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PAVEPREP MEMBRANE REPORT:
INSTALLATION AND MONITORING

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by

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16. Abstract

This report summarizes an investigation designed to determine the effectiveness of PavePrep membrane in reducing reflection cracking and related distress of overlays placed over concrete pavement.

PavePrep membrane was installed on five pavement overlay projects and one bridge deck overlay project.

On the first three trial installations, which have now been in service from 1 to 5 years, PavePrep membrane did not provide a significant reduction in the incidence of reflection cracking either with respect to the time to first cracking or the subsequent overall percentage of cracking. The two remaining projects, constructed in 1987, have not been in service long enough to draw definitive conclusions. However, the initial signs of reflection cracking are present in both test and control sites on the latter two projects.

A life cycle cost analysis indicates that, to be economically justified, the use of PavePrep would have to extend the life of an overlay by an additional four years. Based on its performance to date, there is no basis for assuming that the performance of the membrane-treated overlays could rise to the point of a four year extension of service life.

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1.0 OBJECTIVE

This report summarizes an investigation designed to determine the effectiveness of PavePrep membrane in reducing reflection cracking and related distress of overlays placed over concrete pavement.

2.0 BACKGROUND

A variety of solutions have been proposed for the long-standing problem of reflection cracking of bituminous overlays placed on Portland cement concrete pavements. One approach to this problem -- which has been used with mixed success by a number of states[Ref. 1-6] -- is to place a stress-relieving membrane beneath the resurfacing.

Historically, each of several experimental installations of crack control membranes by the New Jersey Department of Transportation has been unsuccessful. As noted in a recent paper[Ref. 7], one of the probable reasons for the Department's lack of success in these past efforts is that New Jersey employs a unique concrete pavement joint design which poses a particularly acute problem with respect to reflection cracking. That is, most of our concrete pavements are of an expansion joint design with 3/4" wide joints placed at approximately 78' intervals.* As a consequence of this relatively long joint spacing, the temperature-induced joint movements that contribute to reflection cracking are more pronounced than would be expected in a conventional contraction joint design.

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*Certain of our older (30 + years) concrete pavements were constructed with slab lengths which varied from 15' to 200', most of which also incorporated the expansion type joint design.

Despite our previous lack of success in the use of reflection crack control membranes, the Department has continued to evaluate promising new materials. One such material is PavePrep membrane, a product which consists of an asphalt mastic between two layers of polypropylene fabric. According to the manufacturer, this material reduces the incidence of reflection cracking, waterproofs the underlying joints, and reduces "tenting" at the reflection crack. (Tenting is the phrase used to describe the development of a small hump in the bituminous overlay over the underlying transverse joints.)

This report documents the installation and monitoring of PavePrep membrane on five pavement overlay projects and one bridge deck overlay project. These various overlays included both initial (first generation) and second generation overlays. Four of these experimental projects were designed experiments (i.e., containing both treated and untreated (control) sections). The other pavement overlay project and the bridge deck overlay were uncontrolled tests, installed by Department Operations personnel.

The monitoring program consisted of conducting periodic condition surveys to determine the percent of reflection cracking on selected test sections treated with the membrane and on control sections, electrical resistivity tests (ASTM D3633-83) to monitor the waterproofing properties of the treated pavement sections, and the use of a 10' straightedge across the joints to monitor tenting.

3.0 TEST SECTIONS

The New Jersey Department of Transportation has installed a test section of the membrane on each of five overlay projects and one bridge overlay project. These test sections are discussed by route number below:

3.1 U.S. Route 206, Chester

This project entailed overlaying of an existing PCC pavement with two 10' wide lanes and transverse joint spacing of 35'. PavePrep membrane was installed over twelve of the transverse joints in September 1982. The test section was constructed in the northbound lane and the control section was designated in the southbound lane opposite the test section. The entire project was overlaid with three inches of bituminous concrete.

