Reflective Cracking and Tenting in Asphaltic Overlays

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The effects of reflective cracking on the performance of recycled asphaltic pavement overlays were investigated. Two 1/2-mi sections for full removal of the existing asphaltic pavement and replacement with recycled material on the existing crushed gravel base course were selected. The pavement performance after partial removal of the existing asphaltic pavement and placement of a recycled overlay was compared with the performance after complete removal and replacement with recycled asphaltic pavement. Severe tenting (called tenting because of the tent-like structure produced at transverse cracks) developed during the freeze months of January, February, and March. The Present Serviceability Index (PSI), an indicator of ride quality, deteriorated from 3.4 in October 1985 to 1.7 in February 1986 (on a scale of 0 to 5, 5 being the best). In an attempt to solve this serious tenting problem, three different treatments were applied to the pavement. Retrofit edge drains were installed in 1987 to remove infiltrated water from the pavement structure. Retrofit transverse drains or transverse interchannel flow (TIC) drains were installed in 1988 directly under the transverse cracks to remove the infiltrated water. Crack sealing was performed in 1988 to prevent water from entering the pavement through the transverse cracks. Reflective crack study results in the 7-year period 1981 to 1988 indicate 58 percent more transverse (reflective) cracks occurred in the partial removal and recycled overlay sections than in the full removal and replacement sections. The performance, as measured by PSI, deteriorated at a faster-than-normal rate, which appeared to be increasing. The retrofit edge drains and retrofit TIC drains were found to be ineffective in solving the tenting problem. Transverse crack sealing appeared to be somewhat successful.

Construction of a recycled asphaltic overlay project, which called for 100,000 tons of recycled asphaltic paving, was begun in District 7 in Rhinelander, Wisconsin, in April 1981. Major steps in the project were cold milling the top 3½ in. of the 6-in. existing asphaltic concrete pavement and replacing it with a 4-in. overlay of recycled material. After the cold-milling operation had started, the chief construction engineer examined the milled surface and became concerned about the reflective cracking that occurred soon after completion of the overlay. The remaining mat (placed in 1956) had many relatively wide transverse cracks. This concern about reflective cracking and its possible effect on pavement performance led to the suggestion of a study to evaluate the effects of reflective cracking on the performance of recycled asphaltic overlays.

In May 1981 the Engineering Research Advisory Committee, now the Council on Applied Research, agreed that two ½-mi sections for full removal of the existing 6-in. mat and replacement with 5 in. of recycled material on the existing crushed gravel base course be constructed. This would allow a comparison of the pavement performance after partial removal and overlay with the performance after full removal and replacement.

After construction of the project, severe tenting (called tenting because of the tent-like structure produced at transverse cracks) developed during the freeze months of January, February, and March. In 1985, the District Materials Section began monitoring the effects of tenting in the reflective crack test sections, using both the road meter and the California-type profilograph. The road meter measures the ride quality of the pavement. The Present Serviceability Index (PSI) deteriorated from 3.4 in October 1985 to 1.7 in February 1986. In an attempt to solve this serious tenting problem, three different treatments were applied to the pavement: retrofit edge drains, retrofit transverse interchannel flow (TIC) drains, and crack sealants.

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PROJECT DESCRIPTION

This 22-mi project is located on US-51 between Mercer and Hurley in Iron County. Except for two short grading sections totaling approximately 1 mi, the remainder of the 22 mi consists of an old 20-ft-wide portland cement concrete (PCC) pavement covered with 9 in. of gravel and 6 in. of asphaltic concrete. The asphaltic concrete consists of two 3-in. mats, one placed when the gravel lift was built in 1956, the second in 1969. The grading sections had the same pavement structure except that the 9-in. gravel lift was placed on the prepared earth subgrade instead of the old PCC pavement.

The top 3½ in. of the 6-in.-thick, 22-ft-wide existing bituminous concrete pavement was cold milled and replaced with a 30-ft-wide, 4-in. overlay of recycled asphaltic pavement. The old 2½ in. asphaltic pavement remained after milling and carried 2-way traffic during construction.

