Evaluation of Concrete Pavement Restoration Techniques on I-65

A. SAMY NOURELDIN AND REBECCA S. MCDANIEL

Construction of asphalt overlay layers on top of old concrete pavements is considered an efficient pavement rehabilitation strategy. These asphalt overlay layers, however, are usually subject to reflection cracking and high tensile and shear stresses related to movement of the old concrete slab and the resulting composite nature of the new pavement section (flexible/rigid section). In addition, these asphalt overlay layers are usually vulnerable to rutting-type distresses, which may be occurring more frequently with the recent increases in trucks carrying extremely heavy gross weights (more than 100,000 lb) and frequently reported high tire pressures (more than 120 psi). Concrete (rigid) pavements have the advantage of being rut-resistant compared to asphalt (flexible) pavements. The jointed reinforced concrete pavement (JRCP) has been very successful in Indiana's highway network. The pavement life span between major maintenances was proven to be considerably long (15–20 years). The purpose of this study is to evaluate concrete pavement restoration (CPR) techniques as viable alternatives to the placement of bituminous overlay layers. Statistical inferences were obtained for the effect of these CPR techniques on the improvement in ride comfort (represented by roughness measurements) and safety against skidding (represented by skid resistance or friction measurements). In addition, applying CPR techniques and then resurfacing (adding overlay layers) were compared against two consecutive resurfacing applications. This comparison was made to evaluate the CPR techniques in case future resurfacing is warranted to increase the pavement structural capacity. It was concluded that the CPR techniques have improved the ride comfort and friction (skid resistance) numbers significantly. Cost-effectiveness of CPR techniques may be doubtful, however, especially when the structural value of the rehabilitated pavement is marginal and needs to be increased with overlays.

An adequate pavement evaluation is essential to the ultimate selection of reliable and cost-effective rehabilitation techniques. The evaluation procedure usually involves problem definition through a determination of the cause and extent of the existing deterioration. Data necessary for adequate pavement evaluation generally include distress types, pavement materials, existing structural design, traffic loadings, climatic information, and deflection, roughness, and friction measurements.

This report presents evaluation procedures conducted for a medium-severity, deteriorated concrete pavement surface that was restored utilizing common concrete pavement restoration (CPR) techniques. The original pavement was jointed reinforced concrete pavement (JRCP) with a slab length of 40 ft, width of 12 ft, and thickness of 10 in. The old pavement remained sound for 18–20 years. However, some typical functional distresses were noted.

These distresses were described as corner, diagonal, longitudinal, and transverse cracking and some faulted, spalled, and broken-up joints. The pavement was subject to heavy traffic usage on I-65 (6,000 trucks per day). The deteriorated surface resulted in a rough ride represented by a roughness number of 1,200. Friction values also decreased considerably to hazardously low values (friction number <30).

The restoration techniques used were as follows:

1. Concrete slabs were undersealed with asphalt material to improve the subbase support at the joints.
2. Full-depth patches were used to replace sections of severe pavement breakups.
3. Partial-depth patches were used to repair minor surface distresses.
4. Joints and minor cracks were routed and resealed.
5. Diamond grinding was employed to repair and/or remove faulting at joints and cracks in addition to restoring the smooth riding quality and increasing the skid resistance.

ORIGINAL PAVEMENT CONDITION

A pavement "condition survey" was conducted in the initial stage of the study (1985). The jointed reinforced concrete pavement (JRCP) was sustaining 6,000 trucks per day. It consisted of a 10-in.-thick, reinforced concrete slab over an 8-in.-thick subbase. Slab dimensions were length, 40 ft, and width, 12 ft. The pavement was constructed in 1968 (17 years old at the time of condition survey). The condition survey was performed over the portion of I-65 between 2 miles north of SR-114 and US-231 at Crown Point. The north- and southbound lanes of I-65 (Indiana) between mile markers 217 and 247 (30 miles) were surveyed. The condition survey involved visual inspection, roughness measurements, friction measurements, and deflection measurements.

Visual Inspection

The 30-mile portion of I-65 (two lanes per direction) under study has 7,920 slabs in the northbound (NB) direction and 7,920 slabs in the southbound (SB) direction. Defects were present in 10.7 percent of the SB slabs (848 slabs) and 6.5 percent of the NB slabs (511 slabs). The major type of distress noted was the presence of "transverse cracks" near the midslab for a large number of slabs. Some other corner breaks,

Division of Research, Indiana Department of Highways (IDOH), West Lafayette.

FIGURE 1 Major distresses noted on I-65 portion under study. (top) Faulted crack. (bottom) Broken-up slab.

minor surface imperfections, and faulted and broken-up joints were noted (Figure 1). A rough ride and near slippery conditions were experienced when traveling at speeds higher than 55 mph during rainfall.

Roughness Measurements

A response-type PCA roadmeter roughness measuring system, typically used by the Indiana Department of Highways, was used for this study. Average roughness numbers (RNs) of 1,155 and 1,272 (in ⅛ in. per mile) were obtained (Table 1) for the northbound and southbound directions, respectively. These RNs correspond to predicted serviceability indices (PSI) of 3.1 and 2.9, respectively (*1*). The testing vehicle was operating at 50 mph.

Friction Measurements

The standard towed trailer with ribbed, locked wheel torque measuring, friction testing system (ASTM E274) was used to obtain information about friction (skid resistance). This equipment is also typically used by Indiana Department of Highways.

Average friction numbers (FNs) of 31 and 29 at 50 mph were obtained for the northbound and southbound directions, respectively (Table 2). These average friction numbers (average skid numbers) correspond to coefficients of wet pavement friction of 0.31 and 0.29, respectively. These FNs indicate that the pavement was very near the terminal friction life and that the occurrence of a hazardous situation when traveling at the speed limit (55 mph) was more likely.

Deflection Measurements

Tables 3, 4, and 5 show the average deflection measurements near joints, cracks, and midslab points as measured by the Dynaflect. Average readings of sensors 1 and 5, together with the range, are included. It is important to note that sensor 1 is located between the two loading wheels of the Dynaflect; sensors 2, 3, 4, and 5 are spaced at 1-ft increments from sensor 1 with sensor 5 at the greatest distance (4 ft from sensor 1).

The Indiana Department of Highways pavement evaluation practice makes use of the sensor 1 measurement as an indicator of slab stiffness and the sensor 5 measurement as an indicator of the pavement support stiffness (base or subbase). Readings of $50 * 10^{-5}$ in. or less by sensor 1 and $30 * 10^{-5}$ or less by sensor 5 are indicators of adequate pavement conditions and good pavement support, respectively. These values are frequently obtained from measurements of new pavements. Larger deflection values were obtained at the joints and cracks than at midslab points. This was expected since the joints are designed to move more freely. In general, average deflection values at (or near) either joints or midslab points were less than $50 * 10^{-5}$ in., indicating acceptable pavement structural conditions.