After three years of monitoring of reflection cracking, the report "PavePrep Reflection Crack Control Membrane - U.S. Route 206" was prepared by the Department's Materials Committee. The report noted that "...over 90% of the PavePrep joints as well as the control joints had reflection cracking" and concluded that "...no significant advantage was found in using the PavePrep on the test section". Reflection cracks appeared simultaneously in the test and control sections.

Subsequent surveys of the reflection cracking showed similar results. The results of the latest survey, conducted December 1, 1987, are plotted in Figure 1 and summarized in Table 1. As noted in this figure, the membrane test section has five transverse joints with 100% reflection cracking and three transverse joints with 90% reflection cracking. The remaining treated joints show a small percentage of reflection cracking. In the control section, eight transverse joints display 100% reflection cracking and the remaining joints have a small percentage of reflection cracking. Essentially, there is no significant difference in the amount of reflection cracking in the control and the test section. Pictures of typical reflection cracks over the membrane are shown at the end of this report.

Cores were taken over several transverse reflection cracks in the test section to visually inspect the condition of the membrane after five years service. In all cases, the membrane was not damaged or torn. However, it was

FIGURE 1

U. S. Route 206 Crack Survey
Percent of Reflection Cracks over Joints

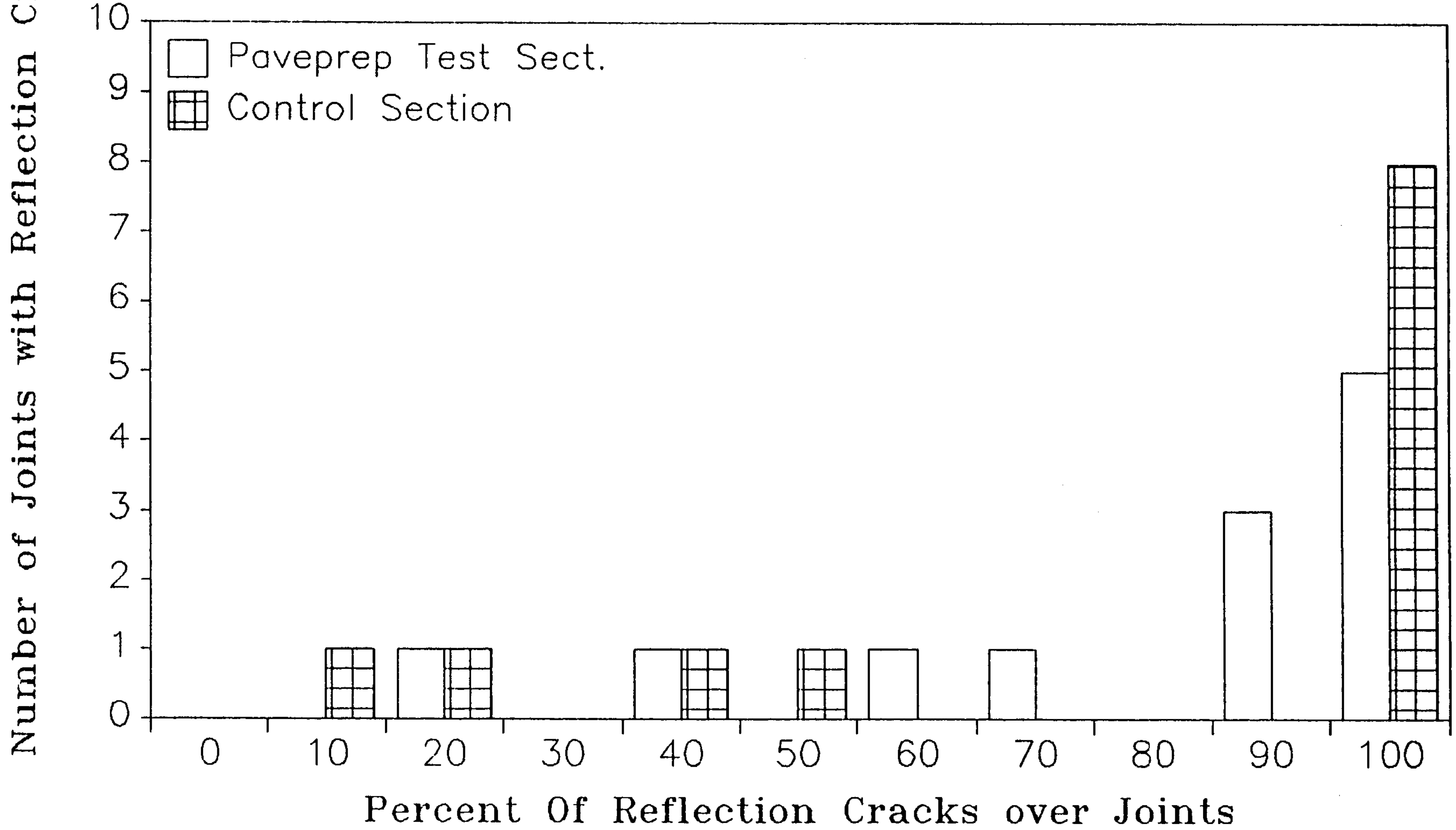


Table 1: Summary of Transverse

Reflection Crack Data

(Survey Date: December, 1987)

		PERCENT OF JOINTS AFFECTED		PERCENT OF TOTAL LENGTH CRACKED	
Project	Age	Control	Test	Control	Test
US 206	5-1/4 yrs.	100%	100%	77%	80%
NJ 91	3-1/3 yrs.	83%	91%	66%	74%
NJ 12	1-1/3 yrs.	--	75%	--	45%

not possible to determine if the moisture had penetrated the membrane and the joint.

A ten-foot straightedge was placed across the reflection cracks on the test section and the control section to determine the amount of tenting. No tenting was observed on either section: All joints were level at the cracks.

