Experimental Rehabilitation of Jointed Portland Cement Concrete Pavement

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A study was initiated in 1981 by the Wisconsin Department of Transportation to demonstrate and evaluate the performance of some innovative rehabilitation techniques on a section of I-90 between STH 30 and USH 18. The existing pavement was a 20-year-old, four-lane, 9-in. reinforced concrete pavement with dowelled contraction joints spaced at 80 ft. The average daily traffic in 1981 on this segment of highway was 36,000, with 30 percent trucks. Eight different full-depth, full-lane-width, portland cement concrete (PCC) patching techniques were tried. Patch lengths were 4, 5, and 6 ft. Eleven percent of the total surface area of the existing PCC pavement was patched. After patching, the eastbound lanes were intermittently ground and westbound lanes were continuously ground. All transverse cracks and joints were filled with a silicone joint sealant. The longitudinal joints were filled with a rubberized asphalt sealant. Five years after the rehabilitation was completed, the condition of the various sections had deteriorated considerably. Pavement serviceability index values for the driving lane of the intermittently ground pavement dropped from 3.1 in 1981 to 1.6 in 1986. Ride quality of the continuously ground pavement dropped to 2.2. The friction quality of the pavement is at the minimum desirable for both the continuously ground and the intermittently ground pavement. Of the patching techniques studied, full-lane-width, full-depth patches with some means of load transfer performed the best. Skewing of joints helped greatly, reducing both the faulting and the slab deflection. The precast patches and the 4-ft cast-in-place patches faulted and deflected the most.

The selected pavement was a 2.0-mi section of I-90 between STH 30 and USH 18 in Dane County, Wisconsin. Because the best rehabilitation techniques for jointed reinforced concrete pavement were not well established in 1981 when a portion of this highway was due for major maintenance, it was decided to utilize a series of techniques and evaluate the resultant performance. Full-depth and partial-depth patching in conjunction with intermittent diamond grinding were tried in the eastbound pavement. The grinding was done upon completion of the patching. Rehabilitation work started on July 6, 1981, and was suspended in November after completion of joint repair and diamond grinding.

BACKGROUND

The existing pavement was originally constructed in 1960–1961. The pavement consisted of 9 in. of reinforced portland cement concrete (PCC) with dowelled joints at 80-ft intervals over a 6-in. crushed gravel base and a 9-in. granular subbase. At the time of rehabilitation in 1981, this section of pavement had many areas of deteriorated transverse joints and spalled intermediate cracks. The pavement that had been removed because of joint failure had been replaced with bituminous patches. These patches had shoved or rutted, producing a poor ride. The 1979 pavement serviceability index (PSI) readings varied between 1.94 and 2.28, on a scale of 1 to 5, and rehabilitation on the Interstate typically begins when the PSI falls below 2.5. Thus, the project was a prime candidate for major rehabilitation efforts. The pavement is subjected to normal midwestern weather conditions, with temperatures ranging from 95°F to −20°F, and an average annual rainfall of 35 in. The original pavement was designed for an average daily traffic (ADT) of 19,600, with 10 percent trucks by 1978. However, by 1981 the actual ADT was over 36,000, with 30 percent trucks. The driving lane was exposed to 1.1 million equivalent single-axle loads (ESALs) per year from 1981 to 1986.

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CONSTRUCTION PROCEDURES

Joint Repair

The Wisconsin Department of Transportation (WisDOT) decided to repair the deteriorated joints by trying eight variations of full-width patch types in 13 test sections varying in length from 1,500 to 5,000 ft. These designated patch types were

1. 6-ft precast,
2. 4-ft cast-in-place,
3. 5-ft cast-in-place,
4. 6-ft minimum cast-in-place,
5. 5-ft cast-in-place with skewed joints,
6. 6-ft minimum cast-in-place with skewed joints,
7. 6-ft minimum cast-in-place with undercut joints, and
8. 6-ft minimum cast-in-place with dowels and tie bars.

