FINAL REPORT

EVALUATION OF CONCRETE SLAB FRACTURING TECHNIQUES IN MITIGATING REFLECTIVE CRACKING THROUGH ASPHALT OVERLAYS

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DISCLAIMER

ABSTRACT

This report presents the results of an evaluation of concrete slab fracturing techniques as a means of arresting or retarding reflective cracking through asphalt overlays placed on severely distressed portland cement concrete pavement. The study involved monitoring the performance of five pavement rehabilitation projects over a period of up to 8 years. Two of the projects were originally constructed of jointed plain (unreinforced) concrete, and the other three consisted of jointed reinforced concrete pavement. The test sections were fractured with a guillotine drop hammer and then seated with a 50-ton pneumatic tire roller. For comparative purposes, control sections, which were not fractured prior to placement of the asphalt overlay, were constructed just beyond the bounds of three of the fractured test sections. Detailed visual condition surveys were conducted annually at all sites. For each survey, the number of occurrences of reflective cracks that formed in fractured sections was directly compared to the number of cracks observed in the control sections to quantify the tendency of fracturing to retard or arrest the formation of reflective cracks.

The results of this study show that fracturing and seating distressed concrete pavements appear to be an effective means of retarding the formation of reflective cracking through asphalt overlays on jointed, unreinforced pavements. In the case of reinforced pavements, however, the fracturing technique was somewhat less successful in that the formation of reflective cracks appeared to be delayed for only about 3 years. Beyond that point in time, the fractured reinforced sections exhibited approximately the same amount of reflective cracking as the control section. The researcher concludes that any observed benefit in terms of extended pavement service life or enhanced ride quality resulting from even a slight delay in reflective crack propagation would likely offset the rather nominal cost of the fracturing and seating operation itself.

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INTRODUCTION

Like other state highway agencies, the Virginia Department of Transportation (VDOT) in recent years has increasingly used asphalt overlays to rehabilitate severely distressed portland cement concrete pavements (PCCP). Unfortunately, reflective cracks that form above joints and cracks in the underlying PCCP drastically reduce the useful lives of the bituminous overlays. During the past 15 years, the fractured slab approach has gained increased acceptance as a means of retarding the formation of reflective cracks.

McGhee[1] suggested that most reflective cracking in asphalt overlays over PCCP is the result of differential vertical movement or displacement at joints and cracks under heavy wheel loads, especially where the existing PCC slabs are curled or faulted. The rate of reflective crack development is a function of the frequency of wheel loadings and the magnitude of vertical movement resulting from these loads. Stoffels and Kilareski[2] reported that thermally induced horizontal movement between the underlying PCCP slabs is also a significant contributor to reflective cracking. In both cases, excessively high strains develop at the bottom of the asphalt layer over joints and cracks, which lead to upward crack propagation.

The concept of slab fracturing before overlaying is based on reducing the movement of the cracked or broken slabs beneath the overlay, thereby reducing critical strains in the asphalt. Methods used to fracture slabs are generally divided into three categories: rubblization, cracking and seating, and breaking and seating.[3] Rubblizing involves reducing the slab into fragments having textural and gradation characteristics similar to a crushed aggregate material. It is usually accomplished with a resonant pavement breaker and has been used successfully on all types of concrete pavements (i.e., jointed plain [JPC], jointed reinforced [JRC], and continuously reinforced [CRC] concrete pavements]. Reduction of concrete into such fragments by rubblizing, however, results in a significant loss of structural capacity.

Crack/seat and break/seat (B/C&S) are fracture techniques intended to produce very short rigid slabs with effective lengths on the order of 12 to 48 in. These two techniques are similar, and the process of cracking or breaking the pavement is usually accomplished with modified pile drivers, guillotines, or spring arm (whip) hammers. A significant distinction between the two techniques exists. Crack/seat is associated with the fractured slab technique conducted solely on JPC (unreinforced) pavements. The intent of cracking is to create closely spaced pieces small enough so that vertical and horizontal movement is reduced but full aggregate interlock is maintained to permit load transfer across the crack with little loss of structural capacity.