CONCRETE PAVEMENT RESTORATION (CPR) TECHNIQUES APPLIED

The CPR techniques applied in the summer of 1985 to restore this jointed reinforced concrete pavement (JRCP) were undersealing, full-depth patches, partial-depth patches, resealing of cracks and joints, and diamond grinding.

Undersealing

Concrete slabs were undersealed with oxidized asphalt to improve the subbase support and eliminate faulting at joints and cracks and to obtain more uniform support for concrete slabs. The Indiana undersealing method has been used successfully throughout the state and proven to be cost-effective in providing good pavement support under concrete pavement slabs. The method simply employs incremental Dynaflect measurements (each 100 ft) to detect locations of poor pavement support. Oxidized asphalt (20–30 penetration) is pumped into these locations, resulting in uniform pavement support and well-seated slab.

Full-Depth Patches

Full-depth patches (Figures 2 through 4) were used to replace sections of severe pavement breakups, for midslab repairs,

TABLE 1 COMBINED AVERAGE ROUGHNESS NUMBERS AND PREDICTED SERVICEABILITY INDEX (PSI)

Year	NB	SB	Average	PSI
1985 (Before CPR)	1155	1272	1214	3.0
1985 (After CPR)	215	247	231	5.0
1986	401	399	400	4.4
1987	426	408	417	4.3
1988	510	498	504	4.1

Note: *Predicted serviceability index values are based on the regression equation:

$PSI = 11.73 - 2.83364 \log (RN)$, $R^2 = 0.68$, Reference No. 1

*Testing vehicle speed was 50 mph.

*Roughness numbers are in 1/8 inch per mile.

TABLE 2 COMBINED AVERAGE FRICTION NUMBERS

Year	NB	SB	Average
1985 (Before CPR)	31	29	30
1985 (After CPR)	40	44	42
1986	49	45	47
1987	40	42	41
1988	34	34	34

*FN of 30 corresponds to a coefficient of wet pavement friction 0.3.

TABLE 3 AVERAGE DYNAFLECT MEASUREMENTS AT JOINTS (IN 10^{-5} IN.) FOR NORTH- AND SOUTHBOUND DIRECTIONS

	Sensor #1				Sensor #5			
Year	NB	SB	Average	Range	NB	SB	Average	Range
1985 Before CPR	38	39	39	35-45	20	20	20	15-25
1985 After CPR	40	40	40	35-45	20	20	20	17-23
1986	45	45	45	40-50	19	20	20	17-23
1987	51	52	52	45-60	21	20	21	15-25
1988	59	60	60	52-70	21	22	22	15-25

NOTE: Measurements are for travelling lanes, no significant differences were found between the various sections of the 30 mile portion of I-65.

TABLE 4 AVERAGE DYNAFLECT MEASUREMENTS AT CRACKS (IN 10^{-5} IN.) FOR NORTH- AND SOUTHBOUND DIRECTIONS

	Sensor #1				Sensor #5			
Year	NB	SB	Average	Range	NB	SB	Average	Range
1985 Before CPR	38	40	39	34-44	19	19	19	15-22
1985 After CPR	40	38	39	34-44	20	20	20	15-23
1986	46	49	48	40-55	23	18	22	16-24
1987	54	52	53	45-60	24	21	23	18-25
1988	60	62	61	50-70	25	23	24	22-28

TABLE 5 AVERAGE DYNAFLECT MEASUREMENTS AT MIDSLABS (IN 10^{-5} IN.) FOR NORTH- AND SOUTHBOUND DIRECTIONS

	Sensor #1				Sensor #5			
Year	NB	SB	Average	Range	NB	SB	Average	Range
1985 Before CPR	28	31	30	25-35	18	18	18	14-22
1985 After CPR	30	34	32	25-35	20	20	20	15-25
1986	40	42	41	34-48	23	24	24	18-30
1987	45	47	46	36-50	24	24	24	18-30
1988	50	50	50	40-55	24	24	24	18-30

and at severely broken up joints and cracks. Three types of patches were employed:

1. An inverted "T" patch (midslab repairs);
2. A doweled patch (midslab repairs); and
3. An inverted "T" patch with a doweled contraction joint (at all replaced joints).

All full-depth patches were at least 8 ft long and 12 ft (lane) wide, meeting IDOH Standard Specifications and NCHRP recommendations (*2, 3*) for full-depth patches (6 ft minimum length and 12 ft width).

The inverted "T" patch was constructed by cutting up and lifting broken old slab pieces and removing the existing subbase beneath the deteriorated slabs and underneath the edge of the adjacent slabs (Figure 4). No problems were noted during removal of deteriorated sections or pouring of the fresh concrete. The subbase was not removed for the doweled patches (Figure 3). Dowel bars were used to provide load transfer to the adjacent slabs. Inverted "T" patches with dowel basket assemblies in the center were used at replaced joints. Figure 4 illustrates the construction of this type of patch.

Partial-Depth Patches

Partial-depth patches (Figure 5) were used to repair minor surface distresses, shallow defects, other surface imperfections, and slab corner breaks (distresses less than ½ ft deep).

Resealing Cracks and Joints

Midslab cracks were routed and resealed (Figure 6). Cracks and joints were resealed to inhibit intrusion of surface water and to avoid possible pumping resulting from water penetration. In addition, an open graded paving layer (#5 base, IDOH Standard Specification) was constructed as an edge drainage treatment between the concrete pavement edge and the existing trench drains in locations needing improved drainage.