In addition to the eight designated patch types, a number of other patch lengths were placed during construction (7, 8, 9, and 12 ft). Several partial-lane-width patches were also placed in each test section to repair corner distresses. Partial-lane-width patches were normally 4-ft by 6-ft. All partial-lane-width patches were cast-in-place PCC.

Concrete Placement

All cast-in-place patches were made with standard WisDOT Grade A six-bag mix, premixed and brought to the job site.

The patch was finished by striking off the concrete to existing pavement height. The precast slabs were cast in the contractor's yard to a thickness of 8½ in. A ½ in. portland cement mortar grout was placed as a leveling bed just before the precast slabs were placed.

Joint Repair Sections

The eastbound roadway had seven different sections. This roadway had varying length portions of 4-, 5-, and 6-ft cast-in-place patches, 5- and 6-ft cast-in-place patches were skewed joints, and 6-ft precast patches. In addition, some 4-ft by 6-ft partial-lane-width patches and 7-, 8-, 9-, and 12-ft-long patches were also placed. These patches did not have any type of load-transfer devices.

Most of the westbound roadway was repaired with 6-ft cast-in-place sections—1,500 ft of 6-ft cast-in-place with load-transfer devices and 6-ft cast-in-place with undercut joint patches. The load-transfer devices were spaced at 1-ft centers. Dowel bars, 1¼ in. in diameter by 18 or 24 in. long were placed on the "approach side" and Number 6 deformed bars were put on the "leave side." The undercut slabs required excavation of a minimum of 6-in. undercut depth. In addition to patches with the load-transfer devices and the undercut patches, the westbound roadway was also repaired with partial-lane-width patches and some of variable length. These patches did not have any type of load-transfer devices.

PAVEMENT GRINDING

It was intended that the repaired pavement in the eastbound lanes would be ground only where faulting or other high spots greater than 0.3 in. existed. The entire length of the test section in the westbound lanes was to be ground after patching. The grinding machine used a 6-ft-wide pass, so only two passes were required for each 12-ft-wide lane.

REHABILITATION COST

The total cost associated with this project was $1.1 million. Listed below are some of the bid prices for the various types of rehabilitation techniques:

1. Full-lane-width patches, $40/yd²;
2. Undercut patches, $50/yd²;
3. Dowelled patches, $58/yd²;
4. Partial-lane-width patches, $42/yd²; and
5. Intermittent and continuous grinding, $2.92/yd².

PAVEMENT SURFACE CONDITIONS

Distress and Condition Before Rehabilitation

The driving lane of the existing 9-in.-thick pavement had been exposed to approximately 6,800,000 18-kip ESALs at the time of rehabilitation. The existing pavement had been opened to traffic in 1961 and had been in service for 20 years. According to the AASHTO design method in use in Wisconsin, this pavement would be expected to carry 6,600,000 ESALs during its 20-year life (i.e., before reaching a terminal serviceability index of 2.0). At the time of rehabilitation, the overall average serviceability for the driving lane, which had carried at least 6,800,000 ESALs, was 1.9. The surface condition had deteriorated significantly, and major rehabilitation was required.

Three surface conditions were rated before the planning of the rehabilitation. These three conditions were transverse and diagonal cracking, joint and crack spalling, and patching. The amount of cracking in the eastbound and the westbound lanes was about the same, but there was considerably more patching in the westbound lanes.

As-Rehabilitated Condition

By the end of the rehabilitation process in 1982, approximately 1,157 patches had been placed; almost all of the 700 existing transverse joints had been replaced with a patch of some type and length. Most of the existing transverse intermediate cracks were routed out and filled. Where the intermittent grinding (after patching) was done in the eastbound lane, the rehabilitated pavement had a rather blotchy appearance. The westbound lane had a more uniform appearance.

Distress and Condition after Rehabilitation

The existing distress of the pavement structure was assessed annually from 1982 to 1986 (with exception of 1983) to establish a history of performance. Eight items of distress were observed and ranked (transverse cracking, diagonal cracking, longitudinal cracking, centerline spalling, joint spalling, patching, and surface spalling).

