Crack and Seat Performance

KEUN-WOOK YI

The effectiveness of the crack and seat process in preventing reflection cracking on asphaltic overlays of portland cement concrete pavement (PCCP) is evaluated. New Mexico has approximately 145 mi of PCCP existing on the Interstate system. In a 4-year period from 1984 to 1988, 110 mi was rehabilitated using the crack and seat process. The existing portland cement concrete was cracked and seated and overlaid with asphalt concrete. To further reduce reflection cracking, a paving fabric was used. The areas that were cracked and seated were inspected for distresses, mainly reflection cracking. Roughly 3 percent of the cracked and seated sections exhibited low-severity transverse reflection cracking, whereas the experimental sections not cracked and seated exhibited a high rate of transverse cracking. The crack and seat process with paving fabrics is greatly reducing the reflection cracking that has been a major problem in asphalt overlays of PCCP. This method seems to be a sound alternative for rehabilitating the existing PCCP.

The portland cement concrete pavement (PCCP) in New Mexico is approaching the end of its design life, with deterioration of the PCCP becoming apparent. The deterioration, such as spalling, cracking, joint deterioration, and faulted joints, affects riding comfort and road safety, and increases maintenance costs and vehicle operating costs. The deteriorated PCCP must be replaced or rehabilitated. Slab replacement is costly and causes lengthy traffic delays. To avoid the high costs and delays associated with concrete slab replacement, the PCCP can be rehabilitated by the following methods (*1*):

1. Portland cement concrete (PCC) overlay,
2. Recycled PCCP, and
3. Asphaltic concrete (AC) overlay.

A PCC overlay was used on I-25 in Albuquerque. This method has since been rejected because it is not economical although it is performing well. The recycled PCCP has not been used in New Mexico because the cost is high compared with that of AC overlays.

Reflection cracking is a major problem associated with AC overlays of PCCP. This cracking, which is defined as the surface duplication of cracks and joint patterns of the underlying PCCP, is caused by horizontal and vertical movements of the PCCP (*2*). The horizontal movements are caused by the expansion and contraction of the PCCP slab, whereas the vertical movements are caused by a load moving from one PCCP slab to another.

The purpose of the crack and seat process of PCCP is to reduce the stresses on the AC material that are caused by the horizontal and vertical movements of the underlying PCCP (*2*). In this process, the PCCP is cracked to create smaller pieces that move less than large slabs. When the slab movements are reduced, the stresses that cause reflection cracking are also reduced. The PCCP is first cracked and then seated using a roller to remove any voids under the cracked PCCP, which further reduces the vertical movements of the PCCP slabs.

DESIGN PROCEDURE

Information about the existing roadway is compiled as part of the design and construction process. The information includes the following:

1. Existing typical sections,
2. Strength of the subgrade,
3. Maintenance history,
4. Traffic summary statistics, and
5. Traffic projections.

After gathering the required information, the pavement designer makes a visual inspection of the existing pavement. The pavement distresses are defined using the *Highway Pavement Distress Identification Manual* (*3*).

The New Mexico State Highway and Transportation Department (NMSH&TD) uses the structural deficiency analysis to determine the thickness of plant mix bituminous pavement (PMBP) overlays. The required structural number is calculated using the following:

1. R-value,
2. Regional factor,
3. Traffic projections,
4. Serviceability index, and
5. Design life.

According to Lukanen (*4*), the recommended structural layer coefficients are as follows:

Crack Spacing (ft)	*Structural Layer Coefficient*
1	0.25
2	0.35
3	0.45

The crack spacing required by the NMSH&TD's *Special Provisions for Cracking and Seating Concrete Pavement* (Item No. 451101), is 18 to 24 in. with a maximum spacing of 30 in. By interpolating the data, the crack spacing of 18 in. yields a structural layer coefficient of 0.3 whereas the crack spacing of 24 in. yields a coefficient of 0.35. Because the 18-in. spacing

Materials Laboratory Bureau, New Mexico State Highway and Transportation Department, P.O. Box 1149, Santa Fe, N. Mex. 87504-1149.

has the lower coefficient, it yields a thicker overlay. Thus, it provides the roadway with a more conservative design.