Diamond Grinding

After all patches were constructed, diamond grinding was employed on the whole project to obtain a smoother riding

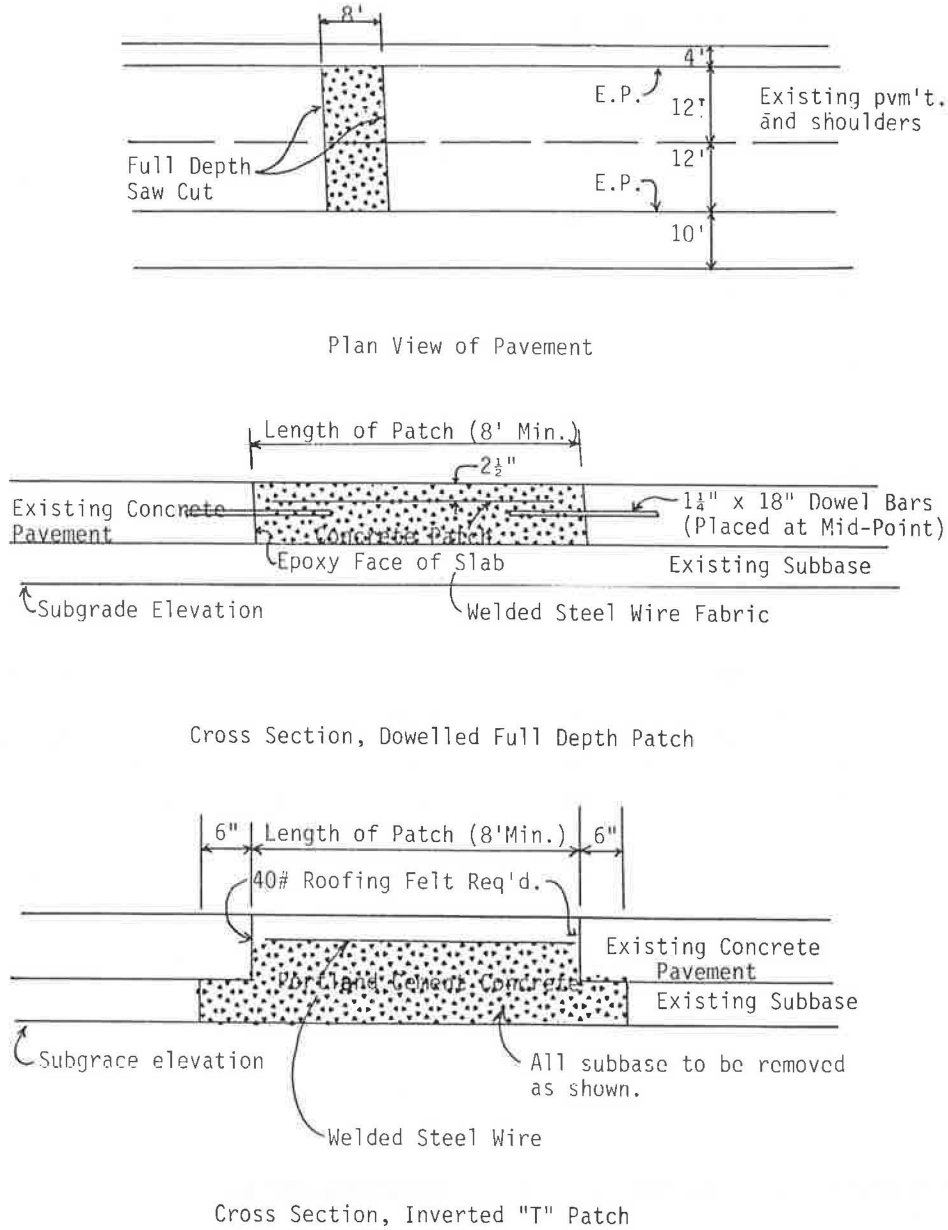

FIGURE 2 Concrete patch details.

quality, eliminate minor faulting at joints and cracks, and improve skid resistance. Figure 7 shows the concrete pavement surface texture after diamond grinding.

Detailed construction specifications for all CPR techniques are available from the authors (appendices) and can be forwarded upon request.

EFFECT OF CPR TECHNIQUES ON PAVEMENT CONDITION

A 3-year "evaluation survey" was conducted on the I-65 portion under study. The evaluation survey was applied annually (summers of 1985, 1986, 1987, and 1988), and pavement conditions were compared to those obtained during the "condition survey" (spring 1985).

The evaluation survey involved visual inspection, roughness measurements, friction measurements, and deflection measurements. The process of preparing the condition survey procedures included review of the literature (*4–12*).

Visual Inspection

Neither faulting nor spalling was observed at the joints. However, many of the routed and resealed cracks faulted about 1/16 in. down in the direction of traffic (measured using a straight edge). These faulted cracks remained almost the same during the 3-year evaluation period, but smaller hairline cracks have developed around them and eventually spalled out under the effect of heavy traffic on I-65 (Figure 6).

Some of the inverted "T," full-depth patches also had about

FIGURE 3 Construction of doweled full-depth patches. (top) Drilling dowel holes for doweled full-depth patch. (bottom) Pouring concrete in doweled full-depth patch.

$\frac{1}{16}$-in. faults at the last joints (in traffic direction). This may possibly be caused by incomplete concrete consolidation in the undercut areas of the inverted "T" patches.

Partial-depth patches placed adjacent to cracks and joints were spalling and broken up. Repairs were required just 1 year after rehabilitation (Figure 8). These distresses were frequently noted throughout the 3-year study period and may have been caused by poor load transfer and differential slab movement across the crack and through the partial-depth patch. In addition, all partial-depth patches that were placed over a crack had cracked (Figure 8). Furthermore, some partial-depth patches were responsible for creating new midslab cracks. This could be attributed to the weakness of the concrete slab due to the reduction of moment of inertia associated with the discontinuity and stress concentration occurring when partial-depth patches are constructed.

It is recommended that the use of partial-depth patches be limited as much as possible and that they be replaced with full-depth patches or bituminous patches; alternatively, it should be accepted that they must be rehabilitated annually.

Riding comfort and pavement texture have improved directly after the application of diamond grinding. No slippery conditions were experienced when traveling at 55 mph on the wet pavement. No significant declines in these qualities were noted during the 3-year evaluation period.

Roughness Measurements

Table 1 gives the combined average roughness numbers (traveling lane) for the northbound (NB) and southbound (SB) directions before employing CPR (1985) and after employing CPR (1985, 1986, 1987, and 1988) for the 3-year evaluation survey period.

The original data were collected by dividing the 30-mile portion of I-65 into six sections, two directions per section (NB and SB) and two lanes per direction (traveling lane and passing lane). The statistical analysis of variance indicated that the effects of section and direction were not significant; hence, the roughness numbers were combined as shown in Table 1. Roughness numbers for the passing lane were significantly lower than those for the traveling lane, as may be expected, owing to the heavy traffic usage of the traveling lane.