PURPOSE AND SCOPE

The objectives of this study were to monitor and evaluate the pavement performance over a period of several years. The effects were determined of reflective cracking in sections in which the existing asphaltic concrete was partially removed and a recycled asphaltic overlay was placed. The pavement performance after partial removal of the existing asphaltic pavement and placement of a recycled overlay was compared with the performance after complete removal and replacement with recycled pavement. Four typical pavement test sections were established as part of the reflective crack research study, and results are based on evaluations of the performance of these four sections.

TEST PROCEDURES

The four test sections were monitored and evaluated by means of a transverse crack survey; a California profilograph profile; material durability evaluation; and the Present Serviceability Index (PSI).

Transverse Crack Survey

A crack survey was conducted in July 1982 after removal of the upper 3½ in. of asphaltic concrete and before the placement of the 4-in. recycled asphaltic overlay. This initial survey was made on only sections 1 and 3 (partial removal and replacement sections). The survey was conducted by District 7 personnel and consisted of measuring and plotting each transverse crack to the nearest foot on a crack diagram. Beginning in November 1983, and each succeeding year through 1988, a crack survey was performed in all four test sections. All transverse cracks were again measured and plotted to the nearest foot on a crack diagram overlay. Transverse cracks that appeared in the overlaid surface of sections 1 and 3 were considered reflective cracks if they were within 1 ft of the original crack in the overlaid pavement surface. The cracks in sections 2 and 4 (full removal sections), were not reflective cracks. No crack survey was conducted in 1985.

California Profilograph Survey

The profilograph is a mobile testing instrument designed to register and record deviations in a pavement surface. The Profile Index (PI) is defined as "inches per mile in excess of the 0.2-in. blanking band." As the pavement roughness increases, the numerical value of the PI increases.

A survey was conducted November 1983 through November 1988, and in March 1987, February 1988, and 1989. No survey was conducted in 1985. The PI was determined by averaging the two northbound and southbound wheel ruts.

Material Durability Evaluation

Cores were taken at transverse cracks to investigate the deterioration. Eight-in. diameter cores were taken in the following sections at the following locations:

1. Pavement Section 1 (partial removal) at Station 108 + 0, 9 ft to the right of the centerline and
2. Pavement Section 2 (full removal) at Station 95 + 17, 12 ft to the right of the centerline and 12 ft to the left of the centerline.

Present Serviceability Index

Users assess the condition of a pavement largely by ride quality. Serviceability is quantified by means of the PSI, which is measured in Wisconsin by the road meter. PSI values range from 0 (impassable road) to 5 (perfect road). Selection of the lowest allowable PSI or Terminal Serviceability Index (P_T) is based on the lowest index that will be tolerated before rehabilitation, resurfacing, or reconstruction becomes necessary. An index of 2.5 or higher is suggested for design of major highways; 2.25 is suggested for highways with lower traffic volumes.

Road meter inventory PSI results are available on sections 1–4 for the following months: August 1981, November 1983, November 1984, November 1986, March 1987, November 1987, February 1988, November 1988, and February 1989.

EXPERIMENTAL PAVEMENT TREATMENT SECTIONS

TIC Drains

Slotted pipes were installed in September 1988 directly under the transverse crack at the interface of the asphaltic pavement and the gravel base course from Station 762 to Station 794. Twelve drains were installed from Station 762 to Station 794.

The intent of the slotted pipe was to drain infiltrated water from the area of a transverse crack (through the use of a mini-French drain) in an effort to prevent tenting during winter frost.

Two methods of installing the pipe were used. The retrofit method uses a pneumatic piercing tool to advance a hole (tunnel) from the edge of the asphaltic pavement to the centerline. The tool is backed out and a PVC slotted pipe is inserted. The trench method uses a wheel trencher to cut a 3-in. slot along the transverse crack about 12 in. deep. A slotted PVC pipe is installed in the trench and backfilled with washed limestone chips to the bottom of the existing asphaltic pavement and then backfilled with asphaltic material to match the adjacent pavement thickness.

The PVC drains slope and flow onto the inslope. The Wisconsin Department of Transportation (WisDOT) Applied Research Section installed a tipping-bucket flow meter to measure flow at one location. The performance of the TIC drain system was evaluated by a California-type profilograph and by a tipping-bucket flow meter.