Results of Distress Survey

The results of the annual distress and condition surveys from 1982 to 1986 indicate a steady increase in all distress consolidated measures (Tables 1 and 2). As indicated, the total amount of square footage of patching increased with time. Some of this was due to the replacement of patches with larger patches during the 5-year study period. At the termination of the study in 1986, there was need for more patching to replace failed patches or to repair areas of spalled concrete.

After 5 years of performance, the following statements appear to be substantiated by the data collected:

1. Those patches where load transfer was provided, either by dowel bars or undercutting, had failed the least and thus performed the best.
2. The partial-lane-width patches and the precast patches had faulted, deteriorated, and failed the most.
3. More cracking within the cast-in-place patches occurred for the shortest-length patches (4 to 6 ft) than in the longer ones (7 to 8 ft).
4. Cast-in-place patches longer than 8 ft tended to crack both longitudinally and transversely.
5. The optimum patch length for cast-in-place patches without any load-transfer devices appears to be 7 to 8 ft (for

undercut patches and patches with load-transfer devices the optimum length may be less).

Faulting

Fault depths were measured with a fault gauge about 2 ft from the edge of the pavement. Fault depth measurements were obtained before rehabilitation (in 1981) at the deteriorated joints and then annually from 1982 to 1986 at the two joints formed by the new patches. Before rehabilitation, the average fault depth at the joints in the driving lane (DL) was 0.28 in., and 0.09 in. in the passing lane (PL).

The fault measurements collected between 1982 and 1986 indicated that the provision of the load transfer had a significant impact on the amount of faulting that occurred (Tables 3 and 4); for example, the increase in faulting measured at the approach side of the 6-ft cast-in-place patches (with load transfer) was only 0.01 in. in the evaluation period compared with an increase of 0.10 in. for the 6-ft cast-in-place patches without load transfer.

Average fault depth (average of approach and leave sides) was plotted against patch length (Figure 1). The results show that there is a decrease in faulting with an increase in patch size up to 7 or 8 ft. The shorter the size of patch, the more faulting (all other factors being equal). Thus, of all the designated patch types, the 4-ft cast-in-place patches had faulted the most. It appears that placing patches at a skew to the centerline did, in fact, serve to keep the faulting approximately 38 percent less than that which had occurred for the patches placed perpendicular to the centerline (averaged from 1982 to 1986). There was no significant difference in faulting between right-hand-forward (RHF) and the left-hand-forward (LHF) skewing for the same patch size. The 6-ft precast patches faulted more than the 5-ft transverse cast-in-place patches, but less than the 4-ft cast-in-place patches. Some of the faulting in the precast patches was due to difficulty in getting the patches placed at the proper elevation during construction.

Fault measurements were taken on patches in every category except the 4- by 6-ft partial-lane-width patches (it was obvious these smaller patches had failed to perform because of significant faulting and cracking).

TABLE 1 DISTRESS AND CONDITION SURVEY RESULTS: 1982

Joint/Crack Spalling

	In or Next to New Patches, LF		Old PCC, LF	
	DL	PL	DL	PL
Total				
EB (15,000' Centerline)	141	108	239	115
WB (14,500' Centerline)	51	4	249	210
Grand Average/Station (EB & WB Combined)	0.7	0.4	1.7	1.1

Patch Cracking
(both directions and lanes grouped together)

Patch Type*	No. in Project	No. Cracked	Type of Crack**	% Cracked
4' CIP	88	2	Longitudinal	2.3
5' CIP	136	3	Longitudinal	2.2
6' CIP	497	4	Longitudinal	0.8
6' Precast	29	2	Longitudinal	6.9
6' CIP Undercut	39	0	- - - - -	0
6' CIP Dowelled	50	0	- - - - -	0
7' CIP	22	0	- - - - -	0
8' CIP	25	0	- - - - -	0
9' CIP	19	1	Transverse	5.3
10' CIP	13	0	- - - - -	0
11' CIP	4	0	- - - - -	0
12' CIP	11	1	Diagonal & Transverse	9.1
TOTAL	933	13		

* Transverse RHF, and LHF all grouped together

** A longitudinal crack is longitudinal with respect to the pavement centerline thus, it would be approximately 6 feet long in a 6' x 12' patch.