Predicted serviceability index (PSI) is also included in Table 1 for comparison purposes. It can be concluded that CPR is

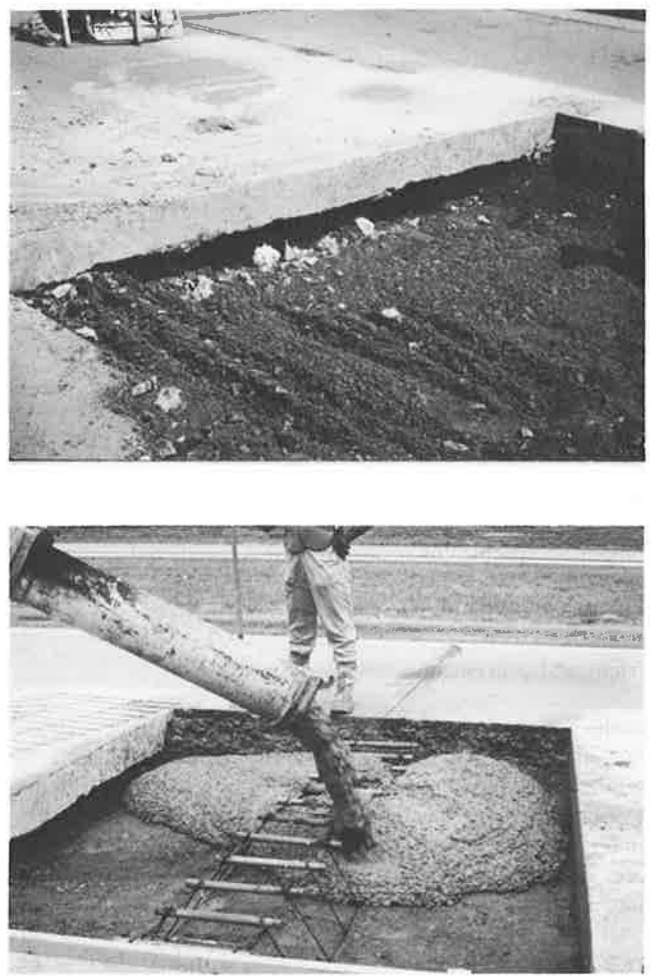

FIGURE 4 Construction of inverted T full-depth patches. (top) Excavation for full-depth inverted "T" patch. (bottom) Pouring concrete for inverted "T," full-depth joint replacement patch.

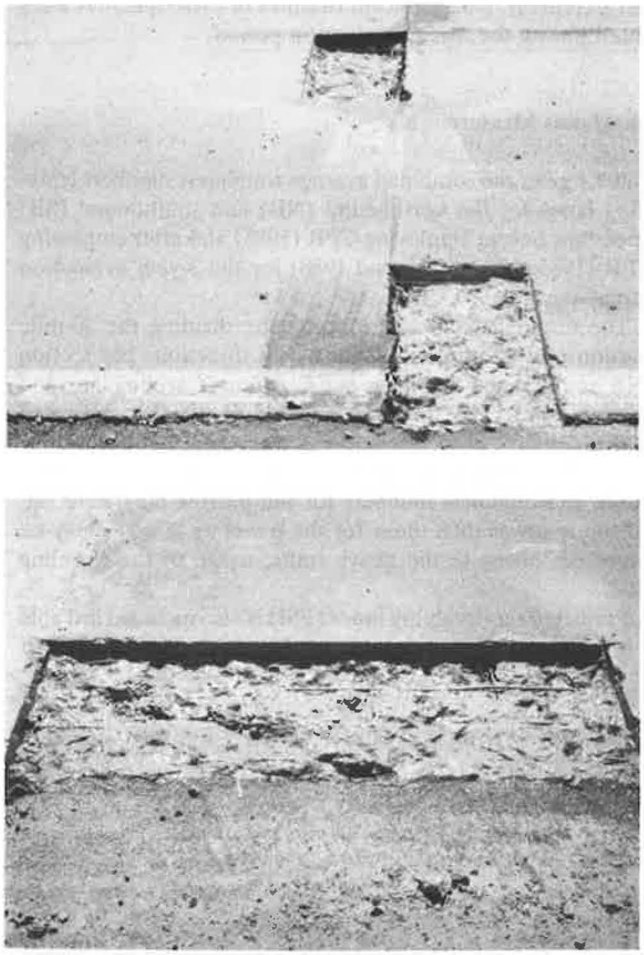

FIGURE 5 Construction of partial-depth patch. (top) Prepared partial-depth patches. (bottom) Epoxy coating on slides of a prepared partial-depth patch.

very successful in improving riding comfort and level of service, as indicated by the RN and PSI values. In addition, this improvement was sustained for a period of 3 years and may remain acceptable for a 6-year period (predicted from Figure 9).

Friction Measurements

Table 2 gives the combined average friction numbers (traveling lane) for the northbound and southbound directions before employing CPR and after employing CPR (1985 through 1988) for the 3-year evaluation survey period. Data were combined for the same reasons given earlier for combining roughness data. Passing lane friction numbers were significantly higher than those for the traveling lane.

CPR techniques (diamond grinding) have improved the friction numbers significantly (Table 2, Figure 10). The improvement in skid resistance, however, was predicted to remain for only 4 years (Figure 10), and another rehabilitation should be required to improve the pavement condition after those 4 years.

Deflection Measurements

Joints, Cracks, and Midslab

Tables 3, 4, and 5 give the average deflection values (traveling lane) before and after employing CPR. The traveling lane was considered to be more critical because it carries heavy truck traffic more frequently. The passing lane was eliminated from computing averages and had significantly lower deflection values than the traveling lane. Average deflection values were also combined for the six sections (covering the entire 30-mile portion) for the same reasons, explained earlier, that roughness and friction measurements were combined.

CPR techniques absolutely did not improve the slab structural capacity (as indicated by the increase in deflection values from 1985 through 1988, Tables 3, 4, and 5). This is attributed to the fact that all the CPR techniques used were only repairs of functional failures.

Undersealing maintained the subbase support for the 3-year evaluation period (see sensor 5 readings, Tables 3, 4, and 5). The increase in slab deflection (sensor 1 readings) is probably related to the cumulative effect of heavy traffic repetitions on I-65 during the study period. Predicted deflection values in 1989 (Figure 11) exceed $50 * 10^{-5}$ significantly, indicating the need for adding overlay layers on top of the concrete slabs by 1989.

Load Transfer Testing

Load transfer across the joints and cracks was evaluated 1 year after employing CPR (1986). Deflection was measured ½ ft before the joint or crack (by sensor 1) and ½ ft after the joint or crack (by sensor 2). The IDOH rigid pavement evaluation practice makes use of the deflection ratio (sensor 2/sensor 1) as an indicator of load transfer across joints and cracks. Ratios of 0.90 or more usually reflect a frozen joint. Ratios of 0.75 to 0.90 indicate good load transfer; values of 0.50 to 0.75 indicate fair load transfer; and ratios of less than 0.50 indicate poor load transfer.

