Breaking and Seating of Concrete Pavements: Kentucky's Experience

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Breaking and seating has been utilized extensively in Kentucky for rehabilitation of portland cement concrete pavements for the past 10 years. To date, 1345 lane-km (836 lane-mi) of Interstate pavements and 470 lane-km (292 lane-mi) of parkway pavements have been rehabilitated. Overlay thicknesses have ranged from 114 to 240 mm (4.5 to 9.5 in.). The sections that have been overlaid generally have performed well. Localized areas of distress generally have been observed in the wheel tracks of the driving lane. Research is currently being conducted to relate this type of distress to areas of poor drainage. Kentucky is currently conducting a survey of all broken and seated concrete pavements on Interstate highways and parkways throughout the state. This survey includes a detailed visual survey and falling weight deflectometer testing to determine the in situ condition of the pavement structure. These data, combined with rideability index and condition points, will be used to analyze performance of this type of rehabilitation. Information gained from this study may be used to modify the current design and construction procedures if necessary. On the basis of the experience gained, Kentucky will continue to use breaking and seating of concrete pavements as a rehabilitation alternative.

Rigid [portland cement concrete (PCC)] pavements have been used extensively on the Interstate and parkway system throughout Kentucky. Many of these pavements are nearing the end of their design lives and are beginning to show signs of deterioration, spalling, cracking, joint deterioration, and faulting at joints.

Breaking and seating has been used extensively in Kentucky for rehabilitation of PCC pavements for the past 10 years. To date, 1345 lane-km (836 lane-mi) of Interstate pavements and 470 lane-km (292 lane-mi) of parkway pavements have been rehabilitated. Several test sections have been constructed to evaluate construction techniques to use and appropriate factors to consider in design procedures. Projects have been constructed with overlay thicknesses ranging from 114 to 240 mm (4.5 to 9.5 in.).

In general, all sections that have been rehabilitated are performing well. To date, no large-scale resurfacing has been conducted on any of the projects. Localized areas of distress that have been observed generally are in the wheel tracks of the driving lane.

The relationship between the size of the broken particles and the behavior of the rehabilitated pavement has been studied for some time. Small particles will reduce or possibly eliminate reflective cracking in the overlay but will use the least structural potential of the existing concrete pavement. Very large particles may maximize the structural potential of the existing pavement but will permit increased movements of the broken slab, thereby increasing the potential for reflective cracking.

Previous research in Kentucky indicated that, generally, an effective modulus of 62 to 278 MPa (9,000 to 30,000 lb/in.^{2}) may be associated with concrete broken into 75- to 150-mm (3- to 6-in.) particles; an effective elastic modulus of 345 to 6800 MPa (50,000 to 1 million lb/in.^{2}) may be associated with fragments of 457 to 610 mm (18 to 24 in.), and an effective elastic modulus of 4100 to 13700 MPa (600,000 to 2 million lb/in.^{2}) may be associated with 762- to 915-mm (30- to 36-in.) particles (*1*).

Other research has indicated various relationships relating broken particle size and effective elastic modulus. Models have been developed for rubblized concrete and crack and seat concrete. No model was developed for broken and seated concrete because of the large variation in effective moduli that were backcalculated (*2*).

A research study is currently being conducted to evaluate all broken and seated concrete pavements in Kentucky. Falling weight deflectometer (FWD) measurements are being obtained on each project to evaluate the in situ structural condition of the pavement. Effective broken concrete moduli will be evaluated and compared with values currently in use. Detailed visual survey data combined with rideability index and condition points will be used to analyze performance of this type of rehabilitation. The results of this study will provide a means to evaluate the total performance of these pavements and modify the current design and construction procedures if necessary.

DESIGN CONSIDERATIONS AND SPECIFICATIONS

Current Kentucky construction specifications were developed through experience gained during the past 10 years of constructing break and seat projects. Table 1 summarizes the various aspects of the specifications and how they have changed since 1982.

The initial specifications, in March 1982, required 80 percent of the broken particles to be 152 to 304 mm (6 to 12 in.) in size and all particles to be less than 456 mm (18 in.). In June 1982, the particle size specifications were changed requiring 80 percent of the broken particles to be 456 to 608 mm (18 to 24 in.) in size and all particles to be less than 760 mm (30 in.).