A profilograph survey was conducted by WisDOT in February 1988 before the installation of the slotted pipe at transverse cracks, and another profile was taken after the pipes were installed in February 1989. Both profiles were taken at the time of maximum tenting. The effectiveness of the slotted pipe system was evaluated by comparing the magnitude of the tents at transverse cracks in 1988 with the magnitude of the tents in 1989.

Retrofit Edge Drains

In July 1987 two different types of edge drains were placed on US-51 from Station 452 to Station 552. Six test sections were established to monitor the performance of the different edge drain sections. Test sections 1 and 6 were control sections and did not have edge drains. Test section location, type of edge drain, and other information pertinent to the test section follow:

- Section 1: stations 60 to 166 (Control Section 1), three moisture-temperature cells in a 9-in. (Grade 2 crushed aggregate) dense graded base course with existing 6-in. asphaltic concrete overlay.
- Section 2: longitudinal edge drains right and left with 18-in.-deep geocomposite edge drain fabric wrapped, aggregate-filled trench with 4-in. perforated PVC pipe discharge to slope outfalls, three moisture-temperature cells in a 9-in. (Grade 2 crushed aggregate) dense graded base course with existing 6-in. asphaltic concrete overlay, 6-in. jointed concrete plain pavement.
- Section 3: stations 477 to 502, longitudinal edge drains right and left 30-in. deep, geocomposite edge drain fabric wrapped, aggregate-filled trench with 4-in. perforated PVC pipe discharge to slope outfalls, three moisture-temperature cells in a 9-in. (Grade 2 crushed aggregate) dense graded base course with existing 6-in. asphaltic concrete overlay, 6-in. jointed concrete plain pavement.
- Section 4: stations 502 to 527, longitudinal edge drains right and left 18 in. deep, flowed edge drained fabric wrapped, 4-in. perforated PVC pipe discharge to slope outfalls, three moisture-temperature cells in a 9-in. (Grade 2 crushed aggregate) dense graded base course with existing 6-in. asphaltic concrete overlay, 6-in. jointed concrete plain pavement.
- Section 5: stations 527 to 552, longitudinal edge drains right and left 30-in. deep, plowed edge drain fabric wrapped, 4-in. perforated PVC pipe discharge to slope outfalls, 6 moisture-temperature cells in a 9-in. (Grade 2 crushed aggregate) dense graded base course, 9 to 15 in. sand and gravel interlayer, 6-in. jointed concrete plain pavement.
- Section 6: stations 552 to 770 (Control Section 2), three moisture-temperature cells in a 9-in. (Grade 2 crushed aggregate), dense graded base course, 6-in. jointed concrete plain pavement.

Performance evaluation of the edge drains is based on data from the moisture-temperature cells in the gravel base course, daily tipping-bucket outfall and rain data at Station 508 + 15, results of permeability analysis of base course samples, and ride quality of the pavement as measured by the PSI and PI. PSI and PI data from 1986 and 1987 before the installation of the edge drains are available for comparison.

Transverse Crack Sealant

Three test sections were established to determine if tenting could be reduced by sealing transverse cracks to prevent the entrance of infiltrating water. The test sections were as follows: (*a*) stations 67 to 96, (*b*) stations 505 to 510, and (*c*) stations 775 to 800.

A profile of the transverse cracks and a PI of the above sections were established with a California-type profilograph in February 1988 before filling the cracks.

The transverse cracks were sealed with a rubberized hot asphalt sealant in September 1988; the cracks were not cleaned. Profiles were once again taken in February 1989 to determine the effectiveness of crack sealing in reducing tenting.

The sealant was applied again in July 1989. This application was much more thorough. Each crack was routed ¾ in. wide and deep and cleaned and dried with a hot air heat lance before sealing. Profile measurements were taken with a profilograph in February 1990 to evaluate the effectiveness of sealant in reducing tenting.

