APPENDIX A. DOWEL BAR RETROFIT CONSTRUCTION BEST PRACTICES

The following describes and illustrates the dowel bar retrofit construction process. Much of the information contained in this appendix has been adopted, and significantly enhanced from *Dowel Bar Retrofit – Do's and Don'ts*[1]. In addition, descriptions of critical details for ensuring pavement performance are also included.

In general, the dowel bar retrofit process includes the following steps:

1. Using diamond saw blades, sawcut dowel bar slots (three to four per wheelpath).
2. Remove existing concrete within dowel bar slot.
3. Remove diamond blade slurry and other debris from dowel bar slot.
4. Seal existing joint or crack within the dowel bar slot with caulking material.
5. Place dowel bar retrofit assembly (dowel bar, chairs, foam core board and end caps) into the dowel bar slot, centered over the joint or crack.
6. Place, consolidate and cure patching material.
7. Diamond grind surface.

Since dowel bar retrofit performance is highly dependent on construction practices, it is advised that prior to project startup the project inspector consider the following:

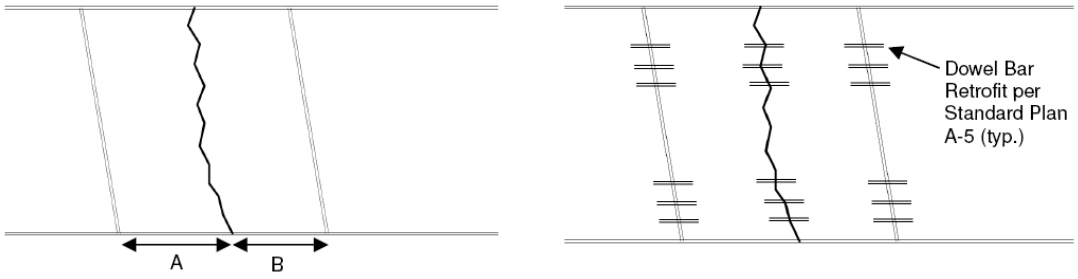
- Become familiar with Construction Plans, Specifications and Special Provisions
- Consider having a preconstruction workshop to ensure contractor and agency understand project requirements
- Consider including experienced personnel during the preconstruction meeting and potentially on the job-site during construction.
- Remember that bridge approach slabs should not be retrofitted.

Dowel Bar Retrofit and Panel Replacement Guidelines

The following images (courtesy Z. Martin) illustrate general guidelines for dowel bar retrofit and panel replacements.

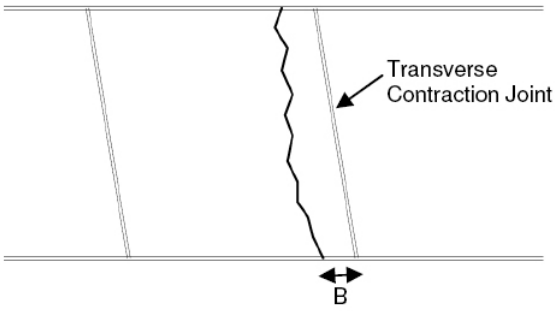
[1] Pierce, L.M., Uhlmeyer, J.S. and J. Weston (2003). *Dowel Bar Retrofit Do's and Don'ts,* Research Report WA-RD 576.1, Washington State Department of Transportation.

Transverse Crack

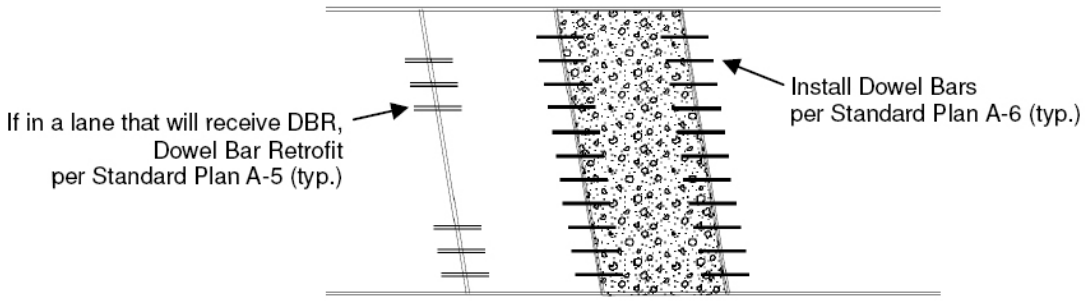


(a) Existing (b) Solution

Figure A-1. Mid panel transverse crack (A and B greater than three feet).



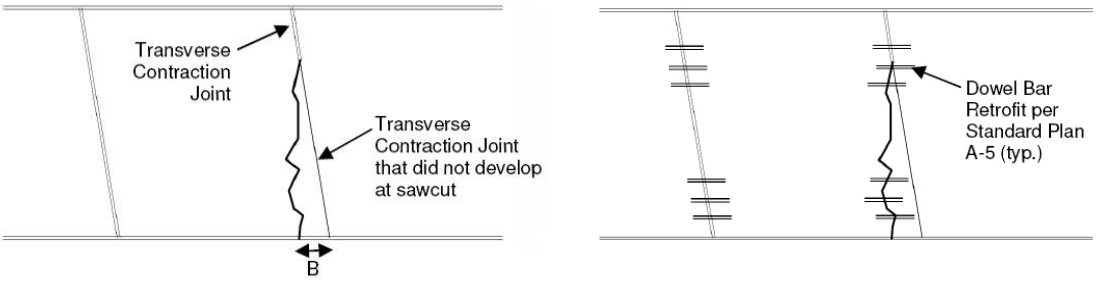
(a) Existing



(b) Solution

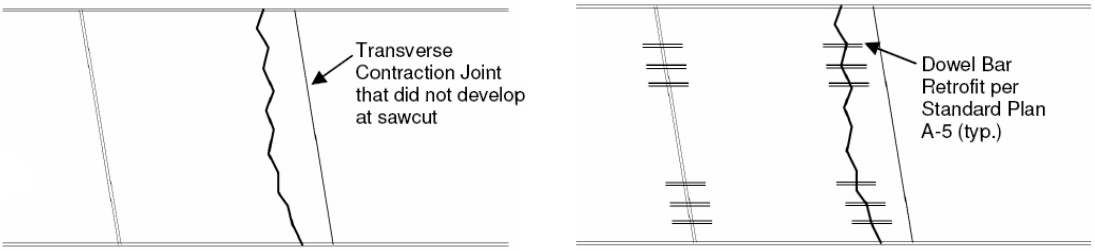
Figure A-2. Existing transverse crack (B < three feet).

Transverse Working Crack



(a) Existing (b) Solution

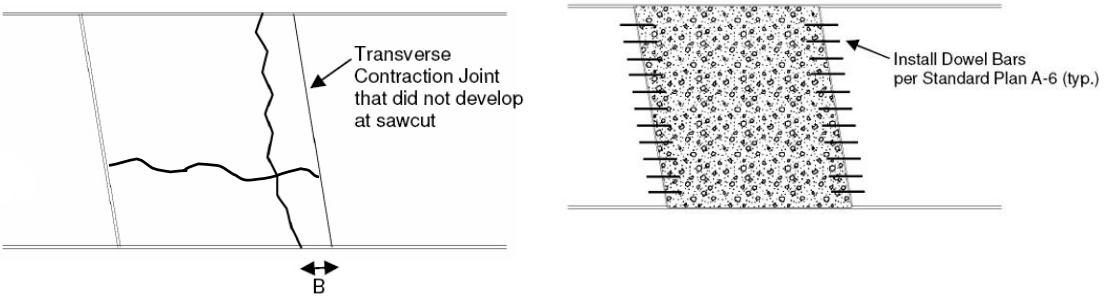
Figure A-3. Working transverse crack.



(a) Existing (b) Solution

Figure A-4. Working transverse crack.

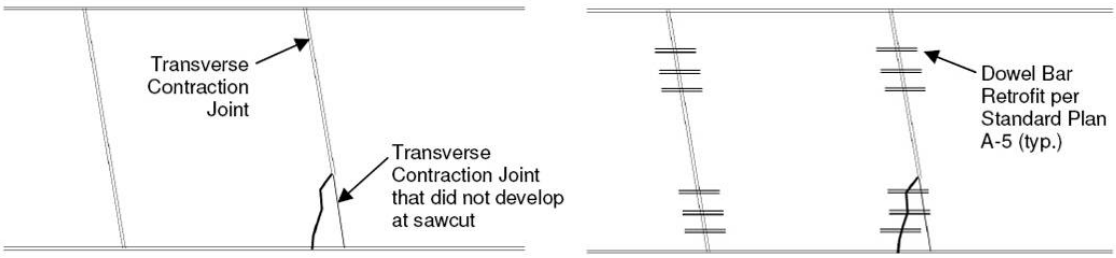
Multi-Cracked and Settled Slabs



(a) Existing (b) Solution

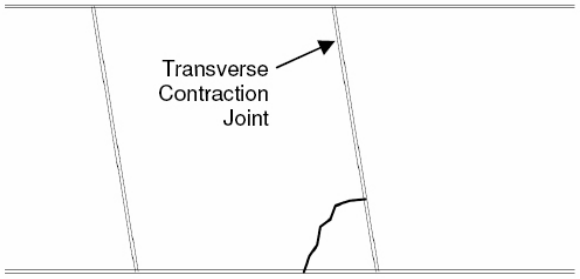
Figure A-5. Multi cracked (two or more) and settled (> ½ inch) slab.

Corner Crack

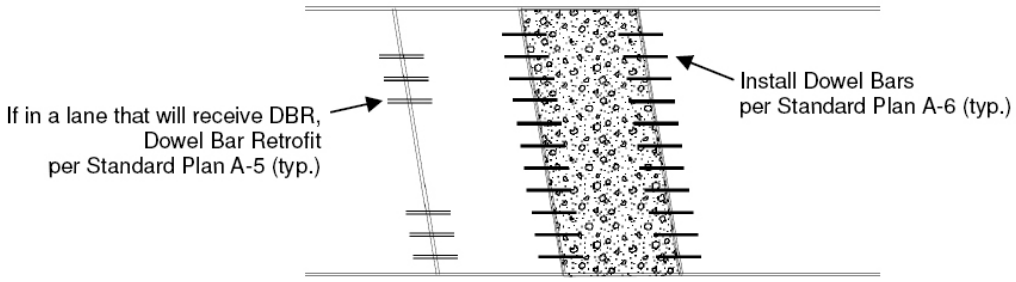


(a) Existing (b) Solution

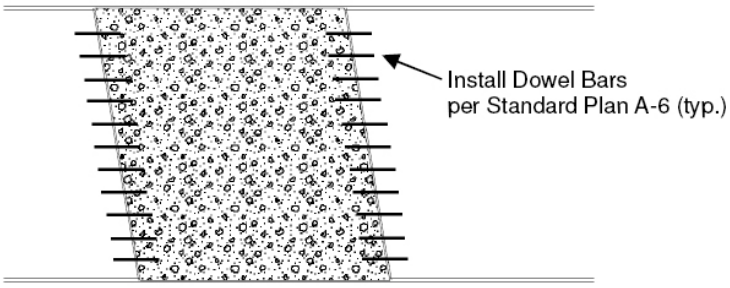
Figure A-6. Working corner crack.



(a) Existing

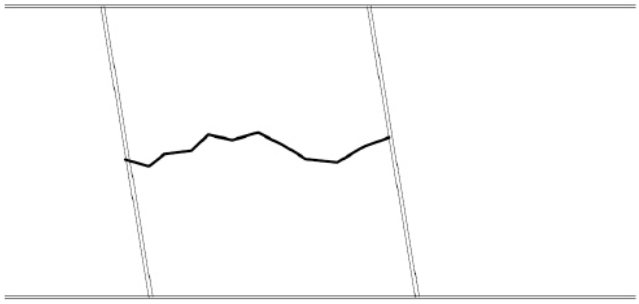


(b) Maximum longitudinal length between crack and transverse joint < six feet

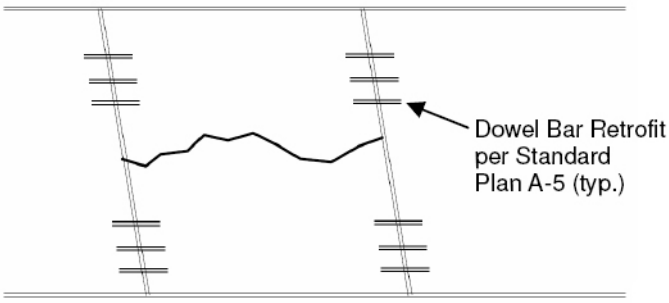


(c) Maximum longitudinal length between crack and transverse joint > six feet

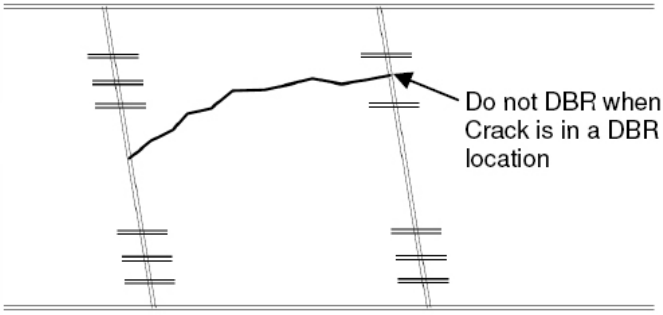
Figure A-7. Corner crack.



(a) Existing



(b) Solution



(c) Solution

Figure A-8. Longitudinal crack.

Cutting Dowel Bar Slots

Figure A-9 illustrates equipment that can saw cut six dowel bar slots in one pass. This device is very effective in cutting both non skewed and skewed transverse joints. This device is also effective in cutting dowel bar slots on transverse cracks, depending on angle of crack skew.

Photo courtesy John Roberts

Figure A-9. Cutting equipment for six dowel bar slots per joint.

Figure A-10 and Figure A-11 shows the equipment for cutting three dowel bar slots per wheelpath. This equipment is effective on non-skewed and skewed joints and transverse cracks.

Photo courtesy John Morris

Figure A-10. Cutting equipment for three dowel bar slots per wheelpath.

Figure A-11. Cutting equipment for three dowel bar slots per wheelpath.

Figure A-12 illustrates equipment to saw cut a single dowel bar slot.

Figure A-12. Cutting equipment for one dowel bar slot at a time.

Figure A-13 illustrates the completed product from the sawcutting operation.

Figure A-13. Cut dowel bar slots on non-skewed transverse joint.

For skewed joints, when using sawcutting equipment that is capable of cutting three or more dowel bar slots per wheelpath or six dowel bar slots per joint (in one pass), dowel bar slots should be cut with sufficient length (Figure A-14) to allow the dowel bar retrofit assembly to be centered over the joint (equal length of dowel bar on either side of the joint).

Proper alignment of the dowel bar slot is essential for minimizing the potential for dowel bar lockup. Lockup is the inability of the dowel bar to move freely as the slab expands and contracts due to curling and warping. If the dowel bar movement is restricted, stresses can be induced within the dowel bar slot and eventual cracking and spalling of patching material may occur. Stresses may also be significant to cause cracking within the concrete panel.

Figure A-15 illustrates dowel bar slots that have not been correctly sawcut on a skewed joint. In this case, the dowel bar slots were cut perpendicular to the skewed joint (as is necessary for non-skewed joints) rather than parallel to centerline.

Figure A-14. Dowel bar slots on a skewed transverse joint.

Figure A-15. Dowel bar slots incorrectly cut on skewed joints.

Slots cut deeper than necessary can contribute to corner cracking (Figure A-16) and patching material failure and the potential of the jackhammer punching through the bottom of

the dowel bar slot. The Contractor/Inspector should physically measure (Figure A-17) the dowel bar retrofit assembly height (including chairs) to ensure proper sawcut depth.

Figure A-16. Dowel bar slot cut and/or chipped to deep.

Figure A-17. Check depth of dowel bar slot.

Dowel bar slot width should also be confirmed to ensure that the dowel bar chairs and foam core board fit snugly against the sides of the dowel bar slot. This will assist in holding the dowel bar retrofit assembly securely in the dowel bar slot during placement of the patching material.

Dowel bar slots should be aligned to miss (Figure A-18) any existing longitudinal crack. Depending on the wander of the longitudinal crack, dowel bar slots could also be eliminated (Figure A-19). If the longitudinal crack was located in the right wheelpath, completely eliminating all dowel bar slots would not be recommended. In this instance, it may be best to place as many dowel bar slots as possible without intersecting the longitudinal crack.

Figure A-20 through Figure A-21 illustrates instances where the dowel bar slot was not placed to miss the existing longitudinal crack resulting in failure of the patching material. Dowel bar slots placed over a longitudinal crack will fail (Figure A-20) within a very short period of time (< 12 months). The failure mechanism is typically debonding, cracking and spalling of the concrete patching material. Shifting dowel bar slots, three to four inches, will prevent this distress while still providing the required load transfer. If a gang saw is used, dowel bar slots may be sawed but not retrofitted, any non-retrofitted sawcuts should be cleaned and sealed with an epoxy resin.

Figure A-18. Dowel bar slots aligned to miss an existing longitudinal crack.

Figure A-19. Left wheelpath dowel bar slots not installed to avoid existing longitudinal crack.

Figure A-20. Failure of dowel bar slot placed over existing longitudinal crack.

Figure A-21. Failure of dowel bar slot placed over existing longitudinal crack.

All existing transverse joints and cracks should be dowel bar retrofitted. Figure A-22 shows a non-working joint (narrow joint opening and excellent joint sealant condition after being in-service for more than 20 years with no maintenance) and a transverse crack that is functioning as the working joint. In this case, the crack should be dowel bar retrofitted and not the joint.

Removing Existing Concrete from Dowel Bar Slots

The existing concrete should be removed from the dowel bar slot using jackhammers weighing 30 pounds or less. Jackhammers should be operated at a 45 degree angle or less (Figure A-23 through Figure A-25). Jackhammers operated in a vertical position can punch through the bottom of the dowel bar slot.

Figure A-22. Transverse crack is functioning as the working joint.

Figure A-23. Maintain jackhammer at no more than a 45-degree angle.

Figure A-24. Jackhammer operation.

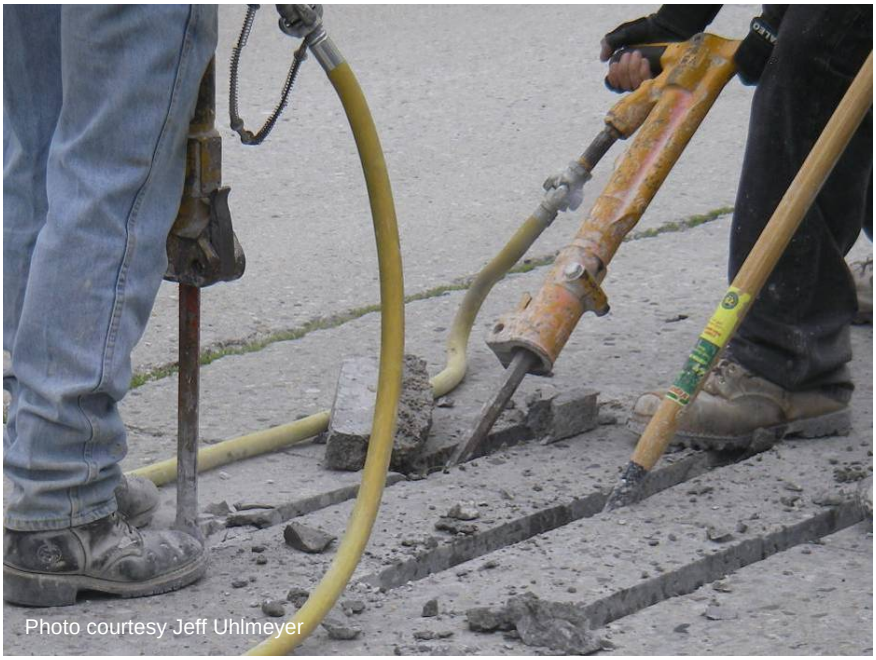


Figure A-25. Removing concrete within dowel bar slot.

Leveling of the dowel bar slot bottom (Figure A-26) helps ensure that the dowel bar will meet alignment tolerances. This work should be conducted with a 15-pound or lighter jackhammer.

Figure A-26. Leveling dowel bar slot bottom.

A breaker bar Figure A-27 and Figure A-28) may be used to expedite the jackhammer removal operation of the concrete within the dowel bar slot.

Figure A-27. Breaker bar.

Figure A-29 illustrates insufficient removal of the existing concrete from the bottom of the dowel bar slot. This high point may result in a skew in the horizontal position of the dowel bar beyond that which is allowed by specification tolerances. If this skew is severe, dowel bar lockup and eventual failure of the patching material may occur. Slot bottom should be leveled using a lightweight (< 15 pound) jackhammer.

Figure A-28. Breaker bar.

Figure A-30 illustrates insufficient removal of the existing concrete at the end of the dowel bar slot. Improper concrete removal could result in insufficient length for the dowel bar to sit level in the dowel bar slot and may not allow for sufficient patching material around the dowel bar. Though this may not be extreme in this case, spalling at the end of the dowel bar slot may occur due to difficulty in obtaining patching material consolidation.

Figure A-31 illustrates a situation where the jackhammer operation caused failure of the bottom of the dowel bar slot. This may have occurred due to operating the jackhammer at an angle greater than 45 degrees, the dowel bar slot was sawcut to deep leaving an insufficient depth of concrete between the dowel bar slot bottom and the bottom of the concrete slab, which was easily broken during the jackhammering process or the use of jackhammers weighing more than 30 pounds.

Photo courtesy Jeff Uhlmeyer

Figure A-29. Concrete not fully removed from the bottom of the dowel bar slot.

Photo courtesy Jeff Uhlmeyer

Figure A-30. Concrete not sufficiently removed from the end of the dowel bar slot.

Removal of the dowel bar slot debris can be quite laborious. The use of a small loader can aid in the clean-up operation (Figure A-32 through Figure A-35).

Figure A-31. Jackhammer punching through the bottom of the dowel bar slot.

Figure A-32. Debris from the jackhammering process.

Figure A-33. Debris removal.

Figure A-34. Debris removal.

Figure A-35. Debris removal.

Cleaning Dowel Bar Slots

After completion of the sawcutting and concrete removal process, debris and saw blade slurry exists in the dowel bar slot (Figure A-36). This material must be removed prior to installation of the dowel bar retrofit assembly. Insufficient cleaning of the dowel bar slot will prohibit adherence of the patching material to the existing concrete, which will result in a bonding failure between the patching material and the existing concrete.

All exposed surfaces and cracks in the dowel bar slot should be sand blasted (Figure A-37 and Figure A-38) and cleaned to bare concrete to remove any diamond saw blade slurry or other debris. The dowel bar slot is considered to be clean when all debris and standing water has been removed from the dowel bar slot sides and bottom. The side of the dowel bar slot is considered clean when wiping the sides of the dowel bar slot, with a clean towel or hand, produces no residue.

Compressed air (Figure A-40 and Figure A-41) may also be used to remove debris, water and slurry from the sides and the bottom of the dowel bar slots.

Figure A-36. Sawcut blade residue on slot walls.

Figure A-37. Cleaning dowel bar slot by shot blasting.

Figure A-38. Dowel bar slot after shot blasting.

Figure A-39. Cleaning shot blasting debris from roadway.

Figure A-40. Removing water and other debris with compressed air.

Figure A-41. Cleaning dowel bar slots with compressed air.

Figure A-42 shows a properly cleaned dowel bar slot.

Figure A-42. Cleaned dowel bar slot.

Removal of debris and slurry residue can be challenging if water is present in the dowel bar slot. If water is present (Figure A-43), slurry residue is redistributed to the bottom or sides of the dowel bar slots by sandblasting or compressed air. More than one attempt at cleaning the dowel bar slot may be required to obtain the desired cleanliness.

Figure A-43. Water must be removed prior to placement of patching material.

Figure A-44 and Figure A-45 shows debonding of the patching material from the dowel bar slot. This distress is typically related to inadequate cleaning of the dowel bar slot. Repair of this distress requires removal and replacement of the patching material.

Figure A-44. Patching material bond failure.

Figure A-45. Patching material bond failure.

Figure A-46 illustrates spalling of the patching material. Potential causes of this distress can be related to consolidation, lack of sufficient aggregate or opening too early to traffic. Figure A-47 illustrates insufficient consolidation in the patching material. Repair, for both instances would include removal and replacement of two to three inches of the patching material.

Figure A-46. Spalling of patching material.

Figure A-47. Insufficient consolidation of patching material.

Figure A-48 illustrates shrinkage cracking of the patching material. This type of cracking is repaired by removal and replacement of distressed patching material.

Figure A-48. Shrinkage cracks of pour back material.

Debris should be removed a minimum of four feet from the dowel bar slots. This material can be reintroduced (Figure A-49) into the dowel bar slot and may result in bonding issues.

Figure A-49. Debris should be cleared to a sufficient distance to prevent intrusion.

Sealing Joint or Crack within the Dowel Bar Slot

Transverse joints and cracks must be caulked (Figure A-50 and Figure A-51) within the dowel bar slot. Caulking material should not extend more than ½ inch beyond either side of the joint or crack. The caulking material will prevent patching material from entering the joint/crack.

Figure A-50. Caulking dowel bar slot sides and bottom.

Figure A-51. Caulked dowel bar slot.

Placement of Dowel Bar Retrofit Assembly

Prior to assembly and placement into the dowel bar slot, dowel bars should be lightly coated with a parting compound. Parting compound that is applied after the dowel bar retrofit assembly has been placed in the dowel bar slot will result in debonding of the patching material. Once the parting compound has been applied, foam core board, chairs and end caps should be installed onto the dowel bar.

The chair design should hold the dowel bar tightly and fit snugly against the dowel bar slot such that movement is minimized during placement of the patching material. Chairs should be strong enough to allow full support of the dowel bar. Chairs should allow at least a ½ inch clearance between the bottom of the dowel and the bottom of the dowel bar slot.

End caps shall be tight fitting, placed on each end of the dowel bar, each allowing at least ¼ inch of movement. Loose fitting end caps will allow movement of the dowel bar within the dowel bar slot, which could lead to failure of the patching material. The dowel bar must be allowed to move within the end cap to allow for expansion and contraction due to curling and warping.

The ⅜ inch thick foam core board (closed cell foam with plastic or poster board faced material) should be of sufficient quality to allow a tight fit around the dowel bar and to all edges of the dowel bar slot during placement of the patching material. Care should be given to ensure the foam core board extends beneath the dowel bar to the bottom of the dowel bar slot. The foam core board should be placed at the transverse joint or transverse crack and at the middle of the dowel bar. The foam core board reestablishes the transverse joint or crack and allows for the expansion of the patching material.

Dowel bars retrofit assemblies must be centered over the existing transverse joint or transverse crack and parallel to the concrete surface.

Figure A-52 shows the assembled dowel bars, chairs, end caps and foam core boards on a flat bed trailer. Dowel bar retrofit assemblies are taken from the flat bed trailer, placed adjacent to the dowel bar slot locations (Figure A-53 and Figure A-54) and inserted into the dowel bar slot (Figure A-55). Figure A-56 shows the dowel bar retrofit assembly at a transverse joint location and Figure A-57 and Figure A-58 shows the dowel bar retrofit assembly at transverse cracks.

Figure A-52. Dowel bar retrofit assemblies.

Figure A-53. Dowel bar retrofit assemblies.

Figure A-54. Dowel bar retrofit assemblies.

Figure A-55. Inserting dowel bar retrofit assemblies into dowel bar slots.

Figure A-56. Dowel bar retrofit assembly at a transverse joint.

Figure A-57. Dowel bar retrofit assembly at a transverse crack.

Figure A-58. Dowel bar retrofit assembly at a transverse joint.

The dowel bar epoxy coating should be inspected and if any discrepancies are present the dowel bar should be rejected. On one particular project, dowel bar corrosion (Figure A-59 and Figure A-60) was determined to be the cause of the dowel bar slot failure.

Figure A-59. Corroded epoxy coated dowel bars.

Figure A-60. Corroded epoxy coated dowel bars.

Placement of Patching Material

Patching material can be batched using a mobile mixer (Figure A-61 and Figure A-62) or in individual batches. If a mobile mixer is used, batching of the individual components must be closely monitored to ensure proper proportioning.

Figure A-61. Mobile mixer.

Figure A-62. Delivery of materials to mobile mixer.

Patching material should not be dumped directly into the dowel bar slot; the impact of the patching material falling directly into the dowel bar slot will cause movement of the dowel bar retrofit assembly. The patching material should be placed adjacent (Figure A-63 and Figure A-64) to and spread with shovel (Figure A-65) toward and into the dowel bar slot.

Figure A-63. Placing patching material.

Figure A-64. Placing patching material.

Figure A-65. Moving patching material into dowel bar slots.

Placement of patching material that causes movement (Figure A-66 and Figure A-67) of the dowel bar retrofit assembly should be rejected and replaced.

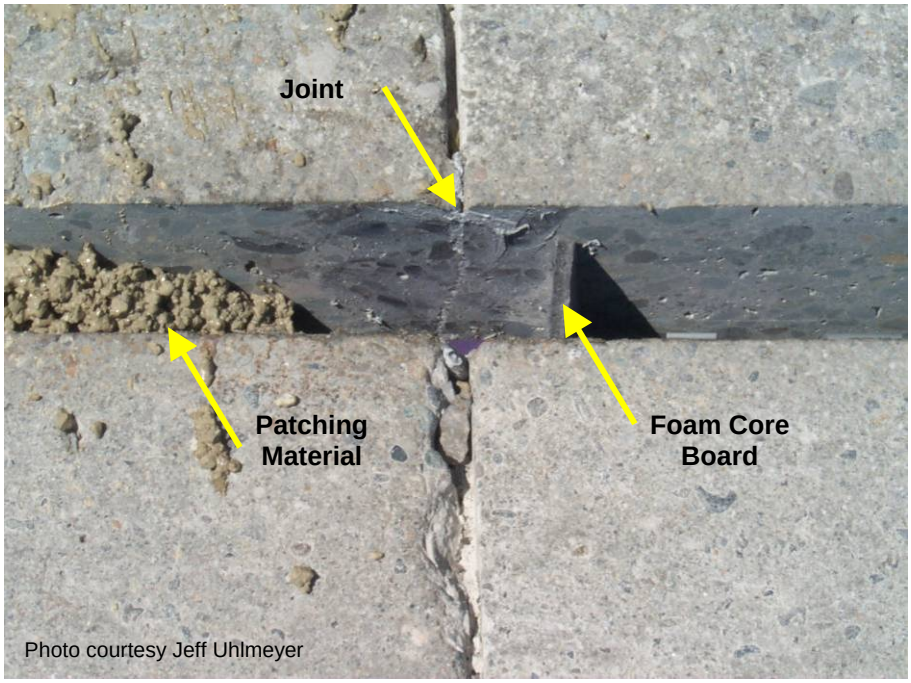


Figure A-66. Movement of bar during placement of patching material.

Figure A-67. Misaligned foam core board.

Patching material consolidation should be conducted with a pencil (or similar) vibrator (Figure A-68). Care must be taken to not relocate the dowel bar retrofit assembly during consolidation.

Figure A-68. Consolidating patching material.

Figure A-69 and Figure A-70 illustrate patching material voids in the vicinity of the dowel bar. The core shown in Figure A-69 was taken from the first dowel bar retrofit project and illustrates lack of consolidation beneath the dowel bar, which could be due to aggregate size

and the inability to move the aggregate around the dowel bar or lack of consolidation. Figure A-70, on the other hand, was taken from a more recent project (2006) and shows lack of consolidation around and above the bar. In this case, it was determined that the aggregate gradation was too large to adequately fit around the bar and WSDOT modified specifications to allow only AASHTO Grading No. 8 (prior to this project, either AASHTO Grading No. 7 or 8 was allowed).

Figure A-69. Poor consolidation.

Figure A-70. Poor consolidation.

During the finishing process, care should be taken to not overwork the patching material (Figure A-71 and Figure A-72). Overworking can lead to segregation and floating of the fine material to the surface of the dowel bar slot. The fine material is susceptible to wear, especially when subjected to studded tires. Patching material should be left ⅛ inch to ¼ inch high (Figure A-73 and Figure A-74), which will be removed during the diamond grinding process.

Figure A-71. Finishing patching material.

Figure A-72. Finishing patching material.

Figure A-73. Patching material should be left high to prevent overworking.

Figure A-74. Patching material left high to minimize segregation.

Curing compound should be applied (Figure A-75) to the patching material as soon as possible after the finishing operation.

Figure A-75. Applying curing compound.

Establishing the transverse joint within the dowel bar slots (Figure A-76) should be conducted within 24 hours after placement. If the transverse joints were originally constructed with a tape joint and the joint is uneven (Figure A-77), the transverse joint should not be sawcut. In this situation, sawcutting a straight line would be challenging without creating slivers that would eventually spall.

Figure A-78 illustrates damage caused by mechanically sweeping the roadway prior to the patching material reaching the required strength. As before, the methodology for repairing this distress is to saw cut, remove and replace two to three inches of the distressed material.

Figure A-76. Establishing joint in patching material.

Figure A-77. Transverse tape joint (original construction).

Figure A-78. Mechanical sweeping prior to patching material reaching strength.

Studded tire wear is one of the more predominant distresses affecting pavement (both HMA and concrete) performance in Washington State. For dowel bar retrofit, the largest impact of studded tires is wear in the dowel bar slot (Figure A-79 and Figure A-80).

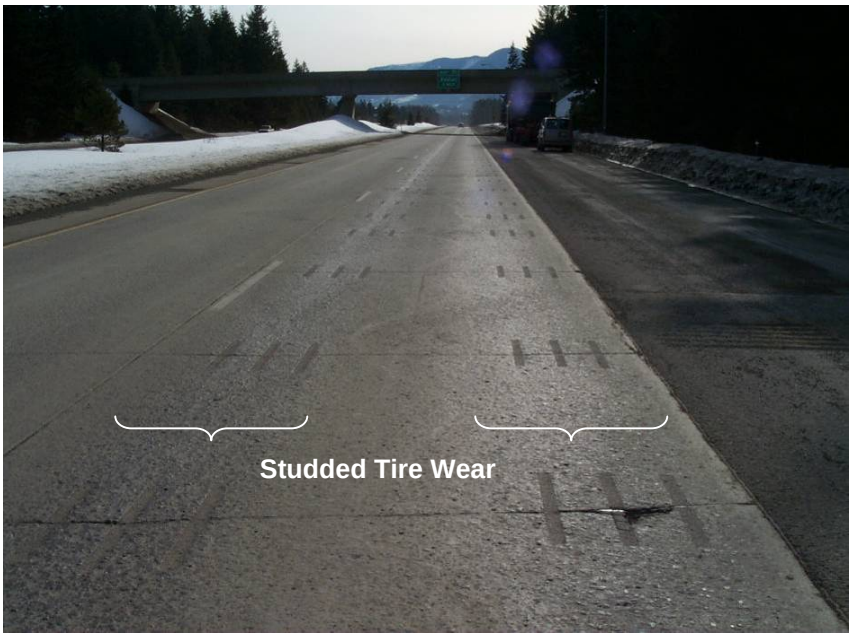


Figure A-79. Wear due to studded tires.

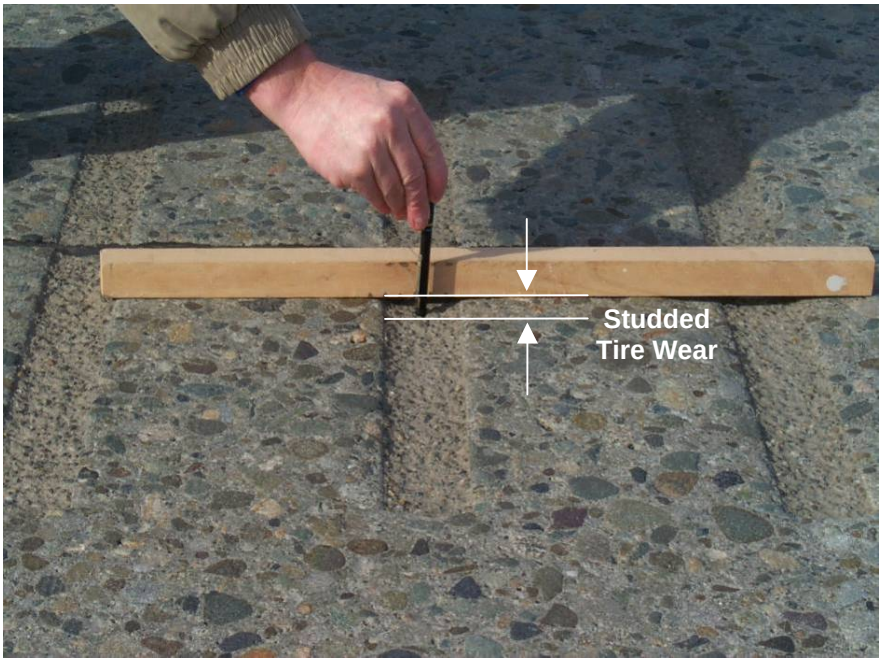


Figure A-80. Wear due to studded tires.

Diamond Grinding

Diamond grinding (Figure A-81 through Figure A-82) should begin within 10 working days of placing dowel bar retrofit patching materials. The primary reason for this specification is to minimize traveler complaints related to intentionally leaving dowel bar patching material high.

Figure A-81. Diamond grinding equipment.

Figure A-82. Diamond grinding equipment.

Figure A-83. Diamond grinding equipment.

Slurry Removal

Removal of the grinding residue from the roadway surface should occur immediately after grinding. Slurry should not be allowed to drain across open traffic lanes and shoulders. Slurry should not be allowed to drain into any waterway, placed on the roadway slope within 200 feet of any waterway, or other areas as designated by the Engineer.

The agencies environmental section should be consulted during the dowel bar retrofit design regarding concrete slurry removal. Some projects will allow slurry to be placed on the roadway slopes while some areas, depending on environmental requirements, will require that the slurry be deposited (and treated as necessary) off site.

Reseal Joints and Cracks

Research studies have been conducted for determining the benefits of resealing concrete joints. There will be no attempt to determine the economic benefits of joint resealing in this document, however, it is recommended that all joints and cracks be cleaned and sealed following the diamond grinding process. The primary reasons are to remove any debris and diamond grinding slurry from joints and cracks and to minimize the amount of water and incompressibles from entering the pavement structure through the joints and cracks.

Completed Product

Figure A-84 and Figure A-85 illustrate successful completion of the dowel bar retrofit process.

Figure A-84. Completed roadway.

Figure A-85. Close-up of completed dowel bar retrofit.

APPENDIX B. STATE SPECIFICATIONS FOR DOWEL BAR RETROFIT

CALIFORNIA

GENERAL

Four epoxy-coated round steel dowel bars per wheel path shall be placed in existing concrete pavement at transverse weakened plane joints at the locations shown on the plans and as provided in these special provisions.

PRECONSTRUCTION CONFERENCE

Supervisory personnel of the Contractor and any subcontractor who are to be involved in the slot cutting and dowel bar placement work shall meet with the Engineer at a preconstruction conference, at a mutually agreed time and location, to discuss methods of accomplishing all phases of the work.

The Contractor shall provide a facility for the conference. The facility shall be within 5 km of the construction site or at a nearby location agreed to by the Engineer and Contractor. Attendance at the conference is mandatory for the project superintendent, construction foreman, subcontractors and equipment operators involved in cutting slots or placing dowel bars. All conference attendees shall sign an attendance sheet provided by the Engineer. Cutting of slots and placement of dowel bars shall not proceed unless the above-mentioned personnel have attended the conference.

The above-mentioned personnel along with the Engineer's representatives shall attend a 4-hour training class on dowel bar placement techniques as part of the preconstruction conference. This training class time shall be in addition to the conference time. The class shall be scheduled no more than 2 weeks prior to the placement of dowel bars. The class shall be held during normal working hours. Selection of the instructor shall be as agreed to by the Engineer and the Contractor.

The training class may be waived if the Contractor can provide written verification of prior acceptable work experience and training involving the placement of dowel bars in existing concrete pavement.

TEST STRIP

The Contractor shall retrofit dowel bars, including concrete removal, placing fast setting grout and pavement grinding, in an initial test strip of concrete pavement at a site directed by the Engineer prior to the start of major operations. The test strip shall be a minimum of one traffic lane width and a minimum of 100 m long. Twenty-four hours after the completion of the dowel bar placement and the filling of the slots with fast setting grout, the Contractor shall take 3 full depth cores, at 3 separate joint locations directed by the Engineer to determine the completeness of the removal and installation operations. Core drilling shall conform to the requirements in these special provisions. If the results of the test strip conform with the plans and specifications, the Contractor may begin production operations using the methods and materials used in the test strip and shall proceed on a performance basis. The working days for the test strip shall be considered as part of the total contract time.

MATERIALS

Dowel Bars

Dowel bars shall be plain, smooth, round, epoxy-coated steel conforming to the requirements in ASTM Designation: A 615/A 615M, Grade 280 or 420, the details shown on the plans and the provisions in Section 52-1.02B, "Epoxy-coated Reinforcement," of the Standard Specifications, except that the two samples required in ASTM Designation D 3963/D 3963M shall be 460 mm long. Epoxy coating of dowel bars shall conform to the provisions in ASTM Designation: A 884/A 884M, Class A, Type 1 or Type 2, except that the bend test shall not apply.

Dowel bars shall be free from burrs or other deformations detrimental to free movement of the bars in the concrete.

Bond Breaker

Dowel bars shall be lubricated with bond breaker over the entire bar. A bond breaker application of petroleum paraffin based lubricant or white-pigmented curing compound shall be used to coat the dowel bars completely prior to concrete placement. Oil or asphalt based bond breakers shall not be used. Paraffin based lubricant shall be Dayton Superior DSC BB-Coat or Valvoline Tectyl 506 or an approved equal. Paraffin based lubricant shall be factory applied. White-pigmented curing compound shall conform to the requirements of ASTM Designation: C 309, Type 2, Class A and shall contain 22 percent minimum nonvolatile vehicles consisting of at least 50 percent paraffin wax. Curing compound shall be applied in 2 separate applications. Each application of curing compound shall be applied at the approximate rate of one liter per 3.7 m^2.

Expansion Cap

Expansion caps shall be tight fitting, commercial quality nonmetallic, non-organic material that will allow a minimum of 6 mm of movement at each end of the bar.

Caulking Filler

Caulking filler used for sealing the transverse joint at the bottom and sides of the dowel bar slot shall be a silicone caulk containing a minimum of 50 percent silicone and designated as a concrete sealant. Caulking filler shall conform to the requirements of ASTM Designation: C 834.

Foam Core Insert

The foam core insert shall be closed cell foam faced with poster board material or plastic faced material on each side or rigid Styrofoam material capable of remaining in a vertical position and tight to all edges during the placement of the fast setting grout.

Dowel Bar Support Chairs

Chairs for supporting the dowel bars shall be either completely epoxy-coated steel conforming to the requirements of ASTM Designation: A 884/A 884M or shall be fabricated of commercial quality nonmetallic, non-organic material. The dowel bar support chairs shall firmly hold the dowel bars centered in the slots during fast setting grout backfill operations. Dowel bar supports shall be designed to hold the bar a minimum of 13 mm above the bottom of the slot while the fast setting grout backfill is placed and consolidated.