3.2 N.J. Route 91, New Brunswick

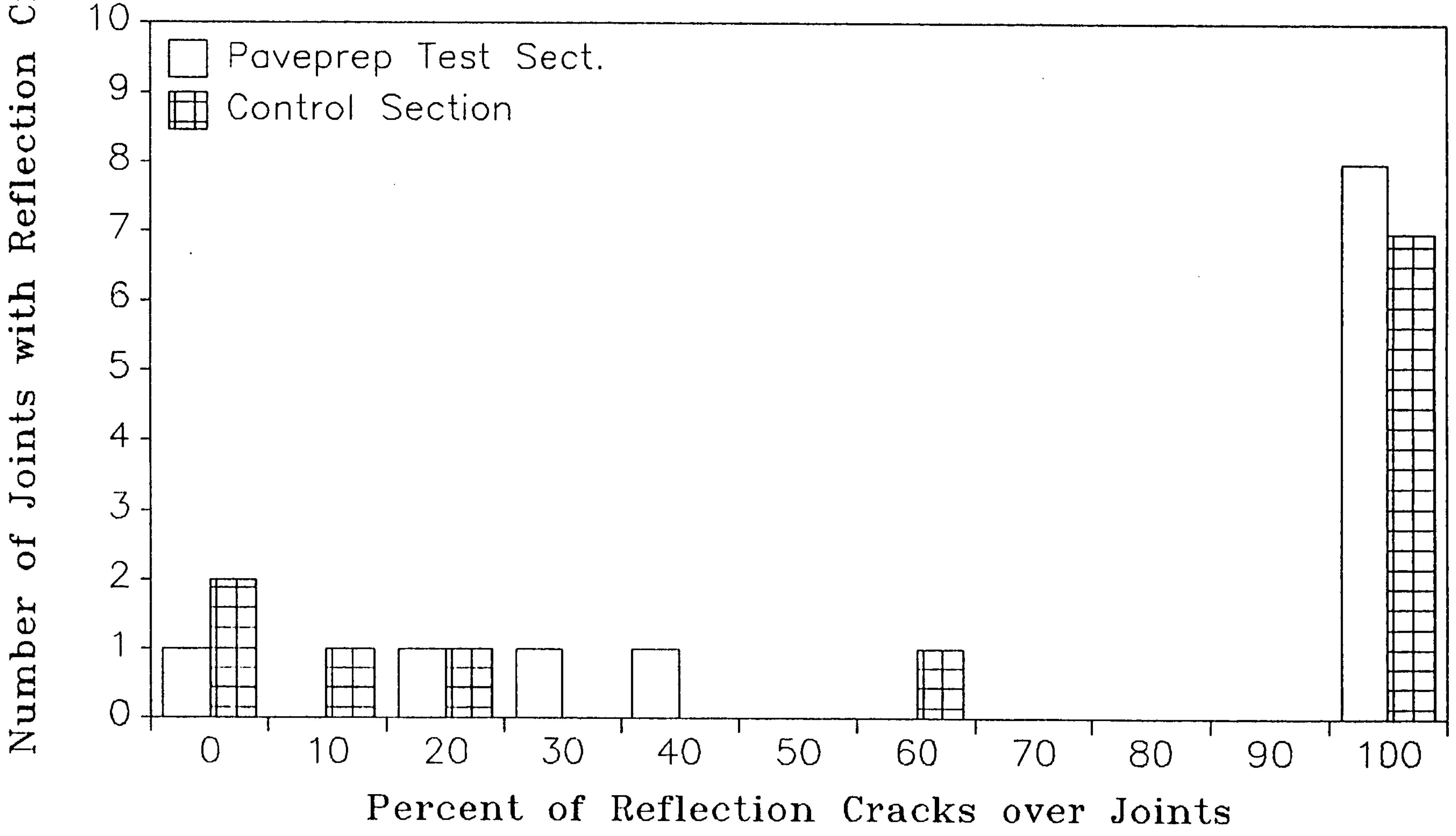
PavePrep membrane was installed over twelve transverse joints, four cracks and the center and edge longitudinal joints of this old, deteriorated concrete pavement in August 1984. The test section was installed in the southbound lane of the two-lane pavement and the control section was designated in the northbound lane adjoining the test section. The entire pavement was overlaid with three inches of bituminous concrete over the existing concrete pavement. On this pavement, the transverse joint spacing was 35' and the lane width was 10 feet.

Periodic crack surveys were performed on the test section and the control section. During the first winter, reflection cracks appeared simultaneously on both the test and control sections.

The results of the latest survey, conducted on December 1, 1987, are plotted in Figure 2 and summarized in Table 1. As noted in this figure, the test section has eight transverse joints with 100% reflection cracking and the remaining joints have a small percentage of reflection cracking. The control section has seven transverse joints with 100% reflection cracking and the remaining joints have a small percentage of reflection cracking. Essentially, there is no significant difference in the amount of reflection cracking at the joints in the control and test sections. Pictures of typical reflection cracks over the membrane are shown at the end of the report.

FIGURE 2

N. J. Route 91 Crack Survey
Percent of Reflection Cracks over Joints



Three treated (mid-slab) cracks in the underlying concrete pavement in the test section have shown no subsequent reflection cracking and one crack has 100% reflection cracking. Similar, mixed results were obtained in the control section: one pre-existing crack completely reflected thru the overlay, one reflected partially, and one did not reflect at all.

In the test section, the longitudinal edge joint has no reflection cracking and the center joint has 30% reflection cracking. In the control section, the longitudinal edge joint has 25% reflection cracking. (No untreated centerline joint was provided in the control section.) Because of these mixed results in the test section, the relative effectiveness of the membrane in preventing longitudinal reflection cracks on this project is difficult to assess.

Cores were taken over several transverse reflection cracks on the test section. In all cases, a visual inspection of the membrane showed that it was not damaged or torn.