Table 6 gives the load transfer coefficients at joints, cracks, and midslab points (the value shown for midslab is to indicate only that when continuity exists the coefficient is very close to 1.0). Load transfer efficiency across resealed joints was relatively good, while at resealed cracks it was only fair.

Load transfer efficiency was also tested at joints for doweled patches and "T" inverted patches (Table 6). Joints of doweled patches had good load transfer. Load transfer at joints of "T" inverted patches was relatively low, probably because of the lack of grain interlock caused by sawed face joints.

Along Patches

Figure 12 illustrates deflection distribution along the patches (doweled and inverted "T"). Lower deflection values were obtained for inverted "T," full-depth patches, which gained more structural capacity by removal of the subbase and its replacement with concrete. Deflection values along the patch were less than $50 * 10^{-5}$, except at joints where they exceeded this value.

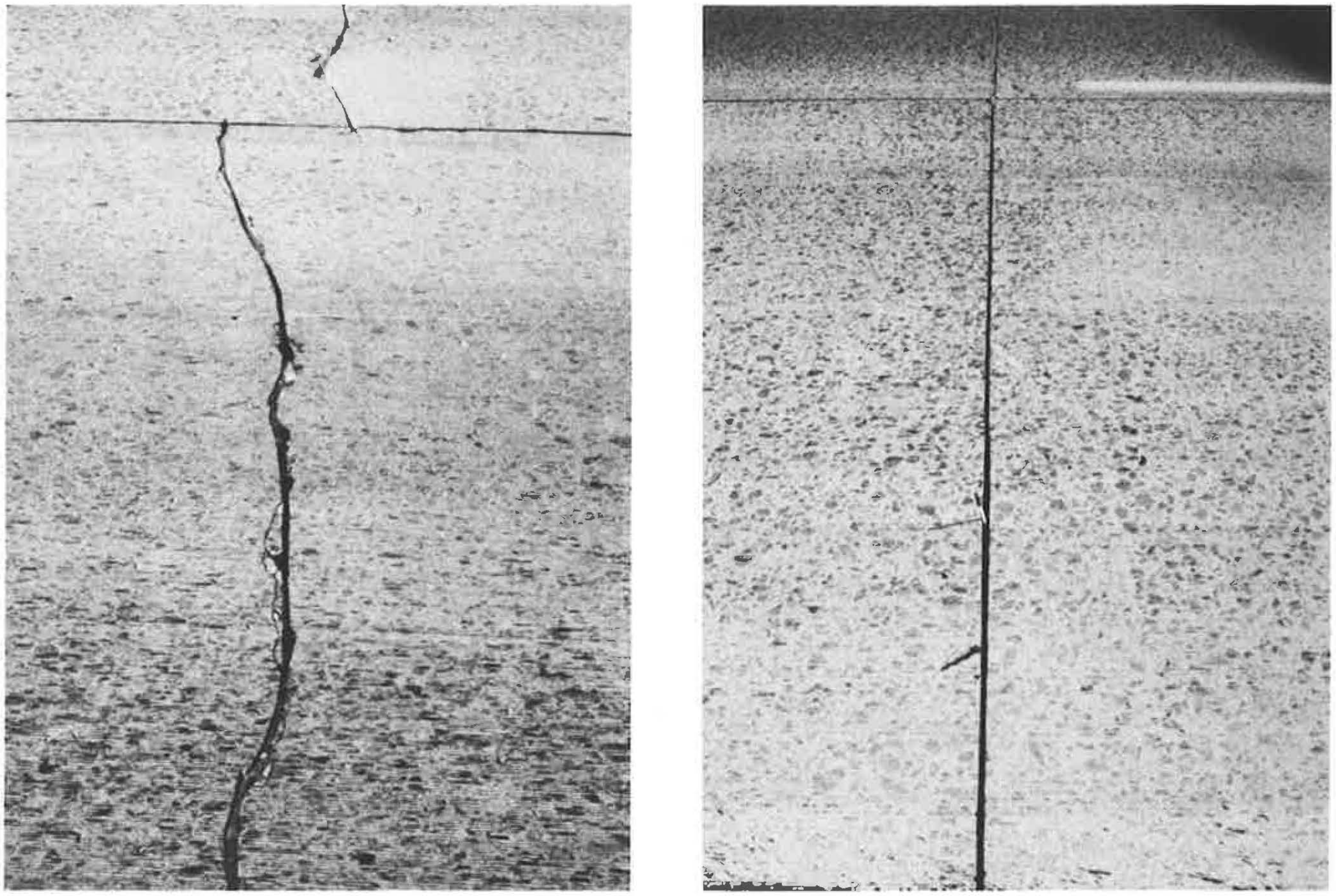

FIGURE 6 Sealing of joints and midslab cracks. (left) Routed and sealed crack. (right) Resealed joint.

COST ANALYSIS

Typical low bid prices on CPR contracts utilizing the three types of full-depth patches considered in this study appear in Table 7. The doweled patches are less expensive than the inverted "T" patches. The lower cost of the doweled patch was probably due to the smaller depth of patch required, since the subbase was not excavated and replaced with concrete.

The inverted "T" patch containing a doweled contraction joint cost approximately \$125 more than the same-sized, inverted "T" patch with no contraction joint. The cost per square yard of the partial-depth patch was almost twice as much as for the full-depth patch, even though the partial-depth patch had only a fraction of the depth of the full-depth patch. It should be noted that the minimum patch size of the full-depth patches was 12 ft by 8 ft. No minimum patch size existed for the partial-depth patches. Therefore, the partial-depth patches required more labor-intensive hole preparation covering a smaller area than the full-depth patches did. The cost of diamond grinding concrete surfaces was about \$3 per square yard. Typical low bid prices for other interstate rehabilitation projects using a conventional 4-in. overlay also appear in Table 7. The conventional 4-in. asphalt overlay cost is around \$5 per square yard. The overlay cost is almost twice as much as that of the diamond grinding treatment; that is, diamond grinding costs the equivalent of a 2½-in. asphalt overlay, although it adds nothing to the structural capacity of the pavement.

The cost comparison presented in Tables 7 and 8 indicates that CPR is more cost-effective than using a 4-in. asphalt overlay. However, values presented are based on the assumption that CPR will restore the pavement for a period of 10 years. This was not true for the I-65 portion under study. Analysis of data indicated that the pavement will need to be overlaid after a period of 4 to 6 years to increase the structural capacity. Data presented in Table 7 are for the I-65 portion under study (CPR, 30 miles) and for another portion of I-65 resurfaced by a 4-in. asphalt layer (7 miles). Although the comparison between these two projects indicates that CPR techniques are more cost-effective (20-year design period), it is not predicted that the CPR techniques will last for the first 10 years of the design period.