Fast Setting Grout

Fast setting grout materials shall conform to the provisions in Section 90, "Portland Cement Concrete," of the Standard Specifications and shall be either (1) magnesium phosphate grout, either single component water activated, or dual component with a prepackaged liquid activator; or (2) modified high alumina based grout; or (3) portland cement based grout. Magnesium phosphate grout, modified high alumina based grout and portland cement based grout shall conform to the following requirements:

Property	Test Method	Requirements
Compressive Strength		
at 3 hours, MPa	California Test 551	21 min.
at 24 hours, MPa	California Test 551	35 min.
Flexure Strength		
at 24 hours, MPa	California Test 551	3.5 min.
Bond Strength: at 24 hours		
SSD Concrete, MPa	California Test 551	2.1 min.
Dry Concrete, MPa	California Test 551	2.8 min.
Water Absorption, %	California Test 551	10 max.
Abrasion Resistance		
at 24 hours, grams	California Test 550	25 max.
Drying Shrinkage at 4 days, %	ASTM C 596	0.13 max.
Soluble Chlorides by mass, %	California Test 442	0.05 max.
Water Soluble Sulfates by mass, %	California Test 417	0.25 max.

Clean, uniform rounded aggregate filler may be used to extend the prepackaged grout. The extension of grout shall not exceed 60 percent of the mass of the grout or the maximum amount of grout extension recommended by the manufacturer, whichever is less. The moisture content of the aggregate filler shall not exceed 0.5 percent. Grading of the aggregate filler shall conform to the following:

Sieve Size	Percentage Passing
9.5 mm	100
1.18 mm	0-5

The amount of aggregate filler shall conform to the manufacturer's recommendation, but in no case shall the grout strengths be less than specified in these special provisions.

Magnesium phosphate grout shall be formulated for a minimum initial set time of 15 minutes and a minimum final set time of 25 minutes at 21°C. The materials, prior to use, shall be stored in a cool, dry environment.

Mix water used with water activated material shall conform to the provisions in Section 90-2.03, "Water," of the Standard Specifications.

The quantity of water for single component type, or liquid activator for dual component type, to be blended with the dry component shall be within the limits recommended by the manufacturer and shall be the least amount required to produce a pourable batter.

Addition of retarders, when required, shall be in conformance with the manufacturer's recommendations.

Silicone Joint Sealant

Low modulus silicone joint sealant shall be furnished in a one-part silicone formulation. Acid cure sealants shall not be used. The Contractor shall use the same brand of silicone joint sealant throughout the project. The compound shall be compatible with the surface to which it is applied and shall conform to the following requirements:

Specification	Test Method	Requirement
Tensile stress, 150% elongation, 7-day cure at 25°± 1°C and 45% to 55% R.H.[e]	ASTM D 412 (Die C)	310 kPa max.
Flow at 25° ± 1°C	ASTM C 639[a]	Shall not flow from channel
Extrusion Rate at 25° ± 1°C	ASTM C 603[b]	75-250 g/min.
Specific Gravity	ASTM D 792 Method A	1.01 to 1.51
Durometer Hardness, at -18°C, Shore A, cured 7 days at 25° ± 1°C	ASTM C 661	10 to 25
Ozone and Ultraviolet Resistance, after 5000 hours	ASTM C 793	No chalking, cracking or bond loss
Tack free at 25° ± 1°C and 45% to 55% R.H.[e]	ASTM C 679	Less than 75 minutes
Elongation, 7 day cure at 25° ± 1°C and 45% to 55% R.H.[e]	ASTM D 412 (Die C)	500 percent min.
Set to Touch, at 25° ± 1°C and 45% to 55% R.H.[e]	ASTM D 1640	Less than 75 minutes
Shelf Life, from date of shipment	—	6 months min.
Bond, to concrete mortar-concrete briquettes, air cured 7 days at 25° ± 1°C	AASHTO T132[c]	345 kPa min.
Movement Capability and Adhesion, 100% extension at -18°C after, air cured 7 days at 25° ± 1°C and followed by 7 days in water at 25° ± 1°C	ASTM C 719[d]	No adhesive or cohesive failure after 5 cycles

Notes:

a. ASTM Designation: C 639 Modified (15 percent slope channel A).
b. ASTM Designation: C 603, through 3-mm opening at 345 kPa.
c. Mold briquettes in accordance with AASHTO Designation: T 132, sawed in half and bonded with a 1.5 mm maximum thickness of sealant and tested in accordance with AASHTO Designation: T 132. Briquettes shall be dried to constant mass at 100 ± 5°C.
d. Movement Capability and Adhesion: Prepare 305 mm x 25 mm x 75 mm concrete blocks in accordance with ASTM Designation: C 719. A sawed face shall be used for bond surface. Seal 50 mm of block leaving 12.5 mm on each end of specimen unsealed. The depth of sealant shall be 9.5 mm and the width 12.5 mm.
e. R.H. equals relative humidity.

The silicone joint sealant shall be formulated to cure after application, on grades of up to 15 percent, recessed below the final surface as shown on the plans.

A Certificate of Compliance for the silicone sealant shall be furnished to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," of the Standard Specifications. The Certificate shall also be accompanied with a certified test report of the results of the required tests performed on the sealant material within the previous 12 months prior to proposed use. The Certificate and accompanying test report shall be provided for each lot of silicone joint sealant prior to use on the project.

DOWEL BAR RETROFIT

Dowel bars shall be installed in existing portland cement concrete pavement as shown on the plans and as specified in these special provisions.

Saw Cutting

Two saw cuts shall be made in the pavement to outline the longitudinal sides of each dowel bar slot. The outline of the longitudinal sides of the each dowel bar slot shall be sawn to the depth and length shown on the plans to place the center of the dowel bar at mid-depth in the pavement slab. The saw cuts for the dowel bar slots shall be parallel with each other and to the centerline of the roadway with a maximum tolerance of 6 mm. Saws shall be equipped with gang mounted diamond blades to provide the desired saw cut spacing and shall be capable of making 8 saw cuts for 4 dowel bar slots simultaneously. A minimum of 4 dowel bar slots in each wheel path will be required. Skewed joints or cracks may require slots longer than those shown on the plans. No additional compensation will be made for additional length or any component of the dowel bar retrofit beyond the limits shown on the plans. Pickup and removal of debris concrete, water residue, or paste from saw cutting shall be immediate. Pickup and removal shall include the use of a high powered, mobile, vacuum-cleaning machine capable of removing all displaced material with a minimum of dust.

Once the saw cutting operation to outline the longitudinal sides of the dowel bar slots has been completed for any work shift, the concrete remaining between the saw cuts shall be removed and replaced with dowel bar retrofit assembly and grout in place within 6 working days.

Concrete Removal

Concrete removal operations and the equipment used to remove the concrete remaining between the saw cuts shall not damage the pavement to remain. Jack hammers greater than 14 kg class shall not be used. If the concrete removal operations cause damage to the pavement that is to remain, the concrete removal operations shall be discontinued and shall not resume until the Contractor has taken corrective measures. Damage to the concrete to remain shall be repaired or replaced at the Contractor's expense.

After removal of large concrete pieces by jack hammering, a small hammerhead shall be used to chip off rocks and burrs from the slot bottom to produce a level surface for the dowel bar support chairs to sit.

Operations shall be scheduled so that the concrete removed during a work shift to shape the dowel bar slots, shall be replaced, in that same work shift, with dowel bars and fast setting grout, prior to the time the lane is to be opened to public traffic. In the event the concrete is removed to place the dowel bars and the Contractor is unable to place the dowel bars and fast setting grout and cure the grout by the time the lane is to be opened to public traffic, the slot shall be filled with a temporary backfill. In no case shall the Contractor leave any slot unfilled prior to opening to traffic.

Temporary Backfill

A sufficient standby quantity of asphalt concrete shall be provided at the project site for placement of temporary backfill in slots where existing pavement is being dowel bar retrofitted. The temporary backfill shall be maintained and later removed as a first order of work when the Contractor places the dowel bar and fast setting grout and cures the grout within the specified time limit.

The asphalt concrete used as temporary backfill shall be produced from commercial quality aggregates and asphalt binder. The grading of the aggregate shall conform to the 9.5-mm maximum medium grading requirements in Section 39-2.02, "Aggregate," of the Standard Specifications.

Prior to placing temporary backfill, building paper shall be placed against all surfaces of the dowel bar slot to facilitate subsequent removal of the temporary backfill. Asphalt concrete for the temporary backfill shall be placed and compacted by methods that will produce a well-compacted backfill with a surface of uniform smoothness, texture and density. The finished surface of the backfill shall match the elevation of the existing concrete pavement.

The material from the removed temporary backfill shall be disposed of in conformance with Section 7-1.13, "Disposal of Material Outside the Highway Right of Way," of the Standard Specifications. When no longer required, standby backfill material shall be removed and disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.

Slot Cleaning and Preparation

Exposed surfaces in the dowel bar slot shall be cleaned by sand blasting to remove debris and to clean surfaces such that clean aggregate is exposed. Where sand blasting operations are being performed within 3 m of a lane occupied by public traffic, the residue, including dust, shall be removed immediately after contact between the sand and the surface being treated. Removal shall be by a vacuum attachment operating concurrently with the sand blasting operation. Debris, excess moisture or residue in the dowel bar slot shall be vacuumed prior to bar installation.

Immediately after vacuuming all debris from the dowel bar slot, the slots shall be cleaned with moisture-free, oil-free compressed air having a minimum pressure of 620 kPa.

Seal Joints and Cracks in Slot

The Contractor shall seal the existing transverse joint at the bottom and the sides of the dowel bar slot with caulking filler. The surfaces to receive caulking filler shall be clean and dry at the time the caulking filler is placed. Caulking filler shall be placed to a minimum of 13 mm beyond the edges of the slot in the existing transverse joint. The portion of any remaining saw cuts in the bottom of the slot which is deeper than the limits shown on the plans for concrete removal and within 150 mm of the existing transverse joint shall be filled with caulking filler. Any cracks exposed within the slot during concrete removal operations shall also be filled with caulking filler.

Placing Dowel Bars in Slots

Dowel bar surfaces shall be cleaned prior to application of the bond breaker. The dowel bars shall be lightly coated with curing compound or factory applied paraffin lubricant prior to placement. The Contractor shall not allow the curing compound, when used, to drip onto the slot walls or bottom. The dowel bar support chair shall provide a minimum of 13 mm clearance between the bottom of the dowel bar and the bottom of the slot. The dowel bars shall be placed to the depth shown on the plans, parallel to the traffic lane centerline and the top of the pavement surface and at the middle of the slot width within a tolerance of 6 mm. Dowel bars shall be centered at the transverse joint, such that not less than 205 mm and not more than 255 mm of the dowel bar extend into each adjacent panel. The dowel bar support chairs shall hold the dowel bar securely in place during placement of the fast setting grout.

The foam core insert shall be placed at the middle of the dowel bar to maintain the transverse weakened plane joint. The existing joint sealant, if any, shall be removed to accommodate the 6 mm to 13 mm thick foam core insert. Two 13 mm by 13 mm tabs to stabilize the foam core insert during backfilling with fast setting grout shall be used. The foam core insert shall be capable of remaining in a vertical position and tight to all edges during the placement of the fast setting grout.

Mixing Fast Setting Grout

Fast setting grout shall be mixed in accordance with the manufacturer's instructions and these special provisions.

The components of prepackaged, dual component magnesium phosphate with a prepackaged liquid activator, shall be combined by mixing the units completely as

supplied by the manufacturer. Portion of units shall not be used. Water shall not be added to dual component magnesium phosphate.

Magnesium phosphate grout shall not be mixed in containers or worked with tools containing zinc, cadmium, aluminum, or copper. Modified high alumina based grout shall not be mixed in containers or worked with tools containing aluminum.

Placing Fast Setting Grout

The Contractor shall fill each dowel bar slot with fast setting grout with the installed dowel bar, expansion caps, support chairs, foam core insert and caulking filler in place. The grout shall be vibrated with a small hand held vibrator capable of thoroughly consolidating the grout material into the slot and around the dowel bars and dowel bar support chairs. All grout shall be placed while fresh and before the grout has taken an initial set.

Grout shall not be retempered. Finishing tools that are cleaned with water shall be dried thoroughly before working the grout.

The surface temperature of the areas to receive the grout shall be 5ºC or above when grout is placed. Methods that are proposed to heat surfaces are subject to approval by the Engineer. The contact surfaces to receive magnesium phosphate grout shall be dry. The contact surfaces to receive modified high alumina based grout or portland cement based grout may be damp but not saturated.

Finishing Grout

The surface of backfilled dowel bar slots shall be rounded 3 mm ± 1 mm above the existing concrete surface, which shall be removed during subsequent grinding work.

Curing Grout

Fast setting grout shall be cured in conformance with the provisions in Section 90-7.01B, "Curing Compound Method," of the Standard Specifications. Attention is directed to "Allowing Traffic over Dowel Bar Retrofitted Pavement," in these special provisions regarding grout curing time and strength gain requirements.

Grind Pavement

Retrofit pavement lanes shall be ground, conforming to smoothness and finishing provisions in Section 42, "Groove and Grind Pavement," of the Standard Specifications and these special provisions. Pavement grinding shall be preformed prior to sawing and sealing the transverse weakened plane joints within the retrofit lanes.

Dowel bar retrofitted transverse joints shall be ground smooth within 30 days from the initial saw cutting for the dowel bar slots. The width of the pavement lane, longitudinal joint to longitudinal joint, shall be ground. All fast setting grout backfilled into the dowel bar slots shall have a minimum cure time of 12 hours before grinding.

MEASUREMENT AND PAYMENT

The quantity of dowel bar retrofit to be paid for will be measured as units as determined from actual count in place.

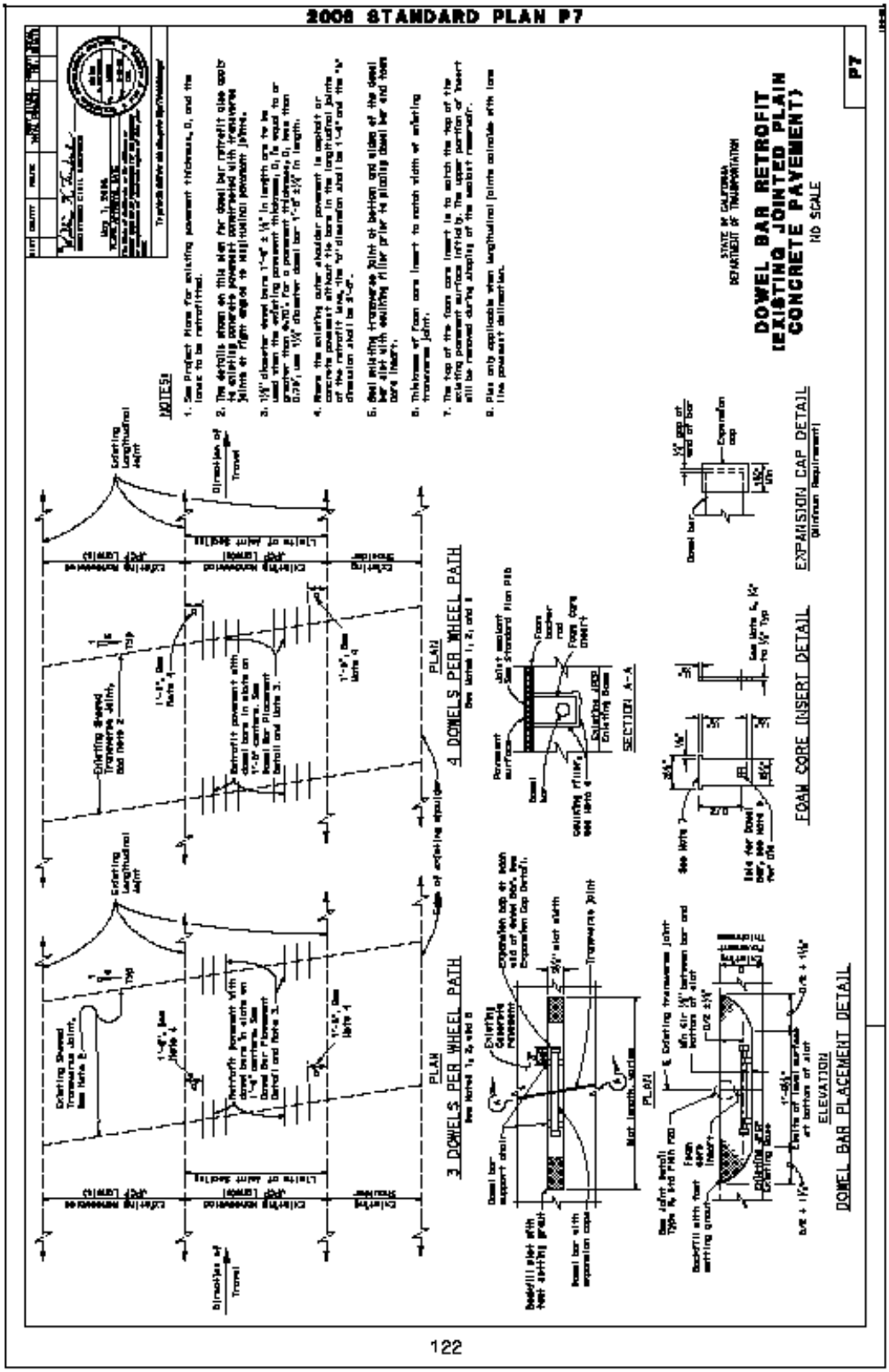
The contract unit price paid for dowel bar retrofit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all the work

involved in placing dowel bar retrofit, complete in place, including placing test strip, repairing any damaged or removed pavement delineation, cutting, blast cleaning, caulking, joint filler, grout backfill, sealing transverse weakened plane joints and disposal of removed concrete, as shown on the plans and as specified in the Standard Specifications and these special provisions and as directed by the Engineer.

Full compensation for furnishing, stockpiling and disposing of standby material for dowel bar slot temporary backfill; and for placing, maintaining, removing and disposing of temporary backfill shall be considered as included in the contract unit price paid for dowel bar retrofit and no separate payment will be made therefore.

Full compensation for providing the facility, Contractor personnel and all the work involved in arranging for the preconstruction conference shall be considered as included in the contract unit price paid for dowel bar retrofit and no additional compensation will be allowed therefore.

The costs involved in providing an instructor at the 4-hour training class as part of the preconstruction conference will be paid for as extra work as provided in Section 4-1.03D, "Extra Work," of the Standard Specifications except that if payment is made by force account as provided in Section 9-1.03, "Force Account Payment," of the Standard Specifications, no markups will be allowed.


2006 STANDARD PLAN P7
DOWEL BAR RETROFIT
(EXISTING JOINTED PLAIN
CONCRETE PAVEMENT)
NO SCALE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
P7
NOTES:
1. See Project Plans for existing pavement thickness, D, and the lanes to be retrofitted.
2. The details shown on this sheet for dowel bar retrofit also apply to existing concrete pavement constructed with transverse joints at right angles to longitudinal pavement joints.
3. 1½" diameter dowel bars 1'-6" ± ½" in length are to be used when the existing pavement thickness, D, is equal to or greater than 6.75", for a pavement thickness, D, less than 6.75", use 1½" diameter dowel bar 1'-0" ±½" in length.
4. Where the existing outer shoulder pavement is asphalt or concrete pavement without tie bars in the longitudinal joints of the retrofit lane, the "a" dimension shall be 1'-0" and the "b" dimension shall be 2'-0".
5. Seal existing transverse joint at bottom and sides of the dowel bar slot with existing filler prior to placing dowel bar and foam core insert.
6. Thickness of foam core insert to match width of existing transverse joint.
7. The top of the foam core insert is to match the top of the existing pavement surface (refer to). The upper portion of insert will be removed during shaping of the asphalt rubber.
8. Plan only applicable when longitudinal joints coincide with lane line pavement delineation.
PLAN
4 DOWELS PER WHEEL PATH
PLAN
3 DOWELS PER WHEEL PATH
SECTION A-A
EXPANSION CAP DETAIL
FOAM CORE INSERT DETAIL
DOWEL BAR PLACEMENT DETAIL
ELEVATION
PLAN

DELAWARE

DESCRIPTION

This item consists of installing epoxy-coated, round steel dowels into existing concrete pavement across transverse joints and/or cracks. Slots are cut using diamond-tipped saw blades, the existing concrete is removed, dowels are placed in the slots across the joints or cracks and filled with a cemenititous backfill material.

MATERIALS

Dowel Bars. Dowel bars shall conform to AASHTO M284. The dowel bars shall be 18 inch long with a diameter of 1½ inch.

The dowel bars shall have an approved bond-breaking material coating, such as a white pigmented curing compound, on all surfaces of the dowel bar, applied either at the manufacturing facility before shipment, or on-site. Do not apply bond breaker while the dowel bars are in place within the pavement section.

Expansion Caps. Expansion caps shall be tight-fitting, commercial quality end caps made of a non-metallic, non-organic material that allows for ¼ inch of movement at each end of the dowel bar.

Dowel Bar Support Chairs. Dowel bar support chairs shall conform to the epoxy-coated steel requirements of ASTM A 884 or fabricated from commercial quality, non-metallic, non-organic material. Dowel bar chairs will be used to firmly hold the dowel bars centered in the slots during backfill operations. The dowel bar chairs shall be placed to hold the bar a minimum of ½ inch above the bottom of the slot while the backfill material is placed and consolidated.

Foam Core Insert. Foam core inserts shall be used to re-establish the joint or crack and shall consist of rigid Styrofoam material or closed cell foam, faced with poster board or plastic material. The foam core insert (joint/crack re-former) allows each side of the slot to expand and contract and shall extend up the bottom of the existing joint sealant reservoir.

Caulking Filler. Caulking filler shall be used for sealing the existing transverse joint or crack at the bottom and sides of the slot to prevent backfill material from flowing into the joint or crack. The caulking filler shall be compatible with all other materials used by the Contractor.

Non-Shrink Concrete Backfill Material. The concrete backfill material shall be a non-shrink concrete that: (1) provides a minimum opening to traffic compressive strength of 2000 psi in 6 hours; (2) exhibits expansion of less than 0.10 percent per ASTM C 531; (3) has a calculated durability factor of 90.0 percent minimum at the end of 300 freeze-thaw cycles per ASTM C 666; and (4) has a maximum 4-day shrinkage value of 0.13 percent per ASTM C596. During the first week of the backfilling operation, a manufacturer's representative shall be on-site to review the Contractor's mixing and handling of the backfill material and shall advise the Contractor and Engineer of any concerns.

Joint Sealant. Hot-pour joint sealants shall conform to the requirements of AASHTO M301 or AASHTO M282.

CONSTRUCTION METHODS

Patching Limits. The areas to be repaired will be indicated on the Plans or identified by the Engineer in the field.

Saw Cutting. The Contractor shall make two saw cuts in the pavement to outline the longitudinal sides of each dowel bar slot. Saw to a depth and length that allows the center of the dowel to be placed at mid-depth in the pavement slab. Saw slots parallel to each other and to the centerline of the roadway with a maximum tolerance of ¼ inch per 12 inch of dowel bar length. The Contractor shall use saws equipped with gang mounted diamond blades capable of cutting a minimum of three slots simultaneously in each wheel path. Skewed joints or cracks may require slots longer than the length specified in the Plans.

Concrete Removal. The Contractor shall use a maximum weight 30 lb. jackhammer(s) to remove the concrete remaining between the saw cuts. If the concrete removal operations cause damage to the pavement that is to remain, discontinue concrete removal operations and only resume after taking corrective measures. Repair or replacement of pavement damaged during concrete removal operations shall be corrected at the Contractor's expense.

During concrete removal operations, a small bush hammer shall be used, as necessary, to produce a flat, level surface within the slot so the backfill flows and consolidates under the dowel bars.

Slot Cleaning and Preparation. The slots shall be sandblasted to remove saw slurry and debris such that clean aggregate is exposed. After sandblasting, the slot shall be cleaned by blowing moisture-free, oil-free compressed air having a minimum pressure of 150 psi to remove any dust, residue, or debris left in the slot.

Sealing Joints and Cracks in Slot. The existing joint and/or cracks at the bottom and the sides of the dowel bar slot shall be sealed with an approved caulking filler to prevent any of the backfill material from entering these areas. Prior to sealing, the surfaces receiving the caulking filler shall be clean and free of moisture. The caulking filler shall not extend beyond ⅜ inch of each side of the existing joint or crack.

Placing Dowel Assembly in Slot. The Contractor shall prevent contamination of the cleaned slot before and during placing of the dowel assemblies to limit the potential of bonding loss with the backfill material. The dowel bars shall be placed to within ½ inch of the midpoint of the slab. The dowel bar shall be placed parallel to the traffic lane centerline and the top of the roadway surface within a tolerance of ¼ inch per 12 inch of dowel bar length. The dowel bars shall be centered at the transverse joint or crack, such that at least 7 inch of the dowel extends into each adjacent panel.

A foam core insert shall be placed at the middle of the dowel bar and 2 inch below the surface of the pavement. The insert shall be placed so it covers the existing transverse joint or crack and is capable of remaining in a vertical position, tight to all edges during backfill placement operations. The joint or crack shall be re-established above the foam core insert of backfill placement by means of sawing when the backfill material has hardened sufficiently.

Mixing and Placing Backfill Material. The backfill material shall be handled, mixed, placed and cured in accordance with the manufacturer's recommendations.

The Contractor shall take extreme care regarding backfill material mix proportions, water cement ratio and the condition of the mixing equipment as improper mix proportioning and/or inefficient mixing apparatus can result in premature deterioration of the backfill material. When using auger type mixing equipment, steps shall be taken to keep the auger flights free from material buildup, causing inefficient mixing operations. Volumetric mixing operations may be allowed such as mobile mixers with the approval of the Engineer.

Each dowel bar slot will be filled with backfill material after placement of the caulking filler, the dowel bar, expansion caps, support chairs and the foam core insert. The Contractor shall ensure that the foam core inserts remain upright and over the existing joint or crack during the backfill process. The backfill material shall be vibrated with a small hand held vibrator capable of thoroughly consolidating the backfill material into the slot around the dowel bars and support chairs.

The Contractor shall slightly overfill the slot and finish the surface of the filled slot level with the existing concrete. The backfill material shall immediately be cured in accordance with the backfill manufacturer's recommendations.

Sealing Joints and Cracks. After the backfill material has set to the compressive strength requirements, the Contractor shall seal joints and cracks with an approved hot-pour sealant.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Dowel bar retrofit is measured by each dowel bar assembly installed and accepted. The contract unit price paid for each dowel bar assembly includes full compensation for furnishing all labor, materials, tools, equipment and incidentals involved in placing dowel bar retrofit, complete in place including: saw cutting of concrete; removal and disposal of concrete; dowel bars, expansion caps and assemblies; core inserts and caulking filler; surface preparation; supplying, mixing, finishing and curing backfill material; and joint sealant material.

IDAHO

DESCRIPTION

This work shall consist of installing epoxy coated dowel bars into existing transverse joints and cracks in accordance with this Special Provision and the details shown in the plans. Sequence of work shall be in accordance with S.S.P. 420, Concrete Pavement Rehabilitation. The Contractor shall have completed three successful projects of similar type and furnish references.

MATERIALS

Dowel bars shall be 38 mm in diameter x 450 mm in length, epoxy coated smooth bars conforming to AASHTO M 254, Type B. The steel for the dowels shall be a minimum of Grade 300 as specified in AASHTO M 31M. The dowels shall be saw cut and free of burrs or projections that would restrict movement. Minor field repair of damage to the epoxy coating shall be made with an approved epoxy repair material. All surfaces shall be epoxy coated including the ends of the bars.

The bond breaking compound shall be liquid membrane-forming compound that conforms to the requirements of AASHTO M 148 (ASTM C 309), Type 2, Class A or B, or other approved release agent.

The dowel bars shall have tight fitting end caps made of non-metallic material that allows for either 6 mm or movement at each end of the bar or 13 mm at one end. The Contractor shall submit to the Engineer a sample of the end caps and obtain approval prior to use on the project.

Chair devices for supporting and holding the dowel bar in place shall be completely epoxy coated or made out of non-metallic materials. The Contractor shall submit a sample to the Engineer for approval prior to use on the project. Chair devices shall provide a minimum clearance of 13 mm between the bottom of the bar and the surface upon which the chair is placed. The chair shall be designed to prevent movement of the bar during placement of the grout.

Caulking filler shall be a standard commercial silicone sealer specified for use with concrete surfaces and shall contain a minimum of 50 percent silicone. The Contractor shall submit a sample of the material to the Engineer and obtain approval prior to use.

Foam core board filler material shall be of variable thickness to match existing joints, a closed-cell foam faced with poster board material on each side and shall have 13 mm high by 25 mm long tabs at the top. Due to original construction methods and subsequent joint maintenance, the joint width may be variable. Field adjustments may be required during installation of the foam core board.

Portland cement concrete pavement removed for the purpose of installing retrofitted dowel bars shall be replaced with either Burke 928 Fast Patch, Thoroc 10-60 Rapid Mortar, L&M Durapatch Highway, Set 45 Caltrans Formulation, Five Star Highway Patch, CTS Rapid Set DOT, or an approved equal. Replacement patching material shall be placed in accordance with manufacturer's recommendations and this Special Provision.

All samples of materials submitted to the Engineer for approval shall be submitted a minimum of two weeks in advance of anticipated use.

CONSTRUCTION REQUIREMENTS

The Contractor shall install dowel bars in the existing portland cement concrete pavement as shown on the details and in accordance with the following:

1. Prior to startup of major operations the Contractor shall provide a test operation. The test operation shall consist of complete dowel bar retrofit at a site as directed by the Engineer. Additionally, 40, 150 mm cores shall be taken at random locations as directed by the Engineer. The cores will be used to verify slab thickness throughout the project. There shall be at least 24 dowel bars retrofit in the test operation. Twenty four (24) hours after completion of the retrofit, the Contractor shall take three 160 mm full depth cores as directed by the Engineer to determine the completeness of installation operations. If the slab thickness is verified to the satisfaction of the Engineer and the retrofits are in accordance with the Special Provisions and details, then upon arrival from the Engineer the Contractor may begin production operations and shall proceed on a performance basis.
2. Slots shall be cut in the pavement as required to place the center of the dowel at mid-depth in the concrete slab. The slots shall not be skewed more than 6 mm from parallel to the centerline of the roadway and shall not be more than 6 mm from plane with the roadway surface. Both these tolerances are per 450 mm of dowel bar length. At least three slots shall be made per wheel path along the transverse joint or transverse crack (see details) simultaneously. Multiple saw cuts in the slot, parallel to the centerline, may be required to properly remove the material from the slot. All slurry and residue shall be collected and disposed of, at Contractor's expense and at a location and in a manner approved by the Engineer.
3. To prevent full depth spalling, any jackhammers used to break loose the concrete shall be less than the nominal 13.6 kg class.
4. All exposed surfaced and cracks in the slot shall be sand blasted and cleaned of all saw slurry and loose concrete prior to installation of the dowel bars. The contraction joint on the bottom and the sides of the slot shall be filled with silicone. No more than 13 mm of joint or crack outside of sawn slot shall be filled with silicone.
5. Dowel bars shall be coated with a bond breaking compound and placed in the approved dowel chair. The dowel bars shall be placed to a depth as shown in the details and in accordance with the plans, parallel to the centerline, at the middle of the sawed slot and parallel to the pavement surface of the lower panel at the transverse joint or transverse crack, all to a tolerance of 6 mm. the mid-point of the dowel bar to the centerline of the transverse joint or crack shall be within 25 mm. The chair design shall hold the dowel bar tightly in place during placement of the grout material. Any chair design that allows movement of the bar during placement of grout will be rejected by the Engineer. End caps shall be placed on the bar prior to grouting.
6. The sawed slot shall be free of all slurry, residues and other foreign material.
7. The foam core board filler material shall be placed at the middle of the dowel bar to maintain the transverse joint or crack. The core board shall fit tightly around the dowel bar and to the bottom and edges of the slot. The existing joint or crack sealant may need to be removed to accommodate the foam core board with the tabs. The tabs are required to stabilize the foam core board during patching material placement. The

Contractor shall caulk the transverse joint or crack at the bottom and the sides of the slot on both sides of the foam core board with silicone. The foam core board shall be capable of remaining in a vertical position and tight to all edges during placement of the patching material.

8. The Contractor shall fill the sawn slot (with the installed dowel bar with caps, chairs, foam core board and silicone in place), with an approved patching material. The patching material shall be thoroughly consolidated in the slot and around the dowel bar with an appropriately sized vibrator (20 mm to 24 mm head diameter) and the surface finished to a broomed finish. Troweling of the material shall be accomplished by moving the material toward the hardened concrete to eliminate the potential for voids on the edge of the patch. The surface of the filled area shall be cured in accordance with the patching material manufacturer's specifications.
9. The Contractor shall thoroughly moisten all surfaces of the slot immediately prior to filling with patching material, unless otherwise directed by manufacturer. Care shall be taken to prevent standing water in the slot. All excess water shall be removed with compressed air. Any patching material which enters the transverse joint or crack shall be removed.
10. All transverse contraction joints are to be sealed as provided for in S.S.P. 423 (included in the contract documents). All transverse cracks are to be sealed as provided for in S.S.P. 425 for repairing pavement cracks (included in the contract documents).
11. Any dowel bars not functioning or damaged shall be repaired or replaced at the Contractor's expense and at no cost to the Department.

METHOD OF MEASUREMENT

Each dowel bar installed, including the 24 retrofit dowel bars completed during the initial test operation, will be measured by the each, complete, in place, including all equipment, labor and material necessary to saw the slot and install the epoxy coated dowel bar as described in this Special Provision. Random coring to verify slab thickness and coring the test retrofit dowel bars will be incidental to the pay item "Dowel Bar Retrofit (Epoxy Coated)".

Basis of Payment. Payment for accepted work will be made as follows:

Pay Item	**Pay Unit**
Dowel Bar Retrofit (Epoxy Coated)	Each

507.08 RETROFIT LOAD TRANSFER FOR PCCP

Retrofit load transfer consists of diamond saw slot cutting and placing dowel bar assemblies in the PCCP, parallel to the centerline of the roadway without damaging adjacent PCCP. The diamond-sawed slot shall be cut using two diamond saw blades per slot to cut the edges of the slot. The PCC within the slot and the burrs and bumps remaining in the base of the slots after cutting shall be removed with hand or mechanical chipping hammers which shall not exceed a nominal 15 lb in weight (mass) and shall be operated at a maximum angle of 45 degrees from the pavement surface.

All surfaces of the slots shall be thoroughly cleaned by sand blasting and all cracks in the slots shall be sealed with a silicone sealer. The slots shall be cleaned and blown dry with compressed air.

Dowel bar assemblies shall be as shown on the plans. Prior to placement, the assemblies shall be coated with a bond breaking material and placed on non-metallic supports in the slots. Dowel bars shall be parallel to the pavement surface.

Rapid setting patch material shall be mixed and cured in accordance with the manufacturer's recommendations. The material shall be placed in the slots and troweled to match existing adjoining PCCP. Excess material removed during placing and troweling shall not be reused.

Transverse contraction joints with retrofitted load transfers shall be sawed for the full lane width and sealed in accordance with 503.03(a) except the joint shall be cut in one operation. Transverse random cracks with retrofitted load transfer slots shall be routed and sealed for the full lane width in accordance with 503.05.

PCCP damaged outside the area of the slots due to Contractor's operations shall be repaired in an acceptable manner or replaced.

507.09 METHOD OF MEASUREMENT

Retrofit load transfer will be measured by each dowel bar assembly installed, complete in place.

Construction activities for the cutting, cleaning of the PCCP, dowel bars, dowel bar supports, dowel bar end caps, foam core board, patching material and all other incidentals will not be measured.

507.10 BASIS OF PAYMENT

The accepted quantities of retrofit load transfer will be paid for at the contract unit price per each assembly installed, compete in place.

Payment will be made under:

Pay Item Pay Unit Symbol

Retrofit Load Transfer.....EACH

The cost of cutting of slots, cleaning, dowel bars, dowel bar supports, dowel bar end caps, foam board, mortar and curing materials shall be included in the cost of the pay item retrofit transfer.

901.07 RAPID SETTING PATCH MATERIALS

Rapid setting patch materials shall be selected from the Department's list of approved Rapid Setting Patch Materials. A rapid setting patch material may be added to the approved list by completing the requirements in ITM 806, Procedure F.

(a) Normal Weather Mixes

Normal weather rapid setting patch materials shall be used for ambient temperatures of 32 - 85°F.

(b) Hot Weather Mixes

Hot weather rapid setting patch materials shall be used for ambient temperatures above 85°F.

(c) Requirements

Rapid setting patch materials shall be capable of being utilized in patches ranging from 1 inch to full depth without bonding agents, no curing material shall be required and shall be capable of being surface sealed with an epoxy sealer.

These products shall not contain soluble chlorides as an ingredient of manufacture nor shall they require chemical additives. The color shall be similar to PCC.

They shall be single packaged dry mix requiring only water just prior to mixing. They shall be packaged in 40 – 60 lb bags with a neat yield of approximately 0.40 cu yd and shall allow at least a 50% extension, by weight (mass) with a ⅜ inch or a ½ inch round aggregate. The minimum shelf life shall be twelve months.

Mixing shall be conducted with small concrete mixers or with a drill or paddle mixer and shall be suitable for finishing with hand tools.

Rapid setting patch materials shall be in accordance with ASTM C 928 with the following exceptions.

Physical Test	Specification	Requirement
Setting Time	ASTM C 266	
Normal Weather		
Initial at 72°F		10 – 20 min
Final at 72°F		12 – 35 min
Hot Weather		
Initial at 95°F		10 – 20 min
Final at 95°F		12 – 35 min
Compressive Strength, Min*	AASHTO T 109	72°F, Normal
1 h		2000 psi
2 h		3000 psi
24 h		5000 psi
Physical Test	Specification	Requirement
28 day		8000 psi

Compressive Strength, Min*	ASTM C 109	95°F, Hot
3 h		3000 psi
24 h		5000 psi
28 days		8000 psi
Relative Dynamic Modulus	ASTM C 666	
Procedure B 300 cycles		95% Min.
Slant Shear Bond Strength, Min.	ASTM C 882	
28 days		2500 psi

Physical Test	Specification	Requirement
Flexural Strength, 24 h	ASTM C 78	
mortar only		500 psi
mortar – aggregate extension		600 psi
Shrinkage, Max.	ASTM C 157	
28 days		0.03%
Scaling Resistance	ASTM C 157	
5 cycles		0 rating, No scale
25 cycles		0 rating, No scale
50+ cycles		1.5 rating, Lt. scale

* Material used shall be neat rapid setting patch material mixed in accordance with the manufacturer's installation instructions.

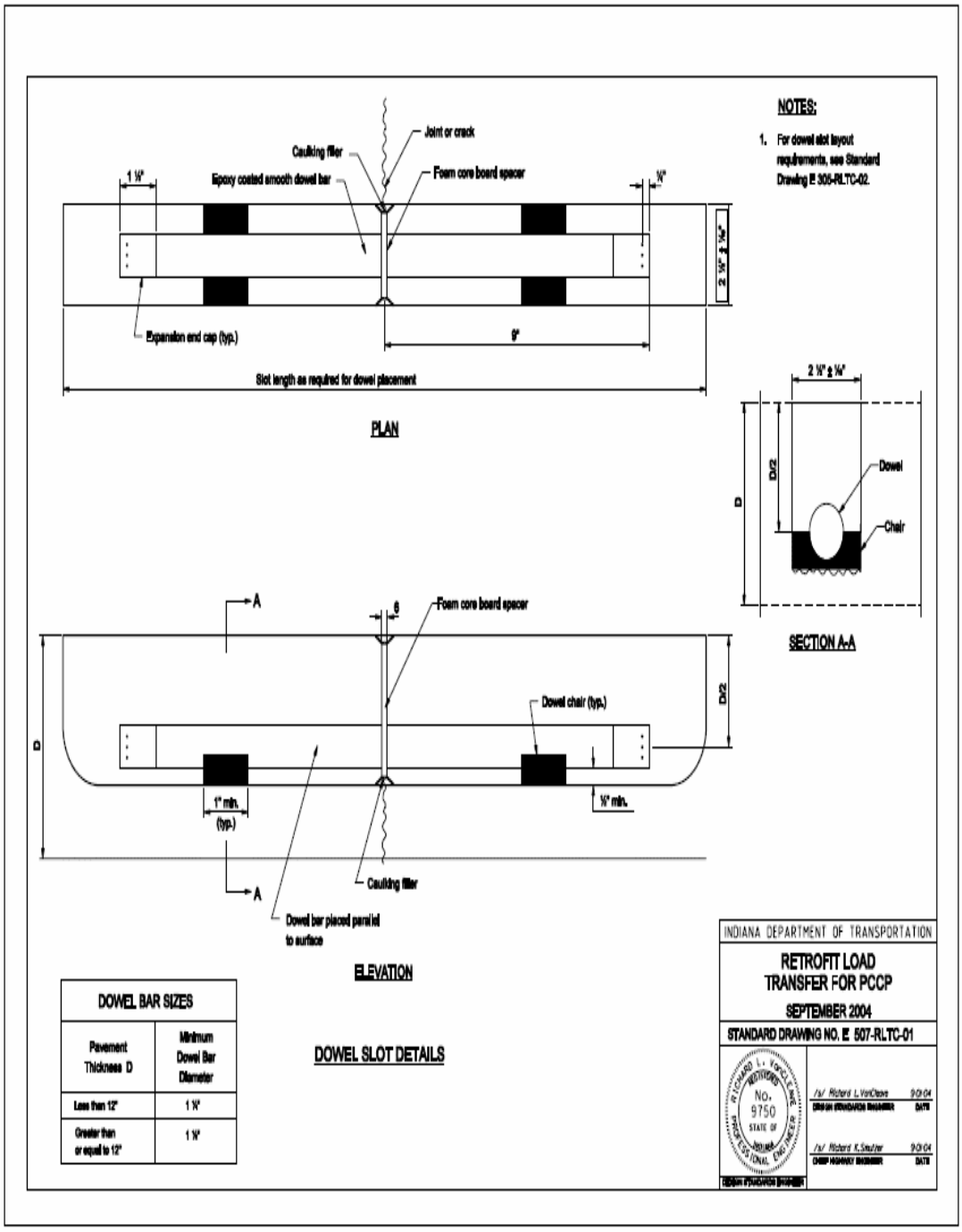
All rapid setting patch materials complying with the specified physical requirements will be subjected to a field performance demonstration. The field performance demonstration will take place as directed. Rapid setting patch materials shall be used to patch a designated site, typical of a standard repair. The site will be evaluated after one year's exposure. Approval will be based on visible signs of distress, such as cracking, crazing, scaling, spalling, wearing, edge fraying, corner cracking, or debonding.

