Breaking-Seating and Bituminous Concrete Overlays of Existing Portland Cement Concrete Pavements

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All previous experience of eliminating reflective cracking of both joints and cracks in Portland cement concrete pavements through bituminous concrete overlays *has not* been successful. Our bituminous concete overlays have principally been 4 in. or less; however, we have experienced significant reflective cracking where over 8 in. of bituminous concrete overlay was applied. It seems most logical and reasonable that if cracks and joints of deteriorated PCC pavements cannot be effectively eliminated by conventional bituminous concrete overlays that the movement of the slabs can be reduced or eliminated by breaking them into smaller pieces. This is exactly what we are doing with the research effort pointed to:

1. Determining the nominal size of breakage,
2. The amount of energy or (rolling) required for seating, and
3. The optimum amount of bituminous concrete to be used in the overlay.

Our first project was awarded to contract in February 1982, on I-71 (Louisville-Cincinnati Road) in Gallatin County for some 13 mi. It was divided into one 8-mi section and one 5-mi section with breaking and seating specified only on the 5-mi section and the two sizes of 3 in-4 in. and 18 in.-24 in. The project was awarded to Eaton Asphalt Paving Company of Covington, Kentucky for $8,734,745 and the unit price for breaking and seating was $0.47/sq yd for the 3 in-4 in. size and $0.40/sq yd for the 18 in.-24 in. size.

In an effort to extend our experimental evaluation, the following changes were made on construction:

1. Extend breaking and seating to include 7-mi of the 8-mi section.
2. Add 1-mi section of 30 in.-36 in. size.
3. Reduce the quantity of 3 in.-4 in. size to only a 1-mi section.
4. Require a 30-ton pneumatic tire roller in lieu of the 8-ton

vibrator roller originally specified for seating the 3 in.-4 in. size.

5. Remove a quantity of PCC pavement at bridge ends in order to avoid a thin bituminous concrete overlay over the broken or unbroken pavements.
6. Include 1-mi unbroken as a control section.

The overlay thickness was established at three 2-in. courses of bituminous base, and 1-in. course of bituminous concrete surface and one ¾ open-graded plant-mixed skid resistant surface. The shoulders received the same treatment except for the open-graded plant-mixed surface. Existing guardrail was in bad need of repair so it was replaced throughout.

A 4-in. polyethylene perforated under-drain pipe was installed as a longitudinal edge drain at the edge of the outside lane and on the inside lane at the bottom sag vertical curves; however, this proved so effective towards the removal of excess water that the pipe was installed throughout on the inside shoulder edge. The existing pavement on this project, as is throughout most of the state, is a 10-in. PCC meshed, dowelled, concrete (25 ft- or 50 ft-joint spacing) on 6 in. of crushed dense graded aggregated base and with 2 in. of bituminous concrete shoulders. The DGA base removed in the trenching operation for installation of the pipe under-drain was used to stabilize the exposed DGA shoulder at the break point.

After two winters, an examination was made of the surface and no reflective cracks were found with the exception of where the overlays were placed on unbroken slabs and near the bridge ends that were not broken or removed. We were encouraged enough by this effort and by the cost received for breaking and seating to go to contract with another project in Jefferson-Shelby Counties on I-64 for 19 mi in July 1982. This work was awarded to Robert L. Carter Company, Inc. of Frankfort, Kentucky, in the amount of $10,248,745. In an effort to gain additional experience with breaking size and the quantity or amount of rolling, the 5.038-mi section of Jefferson County was divided into three equal lengths of experimental sections as follows:

1. Breaking and seating PCC pavement to 6 in.-12 in. size
2. Breaking and seating PCC pavement to 18 in.-24 in. size
3. Breaking and seating PCC pavement to 30 in.-36 in. size

The remaining 14 mi in Shelby County is to be broken and seated to the 18 in.-24 in. size and the unit price received for all sizes in this work was bid at $0.27/sq yd which indicates insignificant differences in the cost of breaking for the various sizes. This was not the case on the previous project and was not anticipated on this project

The bituminous concrete overlays for this work is as follows:

1. Two 2 3/8-in. bituminous concrete base courses
2. One 1½-in. bituminous concrete binder course
3. One 1-in. bituminous concrete surface course
4. One 3/4-in. bituminous O.G.F.C. Surface

As the soil conditions were much more free draining on I-64 than I-71 due to the underlying clays, only one line of perforated under-drain pipe per roadway was specified with an additional 1,000 ft added for the sag vertical curves. One of the bituminous concrete base courses was omitted for a 1-mi section in Shelby County leaving only 4 5/8-in. bituminous concrete thickness over the broken and seated PCC pavement. This was done in an effort to determine optimum overlay thickness.