Cracking through the full depth of the pavement is the ultimate goal. Break/seat, on the other hand, is the process by which JRC slabs are fractured. A significantly higher level of energy is required to accomplish breaking of JRC slabs because of the need to destroy the bond between reinforcing steel and concrete. If steel debonding is not accomplished during the breaking process, the effective slab length is not reduced and the result is a series of broken slabs tied together with bonded steel. In this case, the capacity of the breaking process to eliminate horizontal movement between the fractured slabs is diminished or eliminated.

In all of the mentioned fracturing processes it is necessary to seat the concrete pieces (1) to create a relatively uniform grade to support paving operations, (2) to proof roll for the purpose of locating soft zones in the underlying layers that may need to be removed and replaced with more stable material, and (3) to press the fragments downward to ensure firm contact with the supporting base layer. For both cracking and breaking, several passes of a 30-to-50-ton rubber-tired roller is typically used to seat the fractured slab fragments. For rubblized projects, steel vibratory rollers on the order of 10 tons are commonly used for the seating process.[3]

PURPOSE AND SCOPE

The purpose of this study was to evaluate the capacity of the B/C&S techniques to eliminate or retard reflective cracking in asphalt overlays placed over JCPs in Virginia. This objective was accomplished by monitoring the performance of two crack/seat projects and three break/seat projects that had been in service for up to 10 years. Detailed visual surveys of these five fractured "test" sections and three adjacent "control" sections (i.e., not fractured prior to overlaying) were conducted and analyzed to document and evaluate the performance of the fractured and unfractured pavements relative to one another. Since the sites selected for inclusion in this study had been identified as functionally deficient, and therefore were already scheduled for asphalt resurfacing, these projects were funded entirely by VDOT's Maintenance Division.

METHODOLOGY

This study was conducted by (1) selecting candidate sites and compiling pertinent construction history and distress data, (2) developing construction specifications for pavement rehabilitation using crack/seat and break/seat techniques, (3) monitoring rehabilitation activities and pavement performance by conducting detailed condition surveys at regular intervals, and (4) quantifying and interpreting results of the condition surveys to determine if the fracturing process had a positive effect on pavement performance by retarding or arresting reflective cracking.

Site Selection

Nearly all of Virginia's PCCP are located on interstate and primary corridors in Northern Virginia, the Tidewater area near Norfolk, and in the vicinity of Richmond. The majority of these facilities were constructed of JRC and CRC; pavements constructed of JPC represent only a small percentage of VDOT's concrete network. Although Virginia's experience with the rehabilitation of CRC pavements by overlaying with asphalt is relatively limited, performance of these composite pavements to date has been good. On the other hand, reflective cracking through asphalt overlays placed on jointed concrete pavements has plagued their performance for years. The challenge for this phase of the study was to locate representative jointed concrete pavement sites with moderately high traffic volumes that would be suitable candidates for rehabilitation by overlaying with asphalt.

At the time this study was conceived in 1989, the only JPC pavements in need of rehabilitation were located on an 11-mile section of US Route 13 along Virginia's Eastern Shore. Another shorter section of Route 13 in the same vicinity, which was constructed of JRC, had also deteriorated to a state that demanded rehabilitation at about the same time. The Virginia section of Route 13 along the Eastern Shore, which extends from the Chesapeake Bay Bridge Tunnel at the south end to the Maryland state line at the north, currently supports an approximate average of 16,000 to 20,000 vehicles per day, of which 10 to 15 percent are trucks. This and the presence of reinforced and unreinforced jointed concrete pavements in close proximity rendered several projects on Route 13 excellent candidates for evaluating crack/seat and break/seat methods of PCCP rehabilitation. Another JRC site located on Virginia Route 175 near the northern end of the Eastern Shore was added to the list of the break/seat evaluation sites. Unlike Route 13, which is a four-lane divided facility, Route 175 is a two-lane roadway and supports on the order of 6,700 vehicles per day (of which approximately 7 percent are trucks) in the vicinity of the selected rehabilitation site.

Test and Control Sections

The sites selected for evaluation were subdivided into manageable test sections according to boundaries defined by original project construction. This eliminated the effects of within-section variations in pavement thickness, age, material type, joint spacing, etc. In some cases, test section lengths were shortened to ensure that the visual surveys could be conducted within a reasonable period of time to minimize error attributable to surveyor fatigue.