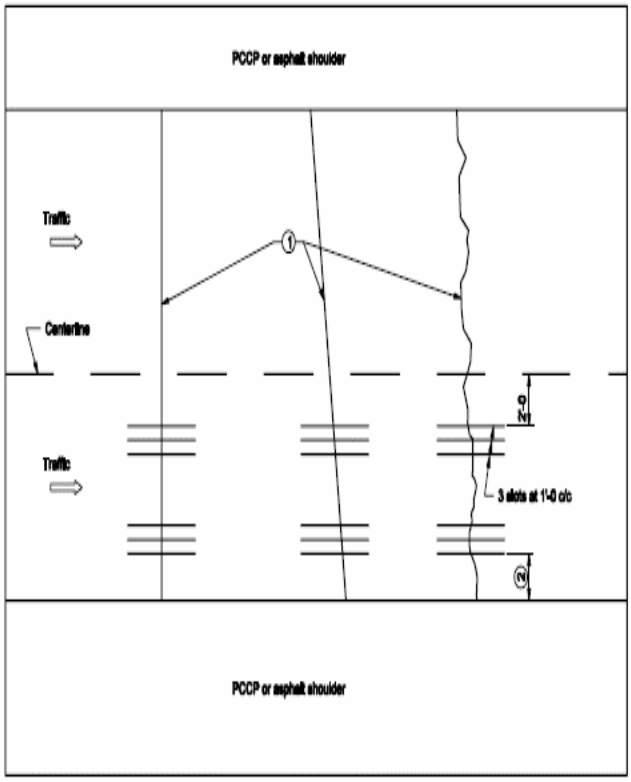
(d) Test Report

Testing shall be performed by a recognized laboratory in accordance with ITM 806. Test reports shall not be more than five years old on January first of the approval year.

901.08 PACKAGED, DRY, COMBINED MATERIALS FOR MORTAR AND CONCRETE

These materials shall be in accordance with ASTM C 387. All packages shall be identified as conforming to ASTM C 387. The markings shall also show the kind and type of material, the net weight in each bag, the yield in cubic feet (cubic meters) or yield in square feet per inch (square meters per millimeter) of thickness and the amount of water recommended for mixing to produce a 2 in. to 3 in. slump.


NOTES:
1. For dowel slot layout requirements, see Standard Drawing E 505-RLTC-02.
Joint or crack
Caulking filler
Epoxy coated smooth dowel bar
Foam core board spacer
1 ½"
¼"
2 ½" ± ¼"
Expansion end cap (typ.)
9"
Slot length as required for dowel placement
PLAN
2 ½" ± ¼"
D/2
D
Dowel
Chair
SECTION A-A
A
6
Foam core board spacer
Dowel chair (typ.)
D
D/2
1" min. (typ.)
½" min.
Caulking filler
Dowel bar placed parallel to surface
ELEVATION
DOWEL SLOT DETAILS
DOWEL BAR SIZES
Pavement Thickness D
Minimum Dowel Bar Diameter
Less than 12"
1 ¼"
Greater than or equal to 12"
1 ½"
INDIANA DEPARTMENT OF TRANSPORTATION
RETROFIT LOAD TRANSFER FOR PCCP
SEPTEMBER 2004
STANDARD DRAWING NO. E 507-RLTC-01
RICHARD L. VONCLEAVE
REGISTERED
No. 9750
STATE OF INDIANA
PROFESSIONAL ENGINEER
/s/ Richard L VonCleave 9/01/04
/s/ Richard K.Snutter 9/01/04



NOTES:

1. PCCP retrofit load transfer may be utilized at perpendicular joints, skewed joints, or at random cracks.
2. If lane width is 12 ft, use 3' offset. If lane width is 14 ft, use 4' offset.
3. Dowel slots shall be constructed parallel to pavement centerline.

INDIANA DEPARTMENT OF TRANSPORTATION

RETROFIT LOAD TRANSFER FOR LOAD

SEPTEMBER 2004

STANDARD DRAWING NO. E 507-RLTC-02

RICHARD L. VANCLEAVE — NO. 9750 — STATE OF INDIANA — PROFESSIONAL ENGINEER

/s/ Richard L VanCleave 9/2/04
DESIGN STANDARDS ENGINEER DATE

/s/ Richard K Snyder 9/2/04
CHIEF HIGHWAY ENGINEER DATE

KANSAS

DESCRIPTION

Retrofit the existing PCCP with epoxy-coated steel dowel bars as shown in the Contract Documents.

MATERIALS

a. Epoxy-Coated Dowel Bars. Provide epoxy-coated (including the ends) steel dowel bars that complies with SECTION 1600. Provide a tight fitting nonmetallic expansion cap on one end of the dowel bars. The Engineer must approve the expansion cap before it is used.

Provide epoxy-coated or nonmetallic chair devices to support and hold the dowel bars. The Engineer must approve the chair devices before they are used.

b. Bondbreaker for Dowel Bars. Provide a bond breaker that complies with SECTION 1700.

c. Caulking Filler. Provide a silicone sealant caulking filler intended for filling cracks in PCCP. The Engineer must approve the caulking filler before it is used.

d. Board Filler. Provide a closed-cell foam core board filler (½ inch thick) faced with poster board material on each side. The Engineer must approve the board filler before it is used.

e. Grout. Provide a product that complies with SECTION 1700 and is prequalified as "very rapid hardening" when extended. The grout may be extended as the manufacturer recommends (maximum aggregate size is ⅜ inch). All extender aggregate used on Contracts must be from a source that has a current Official Quality approval status for Mixed Aggregate per SECTION 1102.

f. Liquid Membrane-Forming Compound. Provide a liquid membrane-forming compound that conforms to the requirements of SECTION 1400.

CONSTRUCTION REQUIREMENTS

Cut slots for the dowel bars into the existing PCCP at the locations shown in the Contract documents. Use a gang saw capable of simultaneously cutting all the slots at one location (one wheel path). Make the slots large enough to provide the minimum clearances shown in the Contract documents. If necessary, make multiple parallel saw cuts to remove the existing concrete from the slot.

If jackhammers are used to break the concrete loose, do not use jackhammers larger than the nominal 30 pound class.

Sandblast and clean all surfaces of the slot. Sandblast and clean all cracks in the slot. Remove all broken concrete and debris from the project.

Fill the transverse crack in the bottom and sides of the slot with caulking filler. Prevent the caulking filler from contacting the surfaces outside the crack.

Before the dowel bar is placed in the slot, cut a piece of the board filler material to fit tightly around the dowel bar and against the bottom and sides of the slot. Place the board filler material vertically above the transverse crack in the bottom of the slot. Keep the board filler material in this position during placement of the grout.

Use chair devices to position and hold the dowel bars parallel (¼ inch) to the pavement centerline and the pavement surface and at the depth shown in the Contract Documents. Coat the dowel bars with an approved bond breaker before the grout is placed.

Place and consolidate the grout as recommended by the manufacturer. Cure the surface of the grouted slots with a liquid membrane-forming compound.

The extended grout must obtain a minimum of 2000 psi compressive strength before the roadway can be opened to traffic, but no sooner than 2 hours.

Saw the transverse joint through the patched areas within 24 hours of the placement of the grout. Saw and seal the joint as shown in the Contract Documents.

MEASUREMENT AND PAYMENT

The Engineer will measure each dowel bar. Payment for "Dowel Bar Retrofit" at the contract unit price is full compensation for the specified work.

1716 RAPID-SET CONCRETE PATCHING MATERIAL

1716.1 DESCRIPTION

This specification covers requirements for rapid setting cementitious materials for concrete repairs.

1716.2 REQUIREMENTS

a. Provide material that complies with ASTM C 928.

b. Freeze-thaw durability will be determined using ASTM C 666, Procedure B. At the end of 300 freeze-thaw cycles, acceptable products must exhibit expansion of less than 0.10% and a calculated durability factor of 90.0% minimum.

c. When allowed in the Contract Documents, extender aggregate may be combined with the neat rapid setting material according to the manufacturer's recommendations. The resulting combined material is subject to the foregoing requirements. Products will be tested neat as received and also extended to the full amount allowed by the manufacturer and will be classified as Rapid Hardening (R1), Very Rapid Hardening (R2), or Ultra Rapid Hardening (R3) based on the results. A product may be classified in one category when tested neat as received and another when tested extended the maximum amount. All extender aggregate used on Contracts must be from a source that has a current Official Quality approval status for Mixed Aggregate per SECTION 1102.

d. Provide material classified as Rapid Hardening, Very Rapid Hardening, or Ultra Rapid Hardening as specified in the Contract Documents. Any prequalified higher class of material may be substituted for a lower class specified at no additional cost. If no class is specified, any prequalified product may be supplied.

e. Provide the same product as prequalified under the AASHTO National Transportation Product Evaluation Program (NTPEP), including water/cement ratio and proportion of extender (if applicable). If the product was prequalified using a manufacturer-provided extender (sand), then the extender may be substituted by using an approved local source at the same extender proportioning established during prequalification.

1716.3 TEST METHODS

Test material in accordance with the applicable parts of ASTM C 928 and ASTM C 666, Procedure B.

1716.4 PREQUALIFICATION

Supply samples for prequalification to the AASHTO National Transportation Product Evaluation Program (NTPEP). Forward an official copy of the test report to the Bureau Chief of Materials and Research for evaluation. Include information regarding the soluble chloride content of the material and the mandatory statement from ASTM C 928 if it exceeds 1 lb/cu yd. Include the metallic iron content and the mandatory statement from ASTM C 928 if it exceeds 1% by mass. Prequalification will be based on satisfactory compliance of NTPEP results with this specification. Products will be classified as Rapid Hardening, Very Rapid Hardening, or Ultra Rapid Hardening in both the neat and extended mixes based on the NTPEP results.

If the NTPEP results comply with subsection 1716.2, the name of the product will be placed on a list of prequalified products maintained by the Bureau of Materials and Research. No rapid setting concrete patch material will be used on KDOT projects unless it has been prequalified. Manufacturers are required to re-qualify at intervals stipulated by NTPEP.

1716.5 BASIS OF ACCEPTANCE

Prequalification as specified in subsection 1716.4.

Receipt and acceptance of a Type C certification as specified in DIVISION 2600.

602.16 DOWEL BAR RETROFIT

This work consists of installing plastic coated 1½ inch diameter by 18 inch long plain round dowel bars into slots cut across and through existing concrete pavement transverse joints. The existing portland cement concrete pavement shall be removed from the slots and the dowel bars shall be retrofitted across the pavement joints. The voids surrounding the dowel bars shall be filled with a concrete patching material. The transverse joints shall be sawed and sealed as required in the plans. All work shall conform to the plan details and the following requirements.

The use of patented processes or devices for simultaneous cutting of slots for dowel bar retrofitting shall conform to Subsection 107.03.

(a) Materials:

Dowel bars shall be in accordance with Subsection 1009.04.

The dowel bars shall have tight fitting nonmetallic end caps that allow for ¼ inch bar movement at each end of the bar. The contractor shall submit an end cap sample to the project engineer for approval prior to installation.

Nonmetallic chair devices shall be used to support and hold the dowel bars in place. The chairs shall be in contact with the bottom and sides of the slot in order to maintain horizontal and vertical dowel bar alignments. The contractor shall submit a chair sample to the project engineer for approval prior to installation.

The form core board filler material shall be ¼ inch thick, constructed of closed cell foam and faced with poster board material on each side.

The caulk for sealing the existing transverse joint at the bottom and sides of the slot shall be a commercial grade of silicone caulk containing a minimum of 50 percent silicone.

A low shrinkage cementitious concrete patching material used to backfill the slots shall be selected from QPL 24 under Rapid Setting Patching Materials for Concrete and shall meet the following requirements.

(1) Compressive strength 3 hr., minimum 3000 psi - ASTM C 109
(2) Compressive strength 24 hr., minimum 5000 psi - ASTM C 109
(3) Shrinkage 4 days, 0.13 percent maximum - ASTM C 157

The contractor shall obtain and provide the manufacturer's technical specifications for approval of the patching product including all additives required to meet the minimum compressive strengths.

Curing compounds recommended by the patching material manufacturer shall be in accordance with Section 1011.

(b) Construction Requirements: The dowel bars shall be installed as follows:

Saw cut slots in the pavement shall be parallel to the centerline of the roadway and to a depth sufficient to place the center of the dowel bar at mid-depth in the pavement. Multiple saw cuts parallel to the centerline may be required to properly remove the

material from the slot. The saw cuts for the slots at each transverse joint shall be made such that the dowel bars can be positioned parallel to the roadway centerline and surface in accordance with plan details.

Jack hammers used to break loose concrete shall not be larger than the 30-pound class. If the 30-pound jack hammer damages the pavement, the project engineer will require the contractor to use a lighter hammer.

All exposed surfaces and cracks in the slot shall be sand blasted and cleaned prior to bar installation. Air compressors shall be equipped with approved oil and moisture traps.

The transverse contraction joint on the bottom and the sides of the slot shall be filled with silicone caulk.

The dowel bars shall be lightly oiled or greased prior to placement. The bar chairs shall provide a minimum of ½ inch clearance between the bottom of the dowel bar and the bottom of the slot. The dowel bars shall be centered over the transverse joint, placed in the middle of the slot to the depth shown on the plans and shall be parallel to the roadway centerline and the roadway surface. The chairs shall hold the dowel bar securely in place during placement of the patching mix.

A ¼ inch thick foam core board shall be placed at the middle of the dowel bar to maintain the transverse contraction joint. The existing joint sealant may need to be cut or removed to accommodate the foam core board. The foam core board shall f it tightly around the dowel bar and to the bottom and edges of the slot. The top of the foam core board shall be flush with the top surface of the concrete pavement. The foam core board shall remain in a vertical position and be tight to all edges during the placement of the patching material.

The contractor shall thoroughly moisten all surfaces on the sawed slot immediately prior to filling with patch compound unless the patching material manufacturer recommends the slot surface to be dry. Care shall be taken to prevent standing water in the slot. All excess water shall be removed with compressed air. The contractor shall fill the slot (with the installed dowel bar, chairs, foam core board and silicone in place) with an approved patching material. The patching material shall be mixed in accordance with the manufacturer's recommendations and with mixing equipment approved by the engineer. The patching material shall be vibrated with a small hand held vibrator capable of thoroughly consolidating the patching compound into the slot and around the dowel bar. The top surface of the filled slot shall be trowel finished and cured. The patched areas shall be cured as directed by the patching material manufacturer.

The contractor shall provide six 2 inch cube molds in accordance with ASTM C 192 for sampling and testing the patching material once for each 4 hours of production or a minimum of once per day. Test specimens shall be made in accordance with ASTM C 192. If the compressive strengths are not being met, production shall cease and the contractor shall take corrective measures to the satisfaction of the engineer.

The patching material shall be allowed to cure for a minimum of four hours before placing any vehicle loads on the repair or as directed.

The transverse joints shall be sawed, then sealed with a sealant complying with Subsection 1005.02(c) in accordance with plan details and the manufacturer's

recommendations. Backer material shall be of the size shown on the plan details and shall be selected from QPL 42.

All dowel bars not functioning or damaged shall be repaired or replaced at no cost to the Department.

602.17 MEASUREMENT

Dowel Bar Retrofit will be measured per each dowel bar installed and accepted.

602.18 PAYMENT

Dowel Bar Retrofit: Payment for dowel bar retrofits will be made at the contract unit price per each, which includes furnishing all materials and performing the work as specified in Subsection 602.16.

Payment will be made under:

Item No.	Pay Item	Pay Unit
602-17	Dowel Bar Retrofit	Each

Dowel Bar Retrofit

a. Description. This work consists of cutting slots at transverse cracks, placing dowel bars in the slots, and filling the void with a concrete patching material. Perform all work according to the Standard Specifications for Construction and as shown on the plans, except as modified herein.

b. Materials. Use dowel bars that are 18 inches long and 1.5 inches in diameter. Use sleeved or epoxy coated dowel bars meeting the requirements of subsection 914.07 of the Standard Specifications for Construction, except that the coating or sleeve shall be the full length of the dowel bar.

Provide expansion caps according to subsection 914.07 of the Standard Specifications for Construction. The expansion caps must provide a minimum of 0.5 inches of expansion space beyond the end of the dowel bar if using only one cap. If an expansion cap is used on each end of the dowel bar, each cap must provide a minimum of 0.25 inches of expansion space.

Provide chairs that will position the dowel bars horizontally in the center of the slot, and will provide 0.5 inches to 0.625 inches between the bottom of the bar and the bottom of the slot.

c. Construction.

1. **Slot Cutting.** Simultaneously cut a minimum of three slots that are centered over the crack, to the dimensions shown in Figure 2. If the crack wanders, cut the slots to ensure at least 6 inches of the dowel bar on each side of the crack. Cut three slots in each wheel path across each crack designated by the Engineer as shown in Figure 1. Cut the slots parallel to each other and the longitudinal joints. The distance from each end of a slot to the nearest longitudinal joint shall not differ by more than 0.5 inches.

   Cut the slots so there is a minimum of 6 inches of dowel bar on each side of the crack. If this is not achieved, cut extensions to the short end of the slots until the 6 inch minimum is achieved.

   In reinforced concrete pavement, the transverse distance from the shoulder or longitudinal joint to the first slot may be increased by up to 2 inches if the reinforcing mesh is inhibiting the removal of the slot concrete to the desired depth or width.

2. **Removal of Concrete.** Remove the concrete remaining in the slots after sawing in such a manner so as to prevent any pavement fractures on the surface, as well as below the slot.

3. **Spall Repair.** Repair minor spalls, as defined in subsection 602.03.P of the Standard Specifications for Construction, using the patching material used to backfill the slot. Intermediate and major spalls shall be repaired according to subsection 602.03.P.

4. **Dowel Bar Placement.** Position the dowels true to the pavement surface and parallel to the pavement centerline.

When using one expansion cap, place it on the trailing end of the dowel bar as shown in Figure 2. Total expansion capability, whether using one cap or two, shall be 0.5 inches.

For cracks equal to or greater than 0.25 inches wide, use compressible material to re-form the crack across the slot. Use material cut to the width of the slot +0.25 inches/-0 inches, that fits around the dowel bar, and is a minimum of 0.25 inches below the existing pavement surface. If necessary, angle the compressible material to match the crack on either side of the slot.

Apply bond release agent over the entire dowel bar prior to placing the dowel bar into the slots. Immediately remove any bond release agent spilled on any slot surface, and clean the slot surface.

5. **Patching.** Mix and place the patching material according to the manufacturer's recommendations. Finish the surface of the patch flush with the surrounding concrete and cure the patching material according to manufacturer's recommendations, even if diamond-grinding of the concrete surface is to occur afterward.

   The Engineer reserves the right to sample the patching material and conduct strength testing to verify that the mixture is meeting the requirements stated below.

Age of sample	Minimum strength (4 inch x 8 inch cylinders)
2 hrs.	2000 psi
4 hrs.	2500 psi
28 days	4500 psi

6. **Opening to Traffic.** Cure the patching material for a minimum of four hours, or as directed by the Engineer, before placing any vehicle loads on the repair.

d. Measurement and Payment.

Contract Item (Pay Item)	**Pay Unit**
Dowel Bar Retrofit, Warranty	Each

Payment for **Dowel Bar Retrofit, warranty** includes all labor, equipment, and materials required to cut and clean the slot, place the dowel bar, repair spalls, backfill with a concrete patching material, and cure the patching material.

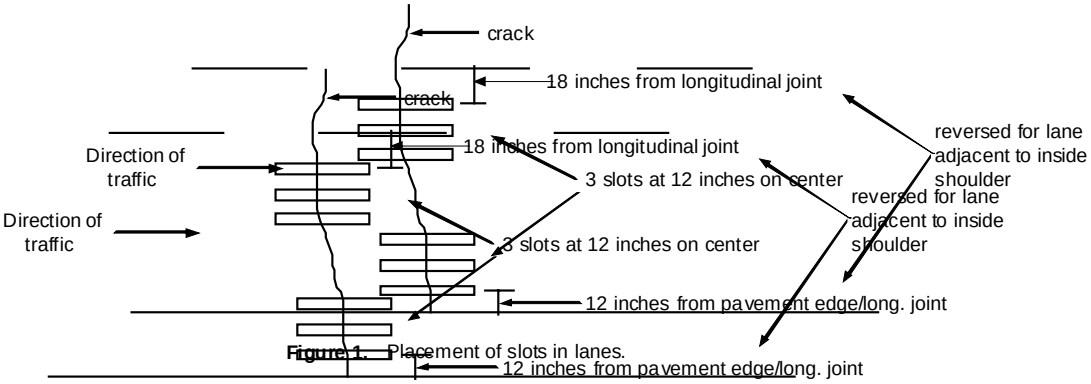


Figure 1. Placement of slots in lanes.

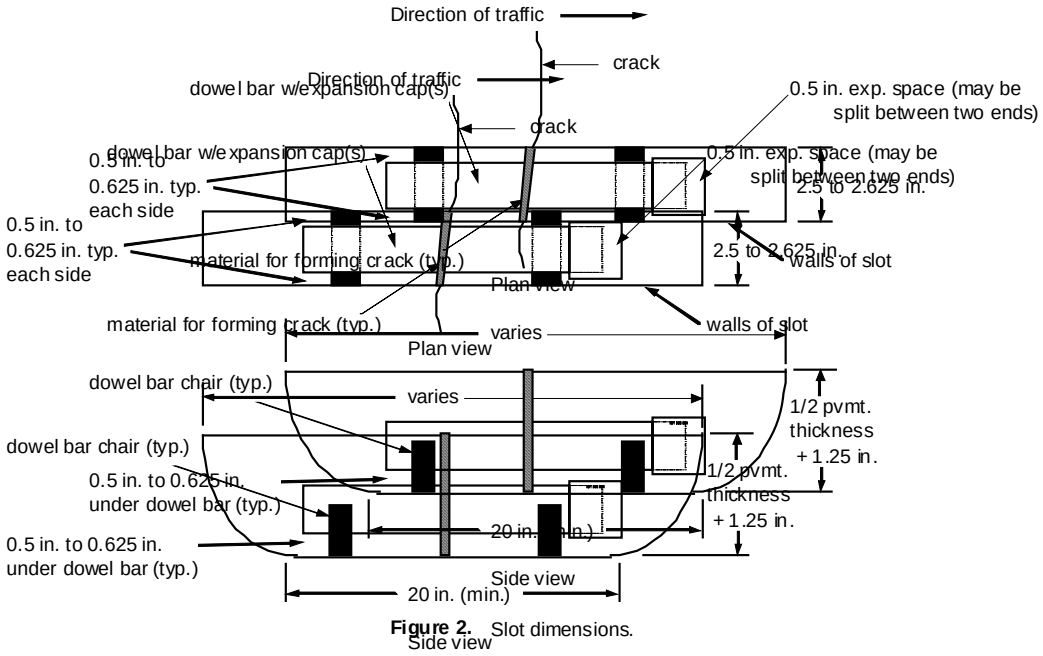


Figure 2. Slot dimensions.

Materials & Workmanship Warranty

a. Description. The materials and workmanship pavement warranty shall consist of the warranty bond and the terms of this special provision, including the appendix. This special provision establishes the common terms and definitions applied to all pavement projects requiring a warranty (the warranted work). The appendix contains information unique to each pavement fix. The Materials & Workmanship Pavement Warranty warrants the Department against defects in materials and workmanship.

b. Definitions.

1. Materials & Workmanship Warranty - The Contractor is responsible for correcting defects in the pavement caused by elements within the Contractor(s) control (i.e., the materials supplied and the workmanship), during the warranty period. Since the Department is responsible for the pavement design, the Contractor assumes no responsibility for defects that are design related. If a defect is attributable to both,

the materials and/or workmanship, and the design, responsibility for correcting the defect shall be shared by the Department and the Contractor; the Contractor is responsible for the percentage of fault attributable to the workmanship and/or materials, and the Department is responsible for the percentage of fault attributable to the design.

2. Acceptance Date of Construction - The date when the warranted work is complete and confirmed in writing on the initial acceptance document, by the Department, to be in compliance with the contract specifications and is open to traffic. This is the date of initial acceptance and constitutes the start date for the warranty period. There may be more than one acceptance date of construction for a project.

3. Warranty Bond - A bond issued by a surety which guarantees that the warranty requirements will be met.

4. Conflict Resolution Team (CRT) - The five-person team responsible for resolving disputes between the Department and the Contractor regarding any claim of non-compliance with the warranty requirements.

5. Driving Lane(s) - The delineated pavement surface used by traffic and the portion of the pavement considered warranted work. Each of the following is considered a separate driving lane.

   - Each individual mainline lane.
   - The sum of all ramp lanes and the associated acceleration/deceleration lanes is considered a separate driving lane.
   - The sum of all auxiliary lanes, such as passing lanes and turnlanes, is considered a separate driving lane.

   Approaches, driveways, shoulders and adjoining transition tapers between various types of pavement are not considered driving lanes for the purpose of this provision.

6. Warranty Work - Corrective action taken to bring the warranted work into contract compliance.

c. Initial Acceptance. The Department and the Contractor shall jointly review all completed warranted work, or a portion thereof, as determined by the Department. If the work does not meet contract requirements, the Contractor shall make all necessary corrections, at their expense, prior to initial acceptance. Initial acceptance will occur as soon as the Department confirms in writing, on the initial acceptance form, that contract requirements have been met for the warranted work. The date on which initial acceptance occurs is termed the Acceptance Date of Construction.

Initial acceptance will be documented and executed jointly by the Department and the Contractor on a form furnished by the Department. A copy of the form will be sent to the Contractor(s) warranty bond surety agent by the Department. Neither the initial acceptance nor any prior inspection, acceptance or approval by the Department, diminishes the Contractor(s) responsibility under this warranty.

The Department may accept the work and begin the warranty period, excluding any area needing corrective work, to accommodate seasonal limitations or staged construction.

Acceptance of material, in penalty, under the Department(s) quality assurance program will not relieve the Contractor from meeting the material and workmanship warranty requirements for the accepted material.

d. Warranty Bond. The Contractor shall furnish a single term warranty bond, in an amount stipulated in the appendix, prior to contract award. The effective starting date of the warranty bond shall be the Acceptance Date of Construction. The warranty bond will be released at the end of the warranty period or after all warranty work has been satisfactorily completed, whichever is latest.

e. Rights and Responsibilities of the Department. The Department:

1. Reserves the right to approve the schedule proposed by the Contractor to perform warranty work.
2. Reserves the right to approve all materials and specifications used in warranty work.
3. Reserves the right to determine if warranty work performed by the Contractor meets the contract specifications.
4. Reserves the right to perform, or have performed, routine maintenance during the warranty period, which routine maintenance will not diminish the Contractor(s) responsibility under the warranty.
5. Reserves the right, if the Contractor is unable, to make immediate emergency repairs to the pavement to prevent an unsafe road condition as determined by the Department. The department will attempt to notify the contractor that action is required to address an unsafe condition. However, should the contractor be unable to comply with this requirement, to the Department(s) satisfaction and within the time frame required by the Department, the Department will perform, or have performed any emergency repairs deemed necessary. Any such emergency repairs undertaken will not relieve the contractor from meeting the warranty requirements of this Special Provision. Any costs associated with the emergency repairs will be paid by the Contractor if it is determined the cause was from defective materials and/or workmanship.
6. Is responsible for monitoring the pavement throughout the warranty period and will provide the Contractor all written reports of the surface treatment(s) condition related to the warranty requirements. The Contractor shall not be relieved of any responsibility based upon a claim that the Department failed to adequately monitor the pavement or to report its findings to the Contractor.
7. Is responsible for notifying the Contractor, in writing, of any corrective action required to meet the warranty requirements.

f. Rights and Responsibilities of the Contractor. The Contractor:

1. Shall warrant to the Department that the warranted work will be free of defects in materials and workmanship. The warranty bond shall be described on a form furnished by the Department. The completed form shall be submitted to the Department prior to award of contract.

2. Is responsible for performing all warranty work including, but not limited to, maintaining traffic and restoring all associated pavement features, at the Contractor(s) expense.

3. Is responsible for performing all temporary or emergency repairs, resulting from being in non-compliance with the warranty requirements, using Department approved materials and methods.

4. Shall notify the Department and submit a written course of action for performing the needed warranty work a minimum of ten calendar days prior to commencement of warranty work, except in the case of emergency repairs as detailed in this special provision. The submittal must propose a schedule for performing the warranty work and the materials and methods to be used.

5. Shall follow a Department approved maintaining traffic plan when performing warranty work. All warranty work shall be performed under permit issued by the Region Utilities & Permits Engineer.

6. May be responsible for reimbursing the Department a portion of any incentive payments paid to the Contractor for early completion of the original work. Reimbursements will be required if the proposed maintaining traffic plan for corrective action requires lane closures during peak hour traffic. Peak hours will be determined by the Region Traffic and Safety Engineer. The daily reimbursement amount shall not exceed twenty five percent of the original daily earned incentive payment. The Department shall determine the actual percentage on a project by project basis.

7. Shall furnish to the Department, in addition to the regular performance and lien bond for the contract, supplemental performance and lien bonds covering any warranty work being performed. These supplemental bonds shall be furnished prior to beginning any warranty work, using Department approved forms. These supplemental bonds shall be in the amount required by the Department to cover the costs of warranty work.

   Shall complete all warranty work prior to conclusion of the warranty period, or as otherwise agreed to by the Department.

   Shall be liable during the warranty period in the same manner as contractors currently are liable for their construction related activities with the Department pursuant to the standard specifications, including, but not limited to subsections 103.06, 107.10 and 107.11. This liability shall arise and continue only during the period when the Contractor is performing warranty work. This liability is in addition to the Contractor performing and/or paying for any required warranty work, and shall include liability for injuries and/ or damages and any expenses resulting there from which are not attributable to normal wear and tear of traffic and weather, but are due to non-compliant materials, faulty workmanship, and to the operations of the Contractor as set forth more fully in subsections 103.06, 107.10 and 107.11 of the standard specifications.

g. Evaluation Method. The Department will conduct pavement evaluations by dividing the project into segments. Each individual driving lane will be divided into segments of 100 contiguous sets of slots as defined in the Appendix. Evaluation will include use of both

the Department(s) Pavement Management System and/or field pavement condition reviews. This evaluation may be waived in emergency situations.

The beginning point for laying out segments will be the Point of Beginning (POB) of the project. Segments will be laid out consecutively to the Point of Ending (POE) of the project. The original segmentation of the project will be used for all successive reviews throughout the warranty period.

h. Warranty Requirements. Warranty work will be required when the following two criteria are met as a result of a defect in materials and/or workmanship.

Criterion 1 -The threshold limit for a condition parameter is exceeded, and

Criterion 2 - The maximum allowable number of defective segments is exceeded for one or more condition parameters for a driving lane.

Specific threshold limits and segment limits are covered in the appendix.

To determine whether the failure to meet the warranty criteria is a result of defects in materials and/or workmanship, a joint field investigation by the Department and the Contractor will be conducted. The Department and Contractor may elect to have a forensic investigation conducted. The decision to undertake a forensic investigation, the scope of it, and the selection of the party to conduct it will be agreed to by the Department and the Contractor. The forensic investigation will be conducted following the Material and Workmanship Forensic Investigation Procedure. If agreement cannot be reached a Conflict Resolution Team (CRT) may be convened in accordance with this special provision. The CRT will then decide the need for a forensic investigation, its scope and the party to conduct the investigation. All costs related to the forensic investigation will be shared proportionately between the Contractor and the Department based on the determined cause of the condition.

During the warranty period, the Contractor will not be held responsible for pavement distresses that are caused by factors unrelated to materials and workmanship. These include, but are not limited to: chemical and fuel spills, vehicle fires, snow plowing, and quality assurance testing such as coring. Other factors considered to be beyond the control of the Contractor which may contribute to pavement distress will be considered by the Engineer on a case by case basis upon receipt of a written request from the Contractor.

i. Conflict Resolution Team. The sole responsibility of the Conflict Resolution Team (CRT) is to provide a decision on disputes between the Department and the Contractor regarding application or fulfillment of the warranty requirements. The CRT will consist of five members:

- Two members selected, and compensated by the Department.
- Two members selected and compensated by the Contractor.
- One member mutually selected by the Department and the Contractor. Compensation for the third party member will be equally shared by the Department and the Contractor.

If a dispute arises on the application or fulfillment of the terms of this warranty, either party may serve written notice that appointment of a CRT is required.

At least three members of the CRT must vote in favor of a motion to make a decision. The CRT may decide to conduct a forensic investigation, will determine the scope of work and select the party to conduct the investigation. All costs related to the forensic investigation will be shared proportionately between the Contractor and the Department based on the determined cause of the condition.

j. Emergency Repairs. If the Department determines that emergency repairs are necessary for public safety, the Department or it(s) agent may take repair action. Emergency repairs must be authorized by the Region Engineer.

Prior to emergency repairs, the Department will document the basis for the emergency action. In addition, the Department will preserve evidence of the defective condition.

k. Non-Extension of Contract. This Special Provision shall not be construed as extending or otherwise affecting the claim process and statute of limitation applicable to this Contract.

l. Measurement and Payment. All costs, including engineering and maintaining traffic costs, associated with meeting the requirements of this special provision are considered to be included in the Contract unit prices for the warranted work items regardless of when such costs are incurred throughout the warranty period. These costs include but are not limited to, all materials, labor and equipment necessary to complete required warranty work.

MATERIALS & WORKMANSHIP WARRANTY APPENDIX FOR
DOWEL BAR RETROFIT FOR LOAD TRANSFER
ACROSS CRACKS IN PCC PAVEMENT

A1. Application. This appendix applies to project warranties involving dowel bar retrofitting across cracks in portland cement concrete pavements.

A2. Limits of Warranted Work. The warranted work includes all dowel bar retrofits within the project limits, unless otherwise indicated in the contract documents.

A3. Warranty Term. The warranty term shall be two years from the date of initial acceptance otherwise termed the Acceptance Date of Construction.

A4. Warranty Bond. The warranty bond amount shall be an amount equal to 100 percent of the contract total for dowel bar retrofitting.

A5. Condition Parameters. Condition parameters are used to measure the condition of the dowel bar retrofits during the warranty term. Each condition parameter has a threshold level with a maximum number of defective segments allowed before corrective action (warranty work) is required. Definitions are as follows:

Slot - An individual dowel bar retrofit location consisting of a dowel bar and the patching material.

Set - A group of three or more slots across one wheelpath in a driving lane.

Segment - One hundred contiguous sets regardless of pavement length. The final segment in each lane may contain fewer than one hundred sets.

Spalling - Broken or missing pieces of concrete on the slot(s) surface or along the slot(s) perimeter that protrudes a minimum of ½ inch into the adjoining pavement or slot.

Scaling - A visible, exposed, rough texture on the slot(s) surface from a loss of either aggregate or mortar.

Broken Slot - Excluding the relief crack, the slot backfill is visibly cracked/broken. The pieces may or may not be susceptible to being dislodged. The relief crack is a single crack that very closely matches up on either side of the slot with the original crack in the adjoining pavement.

Punchdown - Pieces of the cracked/broken slot patching material and/or adjoining pavement have dropped below the pavement surface within a set location.

Associated Crack - A crack, other than the repaired crack, that extends from a slot through the adjoining pavement to the pavement edge/joint, or between slots, which may or may not be associated with a cracked/broken slot.

A6. Warranty Requirements. Table 1 lists the allowable threshold limit and the maximum number of allowable defective segments for each condition parameter. The defective segments do not have to be contiguous and apply to each driving lane per travel direction. Corrective action (warranty work) is required when the maximum number of allowable defective segments is exceeded.

Table 1. Warranty Requirements

Condition Parameter	Threshold Limits Per Segment	Max. allowable defective segments per lane (4)
Spalling (1)	8 slots	2 or 10%
Scaling (2)	8 slots	3 or 5%
Broken Slot	5 slots (3)	2 or 10%
Associated Crack	3 sets	2 or 10%
Punchdown	2 sets	1 or 5%

Notes:
(1) = Min. 10% slot surface area or 12 inches of the slot perimeter is affected
(2) = Min. 10% slot surface area (> ½ inch depth at any point) is affected
(3) = Threshold is 3 slots, if broken pieces have been dislodged
(4) = Use whichever number is higher. Round down to the nearest whole number after the percentage is applied.

A7. Corrective Action. Table 2 lists suggested treatments to correct a defective condition parameter. The Department will accept the listed corrective action if it addresses the cause of the distress. The Contractor may suggest an alternative corrective action subject to the Engineer's approval.

Table 2. Suggested Corrective Actions

Condition Parameter	Recommended Action
Spalling	Repair Slot Patching Material(1)
Scaling	Repair Slot Patching Material(1)
Broken Slot	Remove and Replace (2)
Associated Crack	Variable Fix (3)
Punchdown	Full-Depth Repair (4)

Notes:

(1) = Regardless of condition, the entire surface of the slot backfill is removed to a minimum 1 inch depth. Replacement backfill is the same as existing with no aggregate extension.
(2) = The slot is completely removed and replaced.
(3) = Repair is dependent on severity of crack and associated effects on the slots. Crack can be sealed if less than 1/16 inch width with no evidence of punchdown and the pavement is reinforced. If any slots in a set are broken or the crack extends across both wheelpaths, the condition requires a full-depth, full-width repair across the lane. Other intermediate conditions are subject to the Engineer=s discretion.
(4) = Repair is made full-depth across the entire lane width.

MICHIGAN DEPARTMENT OF TRANSPORTATION
INITIAL ACCEPTANCE FOR
PAVEMENT WARRANTY

CONTRACT ID:_____

CONTRACT SECTION:_____ JOB NUMBER: _____

SURETY NAME:_____

SURETY ADDRESS:_____

CONTRACTOR NAME:_____

CONTRACTOR ADDRESS:_____

IDENTIFY EACH JOB NUMBER, LOCATION AND WORK SEPARATELY

JOB NUMBER	ROUTE NUMBER	CONTROL SECTION	WORK TYPE	DATE ACCEPTED	PROJECT ENGINEER

INITIAL ACCEPTANCE OF WARRANTY WORK APPROVAL

CONTRACTOR=S SIGNATURE:

_____

ENGINEER=S SIGNATURE:

_____

ACCEPTANCE DATE:

_____

cc: Surety Company, Financial Services - Payments

MICHIGAN
DEPARTMENT OF TRANSPORTATION
PAVEMENT WARRANTY BOND

Bond Number _____

KNOWN ALL MEN BY THESE PRESENTS:

That we,_____(hereinafter called the APrincipal@), and _____, a corporation duly organized under the laws of the State of _____ and duly licensed to transact business in the State of Michigan (hereinafter called ASurety@), are held and firmly bound unto the Michigan Department of Transportation (hereinafter called the AObligee@), in the sum of Dollars ($), for the payment of which sum well and truly to be made, we, the said Principal and the said Surety, bind ourselves, our heirs, executors, administrators, successors and assigns , jointly and severally, firmly by these presents.

WHEREAS, the said Principal has heretofore entered into a contract with the Michigan Department of Transportation dated _____under Contract ID and;

WHEREAS, the said Principal is required to guarantee the installed under said contract, against specific pavement defects which may develop during the period(s) of years beginning the date(s) of the Acceptance Date of Construction by the Obligee.

In no event shall losses paid under this bond aggregate more than the amount of the bond.

NOW, THEREFORE, THE CONDITION OF THIS OBLIGATION IS SUCH, that if said Principal shall faithfully carry out and perform the said guarantee, and shall, on due notice, repair and make good at its own expense any and all specific pavement defects in the said work which may develop during the period specified above or shall pay over, make good and reimburse to the said Obligee all loss and damage which said Obligee may sustain by reason of failure or default of said Principal so to do, then this obligation shall be null and void; otherwise shall remain in full force and effect.

PROVIDED HOWEVER, that in the event of any default on the part of said Principal, a written statement of the particular facts showing such default and the date thereof shall be delivered to the Surety by registered mail, within thirty (30) days after the Obligee or his representative shall learn of such default and that no claim, suit or action by reason of any default of the Principal shall be brought hereunder after the expiration of thirty (30) days from the end of the warranty period as herein set forth.

Signed this _____ day of _____, _____.

Contractor

_____

By

_____

Surety _____

_____

By Attorney-In-Fact

MINNESOTA

This work shall consist of dowel bar retrofitting in accordance with the applicable Mn/DOT Standard Specifications, as shown in the Plans and the following:

MATERIALS

(A) The Contractor shall use a "Mn/DOT Approved Non-Shrink Rapid Set Concrete Material for Dowel Bar Retrofit Repairs" conforming to ASTM C 928 and the requirements on file in the Mn/DOT Concrete Engineering Unit. The list of approved products may be found on the Mn/DOT Concrete website at www.mrr.dot.state.mn.us/pavement/concrete/concrete.asp or by contacting the Concrete Engineering Unit. This material may be extended with CA-80 as specified by the manufacturer, as backfill material. Other non-shrink rapid set material may be used if approved by the Concrete Engineering Unit. Any material submitted for approval must be received by the Concrete Engineering Unit a minimum of 30 days prior to the start of work. Any material submitted after that time will not be evaluated.

(B) The release agent used to provide a bond break on the dowel bars shall be a liquid membrane-forming compound conforming to Mn/DOT 3902; e.g., "Duo Guard" by W.R. Meadow or an approved equal. The material shall be applied to the dowel bars prior to their placement in the slots.

(C) After the concrete is removed from the slot, the bottom and sides of the crack shall be sealed with a Mn/DOT approved silicone joint sealant material and allowed to cure for a minimum of 2 hours or until it is tack free (according to the manufacturer's recommendations) prior to placing the patching material. This should be done in a manner sufficient to keep the patching material from leaking into the crack/joint.

(D) The 1¼ inch by 15 inch dowel bars shall be plain steel bars that are 100% epoxy coated on all surfaces and shall conform to Mn/DOT 3302.

The dowel bars shall be provided with tight fitting, clear plastic end caps that will allow for a ¼ inch expansion movement of the bar at each end. The Contractor shall submit samples to the Engineer for approval prior to ordering the end caps.

(E) Compressible foam core board constructed of closed cell foam and faced with poster board material shall be used to reestablish the crack/joint the full width and depth of the slot, as shown in the Plan detail. The material shall be at least ¼ inch thick and a minimum of ⅛ inch thicker than the crack/joint at the surface to ensure no leakage of patching material into the crack. Multiple pieces will not be permitted to obtain the proper thickness. The Contractor shall submit a sample to the Engineer for approval prior to use.

(F) Each dowel bar shall be provided with two, nonmetallic support chairs similar to those shown in the Plans. The support chairs shall provide a minimum of ½ inch clearance between the bottom of the dowel and the bottom of the slot. The Contractor shall submit samples of the supports to the Engineer for approval prior to ordering the support chairs.

(G) Immediately after final finishing, all concrete shall be coated with a modified membrane cure. The material shall meet the requirements of Mn/DOT 3754AMS. Hudson sprayers may be allowed on a performance basis if the coverage rate is doubled and the curing material is from an agitated source. Water based curing compounds shall not be used.

GENERAL CONSTRUCTION REQUIREMENTS

(A) The Contractor shall provide a test operation consisting of complete dowel bar retrofit at a site directed by the Engineer prior to start up of major operations. There will be 24 retrofit dowels in the test operation. 24 hours after completion of the test operations, the Contractor shall take three (3) 6 inch diameter full depth cores as directed by the Engineer to determine the completeness of the removal and installation operations. If the placement is in accordance with the Plans, the Mn/DOT Standard Specifications and these Special Provisions; and if the Contractor's retrofitting operation has not damaged the surrounding in place concrete; then, upon approval from the Engineer, the Contractor may begin production operations and shall proceed on a performance basis. Complete removal and replacement of the dowel installation will be necessary where the core samples are taken. The work in this paragraph shall be paid at the unit price for dowel bar retrofit. The working days for the test section are built into the total Contract Time.