FACTORS AFFECTING PAVEMENT PERFORMANCE

Material Durability

Both the existing material and the material in the overlay will affect the life of the pavement. Most overlay design procedures do not address specific material requirements. It is assumed that both the existing and overlay material will be constructed of durable material and that the proper specifications will be used to ensure this. The existing materials should first be investigated to determine that they have not deteriorated. An overlay designed for a 20-year life placed on an existing pavement that is constructed on materials that will fail in 7 years as a result of durability problems will not reach its design life no matter how well it is designed.

Climate

An overlay that would perform satisfactorily in a warm, dry climate may not perform as well in a cold, wet climate. This is particularly true when reflective cracks are a significant problem. Climates that have extreme heat, extreme cold, continuous moisture, and many freeze-thaw cycles require special consideration.

A "lake effect micro climate" is located in the Hurley, Wisconsin, area and extends from Michigan west to Birch Hill on US-2, west to Upson on STH 77, and south to Pine Lake on US-51.

Because of the continuous precipitation and many freeze-thaw cycles between November and April, this climate may have adverse affects on pavement performance and may require special consideration.

DISCUSSION OF RESULTS

Reflective Crack Research

This part of the research was limited to pavement test sections 1–4. The performance was evaluated through a comparison of the partial removal sections with the full removal sections. Section 1 was compared with Section 2, which is over gravel base course. Section 3 was compared with Section 4, which is over gravel base and old PCC.

Performance of the partial removal and overlay section was evaluated from data collected from the transverse crack survey, the profilograph survey, the material durability investigation, and the pavement serviceability survey.

Transverse Crack Survey

Results of the transverse crack survey for Test Section 1 (partial removal and replacement) compared with Test Section 2 (full removal) is shown in Figure 1. Both sections were constructed over gravel base. Figure 2 shows the rate of reflective cracking, which could only occur in Test Section 1 (partial

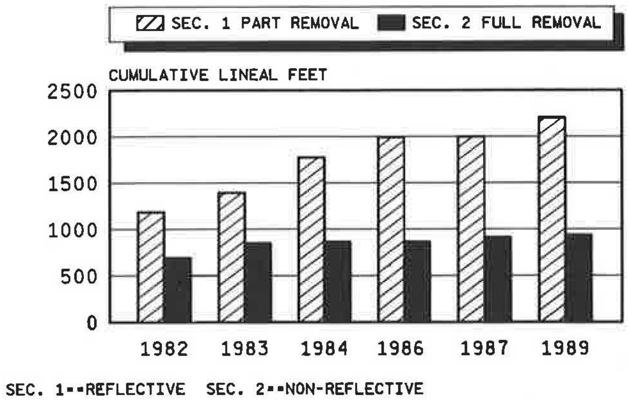

FIGURE 1 Transverse crack counts for test sections 1 and 2 (over gravel base).

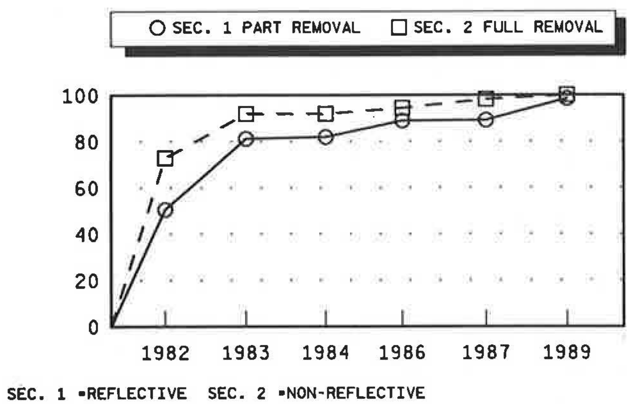

FIGURE 2 Rate (percent) of transverse cracking over gravel base, 1981–1989.

removal and replacement). No reflective cracking could occur in the full removal sections because there were no cracks to reflect.

The data show that there was 6,663 linear ft of transverse cracks in Section 1 in the old asphalt surface after the milling operation and before the placement of the recycled asphaltic overlay in July 1981. By 1989, 8 years after construction, 2,164 linear ft, or 32 percent, had reflected through the 4-in. recycled asphaltic overlay. Figure 2 shows that of the total number of cracks that reflected in the first 8 years, 52 percent occurred in the first year, and an additional 29 percent occurred in the second year, totaling 81 percent in the first 2 years. This indicates that the majority of the reflective cracking takes place in the early years of the overlays.