As the guardrail was in much better condition here than on the previous job on I-71, it was salvaged and raised with a modified offset block at the contractor's option over removing the post and replacing a higher elevation. By salvaging the guardrail post in its present position, reworking the shoulder break point around the existing post necessitated additional handwork. It is much easier to work the shoulder break point when the guardrail post is removed.

Two locations exist where it was necessary to remove some of the existing concrete pavement in order to maintain 16-ft vertical clearance throughout the driving lanes. At these two locations, approximately 1,500 linear feet of pavement was removed and replaced with full-depth asphalt (14 in.) as well as 300 ft of pavement at the ends of each bridge structure. Without recalculating finished profile grades, the transition produced was approximately 1-in. vertical for 100 ft of roadway length. This does not appear to be noticeable provided the original grade is reasonably level.

Deflection measurements (Road Rater methods) are being taken before, during, and afterwards in an effort to analyze the behavior of broken and seated and overlaid concrete pavements. Preliminary indications are that the broken and seated concrete in its worse condition and to the smallest size (near the joints and 3-in-6 in. size) would have a Young's Modulus near that of DGA base. An effort is being made to gather sufficient data on a number of projects to use in the development of an overlay design procedure utilizing the broken and seated PCC pavement.

The National Asphalt Paving Association (NAPA) has, or had a contract with Donahue and Associates, Engineering Consulting Firm in Madison, Wisconsin, to study the state-of-the-art of breaking, seating and bituminous overlay of concrete pavements, and Mr. William E. Poston, Jr., the project engineer, provided a seminar on this subject to our staff and FHWA engineers in the Spring of 1982. A final report was published by Donahue and Associates in April 1982, and is identified as Project No. 11876, which would be most helpful in understanding this subject. At the NAPA 1983 National Convention in Phoenix, a task force was established to accelerate an interest in this work as it appears to offer better performance of bituminous concrete surfaces when laid over PCC.

After our first initial thrust, we discovered a publication of the National Cooperative Highway Research Program Synthesis of Highway Practices No. 92 entitled "Minimizing Reflective Cracking of Pavement Overlays" which is a report of the various research or experimental work under the NEEP 10 to reduce, retard or eliminate reflective cracking.

I was most favorably impressed with the report and of the work done by Mr. Lyons in Louisiana in 1970 with breaking and seating old concrete pavements. He reported complete success of eliminating reflective cracking over a ten-year period with breaking, seating (rolling), and bituminous concrete overlays. This item or subject is in Louisiana's Standard Specifications and requires a 50-ton pneumatic roller for the seating. This work reported thaat breaking alone, rolling alone, or bituminous concrete overlays alone would not eliminate reflective cracking but when done together or in combination, they will be effective. Had we completed a thorough study of the available work in this area, and had found this data, we would have advanced with a greater degree of confidence.

Through November 18, 1983 letting, and to date, we have awarded 13 major interstate projects with over 3.6 million square yards of breaking, seating and overlaying with bituminous concrete. This calculates to be equivalent to 131.7 mi of interstate four-lane or 526.8 lane miles of pavement. The average cost of breaking and seating was $0.30/sq yd (See Attachement No. 1).

In addition to an excellent finished product, a minimum of inconvenience to the traveling public was observed and encountered due to permitting the closure of only one lane at a time and thereby maintaining traffic over the existing roadway at a reduced speed of approximately 10 mph. Two things were done that created good competition which resulted in excellent unit prices and they are: (1) large projects of 5-20 mi in length; and (2) adequate construction time of one to two and one-half construction seasons.

For 12 rigid overlay projects the average or weighted cost per mile was $585,351, which includes various safety related work, such as guardrail and safety drainage boxes. Attachment No. 1 is the summary of the paving quantities and their respective unit prices for some 17 projects.

For four flexible overlay projects the average or weighted cost per mile was $293,713, which also includes various safety related items of work, such as guardrail and safety drainage boxes. These projects are also shown on Attachment No. 1.