If approval of the retrofitting operation is not given, the Engineer may order the Contractor to change their operations and complete another test operation to determine if the Contractor's changes are acceptable. All costs for the additional test section shall be borne by the Contractor. Contractor time will not be extended for the additional test section. For example, if the Contractor chooses to mill the slot for the retrofit and the mill cracks the in place concrete underneath the slot or does unacceptable damage to the pavement surface, the Engineer will order a different piece of equipment for the removal operation.

Traffic control for the test operation shall be in accordance with "Temporary Traffic Control Zone Layouts" or as shown in the Plans. Complete removal and replacement of the dowel installation will be necessary where the core samples were taken. The work in this paragraph shall be incidental to the Contract and no direct payment will be made.

(B) The Contractor shall dowel bar retrofit the {insert project direction here} mainline joints and/or mid panel cracks on {insert highway here}.

(C) The slot shall be parallel with the centerline and surface of the in place roadway. Pickup and removal of debris concrete shall be immediate. It shall include the use of a high power, mobile, vacuum cleaning machine capable of removing all displaced material with a minimum of dust. Approximate slot dimensions are:

26 inches by 2½ inches at the pavement surface
16 inches by 2½ inches at the bottom of the slot

(D) All removed material or material generated by the Contractor's operations of any kind shall be disposed of off the Right-of-Way in accordance with Mn/DOT 2104.3C3.

(E) The Contractor shall use equipment approved on a performance basis by the Engineer to ensure that the bottom of the slot is flat. If jackhammers are used in removal, they shall be limited to a weight of 30 pounds or less.

The bottom of the slots should be sufficiently cleaned with a jackhammer to allow the dowel bar assembly to sit parallel to the pavement surface.

(F) All slots in each wheel path of a mid panel crack or joint shall be sawn at the same time. Depth shall be at the dimension shown in the Plan with a tolerance of ⅛ inch. The Contractor must be aware that due to the skew of the cracks that it is anticipated that the length of the slot will usually be longer than that shown in the Plans. No additional compensation will be made for this additional length for any component of the dowel bar retrofit. If the Contractor uses a saw to cut the slot, the saw shall have a minimum of two blades sawing concurrently on each slot. If under breaking of the slab occurs, three or more blades will be required.

(G) Any water residue or saw slurry created by removal operations shall be contained and vacuumed immediately from the road surface.

(H) The Contractor shall sandblast the slot after the concrete removal operations are complete to remove any loosened material and to roughen the side faces of the slot. There should be no evidence of sawing residue on the vertical sawed faced or bottom of the slot. The vertical sawed faces should be rough to the touch after sand blasting. The Contractor may recommend alternative methods for said roughening for approval by the Engineer. Additional sandblasting will be required if the slots become wet from any source after initial sand and air blasting.

(I) All exposed surfaces and cracks shall be further cleaned with a “moisture and oil free” high pressure air-blasting lance (100 psi minimum) immediately before beginning the sealing work. The Contractor shall protect traffic from sand and air blasting in a manner approved by the Engineer on a performance basis.

(J) Immediately prior to placement of the dowel bar and filler material, the Contractor shall seal the existing transverse joint/crack within the slot as shown in the Plans. The silicone sealant shall be placed so as to provide a smooth surface and tight fit for the compressible foam core board. The joint/crack shall be sealed sufficiently to prevent any of the grouting material from entering the crack.

(K) Dowel bars shall be lightly coated with an approved release agent, fitted with the compressible Styrofoam or cardboard material, the support chairs and the ¼ inch expansion caps on both ends just prior to installation. The dowel bars shall be placed parallel to the centerline and pavement surface, all to a tolerance of ⅛ inch.

(L) Chairs for supporting and holding the dowel bar shall hold the dowel bar in place during placement and consolidation of the concrete placement and vibratory consolidation. If the bar exceeds the ⅛ inch tolerance mentioned above after all operations are completed, the dowel bar installation shall be removed and replaced at the Contractor’s expense.

(M) The compressible foam core board shall be placed to maintain the transverse crack as shown in the Plans. The filler material shall remain in position and tight to all edges during placement of the concrete. If the filler material shifts, for any reason, during

construction operations, the dowel bar installation shall be removed and replaced at the Contractor's expense.

(N) The approved non-shrink rapid set concrete material shall be placed in the slot. All concrete placed in the slots shall be vibrated with a "spud' type vibrator prior to finishing to insure proper consolidation. The finished concrete shall be flush with the adjacent in place concrete with a tolerance of 1/16 inch high and 0 inches low.

(O) If for any reason, shrinkage cracks occur in the repair after placement, the work will be rejected and completely redone at the Contractor's expense.

(P) Traffic by the public or Contractor will not be permitted on the newly placed concrete patching material until adequate strength has been achieved, according to the manufacturer's recommendations. No traffic will be permitted until the complete operation is finished and approval is granted by the Engineer.

(Q) Any damage to the pavement, joints, or shoulders due to the Contractor's operations shall be repaired by the Contractor at their expense.

MEASUREMENT

The Dowel Bar Retrofit will be measured per each except as noted above for unacceptable work.

PAYMENT

Payment for Dowel Bar Retrofit will be made in accordance with the schedule set forth below at the appropriate Contract bid price for the specified unit of measure. Such payment, in each instance, shall be compensation in full for completing the work as specified including, but not limited to, removing the concrete, removing and vacuuming debris, sand and air blasting, sealing, the dowel bar, release agent, chairs, compressible Styrofoam or cardboard material, end caps, non-shrink rapid setting concrete mixture, curing compound, cleanup and any other materials, labor, or equipment necessary to complete the work as specified.

907-509.01 DESCRIPTION

This work consists of retrofitting dowel bars into existing concrete pavement at locations designated on the plans, contract documents or as determined by the Engineer.

907-509.02 MATERIALS

Materials shall meet the requirements of Subsection 700.01 and the following Subsections of Division 700, Materials and Tests.

Fine Aggregate	703.01 and 703.02
Coarse Aggregate	703.01 and 703.03
Water	714.01
Concrete Reinforcement Bars	711.02
Curing Materials	713.01

Debonding Agent. The debonding agent shall be a liquid membrane-forming compound that conforms to the requirement of AASHTO Designation: M 148 Type 1 D or 2, Class A or B.

Dowel Bars. In addition to the requirements of Section 711, the dowel bars shall be smooth 1¼ inch steel bars.

The dowel bars shall have tight fitting end caps, 1½ inches in length, made of non-metallic materials that will allow for a ¼ inch movement of the bar at each end. The Contractor shall submit the Engineer samples of the end caps for approval prior to use.

Joint Filler. The caulk used to fill the existing joint adjacent to the slot and over the filler board, will be a silicone sealant. The silicone sealant shall meet the requirements of Subsection 707.02.1.4. The joint insert material shall be made of ¼ inch thick Styrofoam or fiberboard filler material.

Backfill Material. Backfill material shall be one of the following products or an approved equal. The materials shall be proportioned, mixed and applied in accordance with the manufacturer's recommendation.

Celtite 42-36 (Patching)	Celtite, Inc.
Colma-Dur Gel (Grout & Patching)	Sika
Duracal A. G. (Patching)	U. S. Gypsum Co.
Durapatch HiWay (Patching)	L & M Const. Chem.
DUR-O-WAL CP20	DUR-O-WAL, Inc.
Euco Speed (Patching)	Euclid Chemical
Five Star Highway Patch	Five Star Products, Inc.
Five Star Structural Concrete	Five Star Products, Inc.
Five Star Mag-Phos (Structural Patching)	Five Star Products, Inc.
Futura Rapid Set Conc., Patch	W. R. Meadows (Sealtight)
H. P. Binder, HP-GPA or HP-LV (Grout & Patching)	Hunt Process
HILTI RM-800 Concrete Repair Mortar	HILTI, Inc.
Horn 240 Concrete (Patching)	A. C. Horn, Inc./Tamms
HD-50 Heavy Duty Conc. Patch (Patching)	American Highway Technology (Dayton Superior Corp.)
HD-DOT Patch	Symons (Dayton Superior Corp.)

ThoRoc 10-60 Rapid Mortar	Harris Specialty Chemicals, Inc.
Pike Patch (Patching)	Preco Ind., LTD.
Pilgrim Em 5-2	Pilgrim Permacoat, Inc.
Poly-Carb "Mark 24" (Grout & Patching)	Poly-Carb, Inc.
Pro Grout 90	C. G. M., Inc.
Pro-Poxy 204	UNITEX
Pyrament 505 & PBC	Lone Star Industries, Inc.
Rapid Road Repair	Quikrete Companies
Rapid Set Cementitious Material	CTS Cement Mfg. Co.
Rapid Set Concrete Mix	CTS Cement Mfg. Co.
Re-Crete 5 min. set (Grout & Patching) (All-Crete)	American Highway Technology (Dayton Superior Corp.)
Re-Crete 20 min. set (Grout & Patching) (All-Crete)	American Highway Technology (Dayton Superior Corp.)
Resurf CR	Polymer Conc., Inc.
Resurf II, III & IV (Patching)	Polymer Conc., Inc.
Roadpatch II (Patching)	Thoro Systems Products
Set Instant Conc. (Patching)	Master Builders, Inc.
Set Gout (Grout, Bonding Agent Req'd)	Master Builders, Inc.
Set 45 (Patching)	Set Products
Sikadur 32 HI-Mod. (Grout)	Sika Corp.
Silikal Polymer Concrete (Patching)	Transpo-Materials, Inc.
Stonecrete RPI & Nmi	Stonehard, Inc.

907-509.03 CONSTRUCTION REQUIREMENTS

Retrofitted dowel bars consist of cutting the slot, preparing the slot, placing the dowel bar, backfilling the slot, curing the backfill material and opening to traffic.

a) Cutting the Slots. Slots shall be cut to the dimensions shown on the plans or in the contract documents using a diamond saw slot cutter or an approved milling machine. If the Contractor opts to use a milling machine, the Contractor shall prove to the Engineer that the equipment is capable of removing the slot with minimal damage to the remaining pavement. Either method of remove shall have a positive method of assuring that the slot is aligned parallel to centerline. The slots shall then cleaned, to the satisfaction of the Engineer, to remove any saw slurry or concrete pieces.

The diamond saw slot cutters shall make at least two parallel cuts for each dowel slot, leaving a fin of concrete in between that must be broken out after the sawing. The saw head shall be placed behind the joint, plunged into the concrete and advanced forward across the joint. More than one pass may be required to get the slot to the required depth. The slot must be long enough to allow the dowel to lie across the bottom of the slot without the ends hitting the curvature of the saw cut. After the slots are cut, traffic may be permitted on the pavement over night or as soon as possible thereafter, but in no case to exceed two (2) days. The fins should be removed, the dowel placed and the slot backfilled as soon as possible. No work will be allowed on the adjacent lane while traffic is allowed on unrepaired slots.

When the slots are formed by a milling machine, the milling head shall also be placed before the joint, plunged into the concrete and moved forward across the

joint. The length of the slot should be the same as for sawcut slots. Because the milling operation creates an open slot, traffic will not be permitted on the pavement until the entire dowel retrofitting process is complete.

The dimensions of the slot shall be that shown on the plans or in the contract documents with a longitudinal and transverse tolerance of 3/16 inch. The depth of the slot shall be approximately 1¼ inches lower than half the slab thickness (T/2 + 1¼ inches), so that when dowels placed in slots on chairs, it will allow approximately ½ inch of backfill material will flow completely under the dowel bar.

b) Preparing of the Slots. Preparing the slots constructed with diamond saws consists of removing the concrete fins, flattening the bottom, cleaning the slot and caulking the joint under and around the slot.

Slots being created by using a diamond saw slot cutter will require the removal of the concrete fin(s) between the saw cuts. Small hand-held jackhammers (30 lbs. or less) should be used to remove the fins. Larger jackhammers will not be allowed. The Contractor should start the removal with the jackhammer at the end of the fin and jackhammer down and along the bottom of the saw cuts. or place the jackhammer along the side of the slot and break off the fin. Once the fin is removed, the bottom shall be flattened with a small hammerhead on a small jackhammer to assure that nothing will keep the dowel bar from lying level and interfering with proper dowel alignment.

The slot shall be cleaned before the dowel bar and backfill material are placed. Slot cleaning consists of sandblasting to remove sawing slurry and roughen the sides to improve the bond and then airblasting the slot sides and bottom to remove any loose debris. If touching the slot sides or bottom with your fingers reveals that dust or laitance is still present, the slot must be recleaned.

The final step in slot preparation is caulking the joint on the bottom and sides of the slot. This keeps the backfill material from flowing down into the joint and later inhibit slab expansion.

c) Placing the Dowel Bars. The smooth dowels bar shall be installed in accordance with the detail shown in the plans, contract documents and set out herein dowel bars used for dowel bar retrofit are the same as those used in new concrete pavement construction with a few modifications. The dowel bar shall be a 1¼ inch smooth bar. Before the dowel bar is placed in the slot, it shall be fitted with a non-metallic or epoxy-coated expansion cap on both ends to allow for an expansion on ¼ inch. The dowel bar shall be placed through a Styrofoam or fiberboard joint insert, then attached to chairs that may be either non-metallic or epoxy-coated. The chairs shall be of a size necessary to hold the dowel at least ½ inch above the bottom of the dowel slot so that the backfill material may flow completely under the dowel.

The dowel shall be coated with an effective debonding agent so that it can move horizontally after the backfill material has hardened. The debonding agent must be placed on the dowel bar before the dowel is placed in the slot. Care must be taken to prevent the debonding agent from falling onto the slot sides or bottom, as this will prevent the backfill material from bonding to the concrete.

The dowel bar shall be inserted in the slot so that the chair legs are in the sawcut kerfs or milled edges at the bottom of the slot. This maintains proper dowel alignment by keeping the dowel horizontal and parallel to the pavement centerline and surface. The joint insert shall be placed over the joint with half of the dowel length on each side of the joint. The legs and sides of the chairs should be snug against the slot wall. This keeps the dowel from moving and becoming misaligned during placement of the backfill material.

d) Backfilling the Slot. The backfill material shall be placed in the slots and consolidated with a small vibrator. Care must be taken not to hit the dowel with the vibrator. After consolidation, the backfilled slots shall be broom finished and cured with curing compound or an approved method. After the backfill material has cured and prior to opening to traffic, the top one inch of the joint insert shall be removed and replaced with silicone sealant.

Opening to Traffic. The lane may be opened to traffic after a minimum of 72 hours or when the backfill material has gained a minimum compressive strength of 2500 psi.

907-509.04 METHOD OF MEASUREMENT

Retrofitted dowel bars into existing pavement will be measured per each.

907-509.05 BASIS OF PAYMENT

The quantity of retrofitted dowel bars, complete in place, accepted and measured as prescribed, will be paid for at the contract unit price per each and shall be full compensation for furnishing all labor, materials and equipment necessary for any sawing, milling, cleaning, dowel bars, backfilling, joint filling, sealing, etc. to complete the work.

613.40.1 DESCRIPTION OF WORK

This work shall consist of sawing partial depth slots across cracks, cleaning the slots, placing dowel bars in the slots, placing a joint forming insert to reestablish the crack and backfilling the slots with concrete.

613.40.2 MATERIAL

613.40.2.1 Repair Material. Rapid set concrete patching material shall be used. Prior to use, the material shall be approved by Construction and Materials. Material having completed current testing through AASHTO's NTPEP will be considered for qualification upon submittal of a written request by the manufacturer with accompanying documentation. The material shall be handled, prepared and mixed in accordance with the manufacturer's recommendations. The contractor shall supply a manufacturer's certification to the engineer for each lot of material furnished. Certification shall include the name of the manufacturer and a manufacturer's certification statement that the material supplied is the same as the material that was qualified.

613.40.2.2 Dowel Bars. Dowel bars shall be 1½ x 18 inches and in accordance with Sec 1057, except the entire dowel bar shall be coated.

613.40.2.3 Expansion Caps for Dowel Bars. Caps shall be tight fitting and made of ¼ inch thick non-metallic material that will allow ¼ inch movement at each end of the dowel bar.

613.40.2.4 Joint Insert. To re-establish the crack, a compressible insert, in accordance with Sec 613.20.2.3, shall be used. The material shall fit tight around the dowel bar and to the bottom and edges of the slot. The material shall be capable of remaining in a vertical position and tight to all edges during placement of the repair material to prevent the concrete backfill from flowing into the existing crack and pavement voids.

613.40.2.5 Bar Chairs. Bar chairs may be metal epoxy-coated chairs or a non-metallic material.

613.40.3 CONSTRUCTION REQUIREMENTS.

613.40.3.1 Preparation of Slots. Two saw cuts shall be made in the pavement to outline the longitudinal sides of each dowel bar slot. The slots shall be sawed to a depth and length that allows the center of the dowel to be placed at mid-depth in the pavement slab. The slots shall be 2½ to 4 inches wide. The contractor shall provide a method, approved by the engineer, that will align the slots parallel to centerline of the roadway with a maximum variation of ⅛ inch from a true parallel line. Slots in a wheel path shall be created by using saws with gang-mounted diamond blades, capable of simultaneously making six saw cuts for three dowel bar slots at the desired slot spacing. Equipment shall not cause damage to the existing pavement. All saw slurry shall be removed from the slot and pavement. No water residue or paste shall be allowed to flow onto lanes open to traffic or into closed drainage systems. Pneumatic hammers used to remove the concrete remaining between the saw cuts shall not be larger than 15 pounds. If the concrete removal operations cause damage to pavement that is to remain, the concrete removal operations shall be discontinued and shall not resume until the contractor has taken corrective measures. The pneumatic hammer will not be permitted to break through the concrete and if this occurs, a full depth pavement

repair shall be conducted at the contractor's expense. The bottom of slots shall be flat. The edges of the slots shall be cleaned by blasting to produce a rough surface. Blasting operations shall not damage the surrounding pavement. The newly exposed concrete surface shall be free of spalls, burrs, latence and all contaminants detrimental to achieving an adequate bond. The maximum amount of spalling allowed on the edges of the slots will be ⅜ inch. Slots shall be long enough to place the dowel bars in the slots without the ends of the bars hitting the curved ends of the saw cut.

613.40.3.1.1 After the construction of a slot, the pavement shall not be opened to traffic until all six retrofit dowel bars are in place, cured and the work is completed at that location. The tires of construction vehicles will not be permitted to travel on slots where concrete has been removed.

613.40.3.1.2 Multiple saw cuts parallel to the centerline may be sawed to allow removal of material from the dowel bar slots and to provide a level surface for the feet of the dowel bar chairs.

613.40.3.1.3 All slots shall be cleaned with moisture-free, oil-free, compressed air to remove any remaining dust, residue, debris and moisture. The contractor shall then seal the existing transverse joint and all cracks at the bottom and the sides of the dowel bar slot with an approved caulking sealant to prevent any repair material from entering into these areas.

613.40.3.2 PLACEMENT OF DOWEL BARS, JOINT INSERTS AND REPAIR MATERIAL.

613.40.3.2.1 Prior to inserting a dowel bar in a slot, expansion caps shall be placed on each end of the bar. A dowel bar chair shall hold the bar firmly centered in the slot and at a minimum of ½ inch above the bottom of the dowel slot. The dowel bar chairs shall not allow movement of the dowel.

613.40.3.2.2 When placing the dowel bar in the slot, care shall be taken to avoid getting any graphite grease onto the sides or bottom of the slot. If the debonding agent on the dowel bar contaminates any of the surfaces of the slot, the dowel bar shall be removed and the slot sandblasted to remove the contamination.

613.40.3.2.3 The dowel bar shall be inserted into the slot such that the chair legs are in the saw cut kerfs at the bottom of the slot. The bars shall vary no more than ¼ inch from the pavement surface and shall be parallel to the centerline of the pavement. Bars shall be firmly centered in the slot at the midpoint of the pavement slab. The legs of the bar chairs shall be snug against the slot wall.

613.40.3.2.4 A joint insert shall be placed into the slot as a filler material to maintain the crack as shown on the plans. When in place, the insert shall extend from the bottom of the slot to no more than 1½ inches from the surface of the pavement, with half the dowel length extending on each side of the insert. If for any reason the insert or dowel bars shift during placement of the repair material, the work will be rejected and shall be redone at the contractor's expense.

613.40.3.2.5 Just prior to placement of the repair material, one or more passes of an air blast shall be used to provide a dust free, clean slot.

613.40.3.2.6 The rapid set concrete patching material shall be placed in the slot, consolidated, textured and cured as recommended by the manufacturer.

6.13.40.3.3 RESEALING CRACKS

After the concrete has initial set, the joint insert shall be removed to a minimum depth of ⅜ inch below the pavement surface by sawing. The reservoir shall then be filled with hot-poured, elastic-type, concrete joint sealer in accordance with Sec 1057.

6.13.40.3.4 OPENING TO TRAFFIC

Traffic shall not be permitted on the repaired pavement until the rapid set concrete patching material has attained a minimum compressive strength of 1600 psi, but shall be a minimum of 2 hours or the time recommended by the manufacturer.

6.13.40.4 BASIS OF PAYMENT

The accepted quantity for dowel bar retrofit will be paid for at the contract unit price per dowel bar, complete and accepted in place.

DESCRIPTION

Install epoxy coated dowel bars in the driving lane, on the transverse joints and transverse cracks in the existing portland cement concrete pavement as shown in the plans. Existing construction joints will not be dowel bar retrofitted. The dowels shall be placed after the concrete repair and prior to the diamond grinding operation. Below are the locations for dowel bar retrofit:

MATERIALS

Furnish materials meeting the following requirements:

Epoxy coated dowel bars, 1½ x 18 inches, shall conform to the requirements of Section 1022 in the Standard Specifications and Supplemental Specifications. Epoxy coating of the ends of the dowel bars is optional. The dowel bars shall be uniformly coated with an approved bond breaker in conformance with Paragraph 4 of Subsection 603.03.

The dowel bars shall have tight fitting end caps made of nonmetallic material that allow for at least ¼ inch bar movement at each end of the bar. Chair devices for supporting the dowel bars shall be either epoxy coated or made of nonmetallic material. The chair devices shall provide a minimum clearance of ½ inch between the bottom of the bar and the surface upon which the bar is placed and between the bar and the walls of the slot. The chairs shall be designed to prevent movement of the bar during placement of the grout. Samples of the end caps and chairs shall be submitted to the Engineer for approval before installation.

The caulking shall be a non-sag sealant approved by the Engineer before use.

The foam core board filler material shall be a closed cell foam faced with plastic film, foil or poster board material on each side. The foam core board filler shall be ⅜ ± ⅛ inch thick. The foam core board filler shall be approved by the Engineer before installation.

NON-SHRINK GROUT

The non-shrink grout placed around the dowel bars shall be one of the materials listed in the Approved Products List.

The grout may be extended as the manufacturer recommends. The aggregate for extending the grout must be a sand/gravel approved by Materials and Research Division and meeting the following gradation.

Sieve Size	Percentage Passing
⅜ in.	97 - 100
No. 200	0 - 2

The grout, with maximum aggregate extension, must meet the following strength requirements.

4-hour minimum compressive strength of 3000 psi
24-hour minimum compressive strength of 4500 psi
24-hour bond to dry PCC, 400 psi (California Test 551)

The contractor will furnish materials to be used for making the grout and the mix design, to Materials and Research Division 30 days prior to installation.

A minimum of one set of 3 cylinders will be made from each day's pour from the first grout produced. Additional sets can be made at anytime during grout production. When the lane will be opened to traffic at the end of the day's pour, cylinders shall also be made from the last grout produced and placed. These cylinders shall be tested at the age of 4 hours to verify that the minimum 4-hour compressive strength has been attained before opening to traffic. If minimum grout strengths are not being met, grouting operations shall be suspended until the contractor can demonstrate batch mixing and proportioning proficiency that meets the minimum strength required. Acceptance will be based on meeting the 24-hour minimum strength requirements.

CONSTRUCTION REQUIREMENTS

Slots shall be cut in the pavement with a gang saw capable of cutting at least three slots in each wheel path at a time. The slots shall be cut to the depth required to place the centers of the dowels at mid-depth in the concrete slab. Multiple saw cuts parallel to the centerline may be required to remove the material from the slot.

Jackhammers used to remove the concrete from the slots shall not be larger than the 30-pound class. Care shall be taken to prevent any damage to the pavement or to vehicles traveling in the adjoining lane.

All exposed surfaces and cracks in the slots shall be cleaned by sandblasting or hydroblasting before bar installation. The transverse contraction joint on the bottom and sides shall be filled with non-sag caulking filler.

Chair devices shall be used to support the dowel bars at the depth shown on the plans but shall provide not less than ½ inch clearance around the sides and bottom of the bar. Place the dowel bars parallel to the centerline of the pavement and parallel to the pavement surface. The dowel bars shall be placed within ± ¼ inch of the desired alignment. The dowel bars shall be centered over the transverse joint or crack so that a minimum of 7 inches of the dowel bar extends into the adjacent panel.

Cut a piece of foam core board material (angled if joints are skewed) to fit tightly around the dowel bar. The foam core board shall be placed at the center of the dowel bar flush with the surface of the concrete pavement, or slightly recessed. The foam board shall also cover the existing transverse joint or crack and shall be maintained in a vertical position, tight to all edges, during grout placement operations. The joint or crack above the foam board insert shall be re-established within 8 hours of grout placement by means of sawing when the grout has attained sufficient strength. If the foam board is flush with the pavement or visible, sawing of the slots will not be required.

The non-shrink grout shall be produced with a portable mixer approved by the Engineer. Mobile mixers, as defined by Section 1002.03, Paragraph 15 of the Standard Specifications for Highway Construction, may be used to proportion materials; however, the grout may not be mixed in the chute. The mixer must be capable of proportioning the grout material and automatically recording and printing the material weights. All grout shall be placed immediately after mixing and before the grout has attained initial set. The grout shall not be re-tempered with water.

The contractor shall thoroughly moisten all surfaces of the sawed slot immediately prior to filling with grout. All excess water shall be removed with compressed air.

Immediately after placement, the grout shall be thoroughly coated with white pigmented curing compound.

The grout shall be placed according to the manufacturer's recommendations. The grout shall be thoroughly consolidated with a hand held vibrator so the grout completely surrounds the dowel bars and support chairs. The grout shall be placed so that the material is at least ⅛ inch higher than the pavement if the pavement is to be diamond ground. If the pavement is not to be ground, the grout shall be finished flush with the surface. Dowel bars that must be removed due to poor workmanship and/or material failure, must be replaced with new bars. The repair work shall include diamond grinding. Any additional traffic control needed due to required retrofit repairs shall be performed at no additional cost.

TEST SECTION

The contractor shall construct a test section consisting of slot sawing, concrete removal, dowel bar placement and grout mixing and placement at a location selected by the Engineer. The test section shall be at least one full lane width and consist of at least 10 but not more than 50 joints. The test section shall be placed in the presence of the Engineer and a representative from Materials and Research. Full depth cores will be taken from the test section to determine the quality of the placement operation.

METHOD OF MEASUREMENT

Dowel Bar Retrofit will be measured by the each bar placed.

BASIS OF PAYMENT

Payment for Dowel Bar Retrofit will be paid at the contract unit price per each for the item "Dowel Bar Retrofit." Payment will be full compensation for all work prescribed in this specification.

409.03.15 Retrofit Dowel Bar

Attend a 2-hour mandatory Pre-Activity workshop with NDOT personnel and the Contractor's personnel that will be involved with the dowel bar retrofit work prior to commencement of this work.

A. **Slot Cutting**. Cut dowel bar slots parallel to the existing centerline with diamond bladed cutting equipment. Use self-propelled saw cutting equipment with gang mounted blades capable of cutting at least three slots at a time. Cut slots 2½ inch wide or as required to insert dowel bar chairs, a depth of 6¼ inch or as required to place the center of the dowel bar at mid depth of the slab. Cut slots long enough so the dowel bar can be centered over the transverse joint.

B. **Break Out Slot Concrete**. Concrete removal operations and equipment used to remove the concrete shall not damage the pavement to remain. If the concrete removal operation causes damage to the pavement, as determined by the Engineer, the concrete removal operations shall be discontinued. Concrete removal operations shall not resume until the Contractor has taken corrective measures, as approved by the Engineer. Damage to the concrete to remain shall be repaired, as determined by the Engineer, at no cost to the Department.

   Limit the weight of jackhammers or chipping hammers to 15 lbs. to chip concrete to the shape of the dowel bar slots as shown in the plans. The Engineer may allow up to 30 pound chipping hammers at his discretion. Sand blast vertical faces of the excavation until ¼ amplitude is obtained. Air blast excavation until dust free prior to placement of dowel bar. Air blast with clean air obtained from compressors equipped with water/oil traps visible to the Engineer. Air tanks are to be drained daily and the traps are to be emptied weekly or as needed.

C. **Dowel Bar**. Place three (3) dowel bars per wheel path, six (6) per joint as shown in the plans. Apply bond breaker to dowel bars prior to placement in the slot. Space dowel bars 1 foot apart and 1.5 foot in from the shoulder and longitudinal joint. Insert dowel bars held in position by non-metallic non-organic chairs. Provide chairs to insure that the dowel bar has a minimum of ½ inch of patching material beneath it and does not allow the dowel bar to shift side to side while placing patching material. Use dowel bar end caps that allow a minimum of ¼ inch of longitudinal movement. Maintain dowel bar alignment in accordance with Standard Plans R-10.1.2 General notes 11, 12 and 13.

   Any chair design that allows for any movement of the bar during placement of the concrete patch will not be approved for use.

   Immediately prior to placement of the dowel bar and concrete patch, protect transverse joint crack at the bottom and sides of the slot as shown in the plans. Prevent any of the patching material from entering the exposed crack during the patching process. The filler material shall be capable of remaining in place and protecting the crack as the patching material is being placed.

   Place a ⅜ inch thick-minimum foam core board filler material at the middle of the dowel bar to act as a bond breaker and re-form the transverse joint. Fit the filler around the

dowel bar and snugly to the bottom and sides of the slot. The foam core filler board when in place will be slightly higher than the existing pavement. The filler must be capable of remaining in a vertical position and tight to all edges during placement of the patch. If for any reason the foam core board filler shifts during the placement of the patch, the work will be rejected and the operation shall be redone by removing all new material from the slot, clean and replace dowel bar and patching material as outlined above.

D. **Patching**. Patching material can be obtained from the QPL 609.02.01a or submit an equal or better material that conforms to the material specification above for approval.

Wet dowel bar slot prior to placement of patching material. Do not leave ponded or free standing water in the dowel bar slots prior to placing patching material. Consolidate the patching material by using a pencil vibrator capable of consolidating the patch material into the slot and around the dowel bars.

Finish the patch so it is flush to the existing pavement. Patch failures due to abnormally high or low surface finishing shall be replaced by the Contractor at no cost to the Department.

Cure all dowel bar retrofit concrete with white-pigmented, wax-based curing compound as specified in Subsection 409.03.12 of the Standard Specifications. Be advised that the curing procedure will move at a more rapid rate due to the fast setting nature of the patching material. Cure fast setting patches immediately after placing patching material. Warmer than normal ambient temperatures may require wet burlap covers in order to avoid cracking.

Patching materials shall meet a minimum of 3,000-psi compressive strength and be in place for 3 hours prior to opening to public traffic and as per the manufactures recommendation.

Use Magnetic Imaging Technology (MIT) to verify the final location of all dowel bars. For MIT testing, you may call, but are not limited to:

H. Thomas Yu, P.E.
Applied Research Associates, Inc. at 916-638-8500

Any sub-standard patches shall be removed and replaced by order of the Engineer at no cost to the Department.

DESCRIPTION

Install new load transfer devices (LTDs) at transverse cracks and joints where indicated in the contract documents.

MATERIALS

Retrofit LTDs. Obtain retrofit LTDs from a supplier appearing on the Approved List for §705-15, Transverse Joint Supports. Each retrofit LTD consists of 1 dowel, 2 expansion caps providing 6 mm of expansion room each, a joint forming medium and 2 epoxy coated or non-metallic supporting chairs having a width equal to the channel width, 65 - 70 mm.

Use 460 mm long, 38 mm diameter, smooth, epoxy coated, Grade 420 steel dowels coated with a bond breaker. Use an epoxy coating appearing on the Approved List for "Epoxy Coatings for Longitudinal Joint Ties" or "Epoxy Coatings for Steel Reinforcing Bars" that is applied by an applicator appearing on the Approved List for "Applicators for Steel Reinforcing Bars".

At least 14 days before saw cutting channels, provide the Engineer:

- The name and address of the retrofit LTD supplier.
- Material certification from the supplier that dowels meet the "Tests" and "Material Requirements" portions of §705-15, except Grade 420 steel is supplied.
- Material certification from the rolling mill as to the type and grade of steel used.
- The brand of epoxy coating and the name and address of the Manufacturer.
- The name and address of the epoxy coating applicator.
- The brand of bond breaker and the name and address of the Manufacturer.
- Material certification from the epoxy coating applicator that the bars have been coated, tested and meet the requirements of §705-14, Longitudinal Joint Ties.
- At least 2 shop drawings from the supplier that detail the:
  - Expansion caps.
  - Width, type and positioning of chairs used to support and align the LTD.
  - Material used as a joint forming medium.

The Engineer will transmit a shop drawing to the Director, Materials Bureau, for approval. The Materials Bureau will approve, approve as noted, or reject the drawing within 14 days of submission to the Engineer. Revise rejected drawings as required by the Materials Bureau and re-submit them to the Engineer. Do not saw cut channels until the Materials Bureau approves the drawings.

Epoxy coating field repairs are not permitted. The Department may perform supplementary sampling and testing of the bars and assemblies to ensure conformance with §705-14 and §705-15.

- Use a joint forming medium that is:
- Compressible, yet rigid enough to maintain it's shape during installation and backfilling.
- Treated with a release agent that prevents bond to the backfill material.
- Deep enough to extend from the channel bottom to the pavement surface.

- Equal to the joint or crack width (+ 6 mm/ - 0 mm).
- Capable of being routed to accommodate joint or crack sealing.

Different widths of joint forming material are required for cracks of different crack widths.

Backfill Material. Use DBR Retrofit Mortar, HD-50, Five Star Highway Patch, or an alternate prepackaged portland cement based patching material submitted for use as an approved equal. Extend the prepackaged material with clean, surface dry crushed stone or crushed gravel meeting §703-02, Coarse Aggregate and having a 1A gradation, maximum. Use an extension rate of 50 - 60 % by weight of the prepackaged material. Do not use crushed slag aggregate. Follow the Manufacturer's mixing instructions. Provide those instructions to the Engineer.

Submit alternate patching material and extension aggregate in 30 kg (maximum) bags to the Engineer for transmittal to the Materials Bureau for approval. Provide the same aggregate that will be used on the contract. Alternate material must meet the requirements of Table 1, Backfill Material Requirements. The Materials Bureau will render a decision on material acceptability within 45 days of submission to the Engineer.

TABLE 1 - BACKFILL MATERIAL REQUIREMENTS

Property	Extension	Minimum	Maximum
3 Hour Compressive Strength	None	24 MPa	-
24 Hour Compressive Strength	None	35 MPa	-
Contraction	None	-	0.05 %
Freeze - Thaw Loss	60 %	-	1.0 %
Bond to SSD PCC	60 %	2.8 MPa	-
Bond to Dry PCC	60 %	2.1 MPa	-
Working Time	60 %	15 Minutes	-
Chloride Content	-	0.0 %	
Magnesium Phosphate Content	-	0.0 %	

CONSTRUCTION DETAILS

Channel Construction. Construct 4 channels per wheelpath (8 per lane). Space channels 300 mm apart on center. Determine the location and length of longitudinal joint ties in the concrete to remain in place outside the repair area. Use a pachometer or other device capable of locating steel embedded in concrete.

If a longitudinal joint tie is within 300 mm of the joint or crack being retrofit, construct the outer channels 75 - 100 mm from the end of the tie. If no ties are within 300 mm of the joint or crack being retrofit, construct the outer channels 450 mm from a longitudinal joint between 2 travel lanes and 300 mm from a longitudinal joint between a travel lane and a shoulder.

For 4.2 m wide slabs, slabs with nonstandard widths, or pavements with longitudinal joints offset from permanent longitudinal pavement markings that define a travel lane, construct the outer channels 450 mm from the nearest edge of the permanent longitudinal marking between 2 travel lanes and 300 mm from the marking between a travel lane and a shoulder. In any case, do not construct a channel within 75 mm of the end of a longitudinal joint tie. The Engineer may require additional dowel bar retrofit construction in nonstandard slab widths to ensure 4 dowels are placed in each wheelpath.

Make saw cuts with a diamond blade concrete saw equipped with a minimum of 3 saw blades of the same diameter. Space the blades on the saw arbor such that resulting channel width equals the supporting chair width. Make the saw cuts parallel to the pavement longitudinal joint and to each other, with equal lengths on either side of the crack. Make the saw cuts sufficiently deep such that, when placed, the longitudinal axes of the dowels are at mid slab and 13 - 19 mm of backfill material will surround the dowels and expansion caps.

Remove concrete between the outer saw cuts with a chipping hammer weighing no more than 13.6 kg, including muffler and bit. Remove concrete burrs such that the dowels will sit parallel to the pavement surface and the backfill material will completely encase the dowel. Schedule operations such that the concrete between saw cuts is removed as close to dowel installation as possible. Do not allow traffic on the channels after the concrete has been removed.

Cleaning Channels. As close to backfill placement as possible, thoroughly abrasive blast all faces of the channel to remove all residue and roughen the surface. Immediately before placement, air blast the channel to remove any remaining debris. The Engineer will check for dust by wiping the channel faces with a dark cloth or glove. Immediately after cleaning, apply a commercial caulk to all crack faces within the channel.

LTD Installation. Apply bonding agents, including water, to the channel faces in accordance with the backfill Manufacturer's instructions. Provide those instructions to the Engineer. If water is used, blow the excess from the repair such that no standing water remains. Do not place primer or backfill material when the concrete substrate is outside the temperature range of 7_C to 38_C.

Immediately after applying the bonding agent, place and support the LTDs in accordance with the approved shop drawings such that the:

- Joint forming medium is aligned with the crack or joint such that no backfill material can enter the joint or crack.
- Supporting chair abuts the vertical channel faces to prevent movement during backfilling.
- Longitudinal axis of each dowel is at the mid-depth of the pavement slab (Å 6 mm).
- Longitudinal midpoint of each dowel is within 25 mm of the crack.
- Longitudinal axis of each dowel is aligned parallel with the pavement centerline and pavement surface such that the maximum misalignment of one dowel end relative to the other is 4 mm.

Backfill Placement. After the dowel is positioned, slightly overfill the entire channel with backfill material. Follow Manufacturer's instructions regarding placement time limits, including those of the bonding agent. Provide those instructions to the Engineer. Thoroughly consolidate the material using narrow (less than 25 mm), hand-held spud vibrators. Do not touch the LTD with the vibrator.

Fill whole channels with each batch of material. Discard the remaining portion of a mixed batch if it will not completely fill a channel, if placement time limits are exceeded, or if the material is not uniformly consolidating under vibration.

Finish the backfill material flush with the surrounding pavement surface with as little hand finishing as possible.

Cure the backfill material in accordance with the Manufacturer's instructions. Provide those instructions to the Engineer.

Opening to Traffic. Open the repairs to traffic no sooner than 3 hours after finishing.

METHOD OF MEASUREMENT

The work will be measured for payment as the number of dowels satisfactorily retrofit into the pavement.

BASIS OF PAYMENT

Include the cost of all labor, material and equipment necessary to satisfactorily perform the work in the unit price bid for Retrofit Dowels in Portland Cement Concrete Pavement. No additional payment will made for extra work required to repair damage to the adjacent pavement that occurred during any operation.

570.04C DOWEL BAR RETROFIT

This work consists of retrofitting epoxy-coated bars into existing concrete pavement.

MATERIALS

a. Curing Compound. The curing compound shall be a wax based liquid membrane–forming compound that conforms to the requirements of AASHTO M–148 (ASTM C 309) Type 1-D or 2, Class A or B.

b. Dowel Bars. The Dowel bars shall be plain, round bars fabricated from steel meeting AASHTO M–31, M-42, or M-53. Dowel bars shall be cut to the required length and cleaned to remove all cutting burrs, loose mill scale, rust, grease and oil. The bars may be sheared providing the deformation of the bars from true round shape does not exceed 0.04 inch in diameter or thickness and shall not extend more than 0.04 inch from the sheared end. Dowel bars shall be epoxy-coated 100 percent on all surfaces. The epoxy coating shall be in accordance with AASHTO M-284. The dowel bars shall also be shop coated with a bond breaking release agent. The bond breaking release agent shall be a curing compound meeting the requirements specified above. The dowel bars shall have tight fitting end caps made of nonmetallic materials that allow for ¼ inch movement of the bar at each end. The Contractor shall submit sample end caps to the Engineer prior to use.

c. Caulk. The caulk for sealing the existing transverse joint crack at the bottom and sides of the slot shall be any commercial caulk designed as a concrete sealant that is compatible with the patch material being used.

d. Foam Core Board. The foam core board shall be constructed of closed cell foam and be faced with poster board material or laminate on each side.

e. Patching Material. "Concrete Patch Mix" shall be Patchroc 10-60, Five Star Highway Patch, Burke 928 Fast Patch, American Highway Technology's (AHT) dowel bar retrofit mortar or an approved equal. The concrete patch mix shall be mixed and placed according to the manufacturer's recommendations.

f. Chairs. The chairs for supporting and holding the dowel bars in place shall be completely epoxy-coated according to Section 836.02 B, or made of nonmetallic material.

g. Concrete Mix Design. The Contractor shall provide the department with a concrete mix design for the patching material that meets a minimum compressive strength of 4,000 psi, in six hours, prior to the beginning of work. This mix design shall include all additives and materials that will be used on the project.