The comparison of the amount of reflective cracking in Section 1 with the amount of cracking (nonreflective) in Section 2 (full removal) shows that there was 915 lineal ft of cracking in Section 2; 58 percent more cracks occurred in Section 1. Figure 2 shows that of the total cracks that occurred in Section 2 in the first 8 years, 73 percent occurred in the first year, and an additional 17 percent in the second year, for a total of 90 percent in the first 2 years.

Results of the transverse crack survey for Test Section 3 (partial removal and replacement) compared with Test Section 4 (full removal) are shown in Figure 3.

Figure 4 indicates the rate (percent) of transverse cracking that occurred in 8 years. Both sections were constructed over an old PCC and gravel interlayer.

The reflective cracking that occurred in Section 3 shows that there was 4,425 linear ft of transverse cracks in the old asphaltic surface after the milling operation and before the placement of the recycled asphaltic overlay in July 1981. In 1988, 8 years after construction, 1,395 linear ft, or 32 percent, had reflected through the 4-in. recycled asphaltic overlay. Figure 4 shows that of the total cracks that reflected in Section 3 in the first 8 years, 56 percent occurred in the first year and an additional 17 percent during the second year, totaling 73 percent in the first 2 years.

The comparison of the amount of reflective cracking in Section 3 with the amount of cracking in Section 4 shows that 825 linear ft of cracking occurred in Section 4; 59 percent more cracking occurred in Section 3. Figure 4 shows that of the total cracks that occurred in the first 8 years in Section 4, 69 percent occurred in the first year, and an additional 16 percent occurred in the second year, for a total of 85 percent in the first 2 years.

Lastly, the cracking that occurred in sections 1 and 2, which were constructed over a gravel base, and sections 3 and 4, which were constructed over an old PCC with a gravel interlayer were compared. The data show that Test Section 3 (over concrete) had 4,425 linear ft of transverse cracks in the ex-

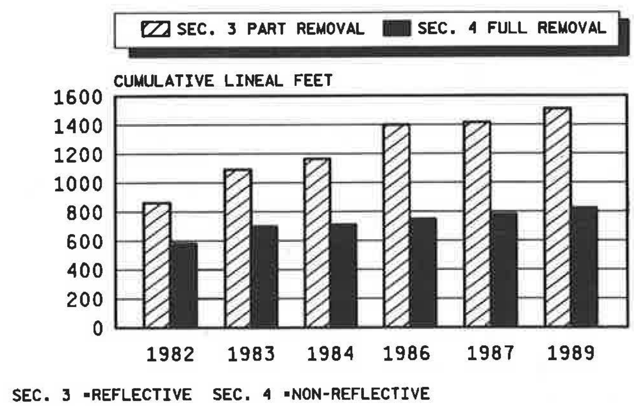

FIGURE 3 Transverse crack counts for test sections 3 and 4 (over old PCC with gravel interlayer).

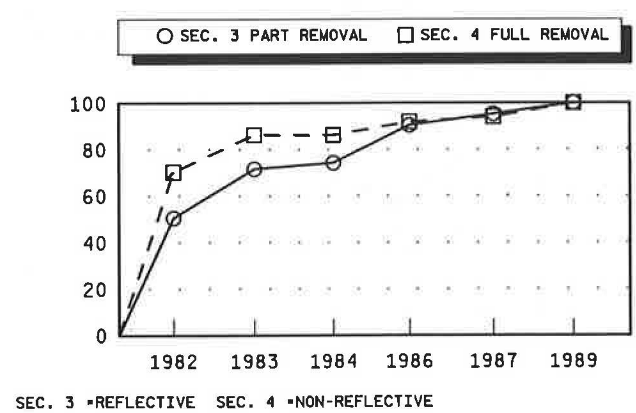

FIGURE 4 Rate (percent) of transverse cracking over old PCC with gravel interlayer, 1981–1989.

isting asphaltic pavement after milling and before placement of the asphaltic overlay. Section 1 (over gravel base only) had 6,663 linear ft, or 51 percent more, existing transverse cracks than Section 3. After 8 years, the recycled asphaltic overlay in Test Section 3 had 1,510 linear ft of transverse cracks. Section 1 had 2,164 linear ft, or 43 percent more, transverse cracking. In the full removal sections, 825 linear ft of transverse cracking occurred in Test Section 4 (over concrete), and 915 linear ft, or 11 percent more, transverse cracks occurred in Test Section 2 (over gravel base).