In order not to steepen the median or ditch cross-slopes excessively, the shoulder widths were reduced by 1 ft. The 6-ft inside shoulder was reduced to 5 ft and the 12-ft outside shoulder exclusive of the guardrail shoulder, was reduced to 11 ft. The paved portion was not reduced. Cross-slopes still appear to be steeper than originally constructed and we have received comments from several other people concerning their safety. Attachment identified as No. 2 is a copy of our current specifications (Special Notes for Breaking and Seating Existing Pavements dated August 30, 1983) which is intended to control the end product and not necessarily the method of breaking and seating. Without better knowledge or guidance, we have keyed-in on an approximate 24-in. size allowing 20% oversize material. The three breakers available to the contractor are: (1) a piled driven hammer, (2) a transverse bar drop hammer (guillotine), and (3) the pecking hammer. Each of these hammers are permitted under our specifications but only the piled driven hammer has been used. Attachment No. 3 is a copy of our instructions issued to the construction personnel which outlines their monitoring technique for breaking and seating operations. It is necessary that the construction personnel daily inspect the performance of the breaker to see that the finished product complies with the specifications. The three things that can affect the cracking pattern are: (1) the size of the hammer and the amount of energy applied, (2) the coverage of the hammer, and (3) the speed or movement of the hammer. The pavement temperature and the strength on the cracking pattern obtained.

In addition to the ¾-in open-graded plant-mixed friction course, I would recommend a 1-in. bituminous concrete surface course, a 1½-in. bituminous concrete binder course, and a minimum of one 2-in. bituminous concrete base course and a minimum of three 2-in. bituminous concrete base courses. The number of base courses should be determined on a project by project basis depending upon the traffic and the structural evaluation. Basically, the same design should be used or specified on the shoulders; however, some additional material savings can be accomplished by increasing the cross-slopes. We have done this on several projects. The open-graded plant-mixed friction course should not be applied to the shoulders.

As can be seen, we are very confident that the work we are doing in breaking and seating and overlaying faulted and severely damaged PCC pavements offers the most promise for better performance than anything we have tried in the past. Time will be the ultimate test; however, we *do not* expect to ever see repetitive reflective cracking through the bituminous concrete overlays.

I will now show a few slides taken on the various projects that depict some of the variables associated with this work.

ATTACHMENT NO. 1

Letting	County	Project Number	Net Miles	1982 A.D.T.	Break & Seat 18"-24" Sq. Yd.	3/4" OGS Ton	1" Bit. Surface Ton	1/2" L & W Ton	Bit. Bind Ton	Bit. Base Ton	D.G.A. Ton
°02-26-82	Gallatin	IR 71-3(30)57 IR 71-3(29)62	13.216*	11,180	343,427Ø	13,640 $39.80	32,487 $21.75	10,393 $21.00		75,190 $19.90	49,638 $ 9.25
°07-23-82	Jefferson Shelby	IR 64-2(115)119 EACIR 64-2(116)24 EACIR 64-3(29)32	19.082*	20,904	508,393 $0.27	20,238 $31.50	49,282 $20.35	14,632 $21.35	60,465 $17.55	229,403 $17.55	71,617 $ 6.75
°05-20-83	Jefferson	IR 264-1(78)20	2.358*	37,645	59,471 $0.35	2,863 $33.54	7,471 $21.64	3,163 $21.64	9,491 $19.88	30,038 $18.92	4,926 $ 7.50
°06-17-83	Boone	IR 71-3(32)71	7.540*	11,657	217,947 $0.34	7,851 $37.71	22,072 $20.43	9,314 $19.57	28,034 $19.98	90,173 $19.57	25,433 $10.08
°06-17-83	Carroll Gallatin	IR 71-2(37)44	12.481*	11,836	333,009 $0.25	12,509 $30.00	32,883 $20.24	14,587 $18.00	44,013 $18.15	148,448 $18.00	24,892 $ 9.50
06-17-83	Whitley Laurel	ACIR 75-2(45)24 ACIR 75-1(44)0	2.327	18.665	65,514 $0.44	4,545 $32.00	12,556 $24.61	3,059 $23.81	9,154 $20.54	66,040 $21.27	19,136 $ 8.52
°07-22-83	Grant-Kenton Boone	EACIR 75-7(64)165	7.936*	45,000	253,489 $0.33	8,643 $30.00	21,841 $20.55	10,416 $18.73	30,197 $18.73	87,776 $15.93	29,645 $ 9.50
°07-22-83	Grant	EACIR 75-6(57)143	11.286*	21,539	342,960 $0.30	12,587 $30.00	30,411 $20.50	14,726 $18.50	44,344 $19.00	114,898 $18.10	20,769 $ 8.40
°07-22-83	Jefferson	EACIR 64-2(119)4 EACIR 64-2(118)5	4.162*	50,000	80,189 $0.55	4,309 $33.00	13,462 $22.60	2,157 $19.80	9,812 $20.15	56,260 $19.80	
°08-19-83	Oldham Henry	EACIR 71 1(64)22	15.410*	13,000	429,066 $0.28	16,523 $31.00	40,422 $19.65	9,804 $18.90	58,407 $17.90	154,081 $17.30	68,103 $ 7.25
°09-02-83	Larue Hardin	EACIR 65-3(29)75	14.466*	19,000	387,858 $0.15	15,693 $32.00	42,763 $21.50	9,725 21.40	61,109 $20.13	165,859 $18.90	49,734 $ 5.20
□09-02-83	Hart Larue	EACIR 65-2(36)61	14.840	18,842		16,182 $32.00	62,986 $21.50	14,841 $21.40	43,489 $20.13		63,553 $ 5.20
□09-02-83	Madison Fayette	EACIR 75-3(49)88	12.669	37,550		14,635 $29.28	47,944 $19.26	8,846 $18.98	27,910 $17.55	9,520 $17.10	65,077 $ 7.15
□09-16-83	Clark	IR 64-5(40)89	12.669	17,000		13,580 $32.42	38,007 $18.53	8,169 $21.19	14,114 $17.14		18,574 $ 7.21
□09-16-83	Clark Montgomery	IR 64-5(4)102	10.565	9,000	 $32.42	11,327 $18.53	27,761 $21.19	6,877 $17.14	4,961	 $ 7.21	13,199
□09-16-83	Jefferson Oldham	EACIR 71-1(65)6	16.317*	30,000 17,500	460,851 $0.32	16,852 $30.88	41,911 $19.39	10,092 $17.72	59,660 $17.72	160,696 $17.34	66,676 $ 6.99
°11-18-83	Scott	IR 75-6(58)135	5.129*	21,159	144,263 $0.35	4,992 $33.35	14,865 $21.80	1,971 $19.65	18,266 $19.65	48,850 $18.65	18,884 $ 8.55
		TOTALS	182.040		3,626,438	197,969	152,772	523,786	1,437,232	609,946	