CONSTRUCTION REQUIREMENTS

Prior to construction, the Contractor shall provide the Project Engineer with the manufacturer's product literature for usage of the patch mix. The Contractor shall install the dowel bars in the existing concrete pavement as shown in the plans and according to the following specifications:

a. Sawing. Slots shall be cut in the pavement with a gang saw capable of cutting a minimum of three slots in the wheel path, at a time. The slots shall be cut to the depth required to place the center of the dowel at mid depth in the concrete slab. Multiple saw cuts parallel to the centerline may be required to properly remove material from the slot.

b. Jack Hammers. Jack hammers used to remove the concrete shall not be larger than the 30-pound class.

c. Cleaning. All exposed surfaces and cracks in the slot shall be sandblasted and cleaned of saw slurry and loose material before installing the dowel. All loose material will be disposed of by the Contractor off of the highway right-of-way.

d. Dowel Bar Chair Placement. Dowel bars shall be placed in a chair that will provide a minimum of ¼ inch clearance between the bottom of the dowel and the bottom of the slot. The dowel bar shall be placed to the depth shown in the plans, parallel to the centerline and parallel to pavement surface of the lower panel at the transverse joint, all to a tolerance of ¼ inch. The chair design shall hold the dowel bar securely in place during the placement of the patch mix.

e. Joint Caulking. Caulk the existing transverse joint crack at the bottom and sides of the slot as shown in the plans. The transverse joint crack shall be caulked to provide a tight fit for the foam core board at the transverse joint and to prevent any of the patch mix from entering the crack at the bottom or the sides of the slot. The sealant shall not extend beyond ⅜ inch of each side of the existing transverse joint crack.

f. Dowel Bar Placement. The dowel bar shall be placed through the foam core board at the specified location. The dowel bar shall be placed so a minimum of 7.0 inches is placed on either side of the transverse joint. The foam core board shall be capable of remaining in a vertical position and tight to all edges during the placement of the patch mix. If for any reason the foam core board shifts during the placement of the patch mix, the work shall be rejected and replaced at the Contractor's expense.

g. Mixing Patch Material. The patch material shall be mixed with a hand mixer. A metering or measuring device for the water is required. The Contractor shall assure that a consistent batch of patch mix is being produced. A mobile mixer is not acceptable. The patching material will be tested by the Engineer at a rate of 1 test for each 4 hours of production. A minimum compressive strength of 4,000 psi in 6 hours is required. If compressive strengths are not being met, production shall cease and the contractor shall resubmit a mix design correcting the strength problems.

h. Existing Concrete Surface Preparation. The existing concrete surfaces inside the slotted area shall be moistened with water, using a hand sprayer immediately prior to placing the patch mix.

i. Placing Patch Mix. The patch mix shall be placed into the slot and vibrated with a small hand-held vibrator to ensure that the patch mix completely surrounds the dowel bar.

j. Curing. The surface of the patched area shall be flushed with a curing compound that meets the requirements specified above. The curing compound shall be applied within 30 seconds after a set of three dowel bar patches have been finished.

k. Spall Repairs. Any spalling that occurs to the transverse joints shall be repaired at the Contractors expense. The joint shall be sawed and sealed as shown in the plans.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Installation of the dowel bars will be measured and paid for as "Dowel Bar Retrofit Type B" for each dowel bar installed and accepted by the Engineer. Payment shall be full compensation for all labor, equipment and materials necessary to complete the work as specified.

OHIO

DESCRIPTION

This work consists of sawing slots across transverse cracks, cleaning the slot, injecting caulking filler, placing a dowel in the slot, filling the slot with a patching material and establishing a joint by saw cut.

MATERIALS

Furnish a one part silicone sealant which does not require a primer for bond to concrete and conforms to the following Table:

Properties	**Requirements**
Flow, ASTM D5893	0.3 inches maximum
Extrusion Rate, C1183 method A	75-350 grams/minute
Tack free time @ 77° F ± 3°F–ASTM C679	20-90 minutes
Specific Gravity - ASTM D 792, Method A	1.010-1.515
Durometer Hardness - Shore A, cured 7 days @ 77°F± 3° F and 45-55% R.H.; ASTM D 2240	10-25 at 0°F
Tensile Stress -@ 150% elongation, 7 day cure @ 77°F ± 3°F and 45-55% R.H.; ASTM D 412, Die C	45 psi maximum
Elongation - 7 day cure @ 77° F ± 3°F and 45-55% R.H.; ASTM D 412, Die C.	800% minimum
Bond to Concrete Mortar: Briquets - Air cured 12 days @ 77° F ± 3°F;**	50 psi minimum
Movement Capability and Adhesion ***	Extend 100% and compress 50%; No adhesive or cohesive failure after 10 cycles at 0°F
Shelf Life	9 months from date of shipment from manufacturer

**Bond to Concrete Mortar: Briquettes molded in accordance with AASHTO T 132 sawed in half and bonded with a thin section of sealant and tested in accordance with AASHTO T 132. Briquette will be dried to constant weight in oven at 212° F ± 9°F.

***Movement Capability and Adhesion: Prepare1 inch x 2 inch x 3 inch concrete blocks in accordance with ASTM C 719. A sawed face will be used for bond surface. Seal 2 inches of block leaving ½ inch on each end of specimen unsealed. The depth of sealant will be ⅜ inch and the width ½ inch. Subject sealant to movement in accordance with ASTM C 719. The magnitude of the movement will be as specified and the rate of extension or compression will be ⅛ inch per hour.

Furnish materials conforming to:

Aggregate	703.02.A.3
Curing material	705.07, Type 2.
Dowel bars	709.13 or 705.01
Dowel bar chairs	709.14 or non-metallic material
Preformed filler	705.03

Patching material. Must meet the performance requirements of ASTM C928, Table 1, R3 concrete material with the following exceptions and additions:

Final Set Time (ASTM C403)	25 minutes minimum
Length Change (ASTM C157) @ 4 days	± 0.13% maximum
Freeze Thaw Durability Factor (ASTM C666)	
Procedure A @ 300 cycles or Procedure B @ 350 cycles,	Durability Factor: 90% minimum

Furnish patching material according to the Departments Qualified Products List (QPL)

Mix prepackaged materials that contain all aggregates needed to produce the desired concrete as specified by the manufacturer. For bagged cementitious materials that need additional aggregates, grade the aggregate according to the patching material manufacturer's recommendation except ensure that 100% passes the ½ inch sieve and a minimum of 85 percent, by weight, passes the ⅜ inch sieve.

EQUIPMENT

Furnish equipment to create slots that has a power driven gang type assembly, consisting of diamond blade saws, capable of sawing a minimum of three slots at one time to the required dimensions, without damage to the surrounding pavement.

Furnish jack hammers weighing less than 30 pounds.

Furnish abrasive blast equipment capable of removing the saw slurry or other foreign material from the exposed surfaces leaving a clean, newly exposed concrete surface free of spalls, latence and all contaminants detrimental to achieving an adequate bond. Ensure water blasting with abrasives in the water is 10,000 psi or less.

CONSTRUCTION

The Engineer will locate and mark cracks to be retrofitted. Provide the Engineer with aerosol spray paint to mark the cracks to be retrofit.

Cut two and ½ inch wide slots into the pavement to a depth which places the center of the dowel at mid-depth in the concrete slab. Make the slots parallel to the centerline of the pavement. Make multiple saw cuts parallel to the centerline if necessary to properly remove material from the slot and to provide a level surface for the feet of the dowel bar chairs. Cut three slots, on one foot centers, in each wheel path, as shown in the standard drawings.

Do not allow traffic across the crack once the concrete has been removed from the slots until all six retrofit dowel bars are in place, cured and completed. Do not allow the tires of construction vehicles to travel on slots where concrete has been removed.

Clean the edge of the slots by approved blast methods to produce a rough surface. Insure any blasting operation does not damage the surrounding pavement. Do not begin abrasive blasting operations until implementing reasonably available engineering controls to limit

fugitive dust that are acceptable to the Engineer. Conform to state, regional and local government agency requirements regarding control of dust generated by the blasting operation.

Caulk cracks at the bottom and sides of the slot with an approved silicone sealant in order to prevent any grout from entering the crack. Apply the sealant with a pressure applicator that forces it into the crack.

Place a ½ inch thick preformed filler board to maintain the crack, as shown in the plan details. Ensure the filler board fits tight around the dowel and to the bottom and edges of the slot. Maintain the filler board in a vertical position and tight to all edges during placement of the patching material. Ensure the filler board extends from the bottom of the slot to no more than 1½ inches from the surface of the pavement. If for any reason the filler board shifts during placement of the patching material, redo the dowel bar retrofit at no expense to the Department.

Ensure the dowel bar chair firmly holds the bar centered in the slot. Obtain the Engineer's approval before using any dowel bar chairs. The Engineer will reject any chair design that may allow movement of the bar during the placement of grout.

Use dowel bars 1½ inches in diameter and 18 inches long. Center the filler board on the dowel. Coat the dowel bars with a thin layer of oil or other bond-breaking material just prior to installation in the slot. Place an expansion cap on each end of the dowels prior to installation. Ensure the expansion caps are tight fitting and made of non-metallic material which will allow ¼ inch movement at each end of the dowel.

Use two chairs to firmly hold the dowel bar in the slot during placement of the patching material. Furnish chairs that are a nominal 2½ inch wide and center the dowel bar across the crack. Ensure the bar varies no more than ¼ inch from parallel to the pavement surface and the centerline of the pavement. Just prior to placement of the patching material, make one or more passes of an air blast to provide a dust-free, clean slot to insure an adequate bond of the patching material.

Mix, place and cure the patching material in accordance with the manufacturer's recommendations. Consolidate the patching material using a vibrator approved by the Engineer. Place the patching material in the slot and finish to produce a smooth, even surface. Cut a 1½ inch deep by ¼ inch wide saw cut, using a hand pushed single blade saw, to re-establish the crack. Make the saw cut within four hours of placing the patching material.

Repair any damage to the pavement due to the Contractor's operation at no expense to the Department.

Cure the patching material for a minimum of four hours before placing any vehicle loads on the repair, or as directed by the Engineer.

METHOD OF MEASUREMENT

The Department will measure the quantity of Retrofit Dowel Bars by the actual number in the complete and accepted work.

BASIS OF PAYMENT

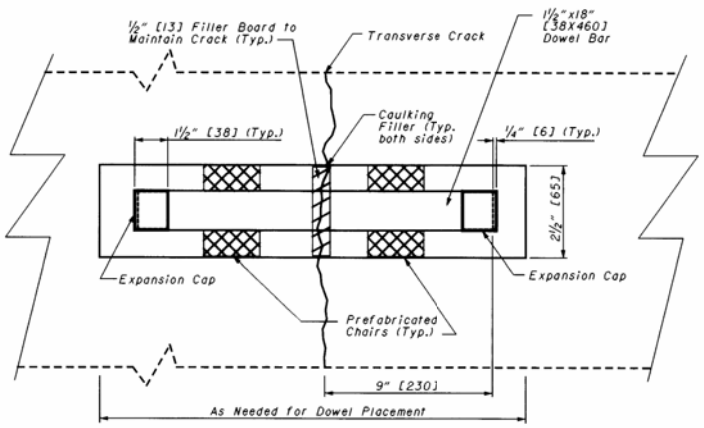
Payment is full compensation for furnishing all materials including paint; sawing and cleaning the slots; installing dowel chairs, dowels, bond breaker material, dowel bar end caps, sealant/caulking material, filler material and patching material; and reestablishing the crack.

The Department will not pay for additional work or materials required due to shifting of the filler board.

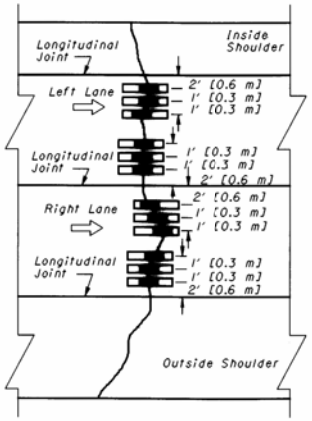
The Department will not pay for any additional work to repair damage to the pavement caused by the Contractor.

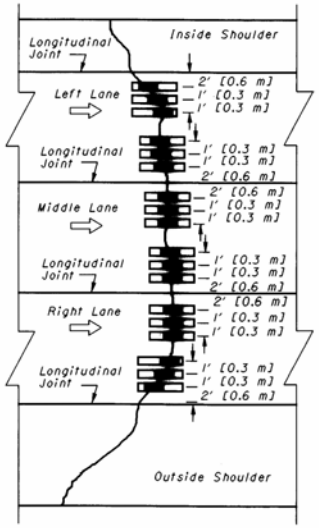
The Department will pay for accepted quantities at the contract unit price as follows:

Item	Unit	Description
258	Each	Retrofit Dowel Bar

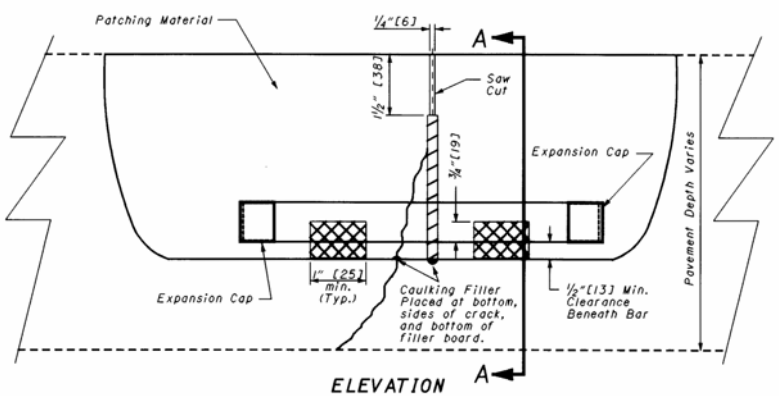


PLAN

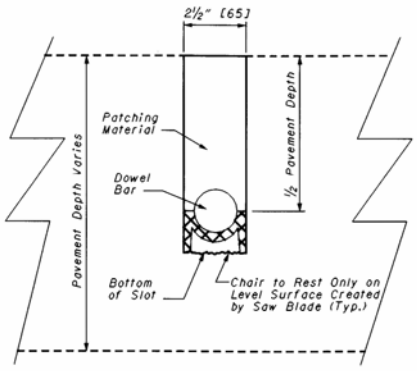




RETROFIT DOWEL BAR SPACING



ELEVATION



SECTION A-A

NOTES

Cracks to be retrofitted will be marked on the pavement by the Engineer.

Prefabricated chair as approved by the Engineer.

1½"x18" [38x460] RETROFIT DOWEL BAR

NEW DRAWING

OHIO DEPARTMENT OF TRANSPORTATION — PAVEMENT ENGINEERING ADMINISTRATOR — 7-15-05 DATE

PAVEMENT DESIGN ENGR. D. Miller

All metric dimensions (in brackets [ ]) are in millimeters unless otherwise noted.

ROADWAY ENGINEERING SERVICES

STANDARD ROADWAY CONSTRUCTION DRAWING

RETROFIT DOWEL BAR

NUMBER BP-2.6

1 / 1

416.01 DESCRIPTION

This work shall consist of restoring load transfer in existing concrete pavement by installing epoxy coated dowel bars across transverse joints or cracks. The work shall conform to the plan details for retrofit dowel bar installation.

416.02 MATERIALS

a. Dowel bars shall be epoxy coated and shall conform to the requirements described in Section 723.09. The dowel bars dimensions shall be as specified in the plans. The dowel bars shall have tight-fitting end caps made of nonmetallic material that allow for ¼ inch movement of the bar at each end.

b. Foam core board shall be ¼ inch thick, constructed of closed cell foam and faced with poster board material on each side.

c. Dowel bar chairs shall be made of nonmetallic material. Chairs shall be designed to hold the dowel bars, in a stable manner (to prevent movement during concrete placement) at the correct location within the required vertical and horizontal tolerances.

d. Cement patching materials used to backfill retrofit slots shall be as specified in Section 701.01. Mixing, placement and curing of this material shall be accomplished according to the manufacturer's recommendations. The patching product may be extended with aggregate meeting the requirements of Section 701.05 and 701.06 except for gradation. The Contractor's supplier of the patching product shall provide a concrete mix design including all additives that meet a minimum compressive strength of 4000 psi in six hours. This mix design shall be performed with the materials that will be used on the project.

416.03 CONSTRUCTION METHODS

The contractor shall install the dowel bars in the existing concrete pavement as shown in the plan details and according to the following specification:

a. Slot cutting method. Slots shall be cut in the pavement with a gang saw capable of simultaneously cutting a minimum of three slots. The saw cuts for all required slots at each transverse joint or crack shall be made such that the longitudinal centerline of each individual dowel bar is placed parallel to the pavement centerline and surface of the lowest panel at the transverse joint. Tolerance for alignment will be ¼ inch.

b. Concrete shall be removed from the slot area with a jackhammer no larger than the 30-pound class. The contractor shall use a lighter hammer if the pavement is damaged with the 30-pound hammer. All exposed surfaces and cracks in the slot shall be sand blasted and cleaned of saw slurry and loose material before installing the dowel. All loose material shall be disposed of off the highway right-of-way.

c. Foam core board shall be placed to maintain the continuity of the existing transverse joint or crack. Foam core board should be sized to fit tightly around the dowel bar and to the bottom and sides of the slot. Existing transverse joints or cracks shall be caulked with approved sealant at the bottom and side of the slot as shown in the plan detail to provide a tight fit for the foam core board and to prevent any of the patch mix from

entering the joint or crack. Excess caulking shall be screeded off to provide a smooth level surface. Foam core board shall be installed such that it remains in position and tight to all edges during the placement of the patch material. Tabs may be used to hold the foam core board in place. Existing joint sealant may be cut or removed to accommodate tabs. If the foam core board shifts during the placement of the patch mix, the work shall be rejected and replaced at the contractor's expense.

d. Dowel bars shall be placed, as a complete assembly with chairs and foam core board attached, across the transverse joint or crack as shown in the plan detail. Chairs shall hold the dowel bar securely in place during the placement of the patch mix and provide a minimum of ½ inch clearance between the bottom of the dowel and bottom of slot. If the dowel bar shifts during the placement of the patch mix, the work shall be rejected and replaced at the contractor's expense. The dowel bars shall have a very thin coat of form release oil applied prior to covering with concrete. Oil shall in no case be allowed to contaminate any of the slots or concrete surfaces to be overlaid.

e. Existing concrete surfaces in the slots shall be clean and dry immediately prior to placing the patch mix, or prepared as recommended by the manufacturer. All excess water in the slot shall be removed before the patching material is placed.

f. Concrete shall be placed into the slot and vibrated to ensure that the dowel bar is completely encased. The diameter of the vibrator head shall not exceed 1¼ inch. Placement when the ambient temperature is below 50 °F shall require prior approval by the engineer.

g. Any damage to the pavement due to the contractor's operation shall be repaired by the contractor at no cost to the department.

h. The top surface of the filled slot shall be trowel finished flush with the existing surface and cured. If diamond grinding is included in the plans, the top surface of the fill slot may be left a maximum of ¼ inch. In no case shall the fill slot be depressed. The curing compound shall meet the requirements of Section 701.07 and shall be applied before the final set of the mortar. The new joint shall be sawed within 24 hours or sooner if directed by the Engineer.

i. The patching material will be tested by the Contractor once for each 4 hours of production or a minimum of once per day. The patching material shall have a minimum compressive strength of 4000 psi in 6 hours. The Contractor's compression testing may be performed up to 24 hours after the cylinders are made. If the compressive strengths are not being met, production shall cease and the Contractor shall resubmit a concrete mix design correcting the strength problems. Contractor shall be allowed to open lanes to traffic only after the minimum compressive strength of 3000 psi has been achieved.

416.04 METHOD OF MEASUREMENT

Retrofit dowel bars shall be measured by each dowel installed and accepted.

416.05 BASIS OF PAYMENT

Retrofit dowel bars, measured as provided above, shall be paid at the contract unit price for:

DOWEL BAR RETROFIT EACH

which shall be full compensation for furnishing all material, equipment, labor and incidentals to complete the work as specified.

527.1 DESCRIPTION

This work is the installation of epoxy-coated, smooth dowel bars into existing concrete pavement across cracks or transverse joints without dowels.

527.2 MATERIAL

(a) Force-Transfer Units. Section 705.3 (a) and (b)

(b) Caulking Compound. Section 705.8(b)

(c) Preformed Cellular Polystyrene. ASTM C 578

(d) Rapid Set Concrete Patching Material. Supplied by a manufacturer listed in Bulletin 15. Use within the shelf life and temperature limitations set by the manufacturer.

(e) Concrete Curing Materials. Section 711.1(a) and (b)

(f) Intermediate Curing Compound. Section 711.2(c)

(g) Concrete Admixtures. Section 711.3

If accelerating admixtures are used, provide only accelerating admixtures that contain no chlorides.

(h) Joint Sealing Material. Section 705.4(a), (b) and (c)

(i) Graphite Lubricant. Section 705.6

527.3 CONSTRUCTION

As shown on Standard Drawing RC 26M and as follows:

(a) Equipment. Provide a power driven, self propelled saw capable of making two parallel cuts per dowel bar slot for a minimum of four slots simultaneously. Do not use equipment that may cause pavement to spall or cause surface aggregates to fracture.

(b) Slot Preparation and Cleaning. Saw cut pavement to place center of dowel at mid-depth of pavement slab. If repair area spans different pavement thicknesses, e.g. mainline to ramp transitions, place at the mid-depth of the thinner thickness. Align saw cuts parallel to roadway centerline. Cut a minimum of four dowel slots simultaneously (eight saw cuts). Provide four dowel bar slots in each wheel path.

Use chip hammer weighing not more than 30 pounds to remove concrete between saw cuts. If pavement damage occurs from 30 pounds chip hammer, use a 15 pound chip hammer. Create a level surface at bottom of slot parallel to roadway surface.

(c) Clean Slots. Clean exposed surfaces of slots. Remove all loose and foreign material by sandblasting or water blasting within 24 hours before concrete placement. Use air blasting as final cleaning within 30 minutes before concrete placement. Reclean areas not repaired within 30 minutes of final cleaning or if contamination occurs before concrete placement. For air blasting, use a compressed air stream of at least 100 psi measured at the source, free of oil, moisture and other contaminates,.

(d) Dowel Preparation and Placement.

1. **Prepare Dowels.** Cut ¼ inch thick preformed cellular polystyrene material to the cross-section dimensions of the slot at the joint. Cut an opening in the polystyrene joint material to allow the dowel to fit without stretching and without gaps. Place the material centered on the dowel to form a temporary joint. Apply graphite bond-breaker lubricant to Type B coated dowel bars, unless a bond breaker lubricant has been applied in the shop. Stir the lubricant and apply by daubing, mopping, or with a gloved hand, to produce a thorough coating. Do not use brushes for lubricant application. Apply the lubricant, as specified, at least 1 hour before placing the concrete around the dowel assembly. Type A coated dowel bars do not require lubricant as per Section 501(i). Place 1½ inch non-metallic expansion caps with ¼ inch clearance from the end of the dowel to the bottom of the cap.
2. **Place Dowels.** Provide plastic or non-metallic chairs with a minimum ½ inch clearance between dowel bar cap and all slot surfaces, including end, both sides and bottom. Place chairs on the bottom of the slot. Place coated dowel bars parallel to roadway centerline and pavement surface, allowing no greater than ½ inch tolerance out of plane. Place dowels to align the temporary joint material with the existing joint or crack. Seal the temporary joint material at the sides and bottom of transverse joint or crack with caulking compound to prevent concrete patching material from entering into existing joint or crack.
3. **Epoxy Bonding Compound.** Apply according to the manufacturer's recommendations.
4. **Fill Slot.** Fill slot with concrete patching material. Vibrate to thoroughly consolidate the material in the slot and around dowel bar. Place concrete patching material. Do not allow the dowel bar to move from the specified position.

(e) Final Finish for Pavements not being Overlaid or Diamond Ground. Finish the surface of the slots to match the existing pavement surface profile, including any existing wheel ruts.

(f) Curing of Concrete. As specified in the applicable parts of Section 516.3(i).

(g) Saw and Seal Joint. Saw and seal transverse contraction joint sealant reservoirs for entire lane width as required.

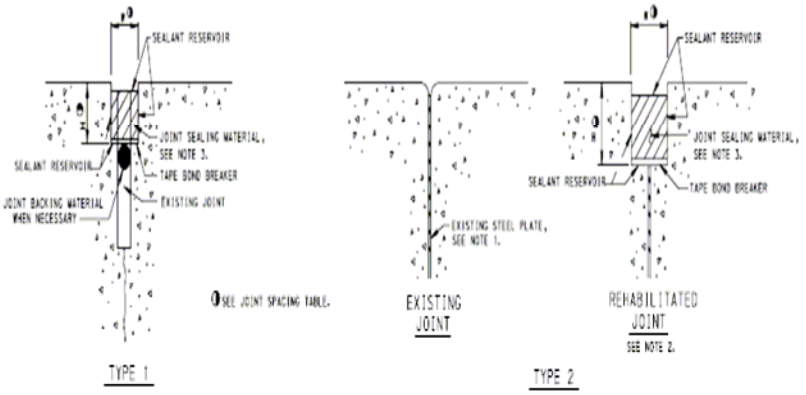
(h) Opening to Traffic. As specified in Section 516.3(q).

(i) Defective Work. Remove and replace dowel retrofits that are considered defective, at no additional cost to the Department. The 28-day minimum compressive strength testing for acceptance will not be conducted for any work that is considered defective.

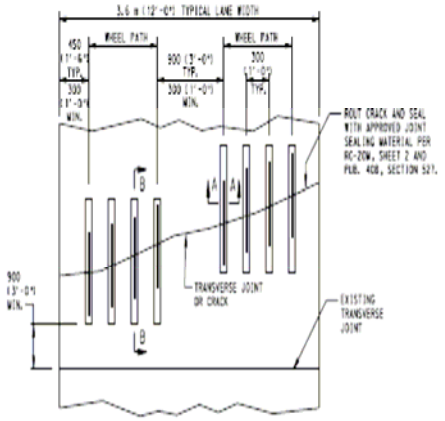
527.4 MEASUREMENT AND PAYMENT

Each

For the existing joint or crack preparation, patching, curing and sealing operations. Includes eight dowel bars per joint or crack.



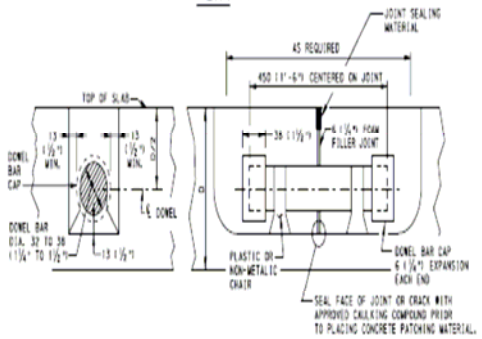
JOINT REHABILITATION



JOINT SPACING	V	H
≥15 m (50'-0")	25 (1")	32 (1 1/4")
≥6 m (20'-0") AND <15 m (50'-0")	19 (3/4")	25 (1")
<6 m (20'-0")	10 (3/8")	19 (3/4")

NOTES

1. EXISTING STEEL PLATE IS EITHER 2.0 THICK (14 GAUGE) WITH LAPPED TOP OR FLAT PLATE 3 (1/8") THICK.
2. REMOVE THE STEEL PLATE WITHIN THE SEALANT RESERVOIR.
3. MAKE THE TOP OF THE JOINT SEALING MATERIAL FROM 3 (1/8") TO 6 (1/4") BELOW THE SURFACE OF THE PAVEMENT.



DOWEL RETROFIT

NOTES:

- FOR DIFFERENT LANE WIDTHS, ADJUST SPACING FROM OUTSIDE BAR TO LANE EDGE AND SPACING BETWEEN CENTER BARS.
- SIZE DOWEL BAR AS SHOWN ON RC-20M, SHT. 1.
- PLACE DOWEL BAR AT THE MID-DEPTH OF THE THINNER PAVEMENT SLAB WHEN REPAIR AREA SPANS DIFFERENT PAVEMENT SLABS.

NOTE: EITHER ALL METRIC OR ALL ENGLISH VALUES MUST BE USED ON PLANS. METRIC AND ENGLISH VALUES SHOWN MAY NOT BE MIXED.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF DESIGN

CONCRETE PAVEMENT REHABILITATION (JOINTS)

RECOMMENDED MAR. 30, 2006
DIRECTOR, BUREAU OF DESIGN

RECOMMENDED MAR. 30, 2006
CHIEF ENGINEER

SHT 8 OF 9

RC-26M

SOUTH DAKOTA

DESCRIPTION

The work consists of installing epoxy coated 1½ inch diameter by 18 inch long plain round dowel bars into existing concrete pavement joints. The existing Portland cement concrete pavement shall be removed and the dowel bars shall be retrofit across the pavement joints.

There is a patent associated with simultaneous cutting of slots for the dowel bar retrofit. The provisions associated with the use of patented devices in conjunction with SDDOT projects is addressed in Section 7.3 of the Standard Specifications. The provision allows the use of patented processes and indemnifies the Department from any claims associated with the use of such patents.

MATERIALS

Dowel bars shall meet the requirements of Section 1010 of the Standard Specifications. All surfaces of the dowel bars shall be epoxy coated, including the ends of the bars.

The dowel bars shall be further coated, prior to installation, with a bond breaking compound. The bond breaking coating shall be either form oil, white pigmented concrete curing compound, asphaltic or other bond breaker conforming to Section 1010.

The dowel bars shall have tight fitting end caps made of nonmetallic material that allows for ¼ inch bar movement at each end of the bar. The Contractor shall submit an end cap sample to the Engineer for approval prior to installation.

Chair devices for supporting and holding the dowel bar in place shall be completely epoxy coated or made of nonmetallic material. The Contractor shall submit a chair sample to the Engineer for approval prior to installation.

The foam core board filler material shall be a ⅜inch thick (minimum), closed cell foam faced with poster board material or plastic faced material on each side. This material is commonly referred to as Foam Core Board by Office Suppliers or a dense closed cell foam insulation material faced with plastic or foil.

The Portland cement concrete pavement that is removed to install the dowel bars shall be replaced with one of the following approved patching products: Patchroc 10-60, Five Star Highway Patch, or L & M Durapatch Highway, or an approved equal. The use of Set 45 will not be allowed.

Patch Material Requirements:

1. Compressive Strength, 3 hr, minimum 3000 psi, (ASTM C-109)
2. Compressive Strength, 24 hr, minimum 5000 psi, (ASTM C-109)
3. Final Set Time-minimum 25 minutes
4. Shrinkage, 4 days, 0.13 percent maximum, (ASTM C-596)

With Maximum Aggregate Extension:

5. Flexure Strength, 500 psi, 24 hr, (California Test 551)
6. Bond to Dry PCC, 400 psi, 24 hr, (California Test 551)

7. Bond to SSD PCC, 300 psi, 24 hr, (California Test 551)

The patching product may be extended up to 100% with aggregate (defined as 10 lbs. of aggregate to 10 lbs. of patching material) as recommended by the manufacture. The aggregate extender shall meet the requirements of Section 820 of the Standard Specifications. Section 820.2 D shall not apply to the aggregate extender. The Contractor's supplier of the patching product shall provide a concrete mix design, including all additives, to meet a minimum compressive strength of 4000 psi in six hours. This mix design shall be performed with the materials that will be used on the project.

The Contractor shall verify the results of the suppliers mix design prior to beginning work. If the suppliers mix design is not satisfactory, the Contractors shall provide the Department with a mix design that meets the requirement prior to the beginning of work. This mix design shall be performed with the materials that will be used on the project.

CONSTRUCTION REQUIREMENTS

The Contractor shall install the dowel bars in the existing Portland cement concrete pavement as shown in the plans and according to the following requirements:

A. Saw cut the pavement to place the center of the dowel bar at mid-depth in the pavement. Multiple saw cuts parallel to the centerline may be required to properly remove the material from the slot. The saw cuts for the six slots at each transverse joint shall be made such that the dowel bars are placed within the following tolerances:

1. Centerline of individual dowel bars shall be parallel to the top of pavement within ± ⅛ inch in 18 inches.

2. Centerline of individual dowel bars shall be parallel to the other dowel bars within ± 1/16 inch in 18 inches.

3. Centerline of individual dowel bars shall be parallel to the roadway centerline ± ½ inch in 18 inches.

B. Any jackhammers used to break loose the concrete shall not be larger than the 30-pound class. If the pavement is damaged by the 30-pound jackhammer, the Engineer will require the Contractor to use a 15-pound hammer.

C. All exposed surfaces and cracks in the slot shall be sand blasted and cleaned prior to bar installation.

D. The dowel bars shall be lightly coated with the bond breaking compound prior to placement. The bar chairs shall provide a ½ inch clearance between the bottom of the dowel bar and the bottom of the slot and chair. The dowel bars shall be placed to the depth shown on the plans, parallel to centerline and the top of the roadway surface and at the middle of the slot, all within the specified tolerances. The chairs shall hold the dowel bar securely in place during placement of the patching mix.

1. Longitudinal dowel bar placement for skewed joints shall be within ±2 inches.

2. Longitudinal dowel bar placement for perpendicular joints shall be within ±1 inch.

E. The ⅜inch thick foam core board shall be placed at the middle of the dowel bar to maintain the transverse contraction joint. The foam core board shall fit tightly around

the dowel bar and to the bottom and edges of the slot. The width of the foam board in its final position shall be 1/16 inch wider than the slot to minimize movement of the foam board and prevent incompressible material from entering the contraction joint during concrete placement. The top of the foam core board shall be flush with the top surface of the concrete pavement.

The Contractor may need to increase the width of the foam core board for pavements with skewed joints. The skew angle may vary for different pavement sections.

F. The Contractor shall thoroughly moisten all surfaces on the sawed slot immediately prior to filling with patching compound. Care shall be taken to prevent standing water in the slot. All excess water shall be removed with compressed air.

The Contractor shall fill the slot (with the installed dowel bar, chairs and foam core board in place) with an approved patching material. The patching material shall be vibrated with a small hand held vibrator capable of thoroughly consolidating the patching compound into the slot and around the dowel bar. The top surface of the filled slot shall be trowel finished and cured. The curing compound shall meet the requirements of Section 821.1 B.

The patching material will be tested by the Engineer once for each 4 hours of production or a minimum of once per day. The patching material shall have a minimum compressive strength of 4000 psi in 6 hours. Department compression testing may be performed up to 24 hours after the cylinders are made. If the compressive strengths are not being met, production shall cease and the Contractor shall resubmit a concrete mix design correcting the strength problems. Price adjustments will be made for low concrete strength when the concrete fails to meet minimum strength of 4000 psi within the 24 hour testing period.

G. The transverse contraction joints shall be sawed and sealed as required in the plans. Any individual dowel bar retrofit not functioning or damaged shall be repaired or replaced at the expense of the Contractor.

METHOD OF MEASUREMENT

Dowel Bar Retrofit will be measured by each dowel bar installed and accepted.

BASIS OF PAYMENT

Dowel Bar Retrofit will be paid at the contract unit price per each dowel bar. Payment shall be full compensation for equipment, materials, labor and all incidentals required.

TENNESSEE

DESCRIPTION

The work consists of installing epoxy coated 1½ inch diameter by 18 inch long plain round dowel bars into existing concrete pavement. The existing Portland Cement Concrete pavement shall be slotted and the dowel bars shall be retrofit across pavement cracks and/or joints.

MATERIALS

Dowel bars, including the ends, shall be epoxy coated. The dowel bars shall also be further coated prior to installation with a bond breaking compound. The bond breaking coating shall be one of the approved products appearing on the Department's Qualified Products List.

The dowel bars shall have tight fitting end caps made of nonmetallic material that allows for ¼ inch bar movement at each end of the bar. The Contractor shall submit an end cap sample to the Engineer for approval prior to installation.

Chair devices for supporting and holding the dowel bar in place during placement of the patching material shall be completely epoxy coated and made of nonmetallic material. The Contractor shall submit a chair sample to the Engineer for approval prior to installation.

The foam core board filler material shall be ¼ inch thick, constructed of closed cell foam and faced with poster board material on each side. The foam core board is to be used when existing transverse joints are being retrofitted.

The caulk for sealing the existing crack/joint at the bottom and sides of the slot shall be a commercial grade of silicone caulk containing a minimum of 50 percent silicone.

The Portland cement concrete pavement that is removed to install the dowel bars shall be replaced with one of the following approved patching products: Patchroc 1060, Five Star Highway Patch, Burke 928 Fast Patch, or an approved equal. The use of Set 45 will not be allowed.

The patching material may be extended with aggregate meeting the manufacturer's recommendations. The Contractor shall provide a concrete mix design, including all additives, to meet a minimum compressive strength of 4,000 psi in 6 hours.

The Contractor shall verify the results of the mix design prior to beginning work. If the mix design is not satisfactory, the Contractor shall provide the Department with a mix design that meets the requirement prior to the beginning of work.

CONSTRUCTION REQUIREMENTS

The Contractor shall install the dowel bars in the existing Portland cement concrete pavement as shown in the plans and according to the following requirements:

1. Diamond saw cut the pavement to place the center of the dowel bar at mid-depth in the pavement. Multiple saw cuts parallel to the center line may be required to properly remove the waste material from the slot. The saw cuts for the six slots at each transverse crack/joint shall be made such that the dowel bars are placed within the following tolerances:

Centerline of individual dowel bars shall be parallel to the top of pavement, parallel to the ether dowel bars and parallel to the roadway centerline within + or – ¼ inch in 18 inches.

2. Any jackhammers used to break loose the concrete shall net be larger than the 30 pound class. If the pavement is damaged by the 30 pound jackhammer, the engineer will require the Contractor to use a 15 pound hammer.
3. All surfaces exposed and cracks in the slot shall be sand blasted and cleaned prior to bar installation.
4. The crack/joint on the bottom and the sides of the slot shall be filled with silicone caulk.
5. The dowel bars shall be lightly coated with the bond breaking compound prior to placement. The bar chairs shall provide a minimum of ½ inch clearance between the bottom of the dowel bar and the bottom of the slot. The dowel bar shall be placed to the depth shown on the plans, parallel to centerline and the top of the roadway surface and at the middle of the slot, all within the specified tolerances. The chairs shall hold the dowel bar securely in place during placement of the patching mix.

   Longitudinal dowel bar placement for skewed joints or cracks shall be within + or - 2 inches. Longitudinal dowel bar placement for perpendicular joints shall be within + or - 1 inch.

6. The ¼ inch thick foam core board shall be placed at the middle of the dowel bar to maintain a transverse contraction joint. The existing joint sealant may need to be cut or removed to accommodate the ¼ inch thick foam core board with ½ inch by 1 inch tabs. The tabs are required to stabilize the foam core board during patching material placement. The foam core board shall fit tightly around the dowel bar and to the bottom and edges of the slot. The top of the foam core board shall be flush with the top surface of the concrete pavement.

   The Contractor may need to increase the width of the foam core board for pavements with skewed joints. The skew angle may vary for different pavement sections.

   The Contractor shall caulk the transverse joint crack at the bottom and the sides of the slot on both sides of the ¼ inch thick foam core board. The foam core board shall be capable of remaining in a vertical position and tight to all edges during the placement of the patching material.

   If for any reason the foam core board shifts during the placement of the patching material, the work shall be rejected and replaced at the Contractor's expense.

7. The Contractor shall thoroughly moisten all surfaces on the sawed slot immediately prier to filling with patching compound. Care shall be taken to prevent standing water in the slot. All excess water shall be removed with compressed air.

   The Contractor shall fill the slot (with the installed dowel bar, chairs, foam core board where used and silicone in place) with an approved patching material. The patching material shall be vibrated with a small hand held vibrator capable of thoroughly consolidating the patching material into the slot and around the dowel bar. The top surface of the filled slot shall be trowel finished and cured immediately

after each group of three dowels are installed. The curing compound shall meet the requirements of the Standard Specifications.

The patching material shall be mixed with a hand mixer. The Engineer will test the patching material once every four hours of production. The patching material shall have a minimum compressive strength of 4,000 psi in 6 hours. Department compression testing may be performed up to 24 hours after the cylinders are made. If the compressive strengths are not being met, production shall cease and the Contractor shall resubmit a concrete mix design correcting the strength problems.

8. The transverse contraction joints shall be sawed and sealed as required in the Standard Drawings within 24 hours after placement of the patching material.
9. Any damage to the pavement due to the Contractor's operation shall be repaired or replaced at the expense of the Contractor.

MEASUREMENT

Dowel bar retrofit will be measured by each dowel bar installed and accepted.

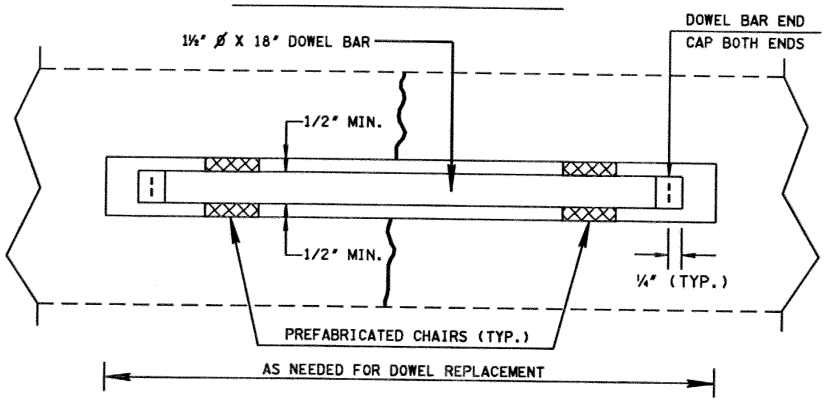
PAYMENT

Dowel bar retrofit will be paid at the contract unit price bid per each dowel bar. Payment shall be full compensation for equipment, materials, labor and all incidentals required.

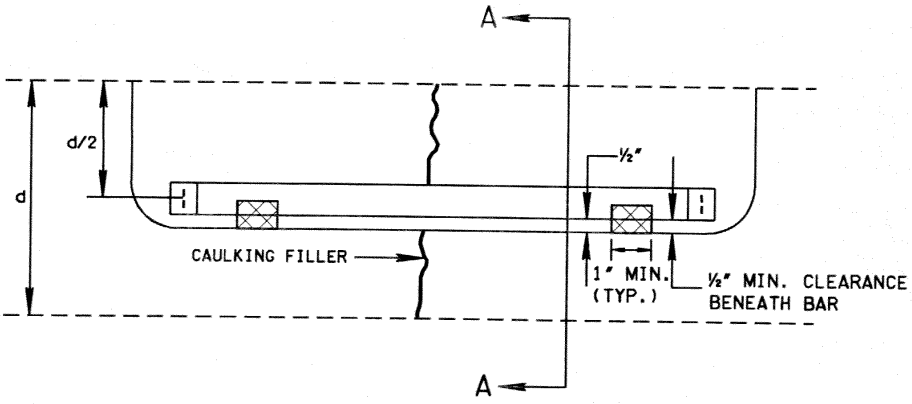
SP503DB

DOWEL BAR RETROFIT DETAILS

SP503DB



PLAN



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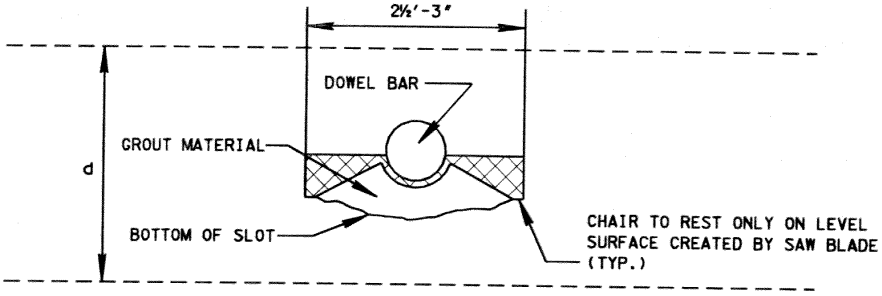
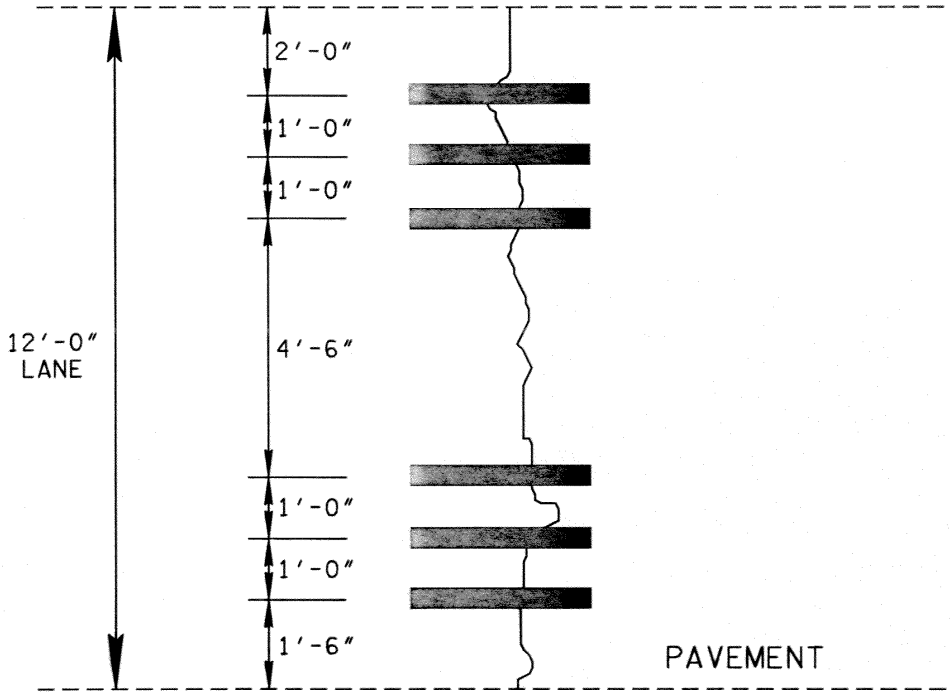


SECTION A-A



DOWEL BAR PLACEMENT

Section 02754 – Dowel Bar Retrofit

GENERAL

1.1 SECTION INCLUDES

A. Procedures and materials for installing coated dowel bars across existing transverse joints and cracks.

1.2 RELATED SECTIONS

A. Section 03211: Reinforcing Steel and Welded Wire

1.3 REFERENCES

A. AASHTO M 148: Liquid Membrane-Forming Compounds for Curing Concrete

PRODUCTS

2.1 MATERIALS

A. Dowel Bars: 1½ inch x 18 inch, smooth steel rod, following Section 03211.

B. Bond Breaking Compound: Use a bond-breaking compound approved by the Engineer.

C. Chair Devices: Coat according to Section 03211, or make of non-metallic materials, the devices used to support and hold the dowel bar in place. Provide a minimum clearance of ½ inch between the bottom of the bar and the surface upon which the chair is placed.