The NMSH&TD recommends that a minimum of 4½ in. of overlay be placed to prevent reflection cracking. The minimum 4½-in. overlay is based on a review of crack and seat work done in other states and in NMSH&TD's Research Bureau. The Research Bureau used a Model 2000 Road-Rater to measure the dynamic deflection response under the following conditions:

1. After the PCCP had been cracked and seated, and
2. After a 5-in. PMBP overlay had been constructed.

These deflections yielded the material characteristics presented in Table 1.

Using the results from this testing and the NMSH&TD elastic-layer program for flexible pavements, a 2½-in. PMBP overlay would be required for this particular project. But experience has shown that the additional thickness is needed to prevent reflection cracking.

CONSTRUCTION PROCEDURE

The construction procedure consists of the following:

1. Removing and replacing the unsuitable slab,
2. Cracking the existing PCCP,
3. Seating the cracked PCCP, and
4. Overlaying with asphalt (PMBP).

Smaller pieces are created by cracking the existing PCCP, minimizing excessive temperature strains of the larger slabs. This process also curtails the horizontal movement in the slabs and reduces the reflection cracking. The existing PCCP is not cracked enough to reduce pavement to rubble but it should contain hairline cracks that extend through the entire depth of the existing PCCP. These hairline cracks allow the load to transfer from one small piece of the cracked PCCP to the next through aggregate interlock, which also allows the PCCP to retain more of its original structural integrity, thus minimizing the overlay thickness required.

The cracking of the pavement can be accomplished by several methods. The types of devices that can be used for cracking the pavement are

1. Modified pile driver,
2. Pecking hammer, and
3. Transverse bar drop (guillotine) hammer.

The guillotine hammer is the only device that has been used in New Mexico. The guillotine hammer is a device that consists of a transverse weight that is dropped from a predetermined height. The height of the hammer is determined by a trial method in which a small section of the project is chosen. The hammer is dropped from different heights onto this section to determine the drop height that is required to create a vertical hairline crack throughout the entire depth of the PCCP.

Once the pavement has been cracked, the surface is cleaned using a power broom, compressed air, or other approved methods. The pavement is proof-rolled with a pneumatic roller weighing at least 50 tons. The rolling continues until the cracked pavement is well seated.

TABLE 1 MATERIAL CHARACTERISTICS AS DEFINED BY ROAD-RATER

MATERIAL DESCRIPTION	THICKNESS (IN)	POISSON'S RATIO	MODULUS (PSI)
PMBP	5.0	0.35	900,000
CRACKED AND SEATED PCCP	8.0	0.20	500,000
CTB	5.0	0.25	175,000
SUBGRADE	-	0.45	8,000

from Project IR-040-5(39)276
- indefinite thickness

Once the PCCP is seated, a leveling course of 1.5 in. is placed. The leveling course is followed by an interlayer, usually of some type of paving fabric (e.g., Petromat). The interlayer is then covered with a minimum of 3 in. of PMBP. Finally, open-graded friction course is placed on top of the final lift of the PMBP.

FIELD EVALUATION

Background Information

Over the years, the NMSH&TD has primarily built PCCP consisting of 8 or 9 in. of PCCP over 4 in. of cement-treated base (CTB). Most of the jobs that are included in this study have 8 in. of PCCP over 4 in. of CTB; two jobs have 9 in. of PCCP over 4 in. of CTB. None of the crack and seat projects had control sections except for Project IR-040-5(40)282, which contains nine different test sections. The project number can be interpreted in the following manner. The first two letters stand for the type of funding. In this case, IR stands for Interstate system rehabilitation. The next three digits are used to identify the route. For example, 040 represents I-40. The next important set of numbers are the last three digits in the project number. These numbers represent the milepost (MP) at which the project begins. Table 2 presents original pavement data (*1*).

Cost

The cost per square yard of cracking and seating varied from $0.25 to $0.80 with an average cost of $0.40. The costs per square yard and the total costs of each of the crack and seat projects are presented in Table 3.

Project Summary

- IR-010-1(49)21. This project was completed in 1987. There are no signs of reflection cracking throughout the project.
- IR-010-1(55)28. This project was completed in 1987. There are no signs of reflection cracking on the pavement.
- IR-010-1(68)55. This project was completed in 1987. There are no signs of reflection cracking in the pavement. However, there is low-severity rutting.