The average fault depth (average of the approach and the leave sides from 1982 to 1986) was plotted against them (Figure 2) for various types of 6-ft-long patches. The results indicate that over a period of 5 years the 6-ft precast patches had faulted the most and the 6-ft cast-in-place patches with the load transfer devices had faulted the least.

Ride

The original intent was to use PSI to compare the ride quality related to the various types and lengths of patches used in each test section. Because different patch types were used in each test section, the rating of individual patch type with respect to ride was not possible. Mixing patches on each test section had no effect on analysis of performance in each patch category. Consequently, ride quality in this paper will focus on the effect of different grinding techniques. The ride measurements on this project were obtained by using a Wisconsin Roadmeter on an annual basis.

The ride data (Table 5) show that the average ride before any rehabilitation was 1.9 in the DL and 2.2 in the PL. The state of Wisconsin generally begins Interstate rehabilitation plans when the PSI falls below 2.5.

Initially, the intermittent grinding raised the PSI above that measured for the previous patched condition by 1.2 (DL and PL combined), whereas an increase of 2.6 points resulted from the continuous grinding process. Unfortunately, this improvement in ride quality did not last very long. During the period between 1981 and 1986 there had been a continuing decline in the ride quality (Figure 3). The PSI value for the intermittent ground section in 1981 was 3.1 compared with 1.6 by 1986, approximately a 48 percent decrease. In 1981 the average PSI value for the continuously ground section was 4.7, but by 1986 this value had dropped to 2.2, a 53 percent decrease. Thus, within the 5-year period (1981 to 1986) the average PSI value for each of the special sections had dropped below 2.5, the level at which rehabilitation should be considered.

Although the effect of grinding on ride quality by patch category could not be evaluated because of mixed patches in the study sections, there is a direct relationship between faulting and ride. Detailed fault measurements were taken for every patch type in this study. Detailed fault measurements could be used to establish a linkage between ride quality and patch type and hence became a reliable performance indicator.

WisDOT performance measurements show that the 6-ft full-lane-width dowelled and undercut patches performed best compared with the other patch categories studied in detail.

Friction

Pavement friction measurements were made annually. A reported friction number (FN) of FN_{40} indicates that the value

TABLE 2 DISTRESS AND CONDITION SURVEY RESULTS: 1984–1986

YEAR	PATCHES (sq.ft.)	TRANSVERSE CRACKING (ft)	LONGITUDINAL CRACKING (ft)	CENTERLINE CRACKING (ft)
1984	76,388	27,763	124	915
1985	79,111	31,714	173	2,041
1986	79,983	33,736	248	4,564

TABLE 3 AVERAGE FAULT DEPTHS IN DRIVING LANE

Patch Type	1982		1984		1985		1986	
	Approach	Leave	Approach	Leave	Approach	Leave	Approach	Leave
4' CIP Transverse	0.35	0.26	0.43	0.30	0.44	0.32	0.40	0.35
5' CIP Transverse	0.24	0.22	0.30	0.31	0.31	0.30	0.31	0.32
5' CIP RHF	0.18	0.18	0.20	0.21	0.27	0.29	0.30	0.30
6' CIP Transverse	0.17	0.20	0.27	0.30	0.27	0.32	0.27	0.35
6' CIP LHF	0.11	0.12	0.15	0.18	0.15	0.23	0.15	0.25
6' CIP RHF	0.13	0.14	0.13	0.21	0.12	0.23	0.14	0.23
6' Precast	0.28	0.23	0.26	0.39	0.39	0.37	0.32	0.43
6' Undercut	0.05	0.09	0.12	0.13	0.12	0.18	0.22	0.13
6' Dowelled (Skewed & Transverse)	0.02	0.13	0.02	0.17	0.03	0.23	0.03	0.22
7' CIP Transverse	0.09	0.11	0.15	0.29	0.18	0.34	0.20	0.33
8' CIP Transverse	0.14	0.18	—	—	—	—	—	—
11' CIP Transverse	0.12	0.18	—	—	—	—	—	—