At one end of most test sections, a length of pavement was left unfractured to enable a direct comparison of performance between adjacent pavements that were identical in all regards with the exception of treatment prior to being overlain with asphalt. In these cases, the break/seat or crack/seat operations were simply suspended some distance in advance of the terminus of the scheduled overlay project. The resulting unfractured lengths are referred to herein as control sections. Tables 1 and 2 are summaries of all pavement sections included in the study.

Table 1. Site Characteristics of Pavement Sections Selected for Inclusion in Study

Section I.D.	Route	County	Length (mi)	Lane Direction	1990 AADT	1990 % Trucks
1-C Test	US 13	Accomac	5.29	NBL	7,500	14
1-C Control	US 13	Accomac	0.08	NBL	7,500	14
2-C Test	US 13	Accomac	5.81	SBL	7,500	14
2-C Control	US 13	Accomac	0.08	SBL	7,500	14
3-B Test	US 13	Accomac	1.70	NBL	8,100	13
4-B Test	US 13	Accomac	2.50	SBL	8,100	13
4-B Control	US 13	Accomac	0.60	SBL	8,100	13
5-B Test	SR 175	Accomac	3.60	EBL & NBL	6,700	7

Table 2. Construction History of Pavement Sections Selected for Inclusion in Study

Section I.D.	Date of Concrete Construction	Pavement Type	Transverse Joint Spacing (ft)	Rehab Date	Concrete Treatment	Asphalt Overlay Thickness (in)
1-C Test	1966	JPC	20	1989	C/S	4.5
1-C Control	1966	JPC	20	1989	Unfractured	4.5
2-C Test	1966	JPC	20	1989	C/S	4.5
2-C Control	1966	JPC	20	1989	Unfractured	4.5
3-B Test	1966	JRC	30	1991	B/S	6.5
4-B Test	1966	JRC	30	1991	B/S	6.5
4-B Control	1966	JRC	30	1991	Unfractured	6.5
5-B Test	1966	JRC	50	1990	B/S	4.5

Pavement Condition Prior to Rehabilitation

A visual examination of each study site was conducted prior to rehabilitation to document surface conditions and locations of transverse joints and cracks for the subsequent analysis of reflective crack propagation. Three sites had been overlaid with asphalt some years prior to the conduct of this study. Cursory visual inspections of the asphalt overlays revealed a high frequency of moderate to severe reflective cracking at all three sites. The asphalt layers were completely removed by milling to expose underlying concrete surfaces prior to fracturing, thereby eliminating the dissipation of fracture energy through the softer asphalt. More detailed visual examinations of the concrete surfaces were conducted here just after removal of the asphalt layers.

All of the reinforced and unreinforced concrete pavement sections comprising the study pavements consistently exhibited joint faulting as the most prevalent distress. Vertical displacements across transverse joints typically ranged from ¼ to ¾ in and averaged on the order of 3/8 in in all sections. Partial and full lane width patching was the second most prevalent distress, with patched slabs representing 8 to 15 percent of the total number of slabs in all test and control sections. Transverse cracking of low to medium severity was also present to varying extents, with approximately 3 to 10 percent of slabs being afflicted in all sections. Other distresses present to a lesser degree included corner cracking, joint and crack spalling, and longitudinal cracking.

Rehabilitation

The novelty to Virginia of this pavement rehabilitation approach required the assembly of contract special provisions for fracturing and seating concrete pavements. VDOT's Construction Division compiled these special provisions, which were based largely on specifications developed for similar projects by other state highway agencies. The VDOT Special Provisions were used for the rehabilitation of all five study sites, which took place during the summers of 1989, 1990, and 1991. The VDOT Special Provisions for Fracturing and Seating Portland Cement Concrete Pavements is provided in the Appendix.

Rehabilitation of pavements using the B/C&S technique is generally conducted in four steps: (1) removing the existing asphalt overlay, if present, (2) breaking or cracking the existing PCC slab, (3) seating the fractured PCC slab, and (4) constructing the new asphalt wearing surface. The specifications used for all of these projects called for the removal of existing sealant and incompressible materials from joint reservoirs prior to fracturing to minimize the potential for slab blowups during cracking or breaking operations. The acceptable degree of fracturing for B/C&S projects is typically defined in terms of crack spacing and pattern dimensions visible on a slightly dampened concrete surface. According to the Special Provisions for these projects, "the existing Portland cement concrete pavement shall be broken throughout the complete depth of the concrete such that the majority of the pavement shall be generally of 18 to 24 inch square size pieces with occasional size pieces up to 30 inches and no more than 20 percent of the pavement material shall be larger than 24 inches." The Special Provisions also require that the pavement be broken transversely such that longitudinal breaks do not exceed 25 percent of the slab length in the longitudinal direction.