To determine the ability of the membrane to waterproof the joints, electrical resistivity tests were performed on two treated joints. The latest test results indicate the presence of water beneath one treated joint but not the other. From these results, it is apparent that moisture does in fact collect beneath at least some of the treated joints.

To determine the amount of tenting across the reflection crack, a ten foot straightedge was placed on the crack. No tenting was observed on either section, i.e., the pavement adjoining the crack was flat and level on both the test and control sections.

3.3 N.J. Route 12, Kingwood Township

Region 1 Materials initiated the installation of PavePrep membrane on two thousand feet of badly deteriorated second generation overlaid concrete pavement on this two-lane rural highway. A total of fifty-two transverse cracks and joints in the old concrete pavement and the longitudinal joints at both edges and center of the overlay were covered with the membrane in August 1986. The pavement was then overlaid with 1-1/2 inches of I-4 mix bituminous concrete top course. No specific control section was established for comparison with the test section. However, the remaining 2-1/2 miles of pavement were not treated with the membrane.

Periodic crack surveys were performed on the test section. During the first winter, reflection cracks appeared simultaneously in the test section and the untreated area. The results of the latest crack survey are plotted in Figure 3 and summarized in Table 1. As shown in the figure, thirteen PavePrep treated cracks/joints display no reflection cracking. Eight treated cracks have 100% reflection cracking. The remaining treated cracks are at least partially cracked. Pictures of typical reflection cracks in the membrane test section are shown at the end of this report.

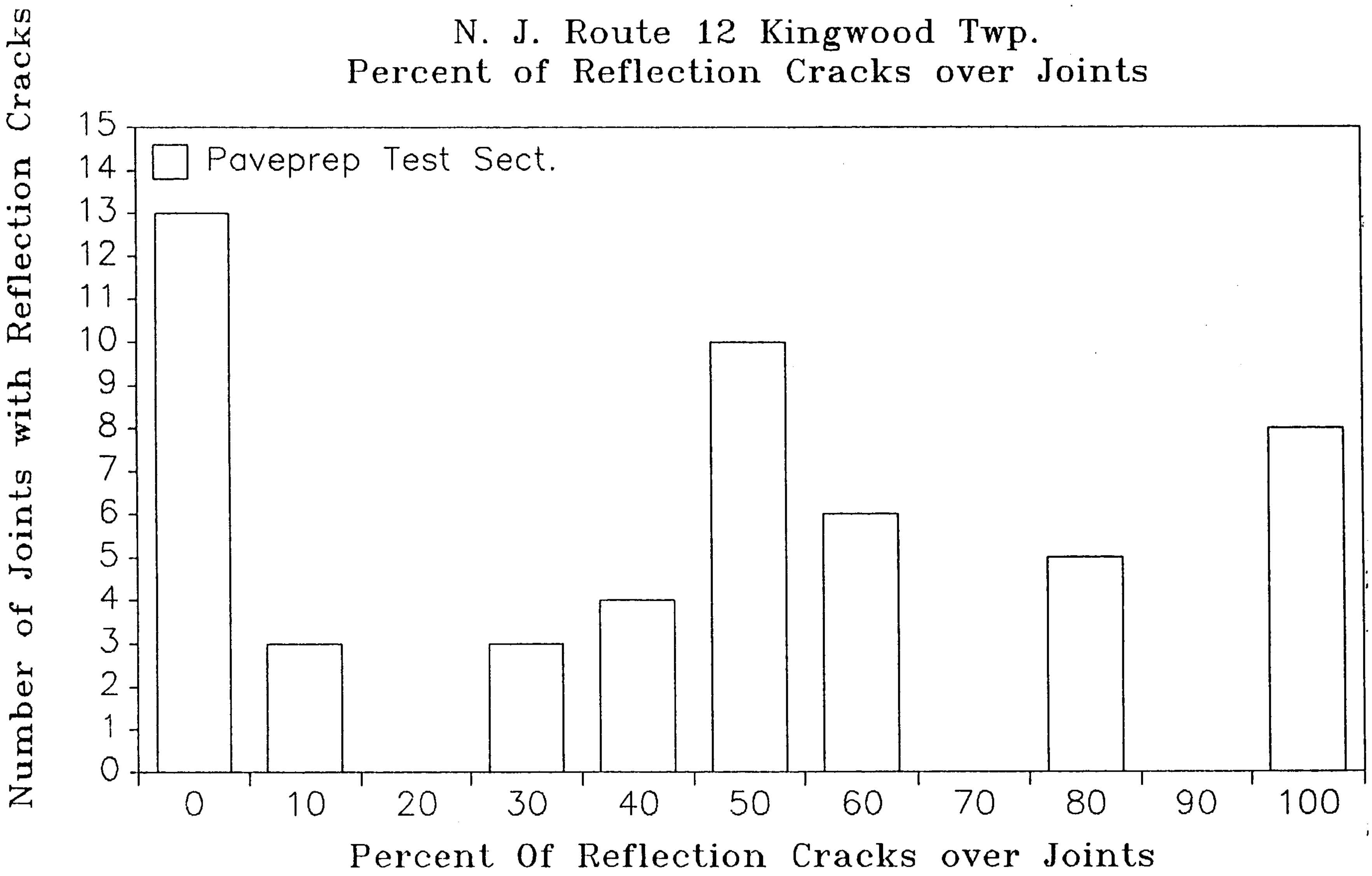
Without a specific control section for comparison, it is obviously difficult to gauge the relative effectiveness of the membrane in reducing reflection cracking on this project. In general, the use of the membrane clearly does not appear to have been effective in controlling transverse reflection cracking: cracks appeared the first winter (the usual pattern) and after only about 1-1/2 years service, have progressed to the point that about 3/4 of the treated joints/cracks are at least partially affected.