TABLE 4 AVERAGE FAULT DEPTHS IN PASSING LANE

Patch Type	1982		1984		1985		1986	
	Approach	Leave	Approach	Leave	Approach	Leave	Approach	Leave
4' CIP Transverse	0.29	0.14	0.32	0.15	0.37	0.16	0.34	0.21
5' CIP Transverse	0.14	0.09	0.21	0.19	0.23	0.16	0.25	0.21
5' CIP RHF	0.10	0.07	0.20	0.07	0.20	0.15	0.17	0.12
6' CIP Transverse	0.11	0.08	0.21	0.15	0.19	0.16	0.23	0.19
6' CIP LHF	—	—	0.07	0.10	0.09	0.11	0.10	0.12
6' CIP RHF	0.07	0.08	0.10	0.12	0.13	0.14	0.16	0.13
6' Precast	0.27	0.13	0.22	0.13	0.32	0.14	0.28	0.15
6' Undercut	0.04	0.02	0.10	0.02	0.10	0.04	0.14	0.06
6' Dowelled (Skewed & Transverse)	0.01	0.06	0.02	0.07	0.01	0.08	0.04	0.08
7' CIP Transverse	—	—	0.12	0.12	0.15	0.19	0.17	0.21
8' CIP Transverse	—	—	—	—	—	—	—	—
11' CIP Transverse	—	—	—	—	—	—	—	—

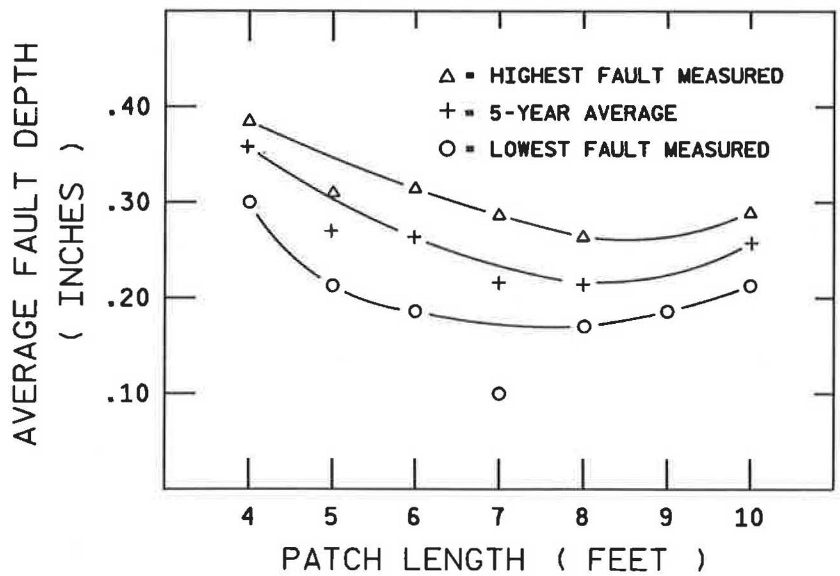

FIGURE 1 Faulting in the driving lane for transverse cast-in-place patches (approach- and leave-side faulting averaged).

was obtained at 40 mph (Table 6). Before any rehabilitation, the average was FN_{31} in the DL and FN_{42} in the PL. Intermittent grinding in the eastbound lanes raised the friction number by 5; continuous grinding raised it by 12.

After 5 years, the intermittently ground sections lost 5 FNs in the DL, whereas the continuously ground sections lost 10 FNs. The FN_{40} in the PL for intermittently ground section was 43, whereas the continuously ground section had a value of 40.