Equipment used to accomplish slab fracturing had to be capable of impacting the pavement with variable force to control fracture spacing while producing full-depth, nearly vertical cracks. In all projects comprising this study, the Wirtgen AG guillotine drop hammer with a 6-foot-wide, 12,000-lb free-falling blade was used to destroy slab action. This device demonstrated particular versatility in creating a broad range of crack pattern densities through its ability to control both equipment speed and drop height, which averaged on the order of 4 and 5 ft for unreinforced and reinforced pavements, respectively. The use of a 6-foot-wide blade required two passes of the hammer for complete coverage of an 11- or 12-ft-wide lane. For the most part, the Wirtgen guillotine consistently produced the specified fracture pattern at all eight study sites. However, the center of the fractured lanes typically exhibited continuous lengths of undesirably shattered concrete particles where the pavement was hammered twice, or more specifically, within the 1- to 2 ft-wide zones where consecutive passes of the 6-foot-wide blade overlapped. The problem of excessive shattering was not addressed at any of the study sites.

After fracturing, each site was seated by rolling a minimum of three passes with a 50-ton pneumatic tire roller to ensure the slab pieces were in contact with the supporting base layer. Areas in the fractured pavement that deflected excessively beneath the weight of the roller were then removed and patched. In all cases, the contractor was required to maintain the fractured and seated pavement in a condition suitable for the passage of traffic prior to placing the asphalt overlay. Next, the fractured and seated surfaces were treated with an emulsified asphalt tack coat and paved with 3 in of asphaltic concrete base mix. As indicated in Table 2, three study sites received a 2-in-thick asphalt intermediate course. The final course for all pavements was a 1½-in asphalt wearing surface, which rendered a total overlay thickness of 4½ in for five sites and 6½ in for the three sites containing intermediate courses.

The cost of the B/C&S operations for the projects included in this study ranged from $0.35 to $0.45 per square yard.

Performance Evaluation

An evaluation of the capacity of slab fracturing to mitigate reflective cracking through the asphalt overlays was made by visually examining pavement surfaces at the study sites at close range on an annual basis from 1990 through 1998. Detailed records were made of all occurrences of transverse cracking during these surveys. In addition to the severity and extent of the observed distresses, their exact locations were documented and mapped to enable an analysis of the propagation of the distresses between control and fractured sites. For each annual survey, the number of occurrences of reflective cracks that formed in fractured sections was directly compared to the number of cracks observed in the control sections to quantify the tendency of the B/C&S technique to retard, if not arrest, the formation of reflective cracks.

Distress Surveys

The pavement surface in both lanes was visually examined once per year by a survey crew of two or three walking along the road and manually recording the occurrences of observed cracking distress. The surveys were led by the same crew leader each year to minimize variation in the data collected between years attributable to human error. The exact locations of cracks were manually sketched on a given site’s survey sheet, which was essentially a plan view of the study site. A copy of a site’s completed survey sheet for a given year was then used as the base sheet for the following year’s survey. In other words, reflective cracks were cumulatively recorded from year to year on the same sheet by logging distresses in a different color of ink each year. The distresses reported herein were identified and classified in accordance with a distress dictionary developed by the Strategic Highway Research Program for engineers and organizations responsible for maintaining pavement infrastructure.[4]

Transverse reflective crack densities were calculated after each annual survey by adding the cumulative total number of reflective cracks observed at each section and dividing the total by the section length site. For the distress density calculation, a transverse crack was treated as one occurrence regardless of the crack's length or width. This analysis did not attempt to capture the effects of deterioration in terms of increasing distress severity, but rather focused on the rate of reflective crack incidence. This enabled us to document the rate of crack reflection. Figures 1 through 5 are graphical representations of the rates of formation of reflective cracks for each study site.