D. End Caps: Place on dowels, tight fitting end caps made of non-metallic materials that allows for ¼ inch movement of the bar at each end. Submit a sample of the end caps to the Engineer for approval prior to use on the project.

E. Caulking Filler: Use a standard commercial silicone sealer specified for use with concrete surfaces. Submit a sample of the caulking filler to the Engineer for approval prior to use on the project.

F. Patching Material: Select from the UDOT Performance Data Products Listing (PDPL) - Portland Cement Concrete Repair Materials - Horizontal, or an approved equal, to replace the concrete pavement that was removed to install the dowel bars. Use mix with ¼ inch nominal maximum aggregate size. Submit a sample of the material to the Engineer for approval prior to use on the project.

G. Joint/Crack Preservation Material: Use a rigid removable material capable of maintaining the joint or crack.

2.2 EQUIPMENT

A. Jackhammers: To prevent spalling, use jackhammer less than the nominal 30 pound class.

EXECUTION

3.1 CONSTRUCTION

A. Saw cut the pavement as required per PV Series Standard Drawings.

B. Jackhammer and sand blast to clean all exposed surfaces and cracks, removing slurry and loose concrete.

C. All residues from the saw, jackhammer and sand blasting process become property and responsibility of the contractor.

D. Fill the contraction joint as per PV Series Standard Drawings.

E. Pre-coat the dowel bars with a bond-breaking compound.

F. Place the foam core board at the middle of the dowel bars to maintain the transverse joint or crack. Fit the foam core board tightly around the dowel bar and to the bottom and edges of the slot. Maintain the foam core board in a vertical position and tight to all edges during placement of the patching material as per PV Series Standard Drawings.

G. Repair or replace at no cost to the Department any dowel bars damaged.

H. Thoroughly moisten all surfaces of the slot immediately prior to filling with patching material. Prevent standing water in the slot. Remove all excess water with compressed air.

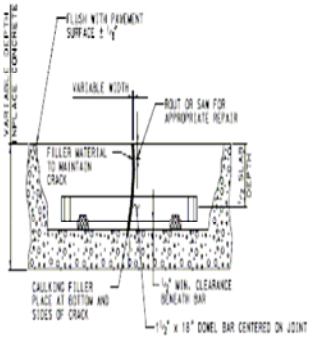
I. Fill the slot with an approved patching material. Consolidate the material in the slot and around the dowel bar with an appropriate size vibrator. Finish patching materials to existing surfaces. Place and cure the patching material according to manufacturer's specifications. Cure using ASHTO M 148, Type 1-D, Class A.

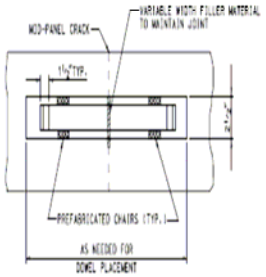
J. Replace any individual dowel bar retrofit not functioning or damaged at no cost to the Department.

K. Remove joint preservation material to a depth of two inches and reseal.

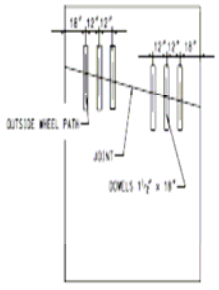
DOWEL BAR RETROFIT

DESCRIPTION: THIS REPAIR IS INTENDED TO BE USED TO ESTABLISH/RESTORE LOAD TRANSFER AT JOINTS





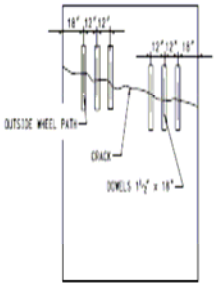
TYPICAL RETROFIT DOWEL LAYOUT
(FOR JOINT)



TYPICAL LANE

PROVIDE DOWEL BARS PARALLEL TO THE CENTERLINE AND TO THE PAVEMENT SURFACE. LIMIT DEVIATIONS FROM PARALLEL TO ¼" IN THE LENGTH OF THE DOWEL BARS.

TYPICAL RETROFIT DOWEL LAYOUT
(FOR MID-PANEL CRACK)



UTAH DEPARTMENT OF TRANSPORTATION
STANDARDS FOR ROAD AND BRIDGE CONSTRUCTION

DOWEL BAR RETROFIT

STANDARD DRAWING TITLE

STD DWG
PV 9

5-01.1 DESCRIPTION

This work consists of rehabilitating or replacing section(s) of Portland cement concrete pavement in accordance with these Specifications and in conformity with the lines, grades, thicknesses and typical cross-sections shown in the Plans or established by the Engineer.

5-01.2 MATERIALS

Dowel Bar Retrofit

Dowel bar expansion caps shall be tight fitting and made of non-metallic material, which will allow for ¼ inch of movement at each end of the bar.

Chairs for supporting the dowel bar shall be epoxy coated according to Section 9-07.3 or made from non-metallic material.

The foam insert shall be closed cell foam faced with poster board material or plastic faced material on each side commonly referred to as foam core board by office suppliers. The foam insert shall be capable of remaining in a vertical position and tight to all edges during the placement of the concrete patching material. Caulking filler used for sealing the transverse joint at the bottom and sides of the slot shall be a silicone caulk.

Concrete Patching Material

Concrete Patching Material shall be used for partial depth spall repair, panel replacement and dowel bar retrofit.

5-01.3 CONSTRUCTION REQUIREMENTS

5-01.3(1)A Concrete Mix Design for Concrete Patching Materials

1. **Materials.** The prepackaged concrete patching material shall conform to Section 9-20. The aggregate extender shall conform to Section 9-03.1(4), AASHTO Grading No. 8.

2. **Submittals and Acceptance.** The Contractor shall use the Manufacturer's recommended proportions for the mix design to be submitted to the Engineer for the concrete patching material. The Contractor's submittal shall include the mix proportions of the prepackaged mix, water, aggregated extender and the proposed sources for all aggregates. Acceptance shall be based on field verification of the prepackaged patching material and that the amount of added water and aggregate extender complies with the mix design.

5-01.3(1)B Equipment

Mobile volumetric mixers shall be calibrated in accordance with Section 6-09.3(1)H. The references to the latex admixture shall not apply.

Air compressors shall be of sufficient size and capacity to perform the work to the satisfaction of the Engineer.

The equipment for grinding cement concrete pavement shall use diamond embedded saw blades gang mounted on a self propelled machine that is specifically designed to

smooth and texture concrete pavement. The equipment shall not damage the underlying surface, cause fracture, or spalling of any joints.

All equipment shall be maintained in good condition.

5-01.3(6) Dowel Bar Retrofit

Dowel bars shall be installed in the existing concrete pavement joints and transverse cracks where shown in the Plans or as marked by the Engineer.

Saw cut slots will be required in the pavement to place the center of the dowel at mid-depth in the concrete slab. The completed slot shall provide a level, secure surface for the feet of the dowel bar chairs. Slots that intersect longitudinal or random cracks shall not be retrofitted. When gang saws are used, slots that are not used shall be cleaned and sealed with an epoxy resin, type I or IV. The epoxy resin shall conform to the requirements of Section 9-26. The transverse joint between Portland Cement Concrete Pavement and a Bridge approach slab shall not be retrofitted.

Saw cut slots shall be prepared such that dowel bars can be placed at the mid depth of the concrete slab, centered over the transverse joint and parallel to the centerline and to the roadway surface.

Placement tolerances for dowel bars

1. ± 1 inch of the middle of the concrete slab depth.
2. ± 1 inch of being centered over the transverse joint.
3. ± ½ inch from parallel to the centerline.
4. ± ½ inch from parallel to the roadway surface.

If jackhammers are used to break loose the concrete they shall weigh less than 30 pounds.

All slot surfaces shall be cleaned to bare concrete by sand blasting or pressure washing. The cleaning shall remove all slurry, parting compound and other foreign materials prior to installation of the dowel. If a pressure washer is used to clean the slots the pressure at the nozzle shall not exceed 4000 psi. Any damage to the concrete shall be repaired by the Contractor at no cost to the Contracting Agency. All wash water shall be cleaned from the slots prior to placement of any slot patching material. Traffic shall not be allowed on slots where concrete has been removed.

Prior to placement, the dowel bars shall be lightly coated with a parting compound and placed on a chair that will provide a minimum of ½ inch clearance between the bottom of the dowel and the bottom of the slot.

The chair design shall hold the dowel bar tightly in place during placement of the concrete patching material. Immediately prior to placement of the dowel bar and concrete patching material, the Contractor shall caulk the transverse joint or crack at the bottom and sides of the slot as shown in the Plans. The caulking filler shall not be placed any farther than ½ inch outside either side of the joint or crack. The transverse joint or crack shall be caulked sufficiently to satisfy the above requirements and to prevent any of the patching material from entering the joint/crack at the bottom or sides of the slot.

A ⅜ inch thick foam insert shall be placed at the middle of the dowel to maintain the transverse joint. The foam insert shall fit tightly around the dowel and to the bottom and edges of the slot and be a minimum of 1½ inch below the existing concrete surface. The foam insert shall be capable of remaining in a vertical position and held tightly to all edges during placement of the patch. If for any reason the foam insert shifts during placement of the patch the work shall be rejected and redone at the Contractor's expense.

Patching material shall be consolidated by using a 1.0 inch or less diameter vibrator as approved by the Engineer. The Contractor shall not overwork the patching material during the patch consolidation process.

The patching material on the surface of the dowel bar slots shall not be overworked, causing segregation and leaving the fine material on the surface. The patching material shall be left ⅛ inch to ¼ inch high and not finished flush with the existing concrete surface.

The joint shall be maintained by saw cutting the surface with a hand pushed single blade saw. The cut width shall be 3/16 to 5/16 inch and the depth 1½ inches. The cut length shall be 2¼ feet long centered over the three retrofit epoxy-coated dowel bars and shall be sawed within 24 hours after placement of the concrete patching material.

Opening to traffic shall meet the requirements of Section 5-05.3(17).

5-01.4 MEASUREMENT

Retrofit dowel bars will be measured per each for the actual number of bars used in the completed work.

5-01.5 PAYMENT

"Retrofit Dowel Bars", per each.

The unit contract price per each shall be full payment for all costs to complete the work as specified, including furnishing and installing parting compound, dowel bar expansion caps, caulking filler, foam core insert material, cement patch where pavement is removed for dowel bar retrofit and for all incidentals required to complete the work as specified.

9-20 CONCRETE PATCHING MATERIAL

9-20.1 PAYMENT

Concrete patching material will be prepackaged mortar extended with aggregate. The amount of aggregate for extension shall conform to the manufacturer's recommendation.

9-20.2 SPECIFICATIONS

Patching mortar and patching mortar extended with aggregate shall contain cementitious material and meet the requirements of Sections 9-20.2(1) and 9-20.2(2). The Manufacturer shall use the services of a laboratory that has an equipment calibration verification system and a technician training and evaluation process per AASHTO R-18 to perform all tests specified in Section 9-20.

9-20.2(1) Patching Mortar

Patching mortar shall conform to the following requirements:

Patching Mortar	ASTM Test Method	Specification
Compressive Strength		
at 3 hours	C 39	> 3,000 psi
at 24 hours	C 39	> 5,000 psi
Length Change		
at 28 days	C 157	< 0.15 percent
Total Chloride Ion Content	C 1218	< 1 lb/yd^3
Bond Strength		
at 24 hours	C 882 (modified by C 928, Section 8.5)	> 1,000 psi
Scaling Resistance (25 cycles)	C 672 (modified by C 928, Section 8.4)	< 1 lb/ft^2

9-20.2(2) Patching Mortar Extended with Aggregate

Patching mortar extended with aggregate shall meet the following requirements:

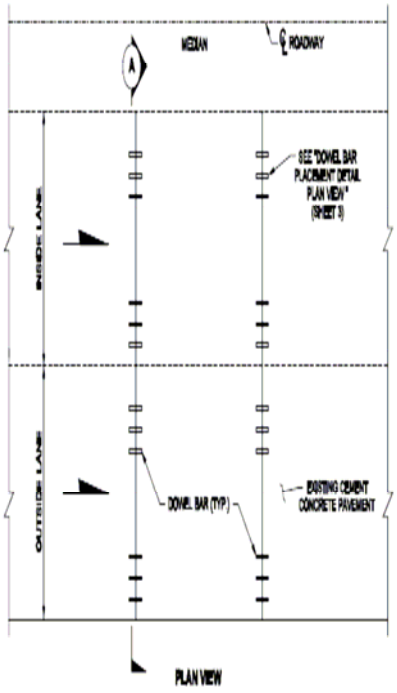
Patch Mortar Extended with Aggregate	ASTM Test Method	Specification
Compressive Strength		
at 3 hours	C 39	> 3,000 psi
at 24 hours	C 39	> 5,000 psi
Length Change		
at 28days	C 157	< 0.15 percent
Bond Strength		
at 24 hours	C 882 (modified by ASTM C 928, Section 8.5)	> 1,000 psi
Scaling Resistance (25 cycles)	C 672 2	Maximum Visual Rating
Freeze thaw	C 666	< 0.10% expansion > 90.0% durability

9-20.2(3) Aggregate

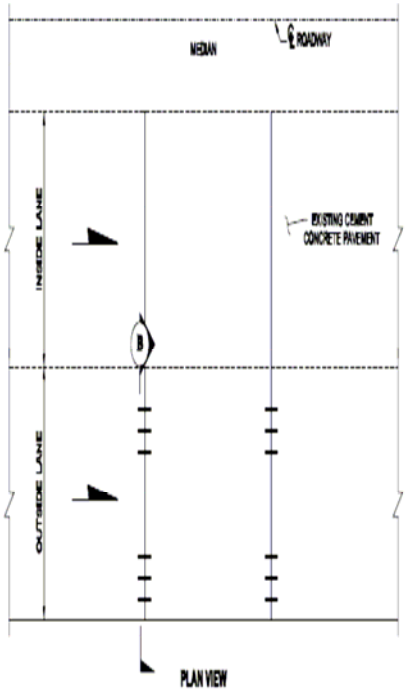
Aggregate used to extend the patching mortar shall meet the requirements of Section 9-03.1(4) and be AASHTO Grading No. 8. A Manufacturers Certificate of Compliance shall be required showing the aggregate source and the gradation. Mitigation for Alkali Silica Reaction (ASR) will not be required for the extender aggregate used for concrete patching material.

9-20.2(4) Water

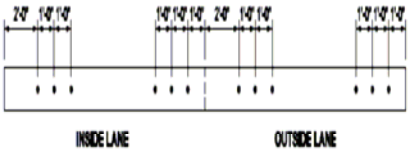
Water shall meet the requirements of Section 9-25.1. The quantity of water shall be within the limits recommended by the manufacturer.



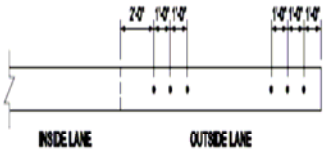
DIVIDED HIGHWAY
(ONE WAY TRAFFIC)
DOWEL BAR RETROFIT
FOR TWO LANES



DIVIDED HIGHWAY
(ONE WAY TRAFFIC)
DOWEL BAR RETROFIT
FOR ONE LANE



SECTION A



SECTION B

EXPIRES JULY 27, 2003

DOWEL BAR RETROFIT FOR CEMENT CONCRETE PAVEMENT

STANDARD PLAN A-5

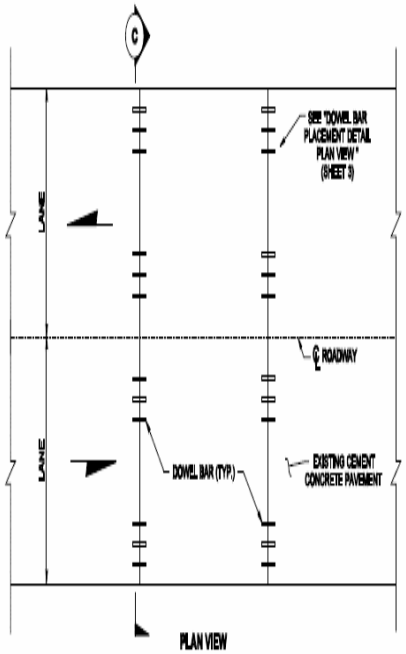
SHEET 1 OF 3 SHEETS

APPROVED FOR PUBLICATION

Harold J. Peterfeso 02-24-03

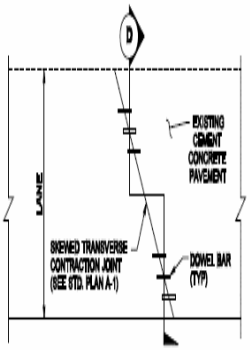
STATE DESIGN ENGINEER DATE

Washington State Department of Transportation



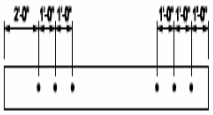
PLAN VIEW

UNDIVIDED HIGHWAY (TWO WAY TRAFFIC) DOWEL BAR RETROFIT FOR EACH LANE

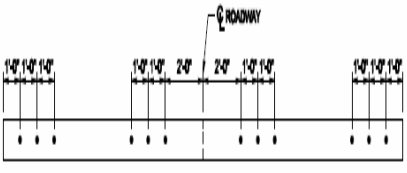


PLAN VIEW

SKEWED JOINT DETAIL



SECTION (D)



SECTION (C)

DOWEL BAR RETROFIT FOR CEMENT CONCRETE PAVEMENT

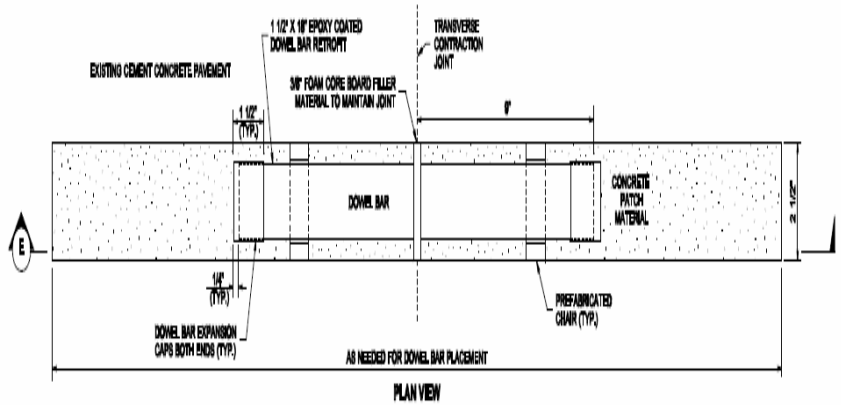
STANDARD PLAN A-5

SHEET 2 OF 3 SHEETS

APPROVED FOR PUBLICATION

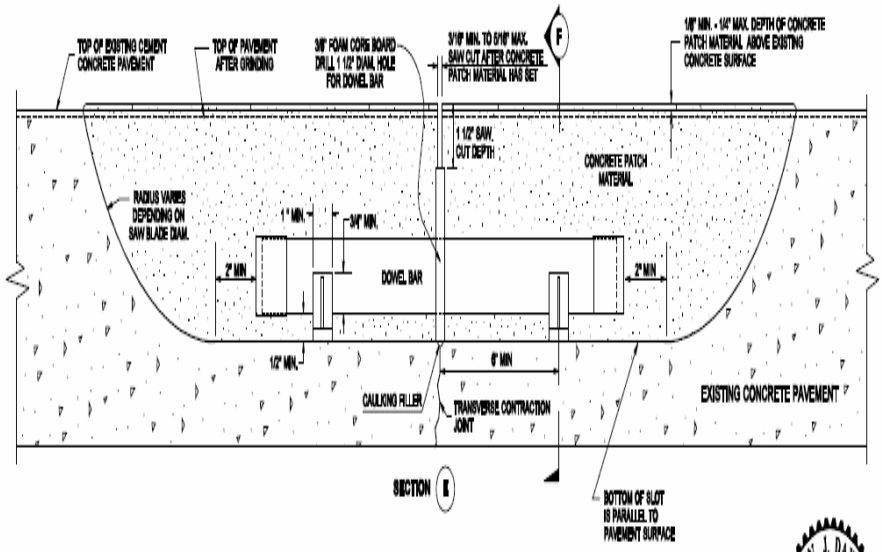
Harold J. Peterfeso 02-24-03

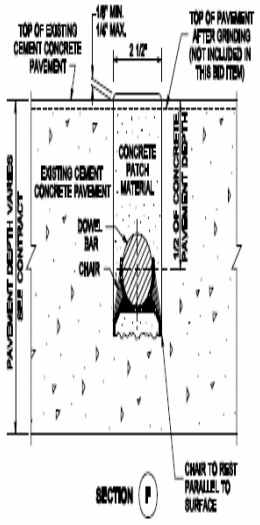
Washington State Department of Transportation



PLAN VIEW

DOWEL BAR PLACEMENT DETAIL





EXPIRES JULY 27, 2003

DOWEL BAR RETROFIT FOR CEMENT CONCRETE PAVEMENT

STANDARD PLAN A-5

SHEET 3 OF 3 SHEETS

APPROVED FOR PUBLICATION

Harold J. Peterson 02-24-03

STATE DESIGN ENGINEER DATE

Washington State Department of Transportation

A. Description

(1) This special provision describes restoring load transfer in existing concrete pavement by installing epoxy coated dowel bars across transverse joints or cracks and warranting the workmanship and materials for three years. The work shall conform to the plan details for retrofit dowel bar installation and as hereinafter provided.

(2) The contractor will be responsible for the pavement performance and shall warranty the work for the finished roadway for a period of three years following completion of the retrofit dowel bar work and opening to public traffic.

(3) Provisions of the warranty work will apply to all concrete mixtures, dowel bars and materials placed as part of the retrofit dowel bar operation.

B. Warranty

(1) The necessary warranty bond for the concrete pavement items will be in effect for the entire three-year warranty period beginning when the warranted retrofit dowel bar work is completed and open to public traffic. The bonding company must have an A.M. Best rating of "A-" or better and the contractor will provide proof of a three-year bond commitment before execution of the contract.

(2) The warranty bond will be 100 percent of the dollar value for the warranted retrofit dowel bars. The bond will insure the proper and prompt completion of required warranty work following completion of the work, including payments for all labor, equipment and materials used according to this specification.

(3) The contract bond, which remains in effect for one year beyond the completion of the project, will also include warranty work as described in Section F of this article. For the remaining two-year warranty period, the contractor shall provide documentation that the warranty bond will be provided in one of the following manners:

1. A single term two-year warranty bond.
2. A one-year renewable, non-cumulative warranty bond for two consecutive terms.

(4) If the warranted retrofit dowel bars are placed by a subcontractor rather than by the contractor, the subcontractor performing the warranted work may provide the warranty bond for the remaining two-year warranty period. If a subcontractor does provide the bond, it shall be a dual obligee bond, naming the contractor and the Wisconsin Department of Transportation as obligees. The subcontractor warranty bond will be one of the following:

1. A single term two-year warranty bond.
2. A one-year renewable, non-cumulative warranty bond for two consecutive terms.

(5) Failure of the contractor, subcontractor or its surety to issue or renew the warranty bond will be considered a default and will result in forfeiture of 20% of the face amount of the bond to the Department.

(6) All warranty work will be as prescribed in Section F of this article. At the end of the warranty period, the contractor will be relieved of the responsibility to perform further warranty work, provided all previous warranty work has been completed.

(7) The contractor shall maintain insurance, in the course of performing warranty work, as specified in subsection 107.26 of the standard specifications throughout the three-year warranty period.

C. Materials

(1) Use epoxy coated dowel bars that conform to the requirements prescribed in subsections 505.2.6.1 and 505.2.6.2 of the standard specifications except that the surface treatment, capable of preventing bond between the bar and the concrete, on the epoxy-coated bars shall be manufacturer applied.

(2) Dowel bars shall have tight fitting end caps made of a non-metallic material that allow for ¼ inch movement of the bar at each end. Prior to use, submit a sample end cap to the engineer for approval.

(3) Use ⅜ inch thick foam core board that is constructed of closed cell foam and is faced with poster board or plastic material on each side.

(4) Use concrete patch material tested as Rapid Set Concrete Patching Materials that conforms to ASTM C928 with the following deletion or addition: Delete sections 1.1.1, 1.1.2 and 1.3. Only use material that: (1) provides an opening to traffic compressive strength of 3000 psi in three hours per ASTM C39; (2) exhibits expansion of less than 0.10 percent per ASTM C531; Section 1.3 of the ASTM C531 should be modified to say this test method is limited to materials with aggregate size of ⅜ inch or less; and (3) has a calculated durability factor of 90.0 percent minimum at the end of 300 freeze-thaw cycles per ASTM C666, procedure A (water shall contain 5% sodium chloride by mass). Prior to use, provide a certification of compliance with the above requirements as prescribed by subsection 106.3.3 of the standard specifications. Patching material shall be extended with a clean natural aggregate. Aggregate extender shall conform to the requirements prescribed in subsection 501.2.5.4 of the standard specifications except that the size requirements are as follows:

Minimum of 95% passing the ⅜ inch (9.5 mm) sieve
Maximum of 25% passing the No. 4 (4.75 mm) sieve

(5) Use acceptable caulking filler for sealing the existing joints or cracks at the bottom and sides of the slot. Acceptable caulking filler includes any commercial caulk designed as a concrete sealant that is compatible with the patch material being used.

(6) Use dowel bar chairs and expansion caps made of non-metallic non-organic material. Chairs shall be designed to fit snugly in the saw cut and shall hold the bar in the lateral center of the slot. Expansion caps will provide for ¼ inch of movement at each end of the dowel bar. Prior to use, submit sample chairs and expansion caps to the engineer for approval.

(7) Provide a concrete curing agent that is a resin of 100 percent poly-alpha-methylstyrene type curing compound meeting ASTM C309, Type 2, Class B specifications and conforming to all requirements listed in the following table:

Properties	Minimum	Maximum
Total Solids, % by weight of compound	42	
Reflectance in 72 hours (ASTM E1347)	65	
Loss of Water, kg/m^2 in 24 hours (ASTM C156)		0.15
Loss of Water, kg/m^2 in 72 hours (ASTM C156)		0.40
Settling Test, ml/100 ml in 72 hours[1]		2
V.O.C. Content, g/L		350
Infrared Spectrum, Vehicle[2]	100% alpha-methylstyrene	

[1] Test Method on file at the department's Materials Testing Lab.

[2] The infrared scan for the dried vehicle from the curing compound shall match the infrared scan on file at the department's Materials Testing Lab.

(8) Shelf life of the product shall be 6 months from date of manufacture. The product may be re-tested by the department's Materials Testing Lab and re-approved, if the physical and chemical properties have not changed, for an additional six months. However, the maximum shelf life shall not exceed one year from manufacture date.

D. Construction

(1) Install the dowel bars in the existing concrete pavement as shown in the plan details and according to the following specifications.

Slots

(1) Cut slots in the pavement using a gang saw capable of simultaneously cutting a minimum of three slots, or by using an alternate method approved by the engineer.

(2) The saw cuts for all required slots at each transverse joint or crack shall be made such that the longitudinal centerline of each individual dowel bar is placed within the following tolerances:

- At the nominal mid-depth of the lower slab ± ½ inch (13 mm).
- Parallel to the top of the pavement ± ½ inch (13 mm) in 18 inches (450 mm).
- Parallel to other bars in the same joint or crack ± ½ inch (13 mm) in 18 inches (450 mm).
- Parallel to the roadway centerline ± ½ inch (13 mm) in 18 inches (450 mm).

(3) Traffic may run on sawed slots for a maximum of two weeks.

Removing Concrete

(1) Remove concrete from the slot area with a jackhammer no larger than the 30-pound (14 kg) class.

(2) Before installing the dowel, sandblast all exposed surfaces and cracks in the slot and clean all exposed surfaces and cracks of saw slurry and loose material. Dispose of all loose material off the highway right-of-way.

Placing Foam Core Board

(1) Place foam core board to maintain the continuity of the existing transverse joint or crack as shown in the standard detail drawing.

(2) Size the foam core board to fit the skew angle of the joint or crack and extend to, or beyond, the top surface of the lower slab. Fit the foam core board tightly around the dowel bar and to the bottom and sides of the slot.

(3) To provide a tight fit for the foam core board and to prevent any of the patch mix from entering the joint or crack, caulk existing transverse joints or cracks with a sealant at the bottom and sides of the slot as shown in the plan details.

(4) Install the foam core board such that it remains in position and is tight to all edges during placement of the patching material. Tabs may be used to hold the foam core board in place. Existing joint sealant may be cut or removed to accommodate tabs. If the foam core board shifts during the placement of the patch mix, the work shall be rejected and the contractor shall repair the work at no expense to the department.

(5) Alternatively, the foam core board may be installed such that it extends a minimum of one inch above the dowel bar and is a minimum of 2 inches below the surface of the pavement. Place the insert so that it covers the existing transverse joint or crack and is capable of remaining in a vertical position, tight to all edges during placement of patch materials. Re-establish the joint by sawing down to the level of the foam core board within three hours of placement of the patch material. If the contractor chooses this method, no damage to the dowel bars will be allowed due to the sawing operation being completed too deep. Contractor operations of placing patch material and sawing must ensure that all material is removed from the joint allowing for the expansion and contraction without generating point to point contact across the joint.

Placing Dowel Bars

(1) Place dowel bars as a complete assembly with chairs and foam core board attached across the transverse joint or crack as shown in the plan details. Chairs shall hold the dowel bar securely in place during the placement of the patch mix. Prior to the placement of the patch mix, the engineer shall approve the placement of the dowels. If the dowel bar shifts during the placement of the patch mix, the work shall be rejected and the contractor shall repair the work at no expense to the department.

Placing Patch Mix

(1) Immediately prior to placing the patch mix, moisten existing concrete surfaces in the slot or prepare the existing concrete surfaces as recommended by the manufacturer, or both. Before patching material is placed, remove all excess water in the slot.

(2) With a portable or mobile mixer, mix patching material according to the manufacturer's recommendations.

(3) Place the patching material into the slot and vibrate the patching material to ensure that the dowel bar is completely encased. The diameter of the vibrator head shall not exceed 1¼ inches (32 mm).

(4) When the ambient temperature is below 50 degrees Fahrenheit (10 degrees Celsius), placement of patching material will require prior approval by the engineer.

(5) If the pavement is not going to be diamond ground, strike-off the surface of the filled area flush with the adjacent concrete. If the pavement is to be diamond ground after completion of the dowel bar retrofit operation, it is acceptable to leave the slot slightly overfilled.

(6) Before placing any vehicle load on the retrofitted transverse joint or crack, cure patching material by the impervious coating method for a minimum of three hours. The coverage rate for the curing agent will be at a rate of 100 square feet per gallon. During this three-hour initial curing period, covering may be needed to prevent excess thermal stress in the patch material.

(7) When the ambient temperature is below 50 degrees Fahrenheit (10 degrees C), the engineer may postpone opening to vehicular loads or require covering during the initial curing period, or both.

Restoring Joints

(1) Restore joints with a saw cut that is at least ¼ inch wide and is deep enough to remove all patching material from the joint. Saw the joint within 24 hours after placement of patching material. After sawing, thoroughly clean the joint or crack to remove loose compressible materials.

(2) If the pavement joints are sealed, remove the existing joint sealant and re-seal the joint with hot pour rubberized asphaltic material. Joint sealing materials and work will be completed and paid for under the applicable item in this contract.

Damage During Construction

(1) At no cost to the department, the contractor shall repair any damage to the pavement due to the contractor's operations.

E. Conflict Resolution Team

(1) The Conflict Resolution Team will have the final authority to make decisions if a conflict occurs. The team will resolve disputes by a majority vote. The team will consist of two contractor representatives, two department (district & central office) representatives and a third party mutually agreed upon by both the department and the contractor. The cost of the third party will be equally shared between the department and the contractor.

F. Pavement Distress Surveys and Contractor Monitoring

Pavement Distress Surveys

(1) The department's Bureau of Highway Construction will conduct distress surveys of the mainline pavement according to the bureau's normal surveying cycle; or if requested by the contractor or district. The bureau's surveying cycle is dependent on the location of the highway and the highway classification.

(2) The pavement distress surveys will be conducted by dividing the highway system into nominal one-mile sections. Two one-tenth mile segments in each mile will be evaluated for pavement distress. One of the segments evaluated will be between 0.3 and 0.4 miles from the start of the section. The department will select the second one-tenth mile segment randomly. If areas other than the surveyed segments are suspected of meeting or exceeding a threshold level, the department

will divide the entire mainline project pavement into 0.1-mile segments and conduct a distress survey in any, or all, segment(s). The distress survey results will be made available to the district, central office, the contractor and FHWA. Pavement distress threshold criterions are listed in Section G of this article.

(3) The first year, the department will determine the random one-tenth mile segments and will survey the selected segments throughout the warranty period. The first survey will identify the segment locations, which will not change thereafter.

(4) If any of the threshold level criterions are met and the contractor does not agree to the validity of the pavement distress survey results, written notification of the dispute will be made to the engineer. The Conflict Resolution Team will resolve the dispute.

Contractor Monitoring

(1) During the warranty period, the contractor may monitor the pavement using nondestructive procedures. Coring, milling, grinding or other destructive procedures may not be performed by the contractor without approval of the engineer in accordance with the permit requirements of Section H.1 of this article.

G. Table of Distress Types, Threshold Levels and Remedial Action

(1) The department will include each of the distress types listed below in the mainline pavement survey. The table lists the remedial action required for each distress type when the corresponding threshold level criterion is met.

Distress Type	Threshold(s) Level	Remedial Action
Distressed Joints within the Dowel Bar Retrofit Slot	Spalling of 1 inch or greater on more than 10 percent of the joints per 0.1 mile segment Or Spalling of 2 inches or greater on 1 percent of the joints per 0.1 mile segment.	Remove and replace retrofit dowel bar.
Cracking in the existing concrete pavement between the slots or across slab to pavement edge (corner crack)	Greater than 1 percent of the joints per lane mile	Standard full depth concrete repair of the pavement.
Loss of surface and concrete patch material within the dowel bar slot	Loss of material greater than ½ inch but less than 1 inch on more than 1 percent of the joints per lane mile Loss of material of 1 inch or greater on more than 1 percent of the joints per lane mile	Surface treatment as approved by the engineer. Remove and replace retrofit dowel bar
Debonding of the patch concrete with the existing concrete on any surface of the slot	Debonding on any one surface on more than 1 percent of the joints per lane mile.	Remove and replace the retrofit dowel bar
Break up or dislodgement of concrete patch material within the slot	One or more cracks in greater than 1 percent of the joints per lane mile	Remove and replace the retrofit dowel bar

- A joint is defined as a transverse joint that is 12 foot long or one pavement lane wide.
- Diamond Grinding shall be done on any joint on which the contractor performed removal and replacement of the dowel bars or on any full depth concrete repair of the pavement as may be required to reestablish adequate ride characteristics as defined under subsection 415.3.11.8, or both.
- All repaired joints will be resealed.

H. Warranty Work

General

(1) The contractor shall perform warranty work during the three-year warranty period at no additional cost to the department. Warranty work consists of remedial work and elective/preventive maintenance.

(2) During warranty work operations, traffic control will be as specified in section 643 of the standard specifications and will conform to Part 6 of the Wisconsin Manual on Uniform Traffic Control Devices.

(3) The contractor will document all warranty work performed and annually provide this information to the Pavement Performance Section of the department's Bureau of Highway Construction.

(4) If warranty work necessitates a corrective action to the pavement markings, raised pavement markers, adjacent lane(s), or shoulders, that additional corrective action will be the responsibility of the contractor.

(5) All warranty work including but not limited to remedial work and elective/preventive maintenance shall require a permit from the department that can be obtained by contacting the district Pavement Engineer.

Remedial Work

(1) Remedial work will be based on the results of the mainline pavement distress or manual surveys, or both.

(2) If any of the threshold level criterion in the table in Section G of this article are met on the mainline pavement and the contractor agrees to the validity of the pavement distress survey results, the contractor shall perform the remedial work prescribed in the remedial action column of the table. Remedial work to be performed and materials to be used will be the joint decision of the contractor and the engineer. The remedial work shall be performed on all segments of the project where a threshold level is met unless otherwise noted under the remedial action. The remedial work shall be applied to the entire segment(s).

(3) Remedial action work required on the mainline roadway will also be performed on the integral concrete shoulders, curb and curb and gutter. Auxiliary lanes impacted by the distress in the mainline warranted retrofit dowel bars will also be repaired as part of the remedial action. If an impasse develops, the Conflict Resolution Team will make a final determination.

(4) Remedial work shall be performed in the same calendar year that the pavement distresses were recorded.

(5) The contractor with the engineer's approval may elect to delay the remedial actions for efficiency of operations. Such delay does not relieve the contractor of the responsibility for appropriate remedial action at the time of the repair.

(6) The contractor with the engineer's approval may elect to delay the remedial actions in order to minimize the impacts of delay and inconvenience to the traveling public.

(7) If at anytime during the warranty period 30 percent or more of the project segments require or have received remedial action, the entire project will receive remedial action as mutually determined by the contractor and the engineer.

(8) The contractor will have the first option to perform the remedial work. If, in the opinion of the engineer, the problem requires immediate attention for the safety of the traveling public and the contractor cannot perform the remedial work within eight hours, the engineer may have the remedial work done by other forces at the contractor's expense. Remedial work performed by other forces will not alter the requirements, responsibilities, or obligations of the warranty.

(9) If remedial action work or elective/preventive action work performed by the contractor necessitates a corrective action to the pavement marking(s), raised pavement markers, adjacent lane(s) and shoulders, then such corrective action to the pavement markings, raised pavement markers, adjacent lane(s) and shoulders will be the responsibility of the contractor.

(10) The contractor will not be held responsible for distresses, which are caused by factors beyond the control of the contractor. However, due to the fact that the dowel bar retrofit work is under the warranty, the contractor may be given the option to make these repairs at reasonable cost to be negotiated with the engineer. Costs for these repairs will be based upon time, materials, labor, equipment costs and traffic control costs and will be consistent with the normal cost of maintenance traditionally performed by county highway forces.

Elective/Preventive Maintenance

(1) Elective/preventive maintenance will be a contractor option. Elective/preventive maintenance to be performed and materials to be used will be coordinated jointly by the contractor and the engineer.

I. Measurement

The department will measure Pavement Dowel Bars Retrofit Warranted by each dowel bar installed and accepted.

J. Payment

The department will pay for measured quantities at the contract unit price under the following bid item:

ITEM NUMBER	DESCRIPTION	UNIT
416.0623.S	Pavement Dowel Bars Retrofit Warranted	Each

Payment is full compensation for furnishing all materials, including epoxy coated dowel bars; sawing slots; removing concrete; installing dowel bars; furnishing and installing patching material; curing the patch material; sawing the joints; furnishing and applying water; for the warranty and warranty bond(s); performing warranty work; and for furnishing all labor, tools, equipment and incidentals required to complete the work as specified.

416.1 DESCRIPTION

This section describes the requirements for installing epoxy-coated dowel bars into existing transverse joints in concrete pavement.

416.2 MATERIALS

Provide materials in accordance with the following:

Material	Subsection
Bond-Breaking Compound	810.2
Caulking Filler	810.3
Chairs	811.2.5
Dowel Bar Retrofit Concrete	810.5
Dowel Bars and Tie Bars	811.2
Dowel Bar End Caps	811.2.2
Foam Core Board	810.4

416.3 EQUIPMENT

Ensure that equipment meets the following:

1. A concrete saw capable of cutting at least three slots simultaneously at least 7.25 in deep;
2. Jack hammers no larger than the nominal 30-poundclass;
3. A sandblaster and an air compressor able to produce oil-free compressed air;
4. A mobile, continuous mixer or a small, portable, motor-driven, batch type mixer at the placement site that accurately proportions materials for the mixture, discharges a uniform mixture and maintains a continuous, steady flow of mixture; and
5. If necessary, a scale, accurate to the nearest pound [kilogram] and other equipment to charge the mixer with the correct proportions of materials.

416.4 CONSTRUCTION

416.4.1 General

Submit a sample of each of the following items to the engineer for approval at least 14 calendar days before use:

1. End caps;
2. Chair devices;
3. Caulking filler;
4. Foam core board filler;
5. Bond breaking compound; and
6. Enough patching material, including the extension aggregate, for a 0.5 ft^3 batch.

Provide saw-cut dowels, free of burrs or projections that restrict movement, with tight-fitting end caps. Repair damage to epoxy coating in the field.

Place dowel bar retrofit concrete in accordance with manufacturer's recommendations. Ensure that samples acquired during production achieve a compressive strength of at least 4000 psi in 24 hours.

If a mobile, continuous mixer is used, calibrate the proportioning equipment for each component of the mixture in the presence of the engineer. During calibration checks and normal use, operate proportioning equipment at the speed recommended by the manufacturer. When a portable batch type mixer is used, provide measuring devices and other necessary equipment.

416.4.2 Test Section

Provide a test section consisting of complete dowel bar retrofit, to include at least 24 retrofits, at a location determined by the engineer before start of major operations. Twenty-four hours after completing the test section, take three 6 inch diameter full-depth cores at locations determined by the engineer to assess the installation. After obtaining the engineer's approval, begin production operations and proceed on a performance basis.

