in adjoining lanes. All three lanes and both shoulders were resurfaced. There was no evidence of fabric roll or tearing under the tracks of the paver even though a fairly liberal tack had been applied.

COSTS OF FABRIC INSTALLATION

Since the fabric was installed by state forces in preparation for resurfacing by contract, no direct cost figures were developed.

However, materials suppliers indicate that the fabric costs approximately 40¢/ft.² (\$4.44/m²). If the cost of installing the fabric approximately equals the cost of the material, the 20 in. (0.5 m) wide fabric can be placed along joints for approximately \$1.50/lin. ft. (\$5.00/m). On 24 ft. (7.2 m) wide pavement with joints spaced at 61.5 ft. (18.8 m), treatment of all transverse joints and the two longitudinal edge joints would add approximately \$20,000/mile (\$12,500/km) to the cost of resurfacing.

RESULTS

Both the fabric test section and the control section have been observed monthly from the time of installation to the present. Reflection cracking began to appear in the transverse joints of the control section during the winter of 1979-80, and by April 1980 was visible at all joints in that section. No cracking occurred in the test section until the winter of 1980-81. The results of a full survey of the test and control sections in April 1982 are summarized in Table 2, where partial cracking indicates cracking only part way across the lane while full cracking is full lane width.

In the table, the distribution of cracking by lane clearly shows the influence of heavy traffic on crack development. Note that cracking in the test section is progressively worse going from the heaviest to the lightest travelled lane.

Table 2
April 1982 Survey

	<u>Percentage of Joints Reflected By Lane*</u>					
	<u>Test Section</u>			<u>Control Section</u>		
	<u>O</u>	<u>M</u>	<u>I</u>	<u>O</u>	<u>M</u>	<u>I</u>
No Crack	0	20	45	0	8	8
Partial Crack	45	55	35	0	8	8
Full Crack	55	25	20	100	84	84

*O = outer lane, M = middle lane, I = inner lane.

As demonstrated in Table 2, the fabric has been very beneficial for three years under traffic. While cracking has reflected through the fabric at most of the joints, many are faint cracks discernable only upon close inspection (Figure 4). Roughness tests indicate that such cracks do not yet contribute to a reduction in pavement ride quality. Joints at which there was no cracking after three years are those shown by earlier deflection tests to fully transfer wheel loads.

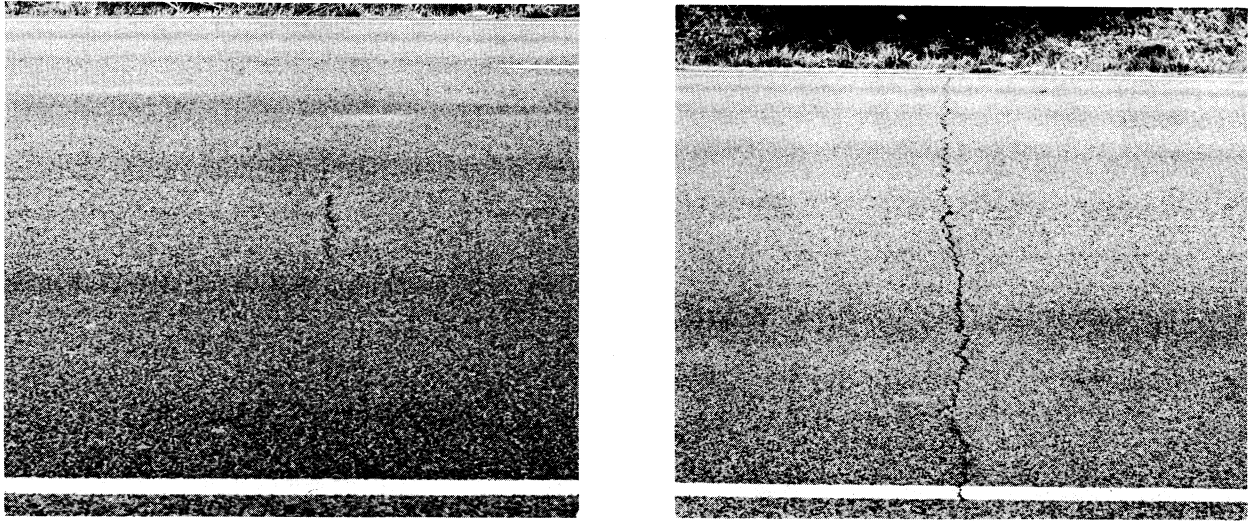


Figure 4. Typical reflection cracks on test section (left) and control section after two years.

Although not shown in Table 2, after three years all joints in the control section have resulted in obvious cracks in the outer lane overlay (Figure 4). This cracking may soon contribute to a rougher than desirable ride.