The pre-existing longitudinal edge crack in the test section has not reflected thru the overlay. The longitudinal edge crack in the untreated area is in similar condition, displaying minor localized cracking (less than 5%).

The longitudinal center joint in the overlay was constructed by butting the second paving mat against the first mat after the first mat was cold. This

FIGURE 3

N. J. Route 12 Kingwood Twp.
Percent of Reflection Cracks over Joints



resulted in a cold joint and the subsequent development of numerous cracks at the center joint. For this reason (i.e., the difficulty in distinguishing between a cold joint crack and a reflection crack), it was not possible to assess cracking along the pavement centerline.

The ten-foot straightedge was laid across five transverse joints in the test section and in the untreated area to determine tenting. A 1/16 - 1/8 inch bump was observed at three of the transverse reflection cracks on the new overlay in the untreated area. No tenting was observed on the reflection cracks in the test section. The significance of these small bumps is unknown. Since they are small, the bumps are not visible without the straightedge and are not noticeable when riding in a small car.

3.4 N.J. Route 15, Bridge Deck, Lafayette

Region 1 maintenance forces installed a PavePrep membrane on the full width of this bridge deck in September 1986. The intent of the installation was to waterproof the deck which had been patched with quick-set concrete. The deck was overlaid with 1-1/2 inches of bituminous concrete.

Periodic observations of the deck indicate that the overlay shows no deterioration. However, no quantitative means are available to analyze the actual benefit of the membrane.

3.5 N.J. Route 181, Sparta

A 600-foot test section of PavePrep membrane was installed on this deteriorated, previously-overlaid concrete pavement in April 1987. The membrane covered all existing transverse reflection cracks in this three-lane pavement. A 600-foot control section was established adjacent to the test section. The entire pavement was overlaid with two inches of Mix I-4 bituminous concrete.

Periodic crack surveys will be made on the sections. At this time, a few fine reflection cracks have appeared on both sections. Essentially, it is too soon after construction to monitor cracking.