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TABLE 1 Specification Comparison

	Specification Date					
	March 1982	June 1982	August 1984	April 1986	January 1987	February 1990
Particle Size	80% 152 - 304-mm, All < 456 mm	80% 456 - 608-mm, All < 760-mm	80% 456 - 608-mm, All < 760-mm	80% 456 - 608-mm, All < 760-mm	80% 456 - 608-mm, All < 760-mm	80% 456 - 608-mm, All < 760-mm
Breaking Equipment	Impact Hammer	Impact Hammer	Impact Hammer	Impact Hammer	Impact Hammer	Impact Hammer
Test Section	Not Required	Not Required	Required	Required	Required	Required
Extent of Breakage	Use of Water to Detect Cracks	Use of Water to Detect Cracks	Use of Water to Detect Cracks	Water Not Permitted to Detect Cracks	Water Not Permitted to Detect Cracks	Water Not permitted to Detect Cracks
Roller (seating)	7.3-metric ton Vibratory Roller or 45-metric ton Pneumatic Tire Roller	7.3-metric ton Vibratory Roller or 45-metric ton Pneumatic Tire Roller	45-metric ton Pneumatic Tire Roller	45-metric ton Pneumatic Tire Roller	32-metric ton (7 passes) or 45-metric ton (5 passes) Pneumatic Tire Roller	32-metric ton (7 passes) or 45-metric ton (5 passes) Pneumatic Tire Roller
Limits of Breaking	< 1,524 m Ahead of Paving	< 1,524 m Ahead of Paving	< 1,524 m Ahead of Paving	< 1,524 m Ahead of Paving	< 1,524 m Ahead of Paving	< 24 Hours Ahead of Paving
Miscellaneous						Vertical Displacement Limited to Less Than 13 mm

1 in = 25.4 mm
1 ton = 0.907 metric ton
1 ft = 0.30480 m

The specifications remained unchanged until 1984, when the use of vibratory rollers for seating was eliminated. The requirement of a test section for verification of breaking and seating was also added at that time. Until 1986, water was used to detect cracks resulting from the breaking operation. This procedure was eliminated because of inspection problems. The wetted surface exposed cracks that were present before the breaking operation. In some cases, these cracks could not be distinguished from the full-depth cracks that resulted from the breaking.

In 1987 specifications were modified to allow for the use of a pneumatic tire roller weighing 32 metric tons (35 tons) with seven passes across the pavement or one weighing 45 metric tons (50 tons) using five passes. The current specifications were last modified in 1990. In 1990 the amount of vertical displacement of the pavement surface during the breaking and seating operation was limited to 13 mm (0.5 in.). In addition, the contractor must allow overnight curing of each course of bituminous overlay before opening to traffic. The contractor must also limit the breaking to less than 24 hr ahead of the paving operation.

LONG-TERM PERFORMANCE

The first broken and seated concrete rehabilitation projects were opened to traffic in 1983. These projects contained test sections that had various breaking patterns [76 to 304 mm (3 to 12 in.), 456 to 608 mm (18 to 24 in.), and 760 to 912 mm (30 to 36 in.)]. Extensive research was conducted during the construction of these projects. Road Rater deflection measurements were obtained before, during, and after the breaking operation to evaluate the effectiveness of the breaking and seating operation (*1*). On the basis of this study, a relationship (previously mentioned) was developed relating the effective stiffness of the broken PCC to the average dimension of the broken particle. This relationship is shown in Figure 1.

The evaluation of long-term performance will be limited to three of the oldest projects. These projects include Interstate 71, Interstate 64, and Bluegrass Parkway. Overlay thicknesses were 178 mm (7 in.) of asphaltic concrete for both Interstate projects and 121 mm (4.75 in.) of asphaltic concrete for the Bluegrass Parkway. The performance evaluation included rideability index (RI), pavement condition rating, detailed crack survey, and Road Rater and FWD deflection measurements. The pavement condition data and rideability index were obtained from normal pavement management activities conducted by Kentucky Transportation Cabinet personnel. The detailed crack survey and deflection measurements were conducted as a portion of the research study for evaluation of broken and seated pavements. The pavement condition rating form used by the Pavement Management Branch of the Kentucky Transportation Cabinet is shown in Figure 2. Pavements are visually inspected to evaluate conditions according to six types of distress and are assigned condition points (demerits) for each. Condition points are assigned for both extent and severity of each distress. The condition points are summed to obtain the pavement condition rating. The total scale ranges from 0 to 100, with 0 being a pavement