Perhaps the most significant benefit of the test materials is the apparent control of cracking over the longitudinal edge joints. At the end of two years there was no evidence of such cracking in the test section while the control section was fully cracked (Figure 5). These joints at the pavement-shoulder interface are acknowledged by many to be a major path of water into the pavement structure. For this reason, the elimination of edge joint reflection cracking could provide an important contribution to pavement performance.

As expected, no reflection cracks have occurred at the joints between the lanes on either the test or control section.

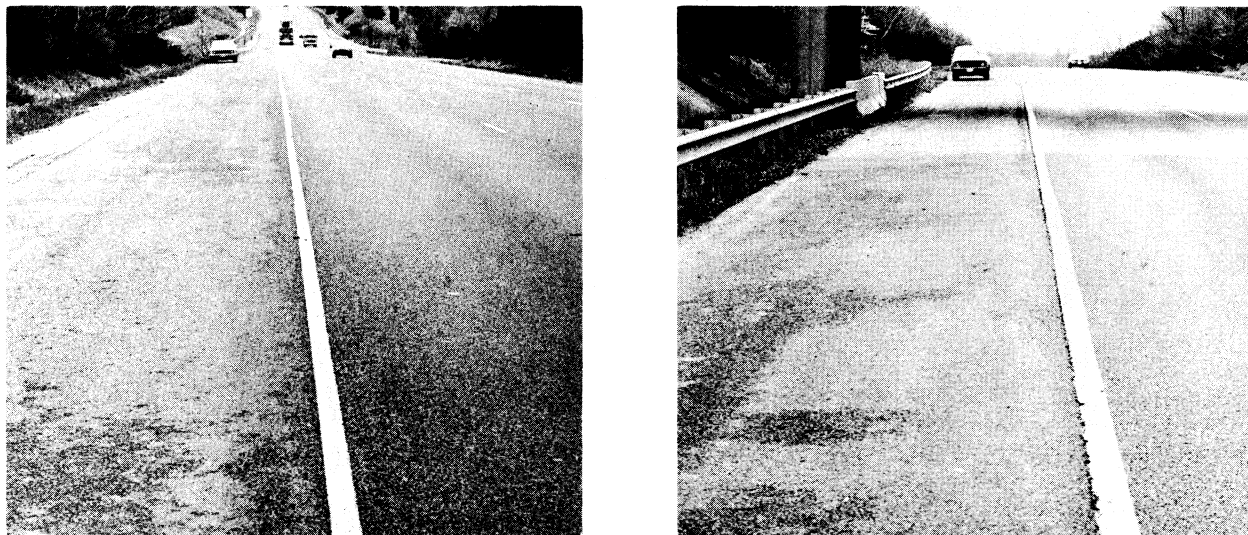


Figure 5. Edge joints on test section (left) and control section after two years.

CONCLUSIONS

The use of a heavy asphalt impregnated polypropylene meeting the specifications appended to this report and applied in 20 in. (0.5 m) wide strips on concrete pavement joints—

1. significantly retarded reflection cracking at the transverse joints;
2. prevented reflection cracking of the pavement-shoulder edge joints for at least three years; and
3. reduced the severity of transverse reflection cracks.

The fabric tolerated heavy traffic volumes for several weeks without significant damage.

RECOMMENDATION

The use of heavyweight construction fabrics similar to that reported on here and applied in a similar manner should be given serious consideration for resurfacings of jointed portland cement

concrete pavements. Such fabrics would be used in narrow strips on transverse joints and on longitudinal edge joints prior to placing bituminous concrete overlays. Uncovered fabric so used should have the capability of sustaining interstate traffic for several weeks without undergoing significant damage.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the personnel of the Manassas Residency and the Dale City area headquarters for their assistance in installing the test section; and R. W. Gunn, technician supervisor, for his assistance in the evaluation.

REFERENCES

1. McGhee, K. H., "Attempts to Reduce Reflection Cracking of Bituminous Concrete Overlays on Portland Cement Concrete Pavements", Transportation Research Board Record No. 700, Transportation Research Board, Washington, D. C., 1979.
2. _____, "A Review of Pavement Performance on Virginia's Interstate System", Virginia Highway and Transportation Research Council, November 1976.

(Supplied by: Materials Manufacturer)

ASPHALT MEMBRANE MATERIAL

DESCRIPTION

- 1.1 This item covers the requirements for furnishing materials and installing reinforced asphalt membrane material in accordance with details specified herein and details as shown on the plans.
- 1.2 The contractor shall include all supplementary tools and equipment necessary or required for a complete, satisfactory and approved installation.