From the results it appears that, although grinding improved both profile and ride, it did not have a similar affect on friction. Before-and-after friction tests of intermittent versus continuously ground sections show better first-year performance in the continuously ground sections. However, friction values converge rapidly after that. Therefore, except for the first year, friction values do not seem to be very different for either grinding technique.

On the basis of considerable experience and observations, sustained friction numbers of 30 or more should be adequate for roadways having low to moderate levels of traffic volume. This indicates that the DLs in both directions were operating close to a minimum desired friction level.

Deflection of Patches

Deflection is defined as the amount of downward vertical movement of a surface due to the application of a load to the

surface. For this study, deflection of patches is defined as the maximum movement of a slab corner, that is, the movement from peak uplift (if any) to maximum downward deflection. The data for slab deflection are presented in Table 7. These data have been adjusted for slab curling. Each entry is the average deflection of both the approach and leave sides of the patch. The slab deflection readings in 1981, 1983, and 1984 were much larger than in 1982, 1985, and 1986, because the warmer average slab temperature in 1982, 1985, and 1986 caused the adjacent pavement slab to be in close contact. The friction thus developed further helped load transfer from one slab to another.

After 6 years of testing, the undercut slabs and those with load transfer devices seem to have the smallest amount of deflection, whereas the precast slabs had the largest. Skewing of slabs helped reduce the amount of deflection; that is, RHF slabs had 46 percent less deflection (averaged over 6 years) than similar-sized transfer slabs, and LHF slabs had 22 percent less.

Partial-Lane Patches

Joint spalls, corner breaks, and other minor surface defects were rehabilitated using partial-lane-width patches. At these locations it was believed that a full-lane-width patch was not necessary to repair the distress. The partial-lane-width patches were 4 ft wide and 6 ft long. All partial-lane-width patches were cast-in-place (CIP). The partial-lane-width patches tended to crack, settle, fault, and deflect considerably more than the full-lane-width patches. Partial-lane-width patches also caused the surrounding concrete to deteriorate from the cutting into the concrete to place a patch and caused spalling and cracking. At the end of 5 years, nearly 95 percent of the partial-lane-width patches had failed.

CONCLUSIONS

Based on 5 years of data collection and observations, the following conclusions appear to be warranted:

1. There was only a 1 percent increase in the area of patching in the 5 years of study, suggesting that the initial selection for joint repair with patching was good.

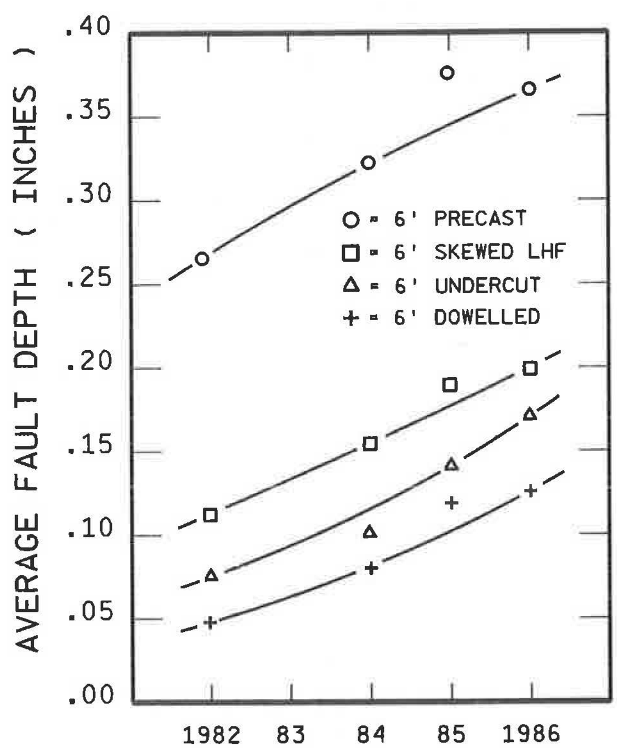

FIGURE 2 Relationship between average fault depth and various rehabilitation techniques over a period of 5 years.