3.6 U.S. Route 130, Gloucester City

An 800-foot test section of PavePrep membrane was constructed as part of the first overlay placed on this old Portland cement concrete pavement in September 1987. The membrane covered all transverse joints and longitudinal joints of the two-lane pavement. A 400-foot control section without the membrane was established adjacent to the test section. The entire pavement was overlaid with three inches of bituminous concrete.

At this time, a few fine reflection cracks have appeared over the transverse joints in the inside lane of the test section and the control section. However, it is too soon after construction to make a meaningful analysis of cracking.

Electrical resistivity tests were performed over three joints in the test section shortly after the overlay was constructed. Those initial resistivity tests suggested that water was being admitted beneath one of the treated joints*; the other two joints appeared to be waterproof.

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*In evaluating the results of the ASTM resistivity test, the readings fall into one of three categories: water definitely present, water definitely not present, or uncertain. Here, unlike the Route 91 tests, the readings were in the "uncertain" zone. (Such tests were performed on two occasions; the second set of readings suggested even greater water penetration.)

4.0 ANALYSIS AND CONCLUSIONS

At this writing, three of the trial installations of PavePrep membrane have been in service long enough to draw conclusions regarding the effectiveness of the membrane in preventing reflection cracking (i.e., the Route 12, 91, and 206 projects). On each of those projects, PavePrep membrane did not provide a significant reduction in the incidence of reflection cracking -- either with respect to the time to first cracking or the subsequent overall percentage of cracking. The two remaining overlay projects (the Route 130 and 181 tests) have not been in service long enough to draw definitive conclusions. However, notwithstanding their short period in service, the initial signs of reflection cracking are present in both the test and control sites on the latter two projects. Viewed as a whole, the New Jersey installations of PavePrep membrane have shown a notable lack of success in reducing reflection cracking.

Given the mixed success of membranes in reducing the occurrence of reflection cracking, many manufacturers of crack control membranes now emphasize the waterproofing aspects of the membranes, rather than the crack control feature. This waterproofing characteristic is claimed to reduce the destructive effect of any cracks which develop.

For the conditions encountered in this study, PavePrep membrane appears to have had mixed success in providing a barrier against the intrusion of water. That is, on one of the two projects which were instrumented to measure water penetration, water was present beneath certain of the joints treated with the membrane. On the other instrumented test section, it appears that water has begun to intrude beneath the membrane. From this, it appears that PavePrep membrane does not consistently prevent the intrusion of water.

The measurements of tenting at reflection cracks -- which was investigated later on in the study at the suggestion of the vendor -- have not yielded any significant findings. That is, the only measurable tenting occurred on the Route 12 project and was of very small magnitude.

The evaluation methodology used in this study mirrors that conventionally used by other agencies and focuses on assessments of the relative percentage of reflection cracking and waterproofing characteristics. While such assessments of the relative incidence of cracking and waterproofing are useful, the ultimate test of the efficacy of any supposed performance-enhancing product (here, a crack-control membrane) is whether its use is cost effective. More specifically, one threshold test is whether the additional construction cost of the membrane is justified on the basis of an extension in service life (e.g., a delay in the time to the next resurfacing). One such analysis has been made of the life cycle costs involved in the use of PavePrep.[Ref. 8] That analysis, which was predicated on an engineering economics methodology outlined in an earlier paper,[Ref. 9] indicated that to be economically justified, the use of PavePrep would have to extend the life of the overlay by about an additional four years. Since the various PavePrep treated test section described here have shown no significant difference in performance in comparison to the untreated controls, there clearly is no basis for assuming that the performance of these test sections could rise to the point of a four year extension of service life.

As noted above, two of the test installations have not been in service for a sufficient period to draw meaningful conclusions. Given the Department's past lack of success with PavePrep, it would appear that the subsequent performance of these test sections is, to a large extent, irrelevant: Even if those test sections perform well, the best that could be said for the membrane is that it has yielded mixed results under New Jersey's service conditions.