TABLE 2 CRACK AND SEAT PROJECT DATA WITH ORIGINAL PAVEMENT DATA

Project Location	Const. Date	Orig. Const. Date	Original Surfacing Data(inches) PCCP	CTB	UTB	ATB	SB	Design AASHTO Soil Class.	Design R Value	Condition of the PCCP at the time of Crack and Seat Fault.	Crack.	Pump.	JS	RA
Interstate 10														
MP 21	1987	1972/75	9	4				A-4/A-6	20	L-M	M	M-H	Yes	No*
MP 28	1987	1962	EBL 8	4	4			A-4/A-6	22	L-M	M-H	M-H	Yes	No*
			WBL 8	3		4	8	A-6/A-7	10					
MP 55	1987	1963/65	EBL 8		4		4	A-6	25	M	M	M-H	Yes	No*
			WBL 8	3		2.5	13	A-4/A-6	15					
MP 63	1987	1965	EBL 8	4	4			A-4/A-6	20	L-M	M	M-H	Yes	Yes*
			WBL 8	3		4	6	A-2-4/A-6	33					
MP 70	1986	1964	EBL 8	4					25/33	L-M	M-H	H	Yes	Yes*
			WBL 8	4				A-4/A-6	17					
Interstate 40														
MP 26	1987	1965	8	4	6			A-2-4/A-6	33	M-H	H	M-H	Yes	No*
MP 31	1987	58/63/64	8	4	4			A-2-4/A-6	33	M-H	H	M-H	Yes	No*
MP 184	1989		8	4	4			A-4/A-6	**	M	H		No	No
MP 200	1989	1968/69	8	4				A-4/A-6	**		H		No	No
MP 271	1986	1970	8	5				A-4	32	M-H	M-H	H	Yes	Yes*
MP 276	1984	1962/63	8	4				A-4/A-6	5-12	M-H	M-H	M-H	Yes	No*
MP 282	1989	1964	EBL 8	4			4	A-4/A-6	**	M-H		M-H	Yes	No
			WBL 8		3	Built over Old US66 2.5" PMBP, 3" UTB, 3" Minimum SB								
MP 291	1986	1963	8	4	4			A-4/A-6	20	M-H	M-H	M-H	Yes	No*
MP 300	1985	1962	8	4				A-2-4/A-6	33	M-H	M-H	H	Yes	No*
MP 308	1986	1961	8	4			4	A-4/A-6	21	M-H	M-H	H	Yes	No*
MP 313	1986	1961	8	4			4	A-4/A-6	21	M-H	M-H	H	Yes	No*
MP 326	1987	1969	9	4				A-4/A-6	20	L-M	M-H	M	Yes	No*

* data from "Crack and Seat Performance", John Higgins
** no data found

SYMBOLS
PCCP-Portland Cement Concrete Pavement ATB-Asphalt Treated Base CTB-Cement Treated Base
UTB-Untreated Base SB-Subbase RA-Reactive Aggregate Degradation JS-Joint Seal Missing
L-Low M-Medium H-High