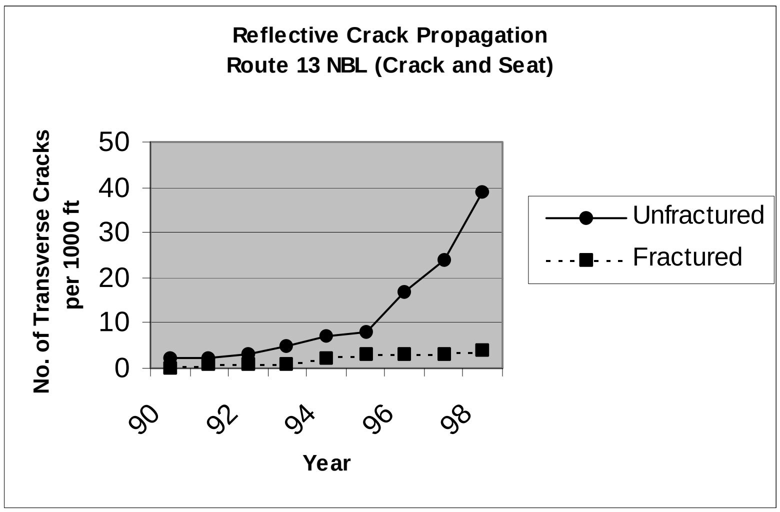

Figure 1. Reflective Cracking Over Time for Site 1, Unreinforced Concrete Slabs

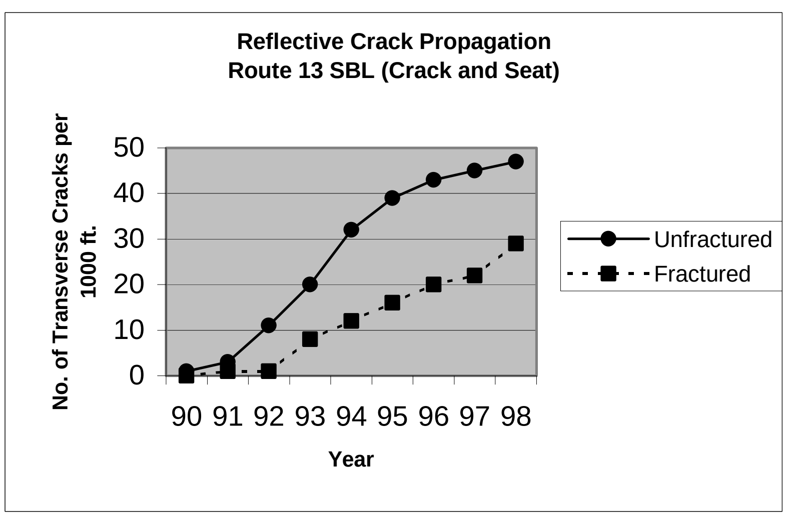

Figure 2. Reflective Cracking Over Time for Site 2, Unreinforced Concrete Slabs

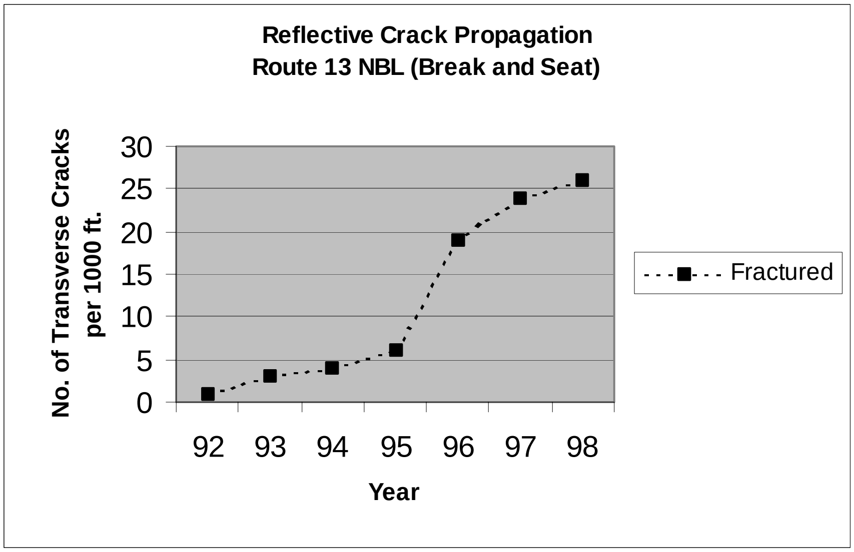

Figure 3. Reflective Cracking Over Time for Site 3, Reinforced Concrete Slabs

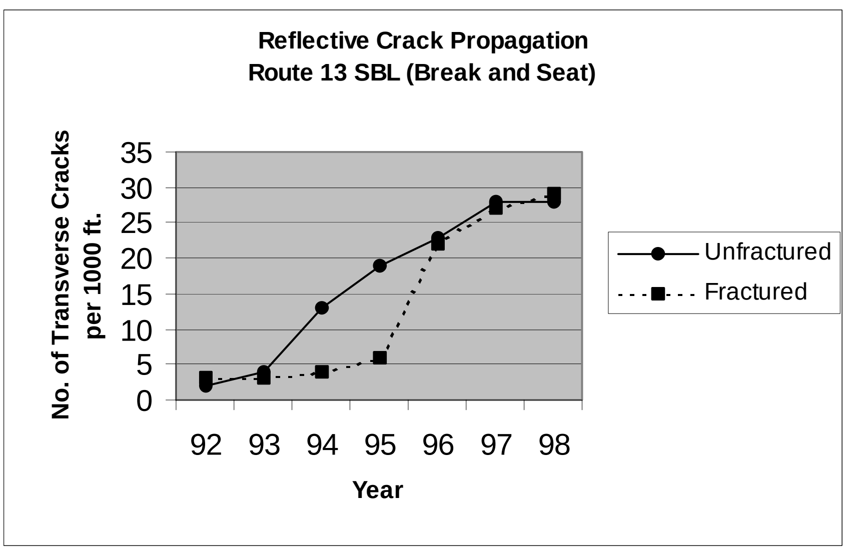

Figure 4. Reflective Cracking Over Time for Site 4, Reinforced Concrete Slabs

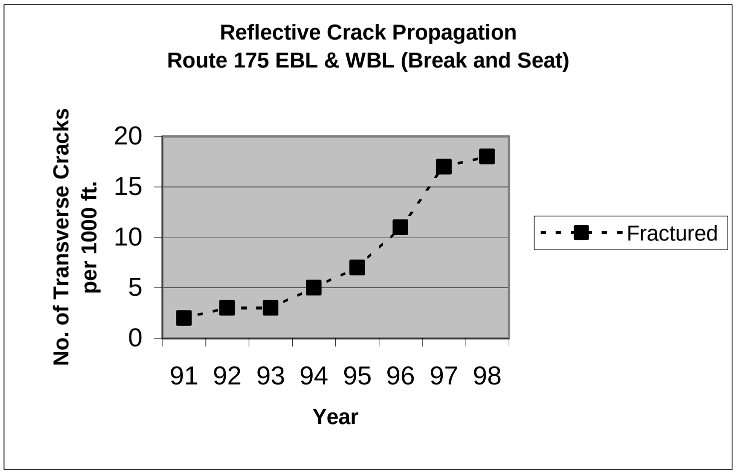

Figure 5. Reflective Cracking Over Time for Site 5, Reinforced Concrete Slabs

DISCUSSION

Figures 1 and 2, which graphically summarize the performance of the two unreinforced concrete pavement rehabilitation projects, suggest that fairly significant differences existed in rates of reflective crack propagation between the fractured (test) and unfractured (control) sections throughout the 8-year evaluation period. In the case of Site 1, rates of reflective cracking remained consistently low from 1990 through 1998 for the fractured section, which exhibited a cumulative total of only three reflective cracks per 1,000 ft of roadway during the final 1998 survey. Beginning in 1995, however, measured reflective crack densities on the paved surface of the unfractured section at Site 1 was approximately 9 cracks per 1,000 ft of roadway, and cracking there increased dramatically to nearly 40 reflective cracks per 1,000 ft in 1998. The reflective cracking trend at Site 2 was similar to that observed at Site 1 in that the control section exhibited a higher rate of crack propagation than did the test section throughout the evaluation period. Although some reflective cracking became visible in the Site 2 control section during the first year after placement, the fractured section at the same site did not begin to exhibit reflective cracks until the third year of the overlay's life. Beyond that time, the incidence of reflective cracking in the test section increased uniformly. Measured crack densities here totaled nearly 30 cracks per 1,000 ft of roadway during the final survey in 1998, suggesting that the slab fracturing operation at Site 2 was not as successful in retarding reflective cracking as that operation at Site 1.