California-Type Profilograph Survey

Figure 5 shows the PI for test sections 1–4. The profiles were taken in November 1983, 1984, 1986, 1987, and 1988. The PIs shown in Figure 5 are the averages of the profiles taken in the two northbound and the two southbound wheel ruts. The November 1983 profiles were taken after the subgrade was frozen; thus, the results are not reliable and will not be used.

Results of the profilograph survey for Test Section 1 (partial removal and replacement) compared with Test Section 2 (full removal) are shown in Figure 5. Both sections were constructed over a gravel base. The data indicate that Test Section 1 had a lower initial PI (was less rough) than Section 2. The PI deteriorated at the same rate from November 1984 to 1987. In 1987, Section 1 continued to deteriorate at about the same rate, but the rate of deterioration in Section 2 leveled off or decreased.

Results for Test Section 3 (partial removal and replacement) compared with Test Section 4 (full removal) also are shown in Figure 5. Both sections were constructed over an old PCC with a gravel interlayer. The data indicate that Test Section 3 had a slightly higher initial PI (was rougher) than Section 4. The PIs deteriorated at the same rate from November 1984 to 1987. In 1987, Section 3 continued to deteriorate at about the same rate, but the rate of deterioration in Section 4 leveled off or decreased.

Both sections 1 and 2, constructed over the gravel base, have PIs about 10 points lower than those of sections 3 and 4, which were constructed over the PCC. Therefore, sections 1 and 2 are smoother than sections 3 and 4.

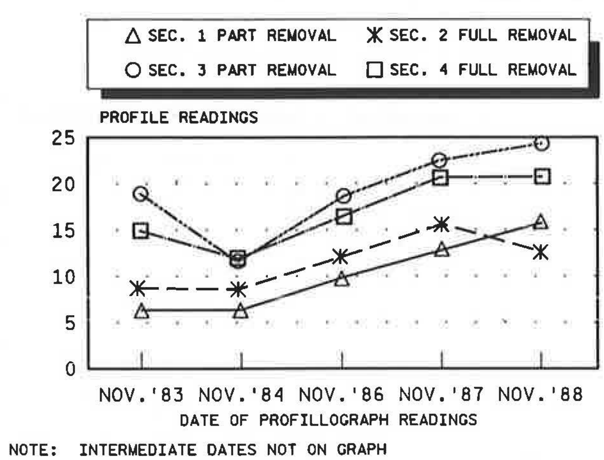

FIGURE 5 PI for test sections 1–4, 1983–1988.

Material Durability Investigation

Cores were taken to investigate the deterioration of the recycled asphaltic material at the transverse cracks. Eight-in.-diameter cores were taken in Test Section 1 (partial removal and overlay) and Test Section 2 (full removal). Both sections were constructed over a dense graded gravel base course, which had a permeability range of 0 to 30 ft per day.

Figures 6 and 7 are photographs of cores of transverse cracks in Test Section 2. The most important result of this investigation is the V-shaped deterioration at transverse cracks that occurred at the interface of the asphaltic pavement and the gravel base. Figures 6 and 7 show cores taken at Station 95 + 17. The core in Figure 6 was taken on the high side of a superelevated curve. It shows poorly developed V-shaped deterioration, whereas the core in Figure 7 was taken on the low side and shows a fairly well-developed V-shaped deterioration. This deterioration could be the result of pumping at the transverse cracks. The core of the high side of the superelevated curve would have less water, and therefore less pumping and less deterioration.

Figure 8 is a photograph of a core of transverse cracks in Test Section 1 at Station 108 + 10. Note the large well-developed V-shaped deterioration. The deterioration developed in the old asphaltic pavement placed in 1956, and was subjected to pumping for 32 years.