- IR-010-2(69)63. This project was completed in 1987. There are no signs of reflection cracking in the pavement. However, there is low- to medium-severity rutting.
- IR-010-2(62)70. This project was completed in 1986. There are no signs of reflection cracking in the pavement. However, there is low- to medium-severity rutting.
- IR-040-1(82)26. This project was completed in 1987. This project does not exhibit any pavement distress.
- IR-040-1(83)31. This project was completed in 1987. This project does not exhibit any pavement distress.
- IR-040-4(40)184. This project was completed in 1989; more time will be needed before an evaluation can be completed.
- IR-040-4(42)200. This project was completed in 1989; more time will be needed before an evaluation can be completed.
- IR-040-5(41)271. This project was completed in 1986. There are no signs of reflection cracking in the pavement. However, there is low- to medium-severity rutting.
- IR-040-5(39)276. This project was completed in 1984; it is the oldest crack and seat project in the state. There is a longitudinal crack near mile marker 279 that is caused by the construction joint of the asphaltic overlay. It is not a reflection crack from the crack and seat process. This project has low- to medium-severity rutting.
- IR-040-5(40)282. This project was completed in 1988. The project contains nine test sections on the eastbound driving lane, each 950 ft in length (see Figure 1). There were two different types of interlayers used in these test sections. One interlayer was the standard paving fabric called AmoPave. The other was Glasgrid, the experimental interlayer used in this project. Glasgrid is a fiber reinforcement mesh for asphaltic concrete purported to prevent reflection cracking. Sections 1 through 6 were cracked and seated. These sections are exhibiting no signs of cracking in the driving lane. Sections 7 through 9 were not cracked and seated. These sections are exhibiting some cracking. Section 7, which contains no interlayer, is exhibiting twice as many cracks (see Figure 2) as Sections 8 and 9, which had the interlayers. The test sections were inspected by James A Scherocman, P.E., consulting engineer, on February 18, 1990. The resulting numbers of cracks are presented in Table 4. The rest of the project was constructed using one of the standard paving fabrics. The project exhibits some transverse cracking in the shoulders and low-severity rutting at the beginning of the project, but no reflection cracking.
- IR-040-5(43)291. This project was completed in 1986. The roadway displays low-severity transverse cracks. These cracks are located throughout the project but they are randomly located and there is no set pattern to them. The number and total length of the cracks are minimal. The roadway also exhibits low- to medium-severity rutting.
- IR-040-5(42)300. This project was completed in 1985. At approximately MP 300.5, they are low-severity transverse cracks. These cracks are in the westbound lane approximately 40 ft apart (see Figure 3). When a core was taken at one of

TABLE 3 COST OF CRACKING AND SEATING

Project Number	Letting Date	Amount of Crack & Seat (SY)	Cost per SY	Total Cost
IR-010-1(49)21	October 1986	200,200	$0.25	$50,050**
IR-010-1(55)28	September 1986	167,050	$0.25	$41,763**
IR-010-2(68)55	May 1987	226,010*	$0.30	$67,803**
IR-010-2(69)63	May 1987	206,620*	$0.30	$61,986**
IR-010-2(62)70	January 1986	304,150	$0.50	$152,075**
IR-040-1(82)26	July 1987	52,900*	$0.35	$18,515**
IR-040-1(83)31	June 1987	92,750*	$0.30	$27,825**
IR-040-4(40)184	March 1988	229,375*	$0.30	$68,813
IR-040-4(42)200	March 1988	180,230*	$0.25	$45,058
IR-040-5(41)271	June 1985	170,830	$0.30	$51,249**
IR-040-5(39)276	June 1984	84,500	$0.77	$65,065**
IR-040-5(40)282	July 1987	245,000*	$0.30	$73,500
IR-040-5(43)291	April 1986	244,050	$0.35	$85,418**
IR-040-5(42)300	March 1985	242,980	$0.35	$85,043**
IR-040-6(41)308	May 1985	130,100	$0.55	$71,555**
IR-040-6(42)313	November 1985	147,000	$0.65	$95,550**
IR-040-6(43)326	August 1986	104,700	$0.80	$83,760**

* - Plan Quantity

** - from "Crack and Seat Performance", John Higgins,FHWA,1987

SY - Square Yards

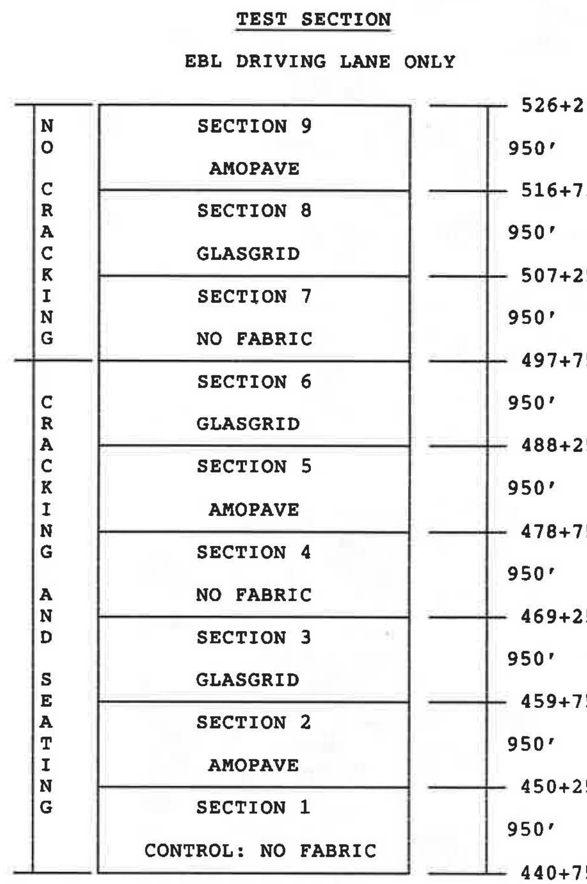

FIGURE 1 Test section.