416.4.3 Installation

Retrofit only existing type A, weakened plane transverse joints with dowels. Cut slots in the pavement, parallel to the centerline of the roadway, to place the center of the dowel at mid-depth in the concrete slab. Simultaneously cut at least three slots per wheel path along the transverse joint or crack, or as approved. If necessary, make multiple cuts in the slot, parallel to the centerline, to properly remove material. Collect and dispose of slurry and residue at an approved location.

Close the lane if slots are sawn too far ahead of the operation and the "fins" formed by the saw cuts begin to break and become a traffic hazard or if traffic begins to cause corner breaks from cracks that develop between slots and the longitudinal shoulder or center line joint. Reopen the lane after the damaged areas are repaired and the retrofitting of the dowel bars is completed. Repair corner breaks or cracks caused by traffic on unfinished slots at no additional cost to the department.

Use a 15-pound jack hammer when breaking the concrete out of the slot, if the 30-pound hammer damages the pavement,

Before installing dowel bars, sandblast and clean the slot of saw slurry and loose concrete. If the crack width of the transverse contraction joint equals or exceeds ⅛ in, fill the joint on the bottom and the sides of the slot with silicone. Minimize the amount of silicone on the side and bottom surfaces of the slot.

Coat bars with a bond breaking compound, place in the approved dowel chair and place as follows:

1. To the depth specified;
2. Parallel to the centerline;
3. At the middle of the slot;
4. With the mid-point of the dowel within 1 in of the centerline of the transverse joint; and

5. Parallel to the pavement surface (ensure that the bar does not deviate more than ¼ in from a plane parallel to the pavement surface, when measured along the length of the bar).

Do not allow movement of the dowel bar in the chair during placement of the grout. The engineer will reject chairs that allow movement of the bar. Ensure that dowel bar sleeves do not collapse during construction.

Place foam core board filler at the middle of the dowel to maintain the transverse joint or crack. Fit the board tightly around the dowel and edges of the slot. Cut or remove existing joint sealant to accommodate the board tabs (which stabilize the board during placement of patching material). Place the board so that it remains vertical and tight against all edges during placement of the patching material.

Fill the slot (with the installed dowel bar with caps, chairs, foam core board and silicone in place), with an approved patching material. Thoroughly moisten all surfaces of the slot immediately before filling. Do not allow standing water in the slot. Remove excess water with compressed air. Thoroughly consolidate the dowel bar retrofit concrete in the slot and around the dowel bar with a vibrator of appropriate size and ensure there are no voids. Finish the concrete to the same surface texture as the adjacent, existing concrete. Trowel the material toward the hardened concrete to prevent voids at the edges of the patch.

Cure the surface of the filled area immediately after finishing, in accordance with the patching material manufacturer's recommendations. Maintain joints by sawcutting the surface within 24 hours of placing the grout.

Seal transverse contraction joints and cracks in accordance with Section 417, Sealing Existing Concrete Pavement Joints and Cracks.

Repair or replace damaged and nonfunctioning dowels at no additional cost to the department. During production, if cores indicate incomplete consolidation of the patching material under or around the dowel bars, stop placement and take corrective action. Obtain the engineer's approval before restarting. If cracks develop in the dowel bar retrofit concrete or if there is any separation or debonding between the dowel bar retrofit concrete and the existing concrete, remove and replace at no additional cost to the department.

416.5 MEASUREMENT and PAYMENT

416.5.1 General

The engineer will measure Dowel Bar Retrofit by each dowel installed, including dowels in the test section.

The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Dowel Bar Retrofit	EA	EA	EA

810.5 Dowel Bar Retrofit Concrete

Provide and use a concrete product pre-approved by the Materials Program or equivalent in accordance with Table 810.5-1, Dowel Bar Retrofit Concrete Material.

Table 810.5-1
Dowel Bar Retrofit Concrete Material

Property	Test	Value
NEAT MATERIAL		
Compressive Strength	ASTM C 109	3000 psi in 6 h 5000 psi in 24 h
Shrinkage in 4 Days	ASTM C 596	0.13 percent , max
Final Set	---	25 minutes, min.
WITH MAXIMUM AGGREGATE EXTENSION		
Flexural Strength	Calif. Test 551	500 psi in 24 h
Bond to Dry PCCP	Calif. Test 551	400 psi in 24 h
Bond to SSD PCCP	Calif. Test 551	300 psi in 24 h

Provide and use coarse aggregate extension in accordance with Subsection 803.2.2, Course Aggregate, and Table 810.5-2, Dowel Bar Retrofit Concrete Gradation Requirements.

Table 810.5-2
Dowel Bar Retrofit Concrete Gradation Requirements

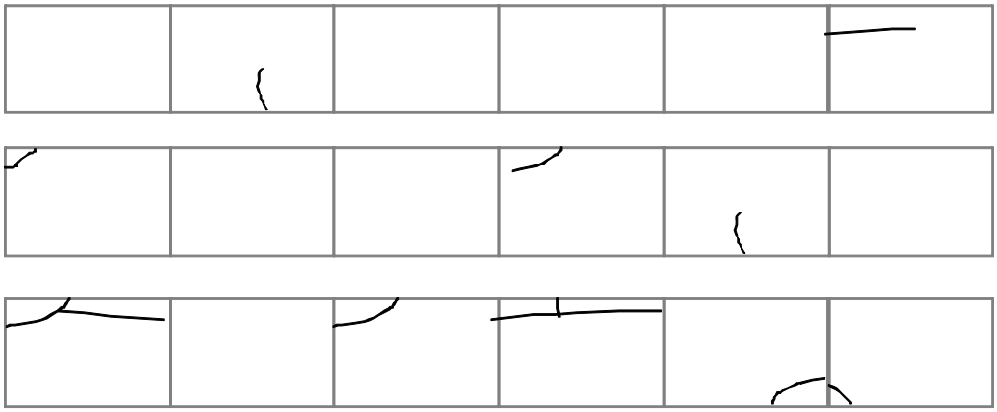
Sieve Size	Percent Passing
⅜ in	100
No. 8	0

Ensure a coarse aggregate extension no greater than eight parts coarse aggregate to ten parts dry patching material by weight [mass]. Provide dry patching material consisting of the manufacturer's cementitious material and fine aggregate. If the fine aggregate is not included as part of the manufacturer's product, blend it with the cementitious material at a proportion recommended by the manufacturer and approved by the engineer. Use fine aggregate in accordance with Subsection 803.2.1, Fine Aggregate.

APPENDIX C. TEST SECTION CRACKING CONDITION

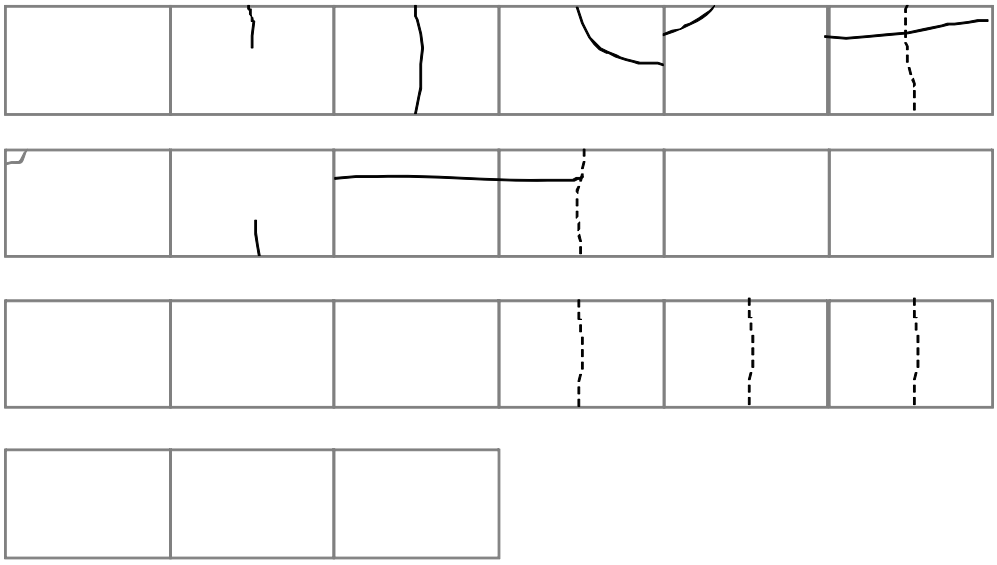
Control Section

MP 77.331



MP 77.283

MP 76.694



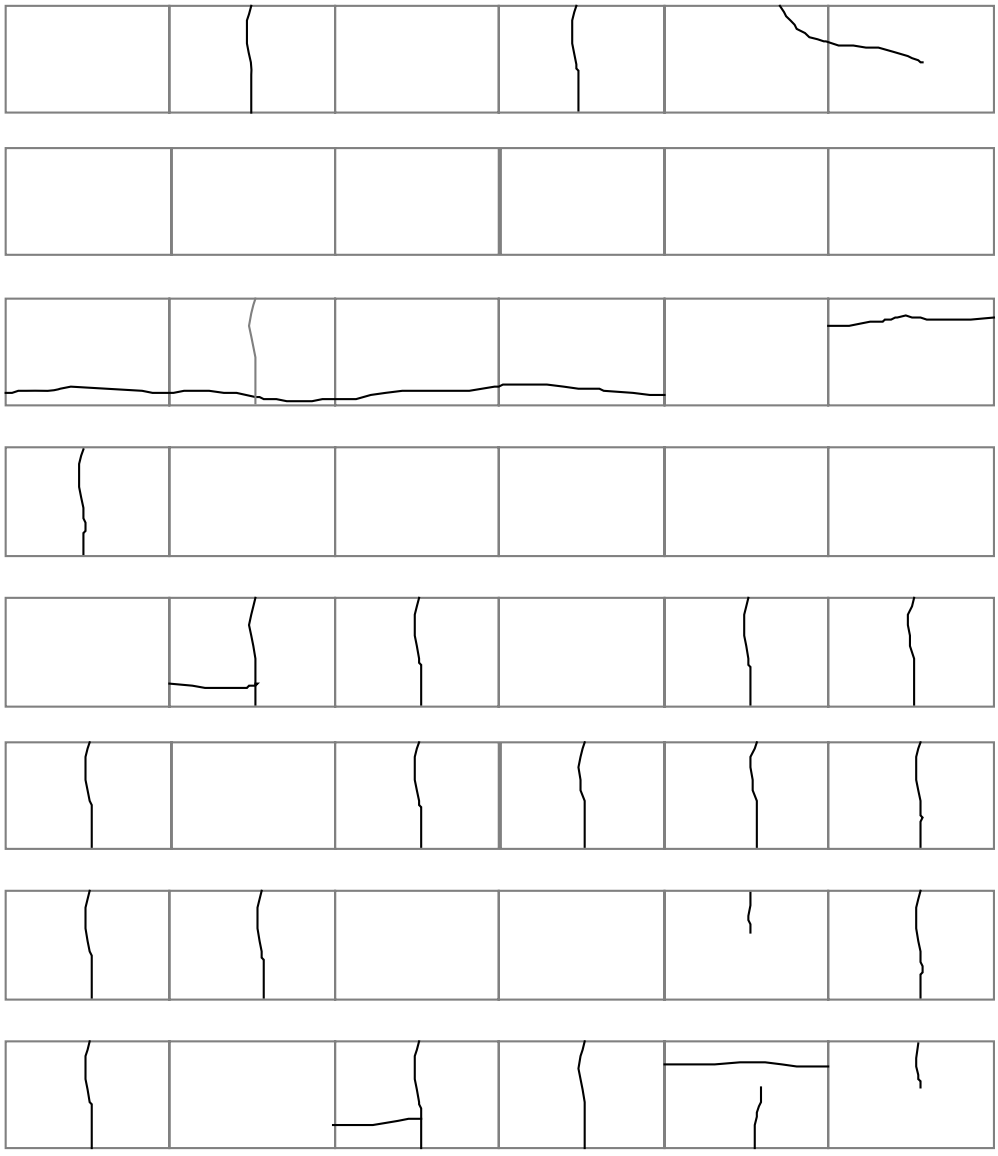
MP 76.638

------ Pre construction ——— 2006 (14 years after construction)

Note (1) – Milepost locations per pavement condition van
Note (2) – Dowel bar retrofit slots were cut in 1996 as part of Contract 4902 but material not removed

Concrete Shoulder Beam

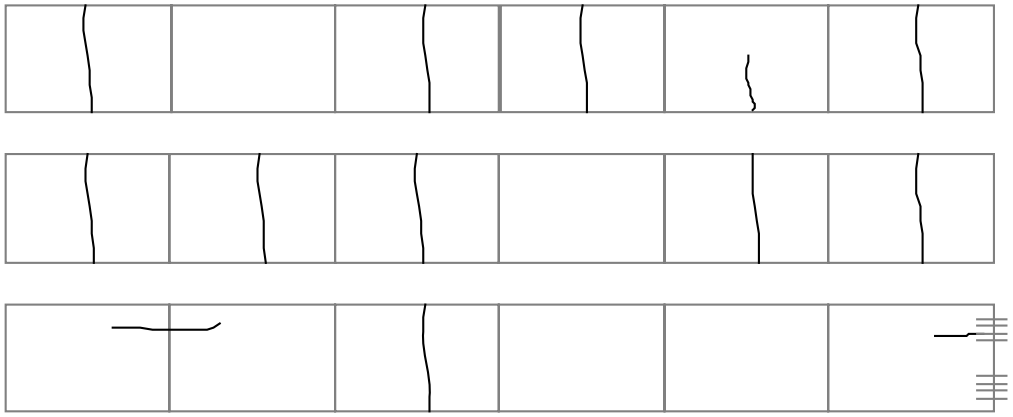
MP 77.280



------ Pre construction ——— 2006 (14 years after construction)

Note (1) – Milepost locations per pavement condition van

Concrete Shoulder Beam



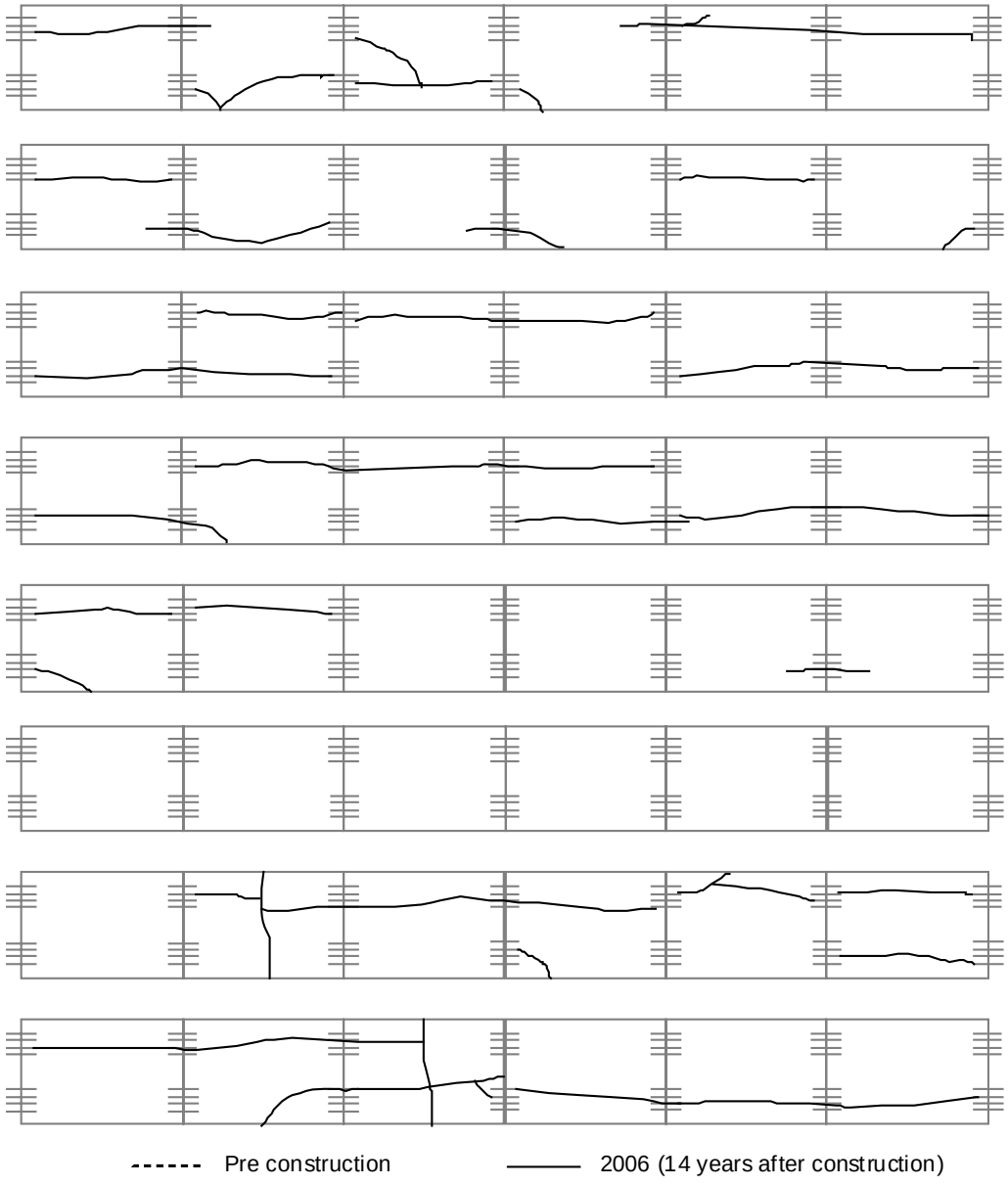
MP 77.091

------ Pre construction ——— 2006 (14 years after construction)

Note (1) – Milepost locations per pavement condition van

Dowel Bar Retrofit and Concrete Shoulder Beam

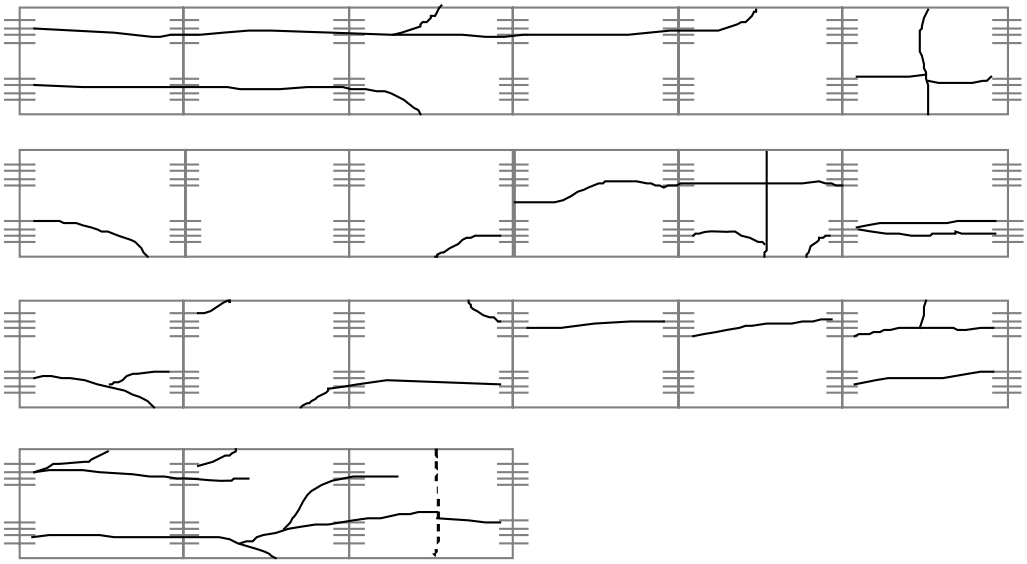
MP 77.091



Pre construction — 2006 (14 years after construction)

Note (1) – Milepost locations per pavement condition van

Dowel Bar Retrofit and Concrete Shoulder Beam



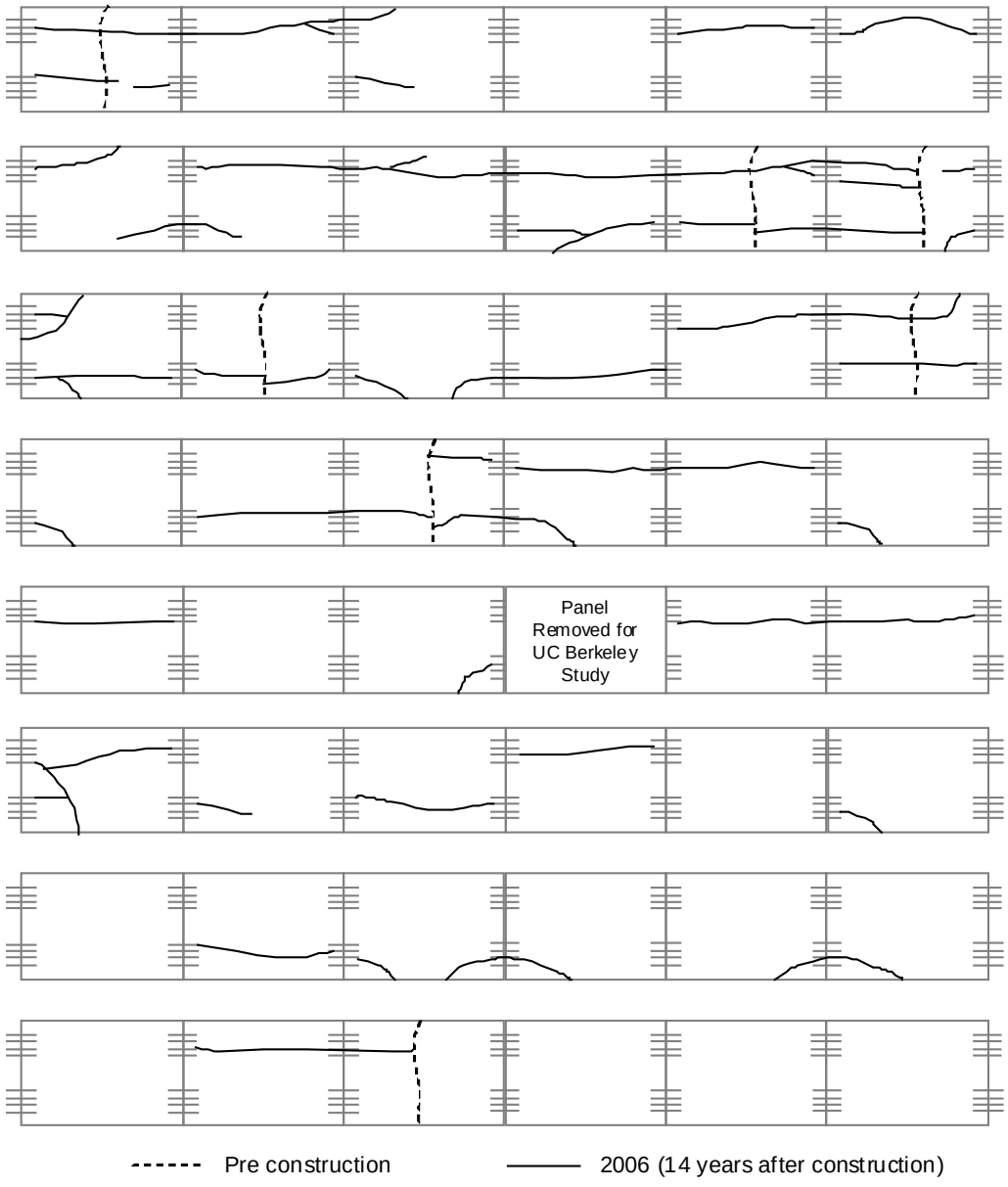
MP 76.889

------ Pre construction ——— 2006 (14 years after construction)

Note (1) – Milepost locations per pavement condition van

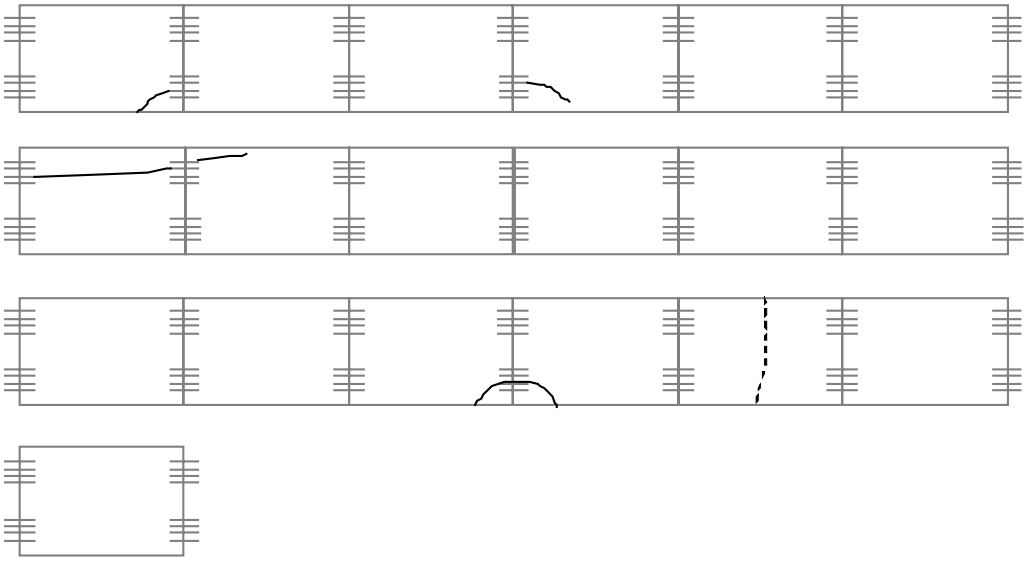
Dowel Bar Retrofit

MP 76.889



Note (1) – Milepost locations per pavement condition van

Dowel Bar Retrofit



MP 76.694

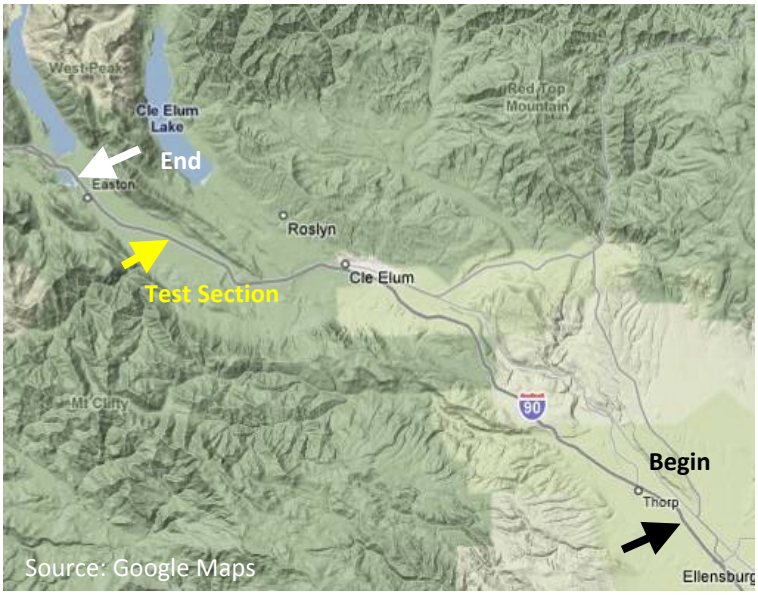
------ Pre construction ——— 2006 (14 years after construction)

Note (1) – Milepost locations per pavement condition van

APPENDIX D. DOWEL BAR RETROFIT PROJECT SUMMARY

PROJECT DETAILS

State Route:	90
Project title:	Kachess River to Yakima River
Project limits:	MP 69.52 to MP 102.49
Direction:	WB
Contract No.:	4107
Year of original construction:	1973
Year of DBR:	1992
Age at DBR:	19 yrs
2006 DBR Age:	15 yrs
DBR length:	0.57 mi
Grinding length:	28.61 mi
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	1065

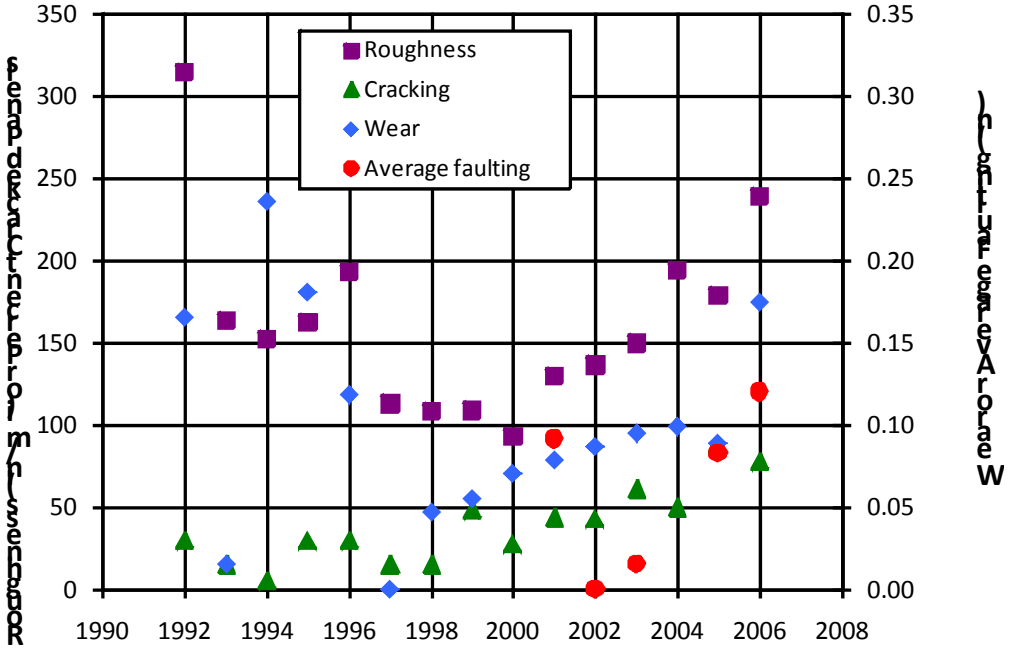


Notes: Dowel bar retrofit test section

PAVEMENT CONDITION								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1993	1,715,500	800,263	0.02	163		15	0	0
1994	2,007,500	933,488	0.24	152		0	5	0
1995	2,226,500	1,036,600	0.18	162		30	0	0
1996	2,117,000	977,288	0.12	193		30	0	0
1997	2,117,000	966,338	0.00	113		15	0	0
1998	2,117,000	939,875	0.05	108		15	0	0
1999	1,861,500	824,900	0.06	109		45	2	1
2000	1,679,000	735,475	0.07	93		19	7	1
2001	1,679,000	724,525	0.08	130	0.09	26	11	6
2002	1,788,500	788,400	0.09	137	0.00	35	4	4

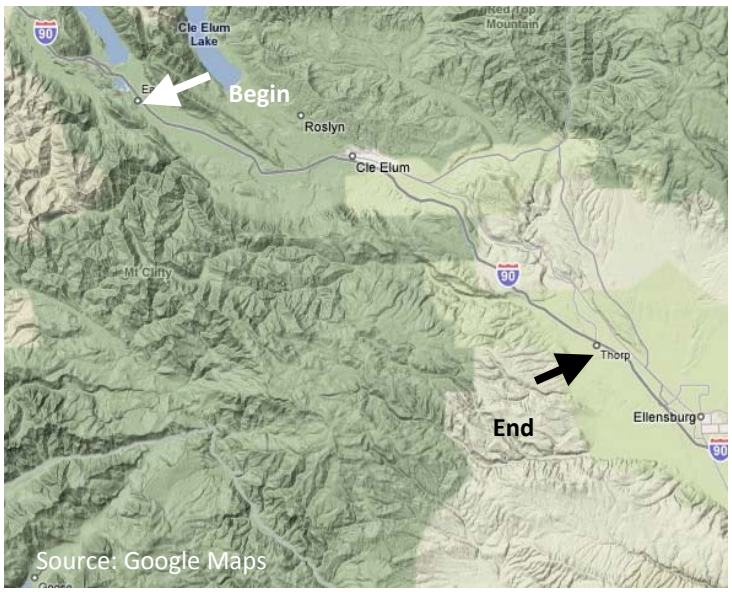
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION								
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	No. Cracked Slabs[3]		
						Low/ Trans.	Med./ Long.	High/ Multi.
2003	1,861,500	809,388	0.09	150	0.02	36	25	0
2004	1,861,500	809,388	0.10	194		49	0	0
2005	1,788,500	783,838	0.09	179	0.08	51	37	0
2006	1,788,500	783,838	0.17	239	0.12	38	32	8
Cumulative	26,608,500	11,913,604						



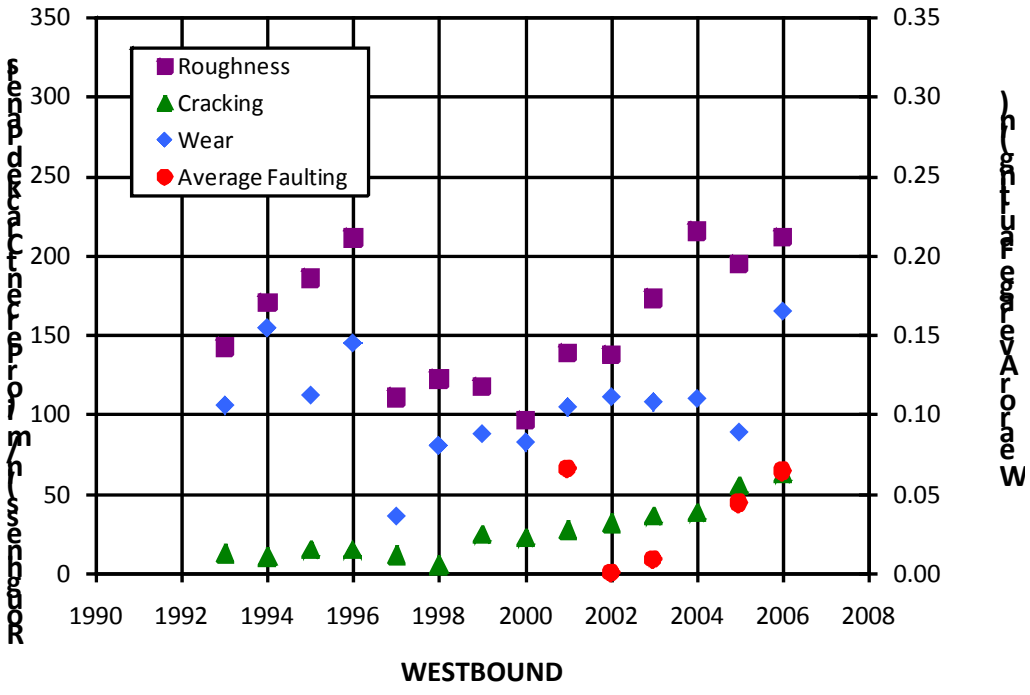
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
State Route:	90
Project title:	Easton Hill to Yakima River
Project limits:	MP 69.52 to MP 102.49
Direction:	WB & EB
Contract No.:	4235
Year of original construction:	1967
Year of DBR:	1993
Age at DBR:	26
2006 DBR Age:	14
DBR length:	30.46 mi
Grinding length:	30.46 mi
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	1065



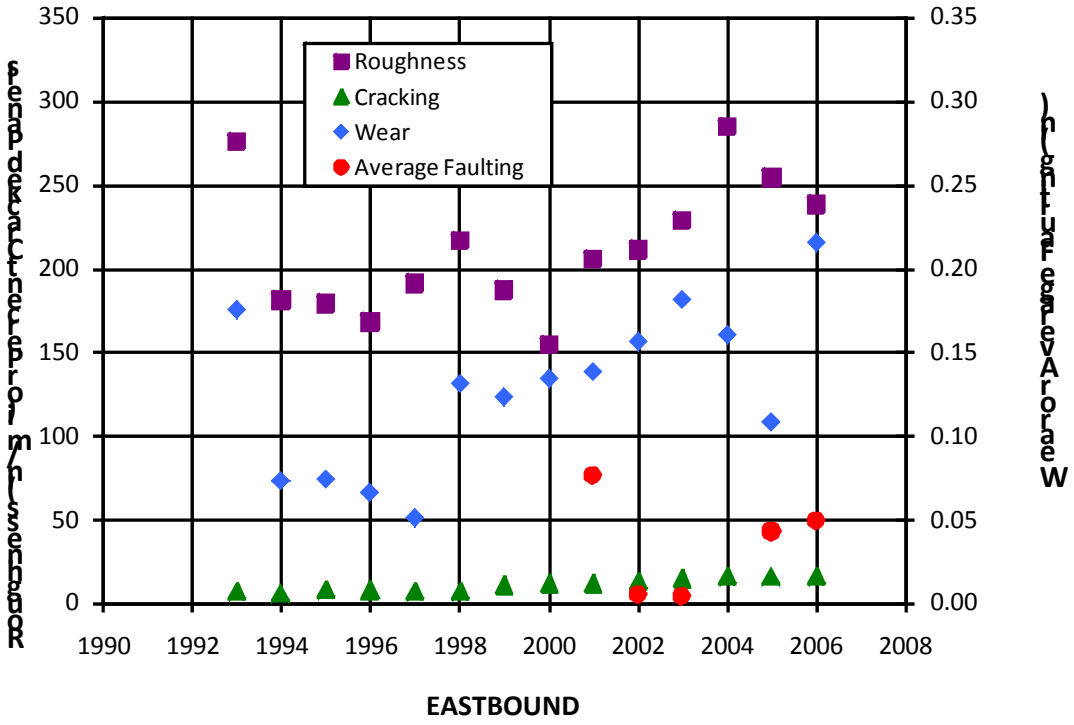
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION – WESTBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1993	1,679,000	782,013	0.11	142		12	0	0
1994	1,898,000	885,125	0.15	170		10	0	0
1995	2,044,000	951,738	0.11	186		15	0	0
1996	1,934,500	892,425	0.14	211		15	0	0
1997	2,007,500	907,025	0.04	111		11	0	0
1998	1,971,000	873,263	0.08	122		4	1	0
1999	1,934,500	850,450	0.09	118		23	1	0
2000	1,825,000	802,088	0.08	97		18	3	2
2001	1,606,000	698,975	0.10	139	0.07	18	6	3
2002	1,752,000	765,588	0.11	138	0.00	24	4	3
2003	1,825,000	791,138	0.11	173	0.01	25	10	2
2004	1,788,500	783,838	0.11	215		34	4	0
2005	1,788,500	783,838	0.09	195	0.04	33	23	0
2006	1,788,500	783,838	0.16	212	0.06	36	24	2
Cumulative	25,842,000	11,551,342						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – EASTBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1993	1,679,000	782,013	0.17	276		6	1	0
1994	1,898,000	885,125	0.07	181		5	1	0
1995	2,044,000	951,738	0.07	179		8	0	0
1996	1,934,500	892,425	0.07	168		7	0	0
1997	2,007,500	907,025	0.05	191		6	0	0
1998	1,971,000	873,263	0.13	216		6	0	0
1999	1,934,500	850,450	0.12	187		10	0	0
2000	1,825,000	802,088	0.13	154		8	2	1
2001	1,606,000	698,975	0.14	205	0.08	10	1	0
2002	1,752,000	765,588	0.16	211	0.00	11	1	1
2003	1,825,000	791,138	0.18	228	0.00	12	1	0
2004	1,788,500	783,838	0.16	284		14	2	1
2005	1,788,500	783,838	0.11	254	0.04	10	5	1
2006	1,788,500	783,838	0.21	238	0.05	5	9	2
Cumulative	25,842,000	11,551,342						



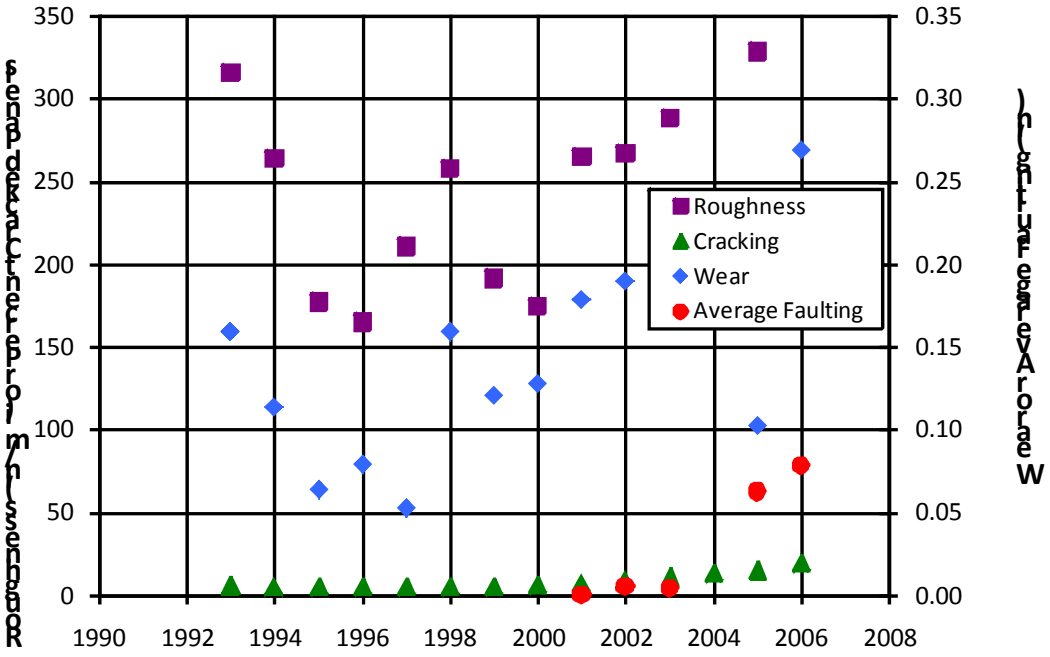
EASTBOUND

[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	90
Project title:	Top of Easton Hill to Silver Creek
Project limits:	MP 67.29 to MP 70.84
Direction:	EB
Contract number:	4340
Original construction:	1976
Year of DBR:	1993
Age at DBR (yr):	17
2006 DBR Age (yr):	14
DBR length:	2.92
Grinding length:	3.55
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	1065

[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1993	1,606,000	756,463	0.16	316		5	0	0
1994	1,825,000	848,625	0.11	264		5	0	0
1995	2,044,000	951,738	0.06	177		5	0	0
1996	1,934,500	892,425	0.08	165		5	0	0
1997	2,007,500	907,025	0.05	211		5	0	0
1998	1,971,000	873,263	0.16	258		5	0	0
1999	1,752,000	781,100	0.12	191		4	1	0
2000	1,642,500	717,225	0.13	175		4	1	0
2001	1,788,500	783,838	0.18	265	0.15	5	1	0
2002	1,898,000	832,200	0.19	267	0.00	6	1	1
2003	1,788,500	783,838	0.21	288	0.00	9	1	0
2004	1,861,500	809,388	0.20	383		11	1	1
2005	1,788,500	783,838	0.10	328	0.06	13	1	1
2006	1,861,500	809,368	0.27	352	0.08	14	1	4
Cumulative	25,769,000	11,530,354						