PSI Survey

PSI data may not be reliable for two reasons: test sections are short, and the extremes in temperature affect the results. Reliable PSI data from test sections 1 and 2 are presented below.

Test year	*PSI*
1980 (before construction)	3.0
1981	4.1
1982	4.1
1984	3.9
1986	3.5
1988	3.3

Reliable PSI data from test sections 3 and 4 are presented below.

Test year	*PSI*
1980 (before construction)	3.4
1981	4.0
1982	3.9
1984	3.7
1986	3.4
1988	3.2

Evaluation of Tenting

A comparison was made to show how different pavement sections react to tenting. The four sections are combined into two groups on the basis of similar pavement components. The two groups are as follows: Group 1—US-51, sections 1 and 3, partial removal and asphaltic overlay over gravel base (dense graded); Group 2—US-51, sections 2 and 4, full removal and replacement with recycled asphaltic pavement over gravel base (dense graded).

FIGURE 6 Core of transverse crack taken from high side of superelevated curve in Section 2.

FIGURE 7 Core of transverse crack taken from low side of superelevated curve in Section 2.

FIGURE 8 Core of transverse cracks in Section 1.

Research data indicate that the above sections are structurally adequate according to WisDOT design criteria. The climate in all sections is locally severe because of lake effect moisture and many freeze-thaw cycles. Subgrade soils for all groups are similar.

In the comparison of transverse cracks, tne number per 500 ft was used as a standard. Data indicate 12 transverse cracks per 500 ft in Group 1, partial removal and replacement, and 6 transverse cracks per 500 ft in Group 2, full removal. Asphaltic cement penetration, which is normally considered to have an effect on transverse cracking, was not evaluated. The magnitude of the tents at transverse cracks as shown on the profilogram are about the same for both groups. The ride quality as measured during the most severe tenting period (February) for both groups was as follows: the PSI was 1.3, and the PI was 80.

Experimental Pavement Treatment Sections

Retrofit TIC Drain

Table 1 shows the location, description of the type of installation, and performance as measured by the profilograph. The performance is measured by the changes in the magnitude of the scallops in tenths of an inch from February 1988 before pipes were installed to February 1989 after pipes were installed.

The magnitude of most of the scallops have increased significantly, except for pipe numbers 4–6, which decreased slightly. In the performance evaluation it was observed that from February 1988 to February 1989 the average PI decreased significantly on all test sections.

No positive results were recorded from the tipping-bucket flow meter. A tipping bucket was installed in late fall; freezing temperatures and deep snow prevented reliable results.

Retrofit Edge Drains

A comprehensive evaluation of the edge drain study was made by Sharma.

Transverse Crack Sealant Performance

Table 2 shows that performance, as measured by the profilograph, was significantly better in February 1989 after the cracks were sealed. From February 1988 to February 1989, the PIs decreased on an average of 23 in./mi. These data were obtained from the profile index on 2 mi of test section. Even considering the overall decrease in the PI, test sections 1 and 2 performed better in February 1989 after being sealed.

CONCLUSIONS

1. The overlay sections (partial removal and replacement) developed 58 percent more transverse cracks than the full removal sections.
2. Most of the transverse cracks (70 to 90 percent) appeared in the first 2 years after construction.
3. Substantially less transverse cracks have developed in both the overlay and full removal test sections, which were constructed over the old PCC pavement with a gravel interlayer. Data indicate about 50 percent less transverse cracks in the milled pavement surface before overlaying (1981), 43 percent less transverse cracks in the recycled overlay pave-