TABLE 5 PRESENT SERVICEABILITY INDEX RESULTS FOR I-90 REHABILITATION, DANE COUNTY

Condition	No Grinding Section		Intermittent Grinding Sections		Continuous Grinding Sections	
	DL	PL	DL	PL	DL	PL
Before Rehabilitation	1.8	2.1	2.0	2.4	2.2	2.2
After Patching, Before Grinding	1.9	—	2.2	2.3	2.0	2.4
Shortly After Grinding	—	—	3.1	3.7	4.7	4.8
One Year After Rehabilitation	1.7	2.4	2.4	3.2	3.8	4.3
Two Years After Rehabilitation	1.5	2.2	2.1	2.9	3.1	3.8
Three Years After Rehabilitation	1.3	1.9	1.8	2.4	2.9	3.8
Four Years After Rehabilitation	1.1	1.9	1.6	2.5	2.6	3.7
Five Years After Rehabilitation	1.2	2.0	1.6	2.3	2.2	3.4

2. Continuous grinding improved the ride quality much more than intermittent grinding, but in 5 years ride quality had fallen to undesirable levels for both types of grinding techniques.

3. Continuous grinding improved the friction values much more than intermittent grinding, but friction quality had fallen in 5 years to near-minimal target levels for both types of grinding techniques.

4. The partial-lane-width patches essentially failed in 5 years.

5. The optimum patch length (with respect to cracking) appears to be 7 or 8 ft; patches shorter or longer than this tended to crack both transversely and longitudinally.

6. The shorter the patches (4, 5, and 6 ft CIP transverse), the more faulting. At 7 or 8 ft the faulting remains the lowest and then increases slowly by an increase in size.

7. The load-transfer and the undercut patches had faulted the least and the 4-ft cast-in-place and 6-ft precast had faulted the most in 5 years.

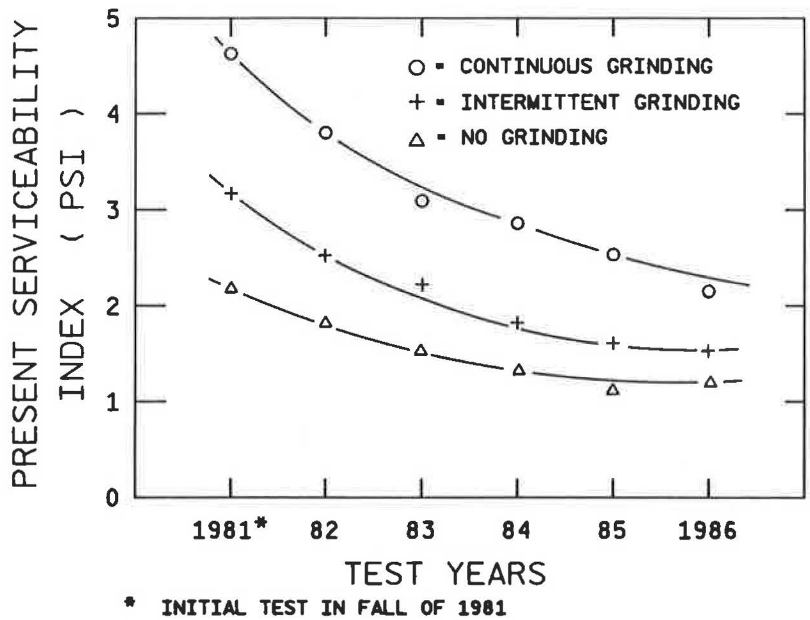

FIGURE 3 Relationship between PSI and various types of grinding techniques.