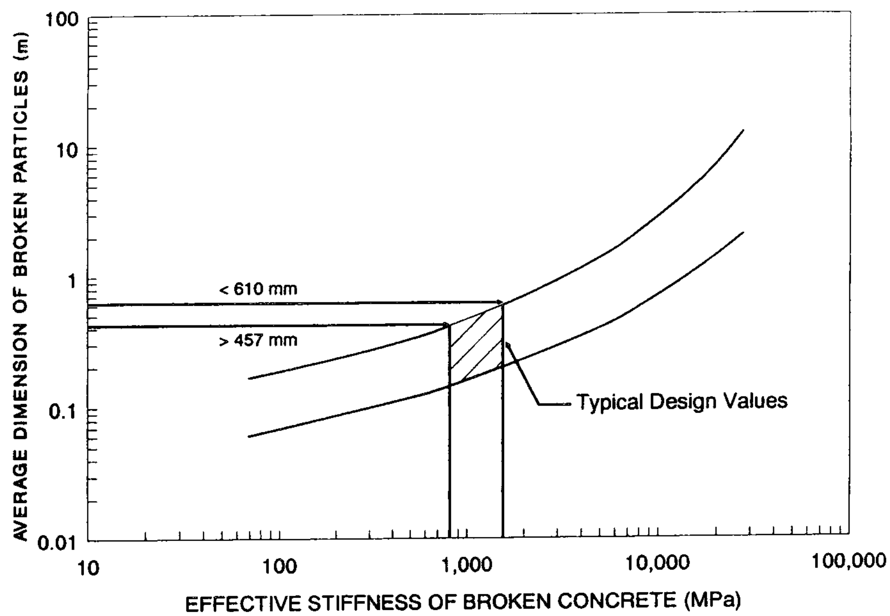

FIGURE 1 Effective modulus of broken concrete.

having no observed distresses. The rideability index is determined using a Mays ride meter.

Interstate 71

The Interstate 71 project was the first large-scale breaking and seating rehabilitation project conducted in Kentucky. The project contains particle sizes of 76 to 304 mm (3 to 12 in.), 456 to 608 mm (18 to 24 in.), and 760 to 912 mm (30 to 36 in.). In addition, there was a control section that was not broken. Each section was approximately 1.6 km (1.0 mi) in length. An asphaltic concrete overlay of 178 mm (7 in.) was placed on each section.

Each breaking pattern has been evaluated separately to determine the effects of the broken particle size on the long-term performance of the pavement. Rideability measurements have been conducted on a yearly basis since construction. The rideability of each section is shown in Figure 3. This figure indicates that the RI before rehabilitation ranged from 2.5 to 3.0. After overlay, all sections had an RI of approximately 4.0. This figure indicates further that there has been very little decrease in RI since construction. There also appears to be no significant difference in performance between the various sections comparing RI values.

Annual condition ratings also have been conducted on each section. The condition ratings for each section plotted as a function of testing year are shown in Figure 4. This figure shows an accelerated deterioration in the unbroken section when compared with the broken sections. Until 1989, all sections were performing in a similar manner. From 1989 through 1991, the condition of the control section deteriorated rapidly—probably the result of an increase in the number of reflective cracks. Since reflective cracking is the primary disease that normally occurs on broken and seated concrete pavements, a detailed crack survey was conducted on these sections in 1990. The results of this survey are shown in Figure 5. This figure expresses the amount of transverse cracking in feet per lane-mile of pavement. It is clear that the control section has considerably more transverse cracking than the other sections. This observation is not unexpected because the pavement was not broken.