MATERIALS

- 2.1 Material specified shall meet the following properties:

Weight	0.8 Lb. Ft. ²
Caliper	0.120 Inches
Cold Flex, (2" x 5" Specimen 180° Bend on 2" Mandrel - 0°F)	No Cracking
Heat Stability, (2" x 5" Specimen Hung Vertically in a Mechanical Convection Oven - 2 Hrs. - 190°F)	No Dripping or Delamination
Flammability, (Self extinguishing, no burn rate when tested in accordance with Federal Dept. of Transportation Specification 302.)	
Percent Elongation (Instron)	100%
Tensile Strength (Instron)	900 Lbs. In. ²
Color	Black
Width*	20 Inches
Length**	300 Feet

*Standard width is 20 inches but can be made up to 46 inches on special orders.

**Standard length is 300 feet, but will be shorter on wider rolls due to weight of material.

- 2.2 Asphaltic Tack. The asphaltic tack to be applied to the pavement surface shall meet the following requirements.

<u>Material</u>	<u>Grade</u>	<u>Specification</u>
Asphalt Cement	AC-20*	AASHTO M 226

*Higher penetration asphalts or heavier coverage may be specified for cold weather applications or in severely cold climates.

- 2.3 Application of Tack: The tack coat should be applied at the rate of 0.10 Gal./Sq. Yd. (approx.) if sprayed. A typical fog coat is all that is necessary in warm weather conditions. In colder temperature conditions, a heavier spray may be needed to insure a good bond. In no case should the tack exceed 0.20 to 0.25 Gal./Sq. Yd. This could cause a slippage of the mat when the heat of the hot mix

re-liquifies the binding agent. Whether tack is being applied by mechanical means or from a pour pot, the edges of the mat are the most important part. See that they are bonded well to the old pavement. Minimum recommended temperature for AC-20 tack is 290°F.

The width of asphalt tack application should be the material width plus 3-4 inches and shall be applied no further in advance of material placement than can be accomplished without losing adhesion abilities of the tack. Weather conditions will be major determining factor here. For example, in cold weather this distance might be no more than 5 feet.

When asphalt emulsions are used, the emulsion must be cured (no moisture remaining) prior to placement of the mat and final wearing course.

- 2.4 Asphalt Sealant: Asphalt cement is recommended as the best choice. Emulsions can be used but must have a complete break before applying mat. An incomplete break could cause a slippage of the material.
- 2.5 Sand: Although not required, small amounts of washed sand may be used to blot excess asphalt if necessary to facilitate movement of traffic or construction equipment over the material prior to the overlay. There should be no need, however, if the correct amount of tack is used. Hot mix can be sanded out on material ahead of paver if material is sticking to tires of trucks or paver and will eliminate such problems should they occur.

EQUIPMENT

- 3.1 Asphalt Distributor: A Distributor or motorized tar kettle, both equipped with a hand held wand, represent the ideal situation for applying the tack. Where not practical or unavailable, a pour pot may be used to secure the material to pavement, using a ribbon effect.
- 3.2 Material Handling Equipment: No special equipment needed for handling the rolls of material. A steel bar can be inserted through the core and suspended in any manner from the back of a truck for easy take-off or simply rolled along the crack manually.
- 3.3 Miscellaneous Equipment: Razor blade knives should be provided to cut the mat. A hand roller may be used to facilitate contact during cold weather applications. During warm weather, the material conforms very well to the surface and even hand rolling is not necessary then.

CONSTRUCTION PROCEDURE

- 4.1 Surface Preparation: The surface upon which the material is to be placed should be free of dirt, water and vegetation. Cracks up to 1 1/2" width need not be filled. Larger cracks or holes are to be filled with a suitable material (cold or hot mix).

- 4.2 Material Placement: The material shall be placed into the tack prior to the time the asphalt has cooled and lost its tackiness. It should be unrolled so that the corners naturally turn down (convenience). Both sides are identical, however, so no change in performance will be lost or gained by positioning either side downward.

Where transverse and longitudinal joints meet, the mat may be butted. Overlap is necessary, however, on bridge decks or where intentional waterproofing is desired. Additional tack is required to bond the two mat areas together where overlapping is used.

Cornering can be accomplished without sectioning material by walking gathered material to one spot and slicing bubble out with razor knife and tacking the overlap.

Removal and replacement of material that is damaged after placement is the responsibility of the contractor.

- 4.3 Materials Overlay: Hot mix overlay can immediately follow placement of the material or delayed and opened to traffic.
- 4.4 General: Air and pavement temperatures during material installation should be sufficient to allow adequate tacking. Material installed in cold weather should be overlaid as reasonably soon as possible. The combination of cold brittle tack and traffic could cause some breaking loose of the mat. During warm weather conditions, this should be no problem.

METHOD OF MEASUREMENT

- 5.1 The unit of measurement of asphalt membrane shall be in square feet.

BASIS OF PAYMENT

- 6.1 Payment shall be made at the contract unit price per square foot of asphalt membrane in place. This price shall be full compensation for furnishing all materials including bituminous tack, and for all preparation and application of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under -

Item Page _____ 6.1 ASPHALT MEMBRANE MATERIAL - PER SQUARE FOOT