SUMMARY OF RESULTS

This study investigated a number of concrete pavement restoration (CPR) techniques. CPR was employed on a 30-mile portion of jointed concrete pavement on I-65 between mile markers 217 and 247 in Indiana in 1985. Three types of full-depth patches (doweled, inverted "T," and inverted "T" with a doweled contraction joint), partial-depth patches, diamond grinding the pavement surface, resealing joints, slab undersealing, and routing and resealing cracks were investigated. The main findings can be summarized as follows:

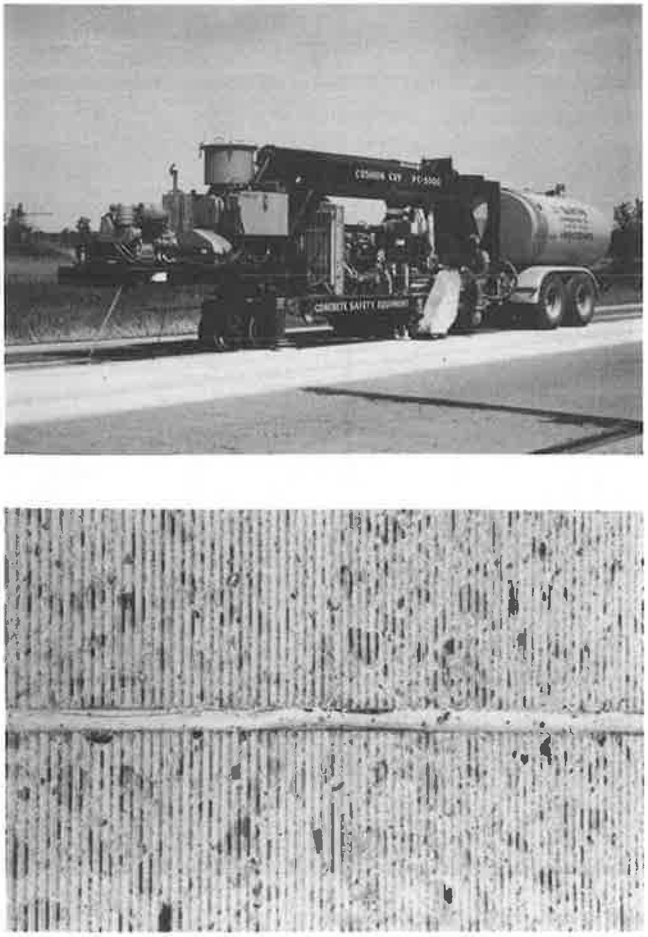

FIGURE 7 Diamond grinding operation. (top) Diamond grinding equipment. (bottom) Concrete surface texture after diamond grinding.

FIGURE 8 Performance problems of shallow-depth patches. (top) Cracking and breakup of shallow-depth patch adjacent to crack. (bottom) Cracking through a partial-depth patch.

1. A condition survey before applying CPR indicated low roadway serviceability (high roughness numbers), hazardously low friction numbers, and some typical functional distresses (transverse cracking, corner breaks, and faulted, broken-up joints). The pavement structural capacity was relatively sound (as evaluated by Dynaflect measurements).

2. Annual evaluation surveys (for 3 years) indicated a significant improvement in serviceability and friction after employing CPR.

3. The pavement life span after using CPR techniques is expected to be between 4 and 6 years (predicted from roughness, friction, and deflection measurements).

4. Slab undersealing helped the slab support (subbase) to remain structurally sound during the 3-year evaluation period. No significant drop in subbase structural condition was noted (according to sensor 5 measurements of the Dynaflect).

5. All full-depth patches performed properly. Doweled full-depth patches have better load transfer at their joint with the pavement, while inverted "T" full-depth patches have better structural capacity.

6. Partial-depth patches performed poorly. This technique has been proven to damage adjacent sound concrete. It is recommended that the use of these patches be limited as much as possible.

7. Diamond grinding provided a smoother ride and improved the surface friction significantly.

8. Structural capacity of concrete slabs was not improved by the CPR techniques used. Deflection values continued to increase annually owing to the increase in heavy truck traffic on I-65.

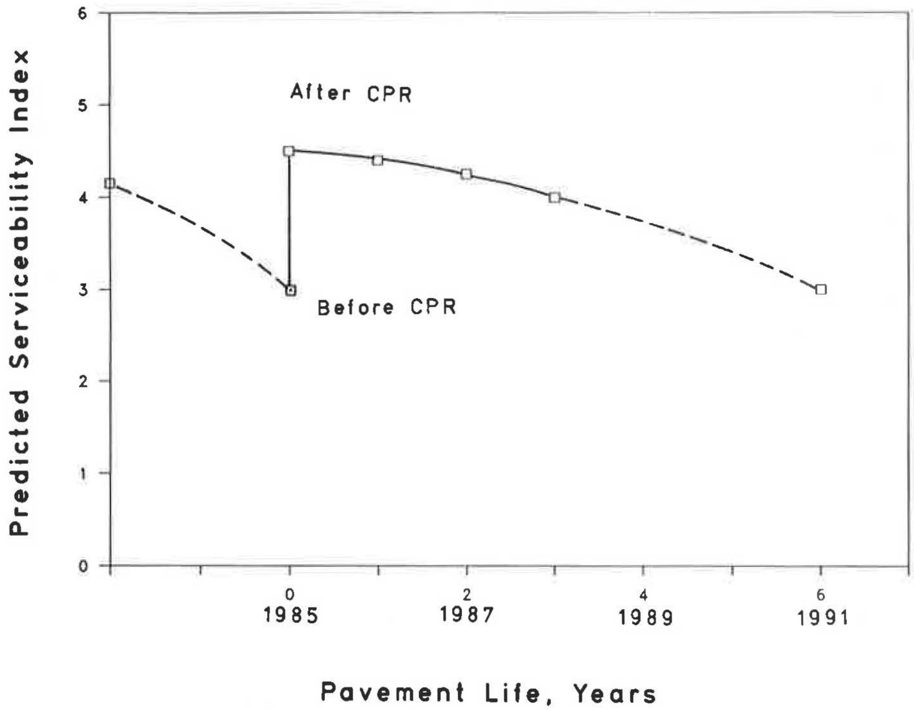

FIGURE 9 Effect of CPR techniques and time on pavement condition (present serviceability index).