Deflection measurements were conducted in 1985 on each section using the Model 400B Road Rater. In 1992, deflection measurements were conducted using a JILS-20 FWD. To compare the deflections from these two test dates, the FWD deflections were converted to Road Rater deflections using correlations developed during previous research in Kentucky. The comparison is limited to the deflections taken at distances of 0, 305, 610, and 915 mm (0, 12, 24, and 36 in.) from the load because the Road Rater has only four sensors. These deflections were then adjusted to a reference temperature of 21°C (70°F) (*3*). The adjusted deflections were then converted to equivalent 40-kN (9,000-lb.) FWD deflections. These comparisons are shown in Figures 6 through 9. These figures show that in each case the 1992 deflections have increased, indicating a decrease in structural condition. The magnitude of each deflection in the deflection bowl has increased, indicating a decrease in strength of the base layers. In addition the deflection bowl has become steeper, which indicates deterioration of the asphaltic concrete layer. The visual survey information also indicates a deterioration of the asphaltic concrete layer, denoted by the increase in the condition index.

Interstate 64

The Interstate 64 project was constructed in 1983 and 1984 and is the second oldest project in Kentucky. The project contains sections with particle sizes of 152 to 304 mm (6 to 12 in.), 456 to 608 mm (18 to 24 in.), and 760 to 912 mm (30 to 36 in.). A 178-mm (7-in.) asphaltic concrete overlay was placed on all sections. The annual performance evaluation was not conducted for each breaking size; however, subse-

PAVEMENT CONDITION EVALUATION FORM 0990
INTERSTATE AND PARKWAYS

ROAD NO: ROAD NAME:

COUNTY: DISTRICT:

FROM: MP:
TO: MP:

ADT(90): LENGTH:

CONSTRUCTED DGA: INCHES CBR: JOINT SPACING: ___
CONTRACTOR FOR ACTION:

DATE	ACTION	PAVEMENT INCHES	PAVEMENT TYPE	SURFACE TYPE	REMARKS

VISUAL CONDITION SURVEY LANE

(DEMERIT POINTS)	MAXIMUM EXT	MAXIMUM SEV	EXT	SEV	SUM	EXT	SEV	SUM
CRACKING	18	13	___	___	___	___	___	___
BASE FAILURES - FAULTING	9	9	___	___	___	___	___	___
RAVELING - WEAR SPALLING	6	6	___	___	___	___	___	___
OUT OF SECTION	6	6	___	___	___	___	___	___
PATCHING	12				___			___
APPEARANCE	__	15			___			___
>---- TOTAL ---->	51	49			___			___

REMARKS: ______________________________

GUARDRAIL: POOR FAIR GOOD SHOULDER: : POOR FAIR GOOD

	INN	OUT	INN	OUT
NUMBER OF LANES:				
PREVIOUS RI (89):	___	___	___	___
RI (90):	___	___	___	___
DECREASE IN RI:	___	___	___	___
RUTTING (INCHES):	___	___	___	___
SKID NUMBER:	___	___	___	___

RECOMMENDATIONS: OVERLAY MILL GRIND YEAR: ________
OTHER ______________ ________

RATERS: RIZENBERGS BURCHETT DADE DATE: __/__/90

REMARKS: ______________________________ RANKING

FIGURE 2 Pavement condition rating form.

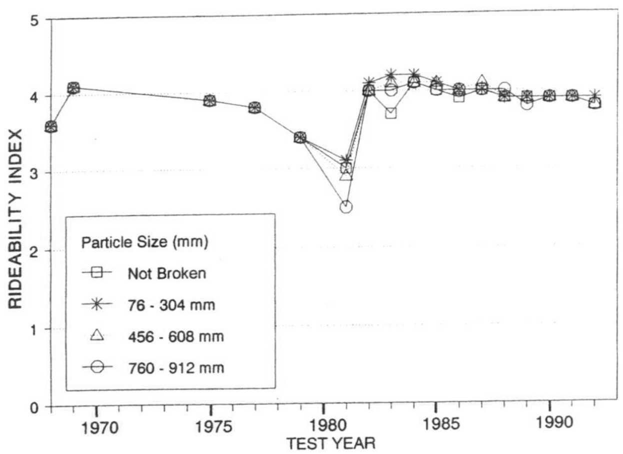

FIGURE 3 Rideability index, Interstate 71.