Of the three reinforced concrete pavement sites in this study, only one site included both control and test sections from which direct performance comparisons were made between fractured and unfractured sections. Figure 4, which summarizes this pavement performance at Site 4, suggests that fracturing the reinforced slabs had the effect of arresting reflective cracking until the fourth year of the overlay's life. Reflective cracks became visible in the control section here during the second year. Measured crack densities reached similar levels between fractured and unfractured sections beyond the fourth year after rehabilitation. Although Site 3 did not include an unfractured test section, Figure 3 indicates that the incidence of reflective cracking here remained fairly low during the first 3 years of overlay life before increasing suddenly from a density of 6 cracks per 1,000 ft to a density of 20 cracks per 1,000 ft in the fourth year. Likewise, data captured for Site 5 indicate a similar trend; reflective crack densities in the new overlay remained at or below 5 cracks per 1,000 ft for approximately 3 years before increasing noticeably for the remainder of the evaluation period.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of this study, the use of the crack and seat rehabilitation technique appears to be an effective means of retarding the occurrence of reflective cracking through asphalt overlays on jointed, unreinforced pavements. The data collected were too variable to support conclusions about the time interval of reflective crack retardation attributable to the crack and seat operations. The break and seat technique used to rehabilitate jointed reinforced concrete pavements appeared to be somewhat successful in retarding reflective crack propagation as well, but only for the first 3 years or so of the overlay's life. Beyond that point in time, the fractured reinforced sections exhibited approximately the same amount of reflective cracking as the control sections. It should be noted, however, that slab fracturing did not eliminate reflective cracking in any of the reinforced or unreinforced projects evaluated. Any observed benefit in terms of extended pavement service life or enhanced ride quality resulting from even a slight delay in reflective crack propagation would likely offset the rather nominal cost of the fracturing operation itself. Stated differently, the employment of the B/C&S rehabilitation technique appears to be a good investment considering that slab fracturing adds only about $3,000 per lane-mile to the project cost, approximately equal to the cost of adding a mere ¼ in of hot-mix asphalt overlay material.

The reduction of pavement structural capacity is the primary concern with rehabilitation by B/C&S. A certain degree of fracturing is required to destroy slab action to an extent whereby reflective cracking is retarded. However, greater overlay thicknesses are required to compensate for the reduction in structural capacity caused by fracturing the concrete. As the number of projects rehabilitated using slab fracturing techniques grows, pavement managers will have greater opportunities to quantify the improvement in pavement serviceability resulting from the induced delays in reflective cracking.

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3. Pavement Consultancy Services. *Guidelines and Methodologies for the Rehabilitation of Rigid Highway Pavements Using Asphalt Concrete Overlays.* Beltsville, Md., 1991.

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APPENDIX

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
HYDRAULIC CEMENT CONCRETE PAVEMENT REPAIR
Breaking and Seating Pavement, Reinforced and Plain

DESCRIPTION

This work shall consist of breaking and seating existing reinforced or plain hydraulic cement concrete pavement for full depth and full panel width in accordance with this provision and plan details.

EQUIPMENT

The device to be used for breaking the concrete pavement shall be capable of producing the desired crack pattern without displacing the concrete more than ½-inch vertically. Destructive techniques as a result of using headache balls, chisel-nosed pile drivers, unguided free falling weights, and other inappropriately designed impact equipment which will lead to undesirable spalling and excessive loss of structural strength will not be permitted. Equipment for breaking concrete pavement shall be capable of impacting the pavement with a variable force which can be controlled in order to produce full depth cracks without crack fanning. (Crack fanning is when the induced crack runs more or less vertical from the surface impact zone but develops lateral tendencies about halfway through the slab.) The approved equipment for breaking concrete shall not produce extensive spalling along the cracks and shall not shatter the pavement or base. A safety screen satisfactory to the Engineer shall be required to protect vehicles in the adjacent lane from flying chips during the breaking process.

PROCEDURES

Any existing asphalt concrete overlays shall be removed from the hydraulic cement concrete pavement prior to breaking and seating operations.