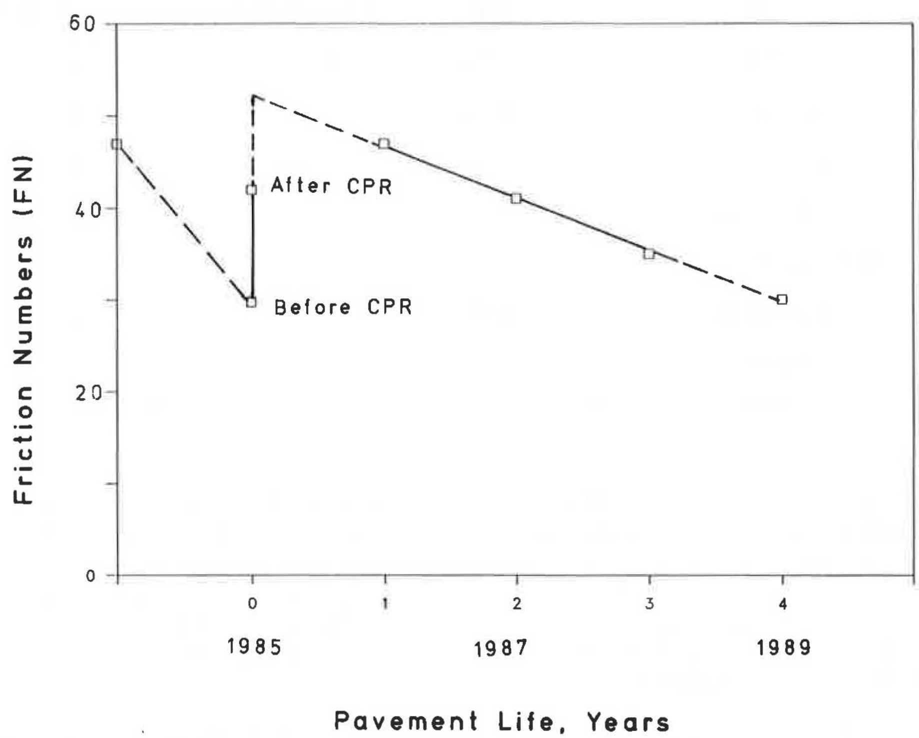

FIGURE 10 Effect of CPR techniques (diamond grinding) and time on pavement condition (skid resistance).

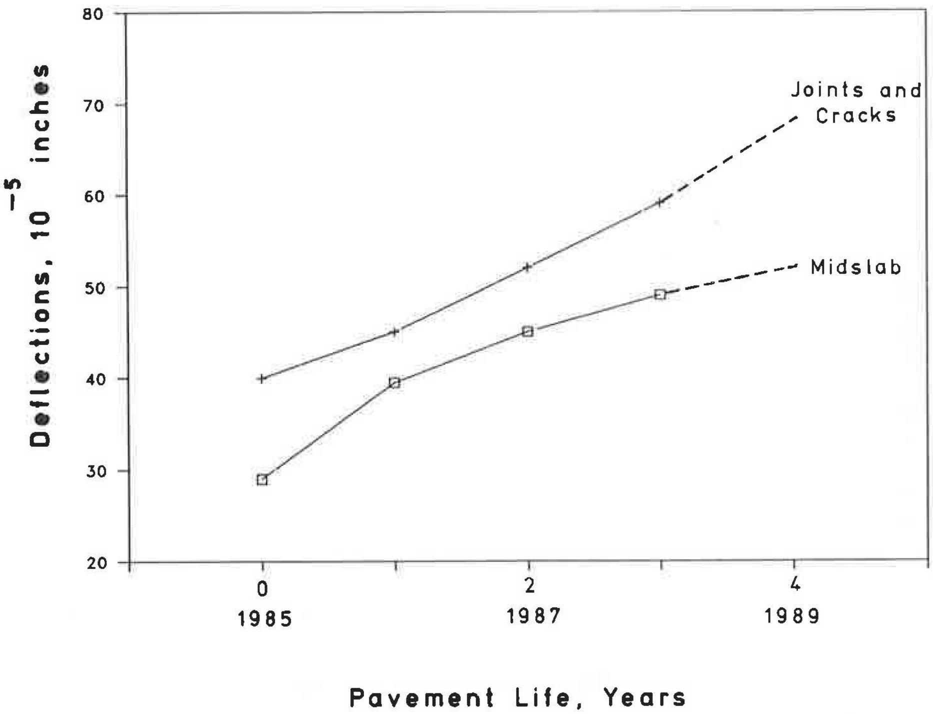

FIGURE 11 Deflection measurements during the 3-year evaluation period.

TABLE 6 LOAD TRANSFER COEFFICIENTS AT DIFFERENT FEATURES (SENSOR 2 READING, SENSOR 1 READING)

Feature	Mean	Standard Dev.	No. of Tests
Midslab	0.96	0.02	10
Joints	0.80	0.10	10
Cracks	0.69	0.21	10
Joints at Dowelled patch	0.80	0.18	20
Joints at Inverted T patch	0.64	0.19	30

9. A comparison between two projects on I-65 (for a design period of 20 years) indicated that employing CPR and then adding a 4-in. asphalt overlay layer after 10 years are more cost-effective than adding a 4-in. asphalt overlay layer and then resurfacing with another 4-in. overlay layer after 10 years. CPR techniques employed in this study, however, are not predicted to keep the pavement structurally sound for 10 years, as was planned.

10. It is recommended that specifications be set for diamond grinding based on resulting improvement in ride comfort (measured by roughness roadmeter) and skid resistance. Financial penalties should be enforced for failure to meet these specifications.

11. Concrete pavements with high deflection measurements at or near maximum tolerable deflection values should be overlaid to increase structural capacity.

12. In general, the CPR techniques employed in this study were effective for 5 years but may not sustain the heavy truck traffic on I-65 for 10 years.