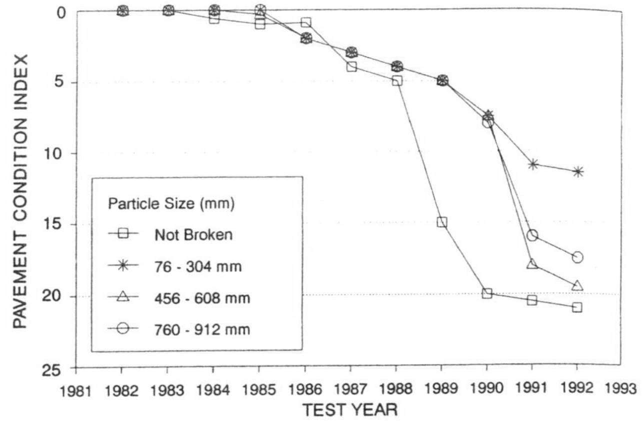

FIGURE 4 Pavement condition index, Interstate 71.

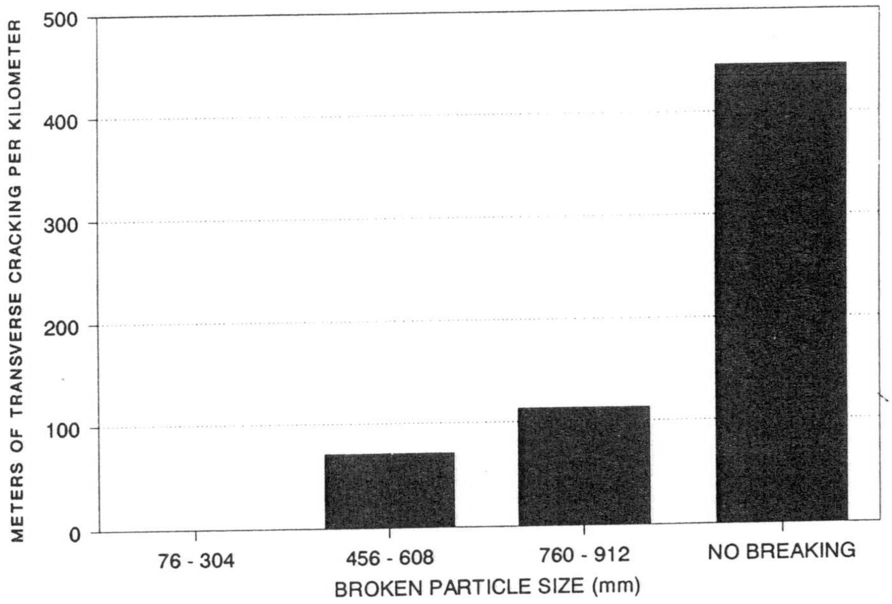

FIGURE 5 Comparison of reflective cracking, Interstate 71.

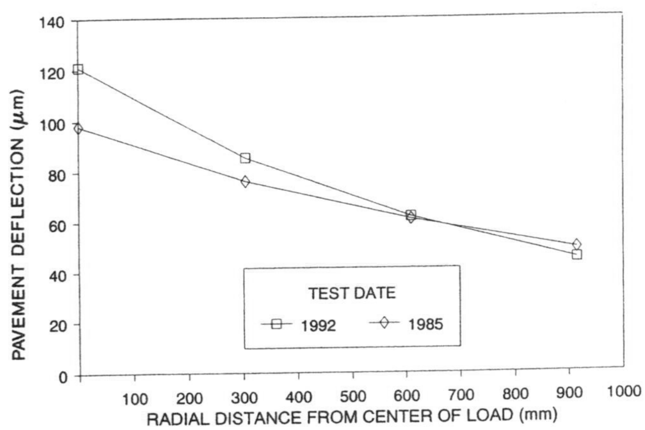

FIGURE 6 Deflection bowl comparison: particles of 76 to 304 mm (3 to 12 in.), Interstate 71.