Ø contains experimental work for 3 in.-4 in., 6 in.-12 in., 18 in.-24 in., and 30 in.-36 in.
(0.47) (0.40) (0.40)

*131.711 miles PCC pavement with heavy bituminous concrete overlays
50.329 miles of bituminous pavements with light bituminous concrete overlays.

° Cost per mile for rigid pavement restoration—$585,351

□ Cost per mile for flexible pavement overlay—$293,713

ATTACHMENT NO. 2

SPECIAL NOTE FOR BREAKING EXISTING PAVEMENT

The existing PCC pavement shall be broken such that the majority of the surface material shall be generally of 24-in. size with occasional pieces up to 30 in. in diameter, and no more than 20% of the material larger than 24 in.

Breaking shall be accomplished with an impact hammer. The hammer shall be capable of delivering such energy as may be necessary to satisfactorily break the pavement. The breaker shall be equipped with a plate-type shoe designed to prevent penetration into the existing surface. Other methods and equipment may be used when authorized by the Engineer in accordance with Section 108.06 of the 1983 Standard Specifications. A screen satisfactory to the Engineer shall be provided to protect vehicles in the adjacent lane from flying chips during the fracturing process when necessary. The Contractor shall exercise care during breaking to protect, and prevent damage to, underground utilities and drainage facilities.

Before breaking operations begin, the Engineer will designate test sections. The Contractor shall break the test sections using varying energy and striking patterns until a pattern is established that will break the pavement to the extent required. The pattern thus established will be used to break the pavement on the remainder of the project. When breaking the test sections, the Contractor shall furnish and apply water to dampen the pavement surface after breaking, so the extent of breakage can be readily determined. The Contractor shall furnish and apply water to a check section at least once each day, so the Engineer can verify that the specified extent of breakage is being maintained. Adjustments shall be made to the energy or striking pattern when the Engineer deems necessary, based on the check sections.

After breaking, the broken concrete shall be rolled with a pneumatic-tire proof roller weighing at least 50 tons. The roller shall be one of the following types:

(1) The roller may be a pneumatic tire roller consisting of four rubber-tired wheels equally spaced across the full width and mounted in line on a rigid steel frame in such 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 50 tons, and ballast shall be such that gross roller weight can be readily determined and so controlled as to maintain a gross roller weight of 50 tons. 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 seven tires, and the requirements in (1) above concerning tire inflation pressure, surface contact pressure, and 50-ton gross weight are met.