ACKNOWLEDGMENTS

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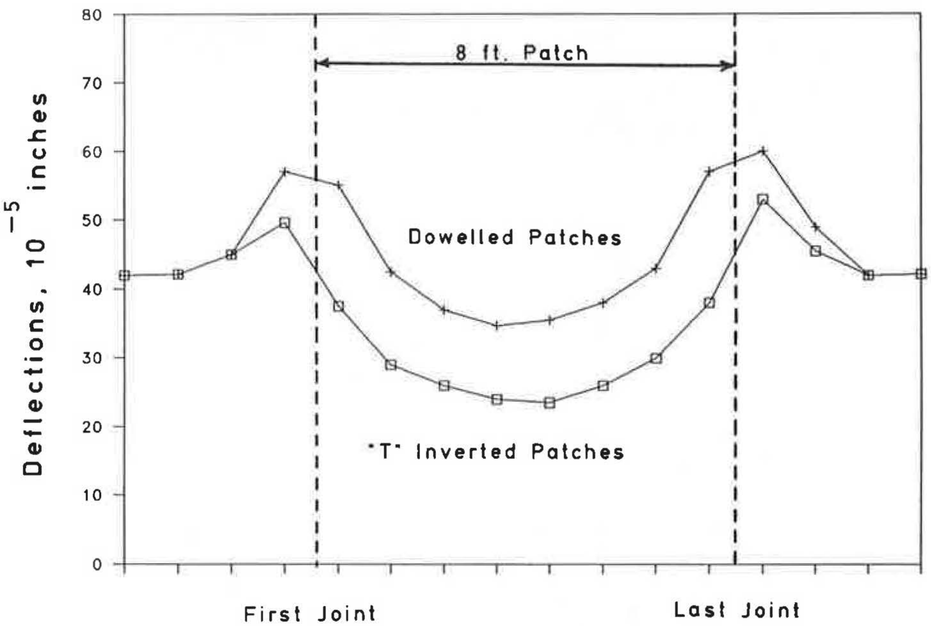

FIGURE 12 Deflection distribution along full-depth patches.

TABLE 7 AVERAGE LOW BID UNIT PRICES FOR RESTORATION TECHNIQUES IN 1985 AND 1986

	Unit Cost	Overall Cost	No. of Low Bids Averaged
Inverted T Full Depth Patch	$79.18/sq.yd.	$845/patch	12
Dowelled Full Depth Patch	$54.47/sq.yd.	$613/patch	4
Inverted T with Dowelled Contraction Joint Patch	$10.39/ft.+ $79.18/sq.yd.	$970/patch	7
Partial Depth Patch	$120/sq.yd.	Variable	4
Diamond Grinding	$ 3.00/sq.yd.		8
4 in. Asphalt Overlay	$ 5.01/sq.yd.		9
250 lb./sq.yd.Base	$ 2.42/sq.yd.		
150 lb./sq.yd.Binder	$ 1.54/sq.yd.		
70 lb./sq.yd.Sand Surface	$ 1.05/sq.yd.		
Joints & Crack Sealing	$ 1.86/sq.yd.		9

Present Worth of Costs (i = 7%)

*CPR and later resurfacing after 10 years = $376,738 per interstate mile.

*Resurfacing and later resurfacing after 10 years = $426,385 per interstate mile.

*Cost savings (20 years design period) = $49,647 per interstate mile.

Figures courtesy of the Indiana Department of Highways

TABLE 8 CPR WITH DIAMOND GRINDING VERSUS ASPHALT OVERLAY

SOUTH CAROLINA — SAMPLE REHABILITATION COST

CPR With Diamond Grinding

I-20; 6.031 miles (Georgia State Line to East of US 25);
Project IR-20-1(56), Bid Prices.

	Quantity	Unit Price
Full-depth Patching	750 sq yd	$60/sq yd
Removal & Disposal of Existing Concrete	750 sq yd	$50/sq yd
Partial-depth Patching	1,000 sq ft	$24/sq ft
Grinding (4 lanes)	217,621 sq yd	$2.48/sq yd
Hole Drilling	12,240 holes	$4/hole
Pressure Grouting	4,080 bags	$22/bag
Clean & Reseal Longitudinal Joints	92,150 LF	$1.53/LF
Clean & Reseal Transverse Joints	78,161 LF	$1.53/LF
		Total Cost

CPR Cost Per Interstate Mile = $\frac{\$1,045,496}{6.031 \text{ miles}}$ = **$173,354***
(2-lanes *each* direction)

Asphalt Overlay Over Concrete

I-26; 2.005 miles in Lexington and Richland Counties; 2-lanes in one direction;
Project IR-26-2(124), Bid Prices.

	Quantity	Unit Price
Pavement Binder #2	3,528 tons	$16.35/ton
Pavement Surface Type 1	1,468 tons	$16/ton
Pavement Binder Asphalt (4.8%)	265 tons	$158/ton
Pavement Surface Asphalt (6.0%)	88 tons	$158/ton
Clean & Reseal Transverse Joints	9,120 LF	$1.36/LF
Shoulder Binder #2	3,116 tons	$16.35/ton
Shoulder Surface Type 1	1,346 tons	$16/ton
Shoulder Binder Asphalt (4.8%)	150 tons	$158/ton
Shoulder Surface Asphalt (6.0%)	81 tons	$158/ton
		Total Cost

Cost Per Interstate Mile = $\frac{\$258,329}{2.005 \text{ miles}}$ = $128,842
(2-lanes *one* direction)

Asphalt Overlay Cost Per Interstate Mile = $128,842 × 2 = $257,684**
(2-lanes *each* direction)

+Items not related to restoration of roadway or shoulders not shown.
*Cost of new concrete shoulders not included.
**Cost of 3½ inch overlay including shoulders which *must* be done when overlaying.
Figures courtesy of American Concrete Pavement Association and its members.

GEORGIA — SAMPLE REHABILITATION COSTS+

CPR With Diamond Grinding
(Actual Prices)

	Project A (11.6 miles)	Project B (11.942 miles)	Average
Slab Removal & Replacement	$ 26,532	$ 14,146	$ 20,339
Spall Repair	$ 50,916	$ 1,000	$ 25,958
Undersealing	$ 2,686	$ 6,232	$ 4,459
Sawing & Resealing Joints	$ 16,509	$ 24,128	$ 20,318
Grinding	$ 91,683	$ 67,632	$ 79,658
Total Cost	$188,326	$113,138	$150,732

CPR Average Cost Per Interstate Mile = $150,732
(2-lanes *each* direction)

Asphalt Overlay
(4-inch overlay, Actual Prices)

	Project C (5.402 miles)	Project D (23.57 miles)	Project E (14.049 miles)	Average
Slab Removal & Replacement	$ 6,009	$ 1,005	$ 5,478	$ 4,164
Undersealing	$ 4,751	$ 5,579	$ 5,719	$ 5,350
Waterproof & Reseal Joints	$ 14,890	$ 20,200	$ 18,888	$ 17,993
Asphalt Overlay	$199,834	$256,844	$222,301	$226,326
Total Cost	$225,484	$283,628	$252,386	$253,833

Asphalt Overlay Average Cost Per Interstate Mile = $253,833
(2-lanes *each* direction)

+Items not related to restoration of roadway or shoulders not shown.
Figures courtesy of American Concrete Pavement Association and its members.

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