5.0 RECOMMENDATION

PavePrep membrane should not be approved for use as a reflection crack control treatment on Department projects.

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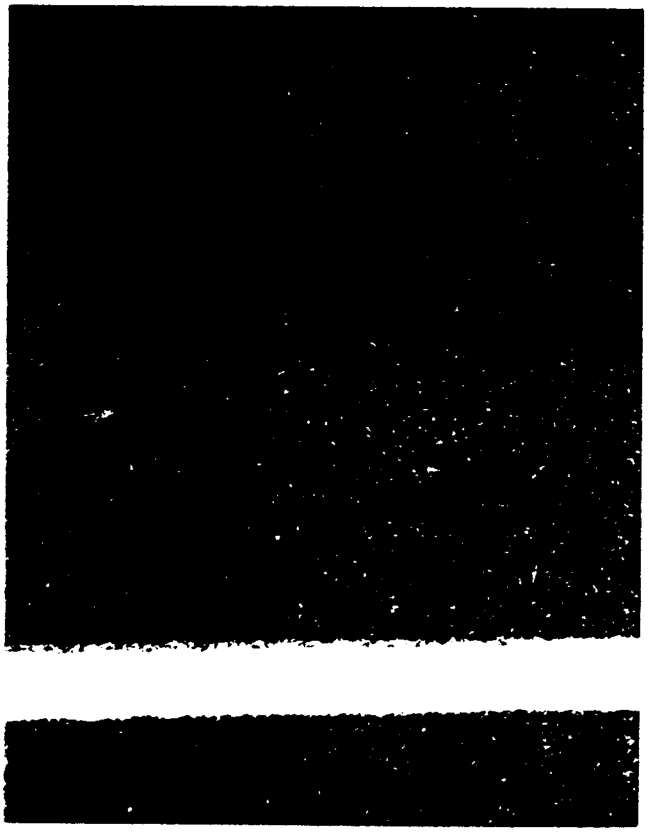
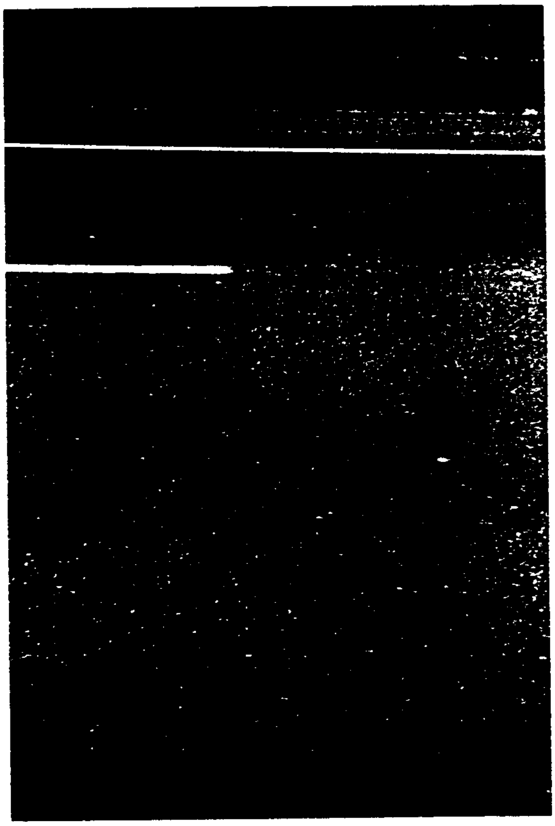
PICTURES OF TYPICAL REFLECTION CRACKS

Left: Typical reflection cracking on Route 91, New Brunswick. Control section at the top of picture. PavePrep test section at the bottom.

Right: Typical reflection crack on Route 206, Chester, PavePrep test section.





Typical reflection cracking on the Route 12 PavePrep test section.