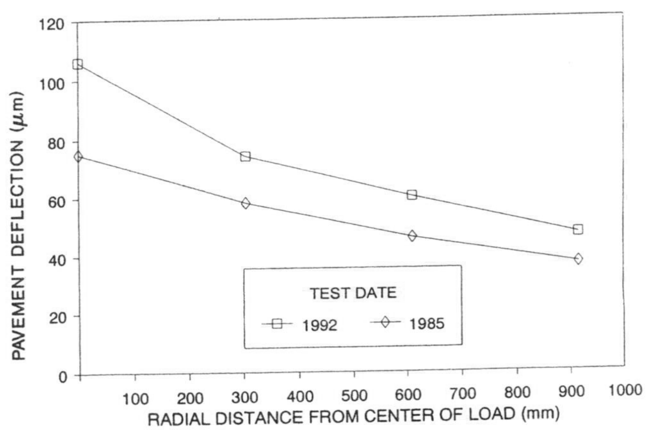

FIGURE 7 Deflection bowl comparison: particles of 456 to 608 mm (18 to 24 in.), Interstate 71.

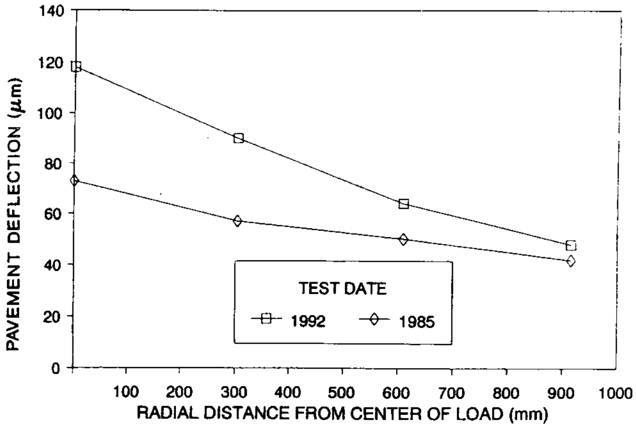

FIGURE 8 Deflection bowl comparison: particles of 760 to 912 mm (30 to 36 in.), Interstate 71.

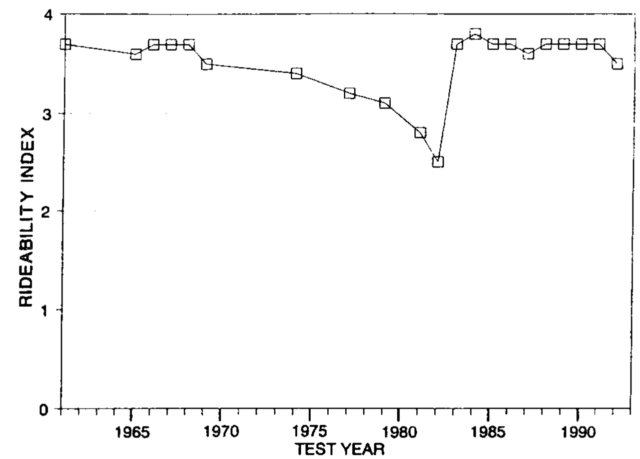

FIGURE 10 Rideability index, Interstate 64.

quent visual surveys indicate that all sections are performing in a similar manner. This pavement has remained in good condition since its construction. Figure 10 contains the rideability history for the pavement since rehabilitation of all sections combined. This figure indicates that the RI had dropped to a low of 1.7 after 23 years of service before rehabilitation. After reconstruction, the RI has remained almost constant. The pavement condition rating has decreased since rehabilitation, as seen in Figure 11; however, the pavement is still in good condition. Deflection measurements obtained in 1985 and 1992 indicate little change in the pavement structural condition.

Bluegrass Parkway

The Bluegrass Parkway project was constructed in 1985 using a thin overlay of 121 mm (4.75 in.). The pavement is currently showing signs of deterioration. The breaking pattern for this project consisted of particle sizes of 456 to 608 mm (18 to 24 in.). Alligator cracking has been observed in numerous areas, indicating base failures. Reflective cracking is evident throughout the project. The observed distresses indicate that rehabilitation will be necessary in the near future.