FIGURE 2 Condition of the roadway on Project IR-040-5(40)282 in the control section without cracking and seating or paving fabric. Note the two transverse cracks spaced approximately 40 ft apart.

FIGURE 3 Reflection cracking evident in a section near MP 300.5 on Project IR-040-5(42)300.

TABLE 4 NUMBER OF CRACKS IN THE EXPERIMENTAL SECTION

	Crack & Seat						No Crack & Seat		
	No Fabric	AmoPave	Glasgrid	No Fabric	AmoPave	Glasgrid	No Fabric	Glasgrid	AmoPave
Location of cracks	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9
Driving Lane									
Inside WP Only	0	0	0	0	0	0	0	0	0
Outside WP Only	0	0	0	0	0	0	3	0	6
Full Width	0	0	0	0	0	0	23	10	8
Full width plus partial passing lane	0	0	0	0	0	0	4	3	1
Passing Lane									
Full width	0	3	5	0	0	0	0	0	0
Full width plus partial driving lane	0	5	3	0	0	0	0	0	0
Full Width-both lanes	0	1	0	0	0	0	2	0	0

NOTE: WP = Wheel Path

the cracks, it revealed that the PCCP was cracked and faulted underneath the transverse crack. In the same lane, there are low-severity transverse cracks near MP 304.5. These are approximately 60 ft apart. There are longitudinal cracks along the center of the eastbound lanes. In one particular area near MP 306.5, there is a cracking pattern that can best be described as a reflective corner break (see Figure 4).

- IR-040-6(41)308. This project was constructed in 1986. The overlay is exhibiting no pavement distress.
- IR-040-6(42)313. This project was constructed in 1986. The overlay is exhibiting no pavement distress.
- IR-040-6(43)326. This project was constructed in 1987. The overlay is exhibiting no pavement distress.

SUMMARY AND CONCLUSIONS

Summary

The crack and seat rehabilitation for PCCP pavement has been used in the State of New Mexico since 1984.

Such projects make up approximately 110 mi or 440 lane-mi of New Mexico's Interstate system. Of the 440 lane-mi, less than 15 lane-mi exhibit reflective cracking. Most of the cracks are low-severity transverse cracks. Throughout several of the crack and seat projects, there appears to be the beginning of reflection cracking. These had not propagated into reflection cracks as of the data of inspection. When cores were taken in these areas, they revealed that there was no reflection cracking present. There are a few areas exhibiting low-severity longitudinal cracks. These longitudinal cracks are located on the edges and in the middle of the lanes. These cracks are caused by construction joints and flexible shoulders adjacent to the PCCP rather than reflection cracks. Many areas were also exhibiting rutting. However, rutting was not a problem associated with the crack and seat process.

FIGURE 4 Reflection cracking, better described as reflective corner break, on Project IR-040-5(42)300.

Conclusions

The test sections in Project IR-040-5(40)282 indicate that the crack and seat process is an effective method of controlling reflection cracking.

The results of the crack and seat process have been excellent, with approximately 3 percent of the current jobs demonstrating low-severity reflection cracking. Currently, this process seems to be a viable method of rehabilitating PCCP. The cost of the process is low compared with other methods of PCCP rehabilitation. The average cost of cracking and seating PCCP is $0.40 per square yard. The low cost makes cracking and seating an excellent alternative.

Recommendations

1. Crack and seat projects need to be monitored and evaluated on a yearly basis.
2. Areas with reflection cracks should be observed for further deterioration. These cracks need to be sealed to minimize any future subgrade damage.
3. The crack and seat process should continue to be used.
4. The test sections on Project IR-040-5(40)282 should continue to be monitored for the crack retarding effect of the interlayer.

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