Rolling shall continue until surface material is well seated and is thoroughly and uniformly compacted, as directed by the Engineer.

Placing of the first course of bituminous concrete base 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 course of bituminous concrete base. No more than 5,000 linear feet shall be broken ahead of the paving operation.

Breaking, seating, and placing the first two courses of bituminous concrete base shall be accomplished one 12-ft lane at a time. The Contractor will be permitted to close one 12-ft lane for a distance of one day of paving of the first course of bituminous concrete base. The first course shall cure for one night before the second corurse of bituminous base is applied. The longitudinal joints in the bituminous concrete base shall be offset 6 in. as required by Section 401.16 of the 1983 Standard Specifications. Then, traffic shall be turned onto the bituminous concrete base and the adjacent 12-ft lane closed and worked in the same manner.

On portions of the project designated to receive only one course of either bituminous concrete base or binder, leveling of the existing surface shall be performed in accordance with the 1983 Standard Specifications.

On portions of the project designated to receive two or more courses of bituminous concrete base or binder, the first course of bituminous concrete placed over the existing pavement and shoulders shall be of uniform depth; contrary to the standard specifications, normal leveling and wedging shall be performed on top of the first course of bituminous concrete, and not on the existing pavement. However, the Engineer may require grader patching to be performed directly on the broken and seated pavement at specific locations where a substantial amount of leveling is deemed necessary. Deviations in the surface of succeeding courses shall be corrected as specified in Section 401.18 of the 1983 Standard Specifications. Paving operations for bituminous courses following the first two courses of bituminous concrete base shall conform to requirements specified elsewhere in the contract.

No bituminous concrete base shall be placed on the project when the natural light is insufficient, unless the Contractor provides artificial lighting satisfactory to the Engineer. Nighttime placing of bituminous concrete binder or surface will not be permitted unless otherwise specified elsewhere in the contract.

The area of existing PCC pavement acceptably broken and seated will be measured in square yards. The width will be the actual width of the existing PCC pavement, and the length will be measured horizontally along the centerline of each roadway or ramp. Payment for the measured area at the contract unit price shall be full compensation for furnishing all labor, equipment, materials, and incidentials necessary to acceptably break and seat the existing PCC pavement, including furnishing and applying water as specified to determine the extent of breaking. Payment will be made under:

Pay Item	Pay Unit
Breaking and Seating Pavement (size)	Square Yard

ATTACHMENT NO. 3

BREAKING EXISTING PCC PAVEMENT

The department has recently let several projects for bituminous resurfacing of existing PCC pavement, in which breaking and rolling of the existing pavement is required. Specific requirements for this work will be included in each proposal. During performance of the work, the following procedures are to be followed to ensure the intent of the contract is met.

(1) *Breaking the existing pavement.* The current edition of the Special Note for Pavement Breaking requires 80% of the fragments to be within an 18 to 24-in. size range, with occasional pieces up to 30 inches. To determine the correct striking force and striking pattern of the impact hammer, the Contractor is required to break the pavement on a test section designated by the Engineer at the beginning of breaking operations. This test section should be about 50 ft long, and should begin and end at a pavement joint. After the test section is broken and wetted (wetting is necessary to make fine cracks visible), and all individual oversize pieces (larger than 24 in.) should be marked, and their surface area calculated. The total surface area of the oversize pieces should be less than 20% of the total area of the test section, and undersize pieces should be few.

(2) *Daily Checks.* Once each day, a section of broken pavement is to be wetted and the extent of breaking checked by using the above procedure. A check station should be selected far enough in advance of paving to avoid unnecessary delay to paving operations. The striking energy or striking pattern should be modified when indicated to be necessary by the daily check.

(3) *Rolling and Seating.* The entire area of the broken pavement must be covered by the 50-ton roller, and all pavement fragments firmly seated. The intent of breaking and seating the pavement is to prevent or retard reflective cracking through the new surface, and individual fragments that might move or rock under traffic loads could cause cracking

of the asphalt overlay. The 50-ton roller shall be moved across structures by methods that will ensure the weight limit on the structure is not exceeded.

The procedures in points (1) and (2) are intended as a guide and not as a substitute for good judgment. The size of individual pieces in the broken pavement should be as uniform as is practical, within the specified size range.

After these procedures have been tried and successfully proven, they will be included in the Construction Guidance Manual.