TABLE 6 FRICTION DATA RESULTS

Condition	Test Date	Friction Numbers, FN40			
		EB		WB	
		DL	PL	DL	PL
Before Rehabilitation	6/29/81	32	42	30	43
		Intermittent Grinding		Continuous Grinding	
Shortly After Grinding	11/05/81	37	45	42	46
One Year After Grinding	9/09/82	35	48	37	44
Two Years After Grinding	9/83	30	42	31	40
Three Years After Grinding	8/84	30	41	32	39
Four Years After Grinding	9/85	33	45	33	42
Five Years After Grinding	9/86	32	43	32	40

Friction numbers were obtained at the standard test speed, and represent the average of 10 to 22 tests.

TABLE 7 DEFLECTION OF PATCHES AT JOINTS

Patch Type	Average Deflection (Driving Lane Only)**						
	n*	11/18/81	10/07/82	11/16/83	10/22/84	10/22/85	10/21/86
6' CIP Undercut, Transverse	n=3	0.0042"	0.0028"	0.0032"	0.0029"	0.0025"	0.0019"
6' CIP Dowelled, Transverse	n=2	0.0061"	0.0025"	0.0042"	0.0029"	0.0027"	0.0024"
6' CIP RHF	n-3	0.0102"	0.0033"	0.0051"	0.0048"	0.0034"	0.0026"
5' CIP RHF	n=3	0.0115"	0.0029"	0.0067"	0.0048"	0.0039"	0.0026"
6' CIP LHF	n=2 to 3	0.0156"	0.0043"	0.0068"	0.0056"	0.0066"	0.0038"
4' CIP Transverse	n=3	0.0182"	0.0045"	0.0107"	0.0082"	0.0085"	0.0059"
5' CIP Transverse	n=4	0.0210"	0.0050"	0.0091"	0.0068"	0.0069"	0.0038"
6' CIP Transverse	n-2 to 3	0.0224"	0.0052"	0.0105"	0.0065"	0.0064"	0.0035"
6' Precast	n=3	0.0248"	0.0053"	0.0093"	0.0078"	0.0073"	0.0040"
7' CIP Transverse	n=1	—	0.0043"	0.0111"	0.0075"	0.0084"	0.0047"
9' CIP Transverse	n=2	—	0.0032"	0.0060"	0.0040"	0.0052"	0.0046"
12' CIP Transverse	n=1	—	0.0039"	0.0079"	—	0.0062"	0.0055"
13' CIP Transverse	n=1	—	0.0051"	0.0075"	—	0.0063"	0.0061"
19' CIP Transverse	n=1	—	0.0044"	0.0054"	—	0.0084"	0.0059"

* n=number of patches measured for deflection. Amount of deflection on approach side and on leave side averaged to give one reading for one patch.

** obtained with accelerometers and a moving 18 kip rear axle load.

8. It appears that placing patches at a skew to the centerline did in fact serve to keep the faulting less than that which occurred for the patches placed perpendicular to the centerline.

9. The undercut patches and those with load-transfer devices had the least amount of slab deflection due to an 18-kip axle load passing over the patch at 40 mph. The precast slabs and the 4-ft CIP transverse slabs had the greatest amount of deflection. The 6-ft CIP skewed (LHF and RHF) patches reduced the deflection by 22 to 46 percent over 6-ft transverse CIP patches.

10. The results of rehabilitation cost analysis indicate that the load-transfer patches should have a service life of at least 7 years in order for them to be cost-effective.

RECOMMENDATIONS

On the basis of 5 years' experience with the Interstate Rehabilitation Study of Jointed PCC Pavement (I-90 in Dane County), the following recommendations appear warranted:

1. Patches should be full lane width, full depth, and skewed.
2. A minimum patch length of 6 ft and maximum of 8 ft should be used.
3. All patches should be dowelled or undercut to achieve load transfer.
4. Partial-lane-width patches should not be used.
5. Continuous diamond grinding should be used rather than intermittent diamond grinding.
6. PCC rehabilitation cost analysis should be performed to justify patching. This is an appropriate problem for computer modeling. Therefore, such a model can and should be developed to address the cost-effectiveness of patching versus complete reconstruction or other options for distressed PCC pavement.

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