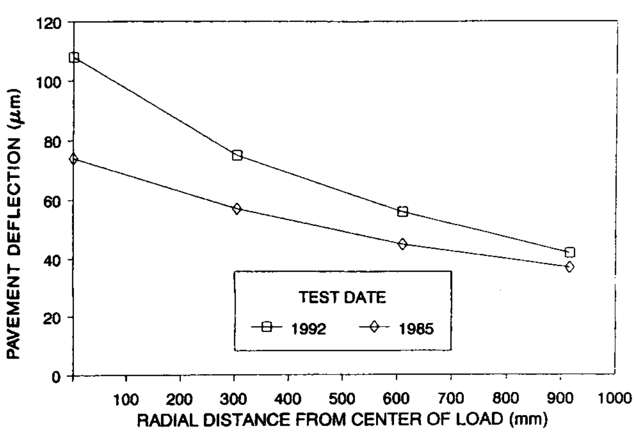

FIGURE 9 Deflection bowl comparison: control section, Interstate 71.

The pavement condition history of the project is shown in Figure 12 for the eastbound and westbound lanes. This figure indicates a steady decline in condition since rehabilitation. The condition rating for the eastbound lanes is approximately 40. In comparison, the condition ratings are 10 and 20 for Interstate 64 and Interstate 71, respectively. There has been

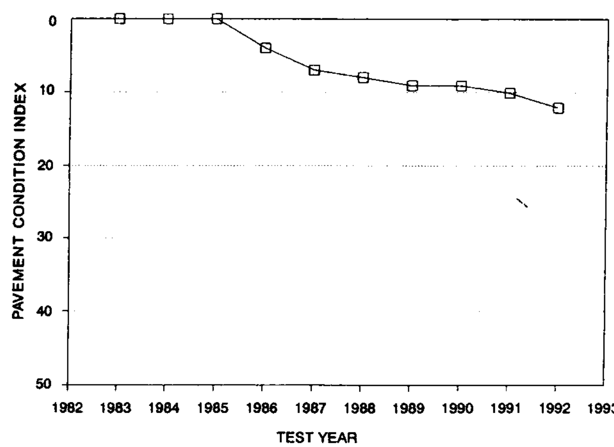

FIGURE 11 Pavement condition index, Interstate 64.

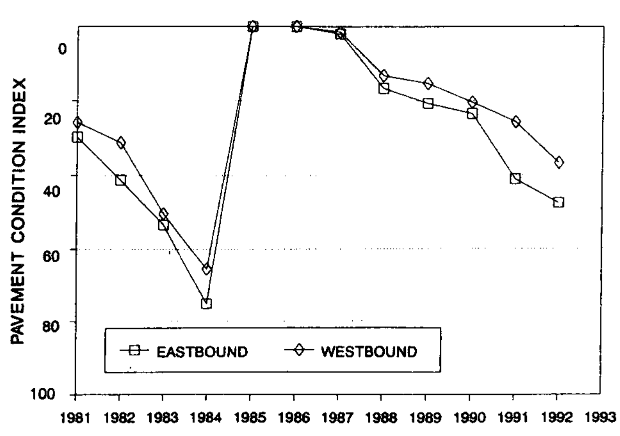

FIGURE 12 Pavement condition index, Bluegrass Parkway.

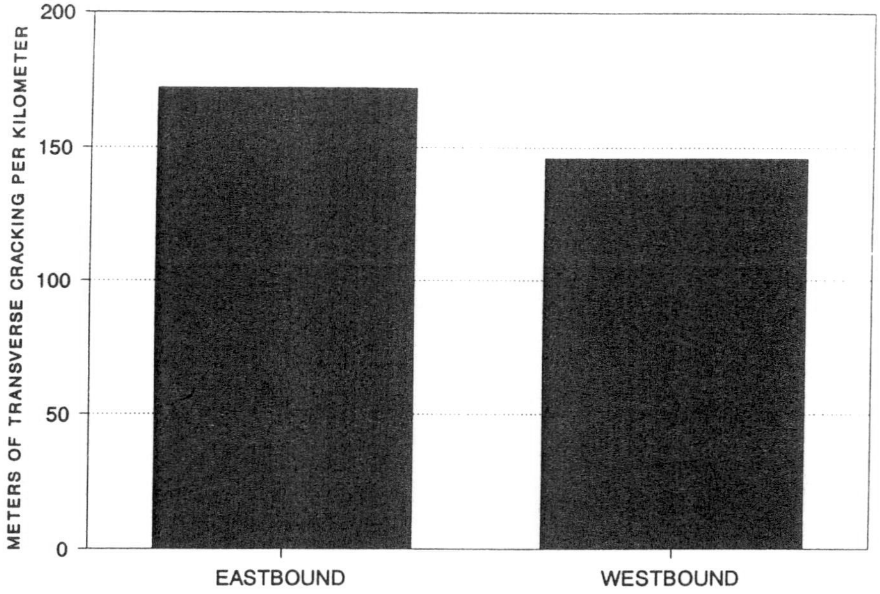

FIGURE 13 Comparison of reflective cracking, Bluegrass Parkway.