The contractor shall exercise caution during his operations of work to protect and prevent damage to underground utilities and drainage facilities.

Before breaking operations begin, the Engineer will designate a test section. The contractor shall break the test section using varying energy and striking patterns and, if necessary, repeated passes of the equipment over the pavement until the test section's pavement is acceptably broken as specified herein. The extent of breakage with the test section shall be used as a guide for breaking the pavement on the remainder of the project. In addition, the contractor shall seat the broken pavement within the test section so that the Engineer may evaluate the effectiveness of the seating operation. Deflection tests shall be conducted in addition to core samples in order to verify the structural condition of the broken and seated pavement. The Engineer may require additional test sections any time during the course of the work.

A. Size Requirements

1. The existing reinforced hydraulic cement concrete pavement shall be broken such that the average size of the majority of the surface material (pieces of broken panels) shall be 18 inches (length and width) with no more than 20% of the pieces larger than 18 inches and no individual pieces larger than 24 inches. The extent of the breakage will be based on cracks visible to the unaided eye when the pavement surface is in dry condition. The use of water to detect additional cracks will not be permitted. The cracks (breaks) shall extend through the full depth of the pavement.

2. The existing plain hydraulic cement concrete pavement shall be broken such that the average size of the majority of the pavement shall be generally of 18 to 24 inch square size pieces with occasional size pieces up to 30-inch and no more than 20% of the pavement material shall be larger than 24 inches. The pavement breaking tool shall not impact the pavement within one foot of existing cracks, pavement joint or edge of pavement. The breaking of plain hydraulic cement concrete pavement shall create full-depth cracks which produce a pattern in the pavement distinguishable after applying water to dampen the pavement surface.

The contractor shall continuously monitor the breaking operation and shall make adjustments in the striking pattern, striking energy, number of passes, or other factors as necessary in order to continually achieve acceptable breaking throughout the project. The breaking operation shall not result in creating a depression in the existing pavement surface greater than ½ inch.

B. Seating of Broken Pavement

The broken concrete shall be seated by rolling with a pneumatic-tire proof roller weighing 35 or 50 tons. The roller shall be one of the following types:

1. The roller may be a pneumatic tire roller consisting of 4 rubber-tired wheels equally spaced across the full width and mounted in line on a rigid steel frame in such a manner that all wheels carry equal loads, regardless of surface irregularities. Roller tires shall be capable of satisfactory operation at a minimum inflation pressure of 100 psi, and tires shall be inflated to the pressure necessary to obtain proper surface contact pressure to satisfactorily seat pavement slabs. At the contractor's option, tires may contain liquid. The roller shall have a weight body suitable for ballasting to a gross load of either 35 or 50 tons, and ballast shall be such that gross roller weight can be readily determined and so controlled as to maintain the gross roller weight. The roller shall be towed with a rubber-tired prime mover.

2. The roller may be a two-axle self-propelled pneumatic-tire roller, providing the roller is equipped with no more than 7 tires, and the requirements in B. 1. above concerning tire inflation pressure, surface contact pressure, and gross weight are met.

A minimum of 5 one-way passes of a 50-ton roller, or 7 one-way passes of a 35-ton roller will be used. A rolling pattern shall be used that will ensure that the entire area of the broken pavement is well seated and is thoroughly and uniformly compacted.

C. Placement of Surface Treatment when required on the plans

Placing of the surface treatment shall follow the breaking and seating operation as closely as is practicable and, in no case, shall the broken pavement remain exposed more than 24 hours. If this 24-hour requirement is not met, breaking operations shall be suspended until all broken existing pavement has been covered by at least one surface treatment course.

Normal leveling shall be performed on top of the first course of asphalt concrete, and not on the existing pavement. However, the Engineer may require a leveling course to be placed directly on the broken and seated pavement at specific locations where a substantial amount of leveling is deemed necessary. The material used as a leveling course shall be as directed by the Engineer.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Breaking and seating pavement (reinforced) and (cracking and seating plan) will be measured and paid for in units of square yards which price bid shall include breaking and seating hydraulic cement concrete pavement (reinforced and plain) leveling course material, for all equipment, labor and incidentals necessary to complete the work.

Payment will be made under:

Pay item	Pay unit
Breaking and seating pavement, reinforced	Square yard
Breaking and seating pavement, plain	Square yard