TABLE 1 SLOTTED PIPE PERFORMANCE

	LOCATION & DESCRIPTION	WHEEL RUTS			
		NBout	NBin	SBout	SBin
No. 1	Sta. 749+63 Lt. & Rt.				
	Retro. .010" slot wo/sock	I-3.5	I-3.0	I-2.0	I-1.0
No. 3	Sta. 750+84 Lt. & Rt.	0.0	0.0	0.0	0.0
	Retro. .020" slots wo/sock	Note: Ave. scallops is 1 inch			
No. 4	Sta. 751+47 Rt.				
	Retro. .020" slots w/sock	I-0.5	D-2.0	D-2.5	D-1.0
No. 5	Sta. 752+36 Lt. & Rt.				
	Retro. .020" slots w/sock	I-1.5	D-1.5	I-2.0	D-3.5
No. 6	Sta. 752+72 Rt.				
	Retro. .020" slots wo/sock	D-1.0	D-1.0	0.0	D-1.5
No. 2	Sta. 753+64 Rt.				
	Retro. .020" slots w/sock	I-0.5	0.0	I-0.5	D-1.0
No. 8	Sta. 755+25 Rt.				
	Trench (3"x10") HDPE w/sock	I-1.5	I-0.5	I-3.5	I-1.5
No. 9	Sta. 756+10 Rt. & Lt.				
	Trench (3"x10") HDPE w/sock Rt.				
	Trench (3"x8") HDPE w/sock Lt.	I-2.5	I-3.0	I-3.5	I-0.5
No. 10	Sta. 756+37 Rt. & Lt.				
	Trench (3"x10") HDPE wo/sock				
	Trench (3"x8") HDPE w/sock Lt.	I-5.5	I-5.5	I-7.0	D-1.5
No. 11	Sta. 758+17 Lt. & Rt.				
	Trench (3"x10") .020 slots				
	PVC w/sock Rt.				
	Trench (3"x8") .020" slots				
	PVC w/sock Lt.	I-7.0	I-8.5	I-4.5	I-1.0
No. 12	Sta. 760+24 Rt.				
	Trench (3"x10") .020 slots				
	PVC w/sock Rt.	0.0	D-1.5	0.0	D-1.0
No. 7	Sta. 761+60 Rt.				
	Retro. .010" slots				
	PVC wo/sock Rt.	I-2.0	I-2.0	D-1.0	I-0.5

NOTE: All trenched pipes have solid PVC from edge of pavement to outlet.
Outlets have rodent protection.

All trenches are 3"x10" on the right. All trenches are 3"x8" on the left

I = Increase D = Decrease

TABLE 2 TRANSVERSE CRACK SEALANT PERFORMANCE

	Avg PI		
Test Section	February 1988	February 1989	Change
1 (stations 67 to 96)	80.1	35.4	44.7 decrease
2 (stations 505 to 510)	81.2	46.9	34.3 decrease
3 (stations 775 to 800)	54.8	58.9	4.1 increase

NOTE: PIs are the average PI of the two northbound and the two southbound wheel ruts.

ment sections 7 years after construction (1988), and 11 percent less transverse cracks in the full removal and replacement sections.

4. The overlay sections and full removal sections had deteriorated at about the same rate (2.5 in./mi/year) from 1984 to 1987. From 1987 to 1988, the overlay sections continued to deteriorate at the same rate, whereas the full removal sections did not deteriorate.

5. The average PSI for all four sections deteriorated from 4.1 in 1981 to 3.2 in 1988, a loss of 0.13 PSI a year.

6. The severe deterioration (V-shaped void) at the interface of the transverse crack and gravel base in Section 1 (partial removal and overlay) was caused by pumping. The deterioration was less severe in the full removal section because the section had been exposed to pumping for only 7 years.

7. Tenting is a severe problem on US-51 during the months of December, January, and February. The ride quality of sections 1–4 during the winter and summer months is compared in the following table.

	Summer	*Winter*
PI	18.6	80
PSI	3.2	1.3

8. TIC drains appear to be ineffective in solving the tenting problem.

9. Performance as measured by profilograph surveys was significantly better in two of three test sections where cracks were sealed. Sections were resealed in July 1989 and reevaluated in February 1990.

RECOMMENDATIONS

1. The transverse cracks should be investigated as part of the pavement performance evaluation in the selection of the type of pavement rehabilitation. If core samples show severe structural deterioration (V-shaped voids at the interface of the transverse crack and the gravel base) the asphaltic pavement should not be overlaid. The existing pavement should be completely removed and either relaid cold and compacted as a base course, or relaid as a recycled asphaltic material.

2. The performance of the test sections should be monitored for the next few years to determine the rate of pavement deterioration.

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