a large increase in distress in the eastbound lanes from 1990 to 1991. The westbound lanes do not show as large an increase. A detailed crack survey was also conducted, and the results are shown in Figure 13. These data also indicate that the eastbound lanes have more transverse cracking than the westbound lanes. This supports the difference in condition rating between the two directions. The rideability index for each direction is shown in Figure 14. This figure indicates a decrease in RI since rehabilitation; however, it has not decreased in the same proportion as the condition points.

CONTINUING RESEARCH

Kentucky is currently involved in several research projects relating to broken and seated concrete pavements. Kentucky is participating in FHWA Special Project 202, which is evaluating the effects of various breaking sizes on joint movement. In addition to the instrumentation installed by FHWA, Kentucky has installed electronic measuring devices in each breaking pattern. These devices provide a continuous record of joint movement over an evaluation period, normally 30 days.

Kentucky continues to survey all the broken and seated pavements in the state. This effort continues to provide valuable information regarding the performance of these pavements. Kentucky has recently rehabilitated a continuously reinforced concrete pavement by rubblizing of the existing concrete slab followed by an unbonded PCC overlay. The concrete was rubblized, and the reinforcing steel was removed. The rubblized material was then overlaid with an asphalt-treated drainage layer followed by conventional PCC pavement. The long-term performance of this project is currently being evaluated.

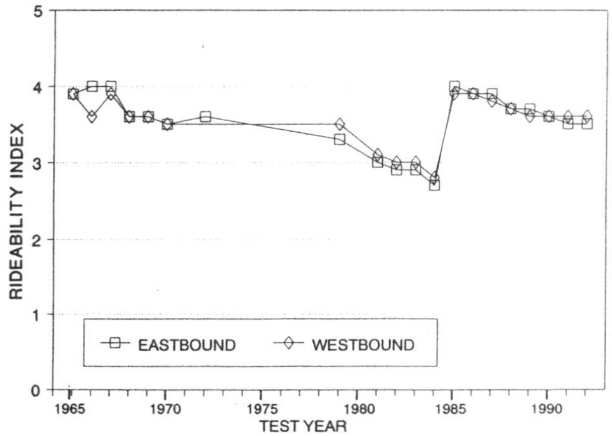

FIGURE 14 Rideability index, Bluegrass Parkway.

SUMMARY AND CONCLUSIONS

Information in this paper documents the procedures that have been used in Kentucky with good success with regard to performance of broken and seated concrete pavements. This type of rehabilitation has been performed routinely for several years; in some isolated areas remedial action has been required. The majority of these areas were base type failures in the wheel tracks of the driving lane. Research is currently being conducted to relate this type of distress to that in areas of poor drainage. These areas may be associated with problems in the pavement drainage system, because all of these projects contain pavement edge drains.

Data collected from Interstate 71 illustrate that the breaking pattern of 76 to 304 mm (3 to 12 in.) would provide the best performance (on the basis of the amount of observed reflective cracking and analysis of condition points). The current Kentucky specifications require the breaking pattern of 457 to 609 mm (18 to 24 in.). This pattern has been chosen on the basis of Kentucky's experience in the construction of these types of pavements. This pattern provides for good constructibility and overall performance.

This method of rehabilitation is considered to be a cost-effective means of extending the service life of the pavement structure. These procedures have been developed through experience in Kentucky. Therefore, conditions in other states may not yield the same type of performance. Kentucky's successful experience with this type of rehabilitation may provide other states with guidelines for development of specifications based on their own experience. On the basis of its experience over the last 10 years, Kentucky will continue to use breaking and seating of concrete pavements as a rehabilitation alternative.

ACKNOWLEDGMENTS

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