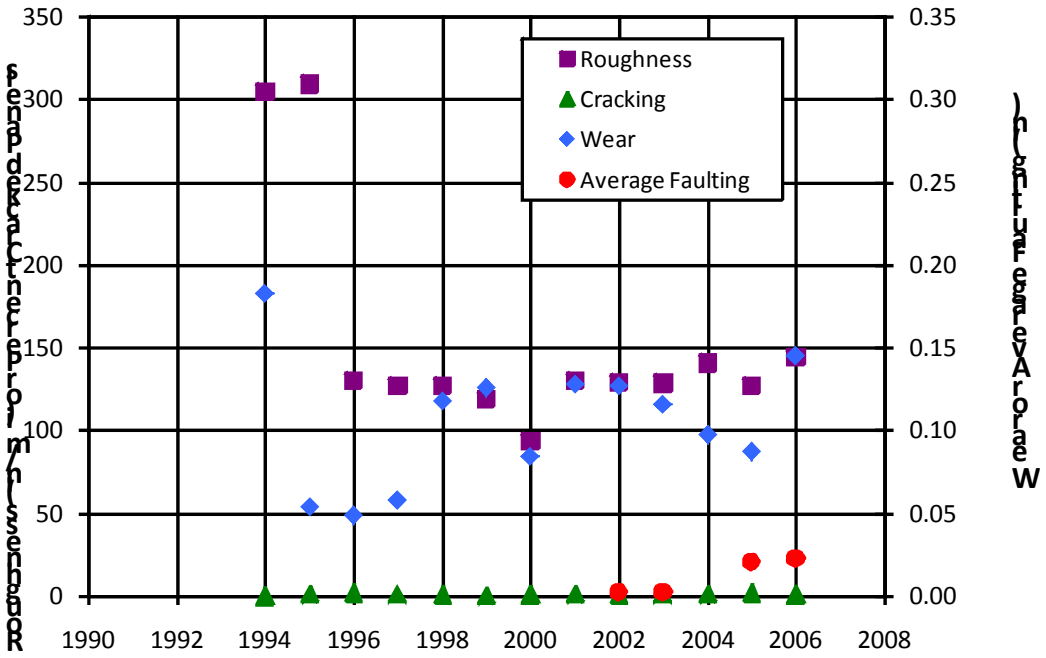


[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Joe Leary Slough to Nulle Road
Project limits:	MP 231.77 to MP 243.47
Direction:	SB
Contract number:	4616
Original construction:	1966
Year of DBR:	1994
Age at DBR:	28 years
2007 DBR Age:	13 years
DBR length:	11.70
Grinding length:	11.70
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	7 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	215

[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1994	1,387,000	589,475	0.18	305		0	0	0
1995	1,533,000	651,525	0.05	309		2	0	0
1996	1,679,000	713,575	0.05	130		2	0	0
1997	1,861,500	782,925	0.06	127		1	0	0
1998	1,934,500	819,425	0.12	127		1	0	0
1999	2,190,000	925,275	0.13	119		0	0	0
2000	2,372,500	1,005,575	0.08	93		1	0	0
2001	2,445,500	1,042,075	0.13	130		1	0	0
2002	2,445,500	1,053,025	0.13	129	0.00	1	0	0
2003	2,591,500	981,850	0.12	129	0.00	1	0	0
2004	2,591,500	981,850	0.10	141		1	0	0
2005	2,482,000	933,488	0.09	128	0.02	1	1	0
2006	2,591,500	981,850	0.14	144	0.02	1	0	0
Cumulative	28,105,000	11,461,913						

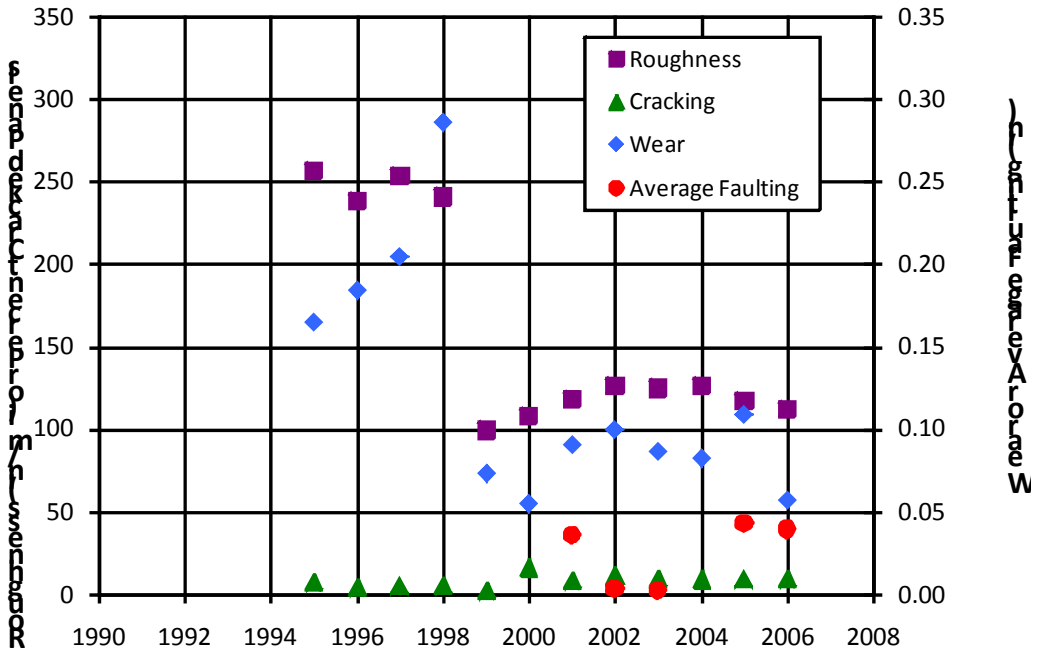


[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Martin Way O'xing to Vic. Mounts Road
Project limits:	MP 109.21 to MP 114.54
Direction:	NB
Contract number:	4706
Original construction:	1969
Year of DBR:	1995
Age at DBR (yr):	26
2007 DBR Age (yr):	12
Lane miles DBR:	5.33
Lane miles grinding:	5.33
PCC thickness:	8.4 inches
Base type:	ATB[4]
Base thickness:	3 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	170

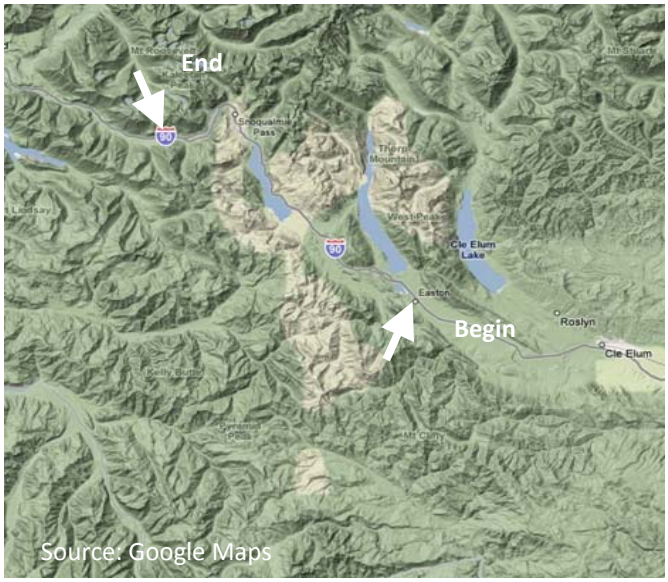
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf
[4] Asphalt treated base

PAVEMENT CONDITION								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1995	3,394,500	986,717	0.16	257		7	0	0
1996	2,956,500	855,317	0.18	239		4	0	0
1997	3,102,500	899,725	0.20	254		5	0	0
1998	3,175,500	916,758	0.29	241		5	0	0
1999	3,832,500	1,095,000	0.07	99		1	1	0
2000	3,905,500	1,120,330	0.05	108		15	1	0
2001	4,489,500	1,293,317	0.09	118	0.04	7	1	0
2002	4,708,500	1,362,058	0.10	126	0.00	10	1	0
2003	4,526,000	1,194,767	0.09	125	0.00	8	1	0
2004	4,635,500	1,216,667	0.08	127		8	1	0
2005	4,453,000	1,177,733	0.11	117	0.04	3	5	1
2006	4,599,000	1,204,500	0.06	112	0.04	3	5	1
Cumulative	47,778,500	13,322,889						



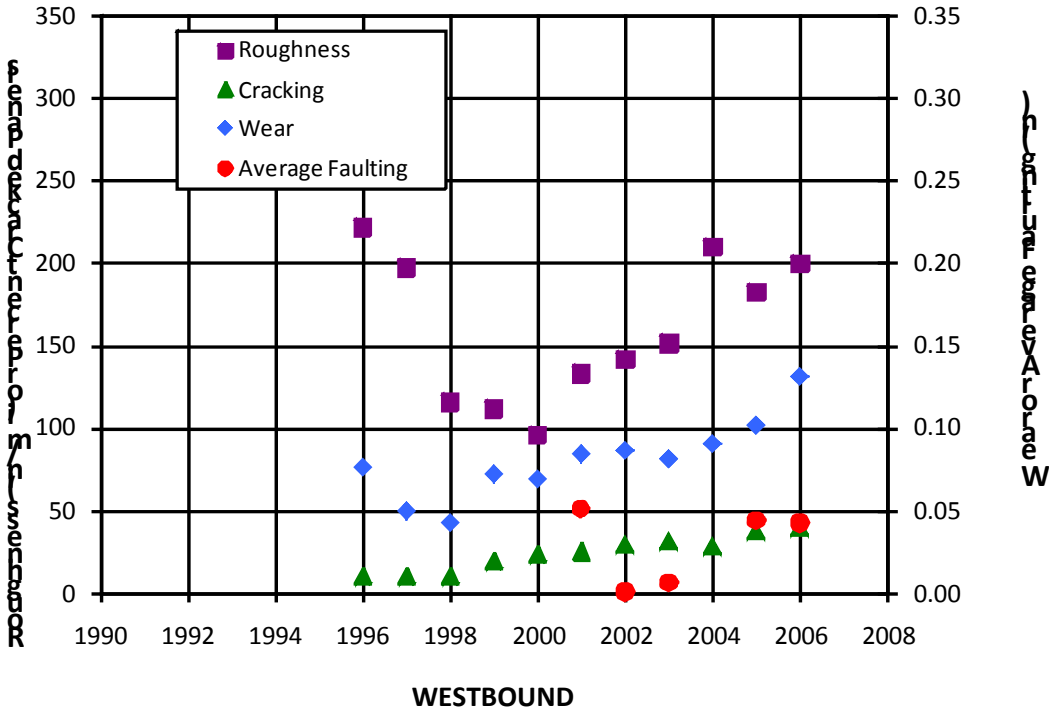
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	90
Project title:	Hyak Vicinity to Ellensburg - Phase 1
Project limits:	MP 39.28 to MP 102.49
Direction:	WB
Contract number:	4902
Original construction:	1967
Year of DBR:	1997
Age at DBR (yr):	30
2007 DBR Age (yr):	10
Lane miles DBR:	38.97
Lane miles grinding:	84.52
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	1075



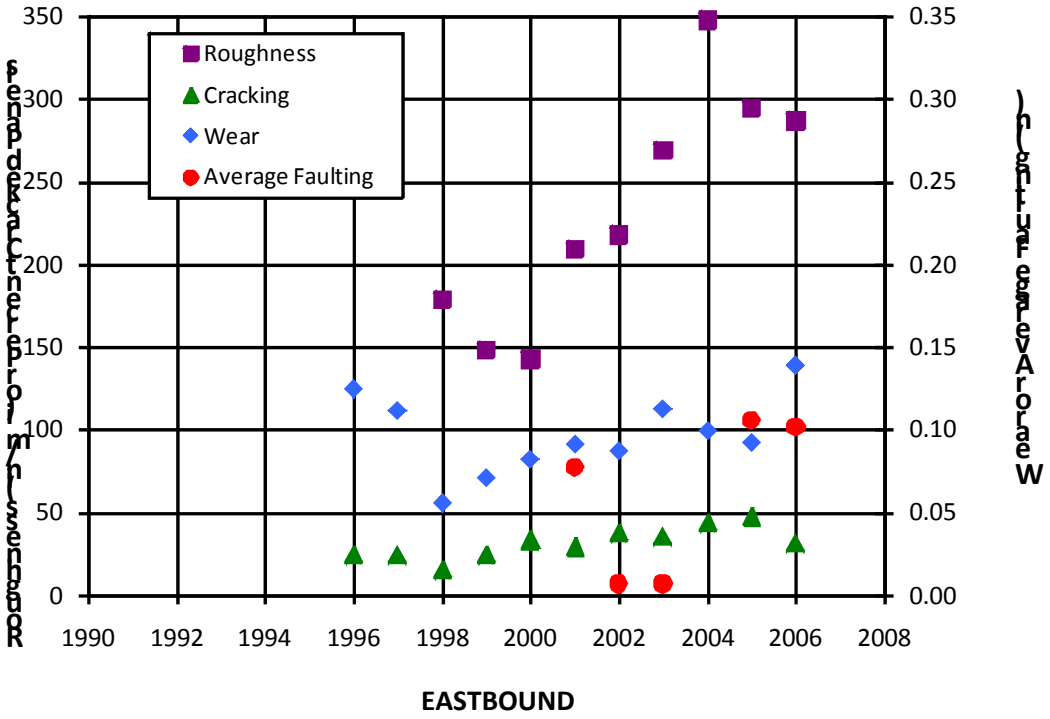
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION – WESTBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/ mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1997	2,226,500	1,010,138	0.05	197		10	0	0
1998	2,299,500	1,024,738	0.04	116		9	1	0
1999	1,934,500	850,450	0.07	111		18	1	0
2000	1,642,500	717,225	0.07	95		19	4	1
2001	1,642,500	717,225	0.08	133	0.05	19	5	1
2002	1,788,500	788,400	0.09	141	0.00	23	5	2
2003	1,861,500	809,388	0.08	151	0.01	24	7	2
2004	1,861,500	809,388	0.09	210		27	1	0
2005	1,825,000	791,138	0.10	182	0.04	23	12	3
2006	1,861,500	809,388	0.13	200	0.04	25	10	5
Cumulative	18,943,500	8,327,478						



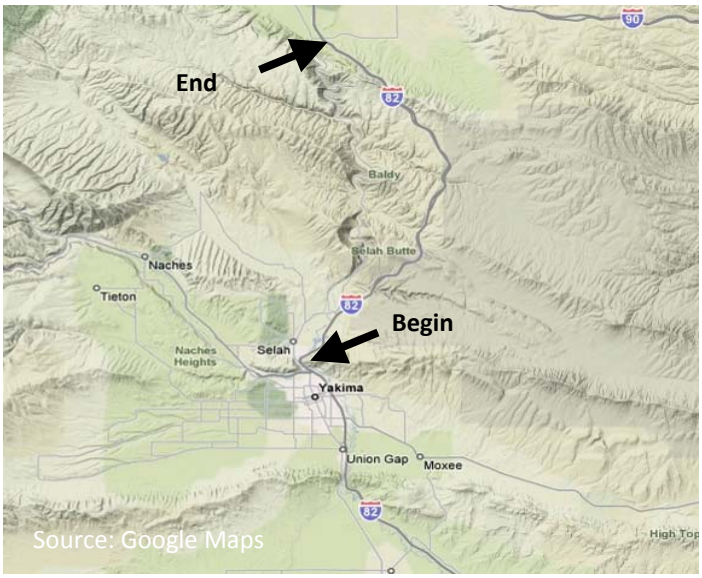
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – EASTBOUND								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1997	2,226,500	1,010,138	0.11	360		25	0	0
1998	2,299,500	1,024,738	0.06	179		15	0	0
1999	1,934,500	850,450	0.07	148		15	5	4
2000	1,642,500	717,225	0.08	143		23	8	2
2001	1,642,500	717,225	0.09	209	0.08	20	6	2
2002	1,788,500	788,400	0.09	218	0.01	25	7	5
2003	1,861,500	809,388	0.11	269	0.01	23	9	3
2004	1,861,500	809,388	0.10	348		27	11	5
2005	1,825,000	791,138	0.09	294	0.11	43	3	1
2006	1,861,500	809,388	0.14	287	0.10	22	2	8
Cumulative	18,943,500	8,327,478						



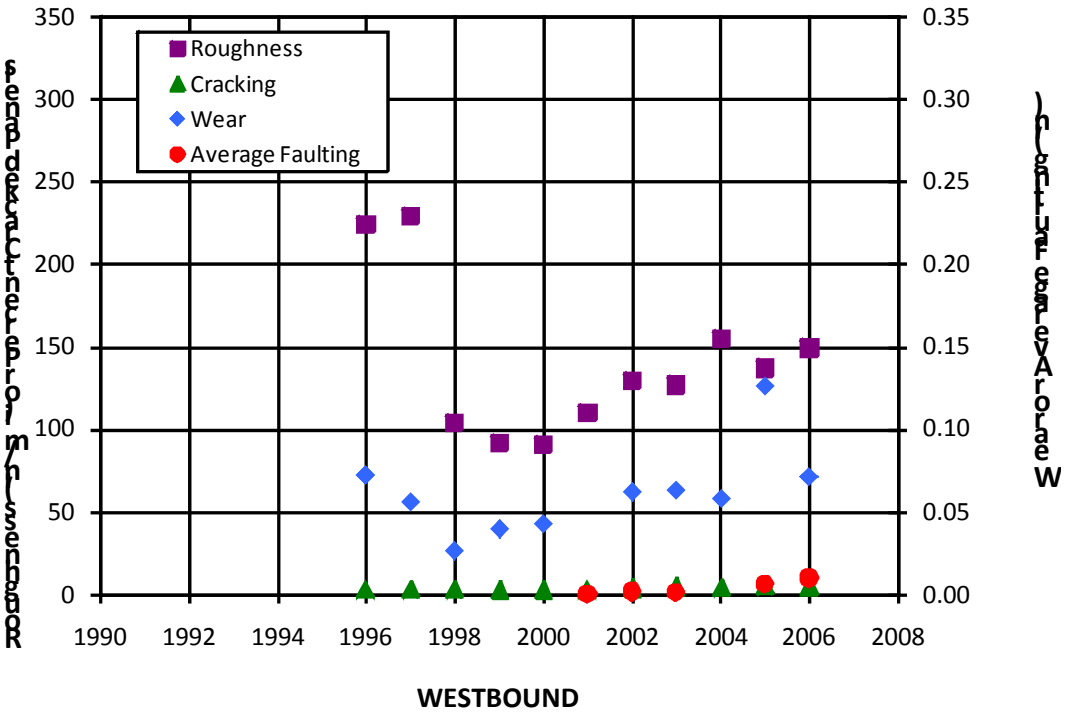
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	82
Project title:	SR 821 to Selah Creek Bridge
Project limits:	MP 3.29 to MP 30.12
Direction:	EB & WB
Contract number:	5009
Original construction:	1971
Year of DBR:	1997
Age at DBR (yr):	26
2007 DBR Age (yr):	10
Lane miles DBR:	46.02
Lane miles grinding:	55.88
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	1011



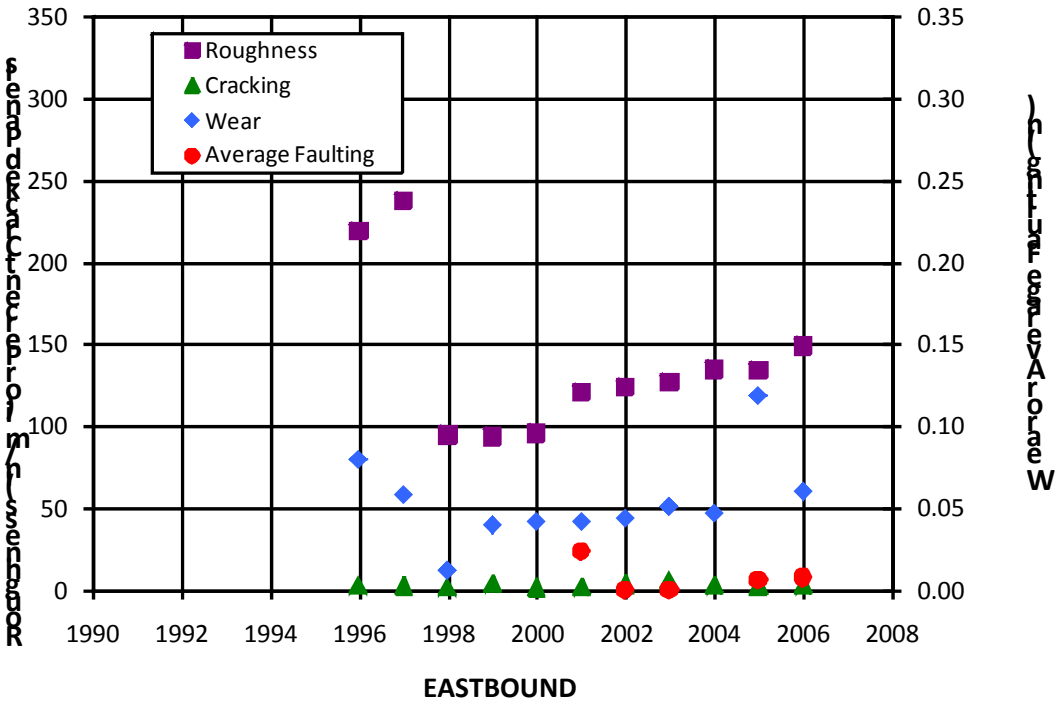
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION – WESTBOUND								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1997	1,350,500	625,975	0.06	229		3	0	0
1998	1,423,500	673,425	0.03	104		3	0	0
1999	1,314,000	609,550	0.04	92		3	0	0
2000	1,168,000	514,650	0.04	91		3	0	0
2001	1,168,000	614,650	0.00	0	0	3	0	0
2002	1,204,500	521,950	0.06	129	0.00	3	0	0
2003	1,241,000	540,200	0.06	127	0.00	4	0	0
2004	1,350,500	573,050	0.06	155		4	0	0
2005	1,387,000	591,300	0.13	137	0.01	5	0	0
2006	1,423,500	609,550	0.07	149	0.01	4	0	0
Cumulative	13,030,500	5,874,300						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – EASTBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1997	1,350,500	625,975	0.06	238		3	0	0
1998	1,423,500	673,425	0.01	95		2	0	0
1999	1,314,000	609,550	0.04	94		4	0	0
2000	1,168,000	514,650	0.04	96		2	0	0
2001	1,168,000	614,650	0.04	121	0.02	2	0	0
2002	1,204,500	521,950	0.04	124	0.00	4	0	0
2003	1,241,000	540,200	0.05	127	0.00	6	1	0
2004	1,350,500	573,050	0.05	135		3	0	0
2005	1,387,000	591,300	0.12	134	0.01	3	0	0
2006	1,423,500	609,550	0.06	149	0.01	3	0	0
Cumulative	13,030,500	5,874,300						



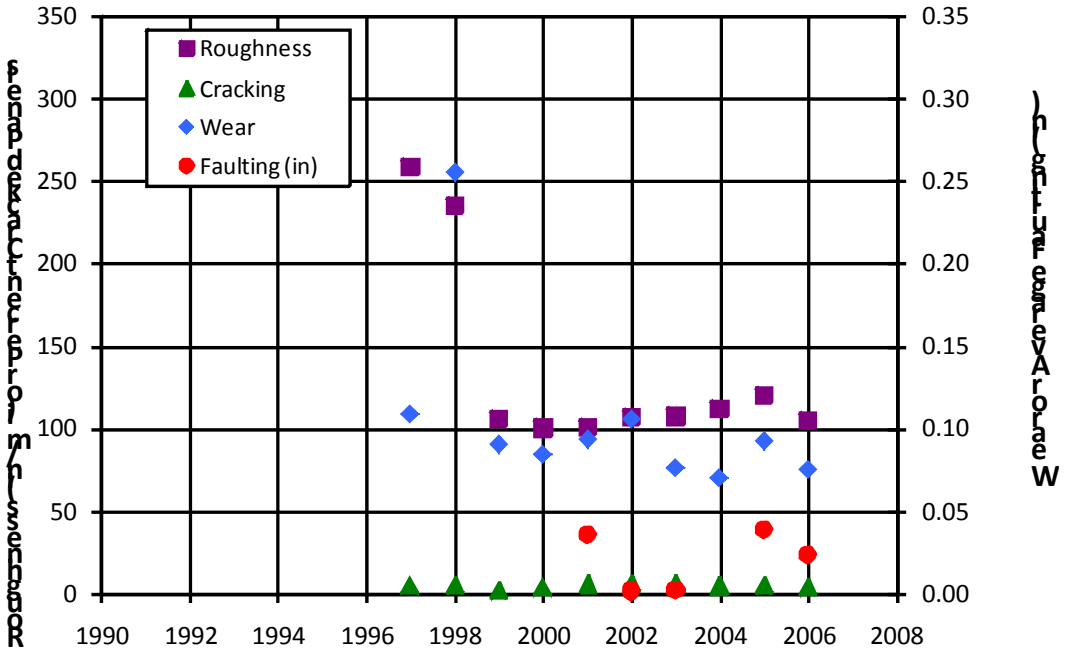
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Martin Way to Mounts Road (SB)
Project limits:	MP 109.19 to MP 116.72
Direction:	SB
Contract number:	5122
Original construction:	1969
Year of DBR:	1997
Age at DBR (yr):	28
2007 DBR Age (yr):	10
Lane miles DBR:	7.53
Lane miles grinding:	7.53
PCC thickness:	8.4 inches
Base type:	ATB[4]
Base thickness:	3 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	170

Notes: Stripping of underlying ATB

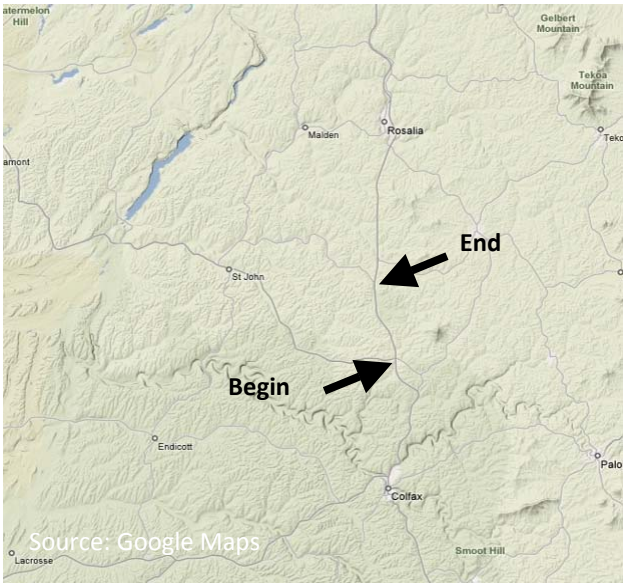
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf
[4] Asphalt treated base

PAVEMENT CONDITION								
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	No. Cracked Slabs[3]		
						Low/ Trans.	Med./ Long.	High/ Multi.
1997	3,102,500	899,725	0.11	259		5	0	0
1998	3,175,500	916,758	0.26	235		5	0	0
1999	3,832,500	1,095,000	0.09	106		2	0	0
2000	3,905,500	1,120,330	0.08	100		3	0	0
2001	4,489,500	1,293,317	0.09	101	0.04	6	0	0
2002	4,708,500	1,362,058	0.11	107	0.00	6	0	0
2003	4,526,000	1,194,767	0.08	108	0.00	5	0	0
2004	4,635,500	1,216,667	0.07	112		5	0	0
2005	4,453,000	1,177,733	0.09	120	0.04	3	2	0
2006	4,599,000	1,204,500	0.08	105	0.02	3	2	0
Cumulative	41,427,500	10,472,558						



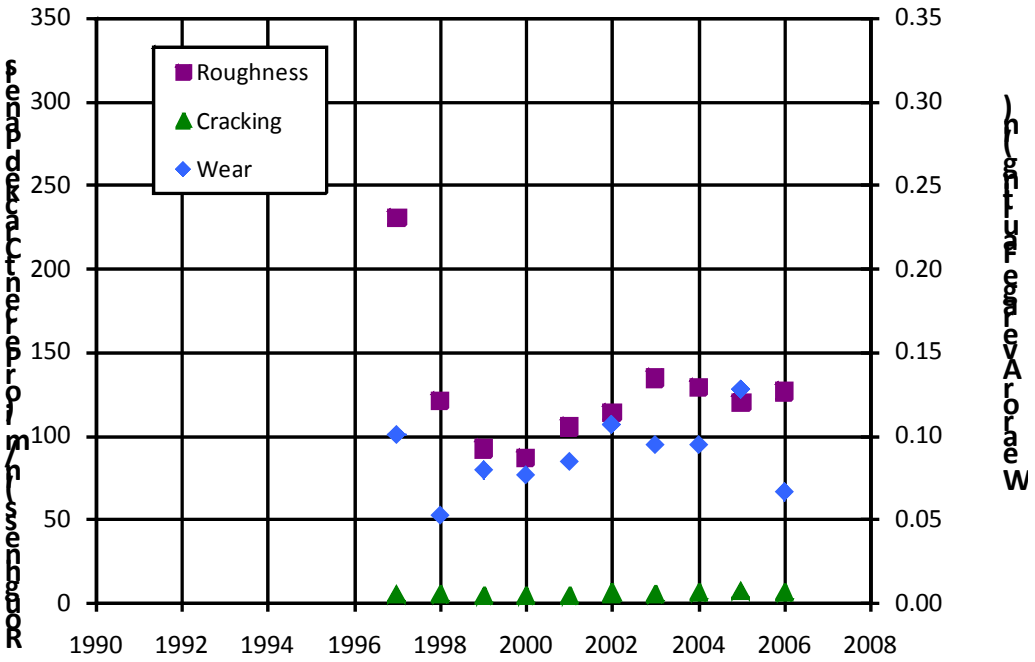
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	195
Project title:	Bridge 195/34 to Bridge 195/38
Project limits:	MP 48.48 to MP 53.76
Direction:	NB
Contract number:	5144
Original construction:	1959
Year of DBR:	1997
Age at DBR (yr):	38
2007 DBR Age (yr):	10
Lane miles DBR:	4.73
Lane miles grinding:	5.28
PCC thickness:	8 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	1113



[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1997	289,445	124,337	0.15	234		5	0	0
1998	298,570	128,298	0.17	249		5	0	0
1999	308,425	132,513	0.10	230		5	0	0
2000	318,280	136,775	0.05	120		5	0	0
2001	327,770	140,808	0.08	92		4	0	0
2002	337,625	145,069	0.08	87		4	0	0
2003	347,115	149,103	0.08	105		4	0	0
2004	356,970	153,364	0.11	113		5	0	0
2005	381,790	152,172	0.09	134		5	0	0
2006	383,250	153,838	0.09	129		6	0	0
Cumulative	3,349,240	1,416,277						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

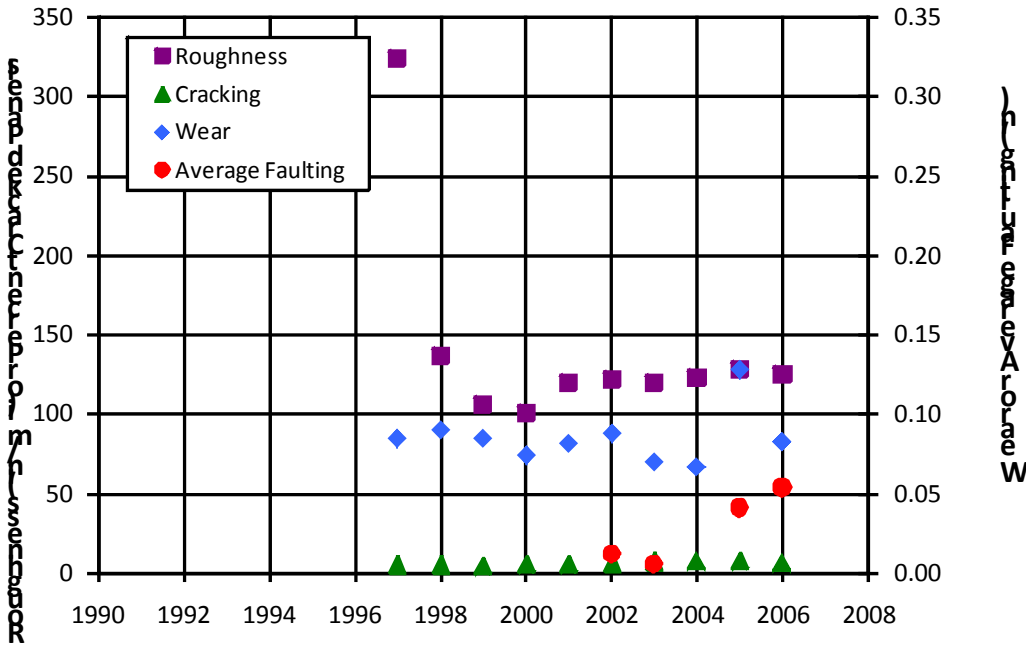
PROJECT DETAILS	
SR:	5
Project title:	N Lake Samish Rd to 36th St UC 5/807
Project limits:	MP 246.06 to MP 253.26
Direction:	NB & SB
Contract number:	5193
Original construction:	1967
Year of DBR:	1997
Age at DBR (yr):	30
2007 DBR Age (yr):	10
Lane miles DBR:	12.24
Lane miles grinding:	14.40
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	291

Notes: Cross-stitching of longitudinal cracks

[1] Coarse = A1-A3; Fine = A4-A7

[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

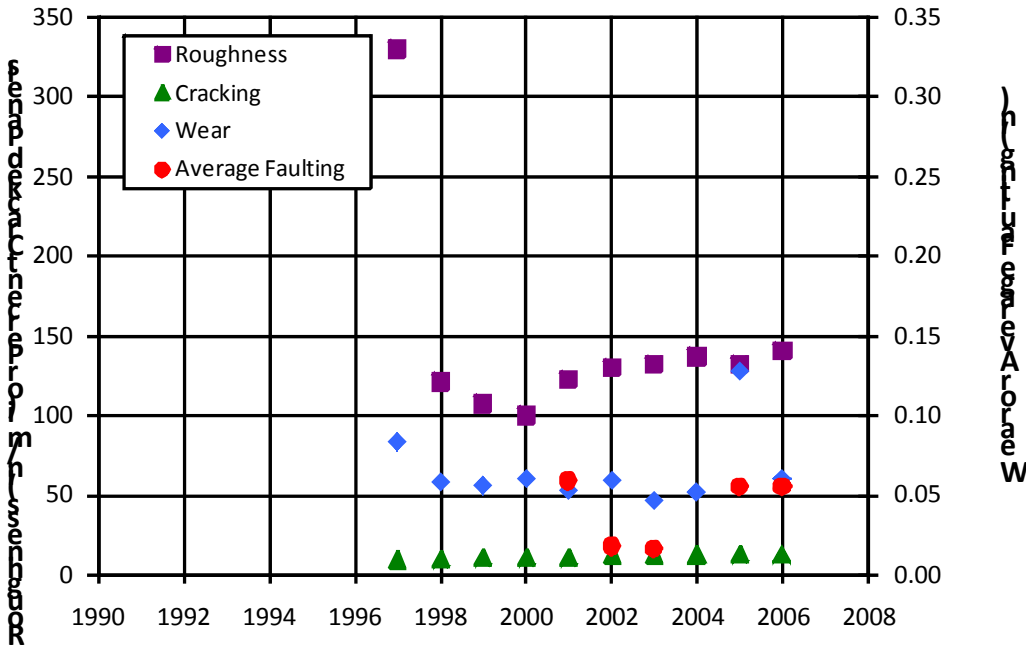
PAVEMENT CONDITION - SOUTHBOUND								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1997	1,971,000	826,725	0.08	324		5	0	0
1998	2,007,500	844,975	0.09	137		5	0	0
1999	2,117,000	899,725	0.08	106		5	0	0
2000	2,372,500	1,005,575	0.07	100		5	0	0
2001	2,445,500	1,042,075	0.08	120		6	0	0
2002	2,336,000	1,009,225	0.09	122	0.01	6	0	0
2003	2,591,500	981,950	0.07	120	0.01	7	0	0
2004	2,664,500	1,007,400	0.07	123		8	0	0
2005	2,591,500	981,850	0.13	128	0.04	3	5	0
2006	2,628,000	1,000,100	0.08	125	0.05	2	4	0
Cumulative	23,725,000	9,599,600						



SOUTHBOUND

[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – NORTHBOUND								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long/.	High/ Multi.
1997	1,971,000	826,725	0.08	330		9	0	0
1998	2,007,500	844,975	0.06	121		10	0	0
1999	2,117,000	899,725	0.06	107		10	0	0
2000	2,372,500	1,005,575	0.06	100		8	2	1
2001	2,445,500	1,042,075	0.05	122	0.06	10	0	0
2002	2,336,000	1,009,225	0.06	130	0.02	11	1	0
2003	2,591,500	981,950	0.05	132	0.02	11	1	0
2004	2,664,500	1,007,400	0.05	137		12	0	0
2005	2,591,500	981,850	0.13	132	0.06	4	8	1
2006	2,628,000	1,000,100	0.06	140	0.05	2	9	1
Cumulative	23,725,000	9,599,600						



NORTHBOUND

[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	NW 319th St to E Fork Lewis R Br
Project limits:	MP 16.6 to MP 18.21
Direction:	SB
Contract number:	5270
Original construction:	1970
Year of DBR:	1997
Age at DBR (yr):	27
2007 DBR Age (yr):	10
Lane miles DBR:	1.61
Lane miles grinding:	0
PCC thickness:	9 inches
Base type:	ATB[4]
Base thickness:	6 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	212

Notes: Dowel bar retrofit lane 2 with HMA overlay (full roadway width) This project was excluded from the dowel bar retrofit performance analysis due to placement of the HMA overlay.

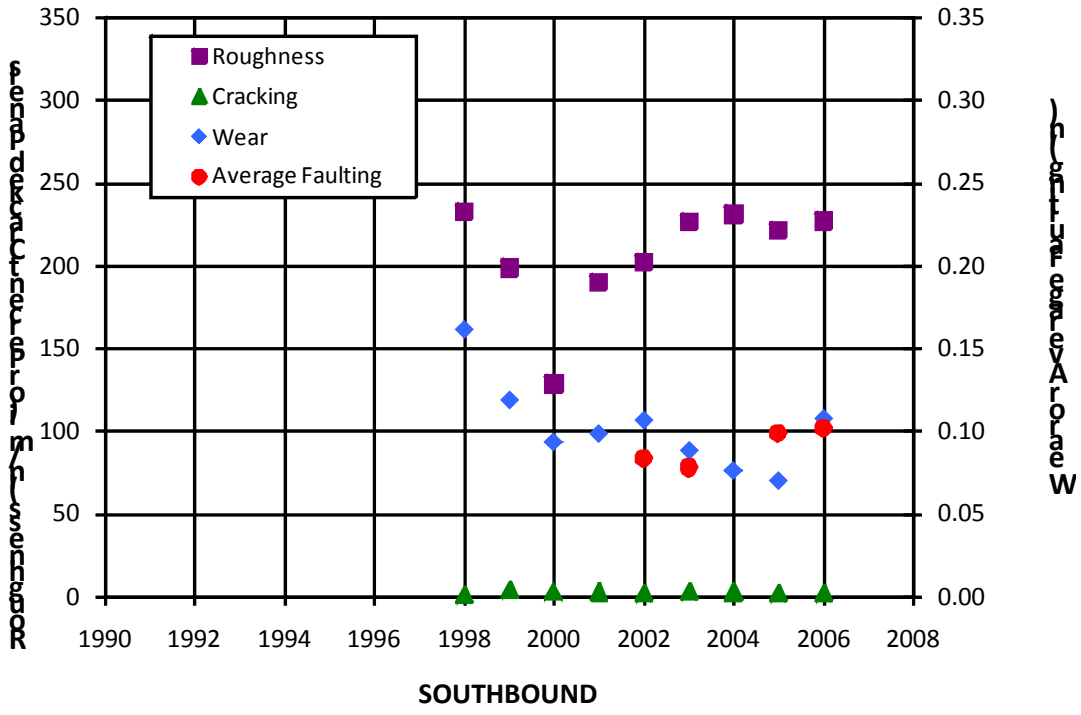
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf
[4] Asphalt treated base

PROJECT DETAILS	
SR:	5
Project title:	Sunset/SR 542 Vic to Nooksack R Br
Project limits:	MP 254.77 to MP 263.05
Direction:	NB & SB
Contract number:	5686
Original construction:	1977
Year of DBR:	1998
Age at DBR (yr):	21
2007 DBR Age (yr):	9
Lane miles DBR:	16.56
Lane miles grinding:	16.56
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	7 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	291

[1] Coarse = A1-A3; Fine = A4-A7

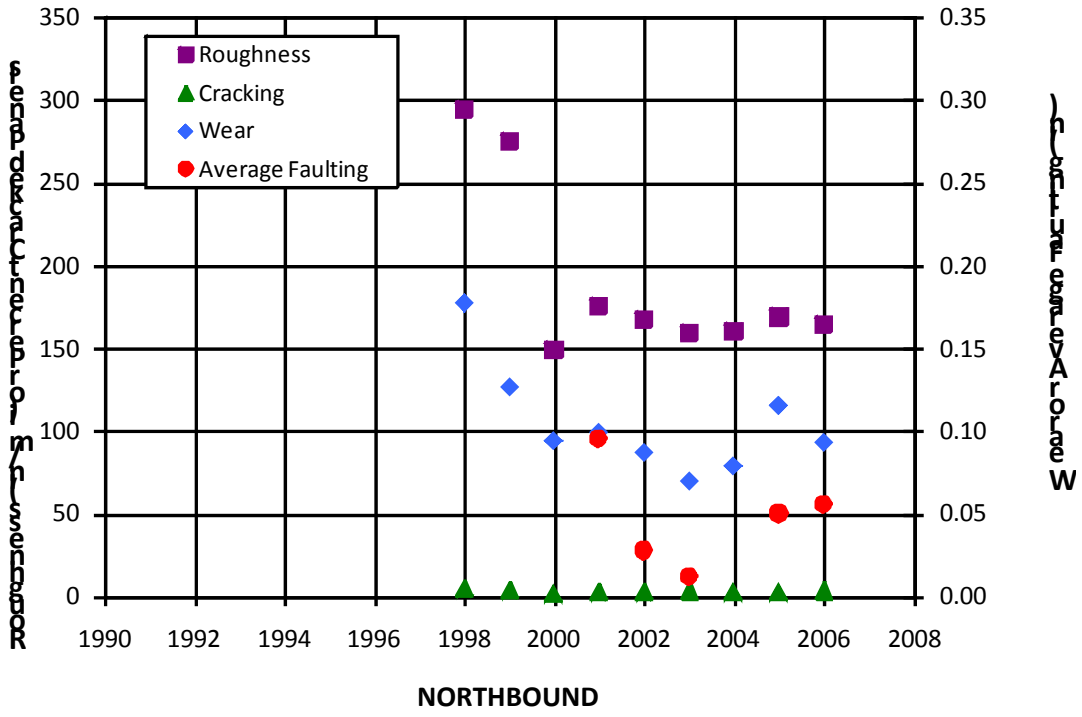
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION - SOUTHBOUND								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1998	1,752,000	730,000	0.16	233		1	0	0
1999	1,788,500	748,250	0.12	199		4	0	0
2000	1,825,000	755,550	0.09	128		2	0	0
2001	1,533,000	587,650	0.10	190		2	0	0
2002	1,569,500	594,950	0.11	202	0.08	2	0	0
2003	1,569,500	584,000	0.09	226	0.08	2	0	0
2004	1,679,000	616,850	0.08	231		2	0	0
2005	1,715,500	624,150	0.07	221	0.10	1	1	0
2006	1,825,000	652,548	0.11	227	0.10	1	1	0
Cumulative	15,257,000	5,893,948						



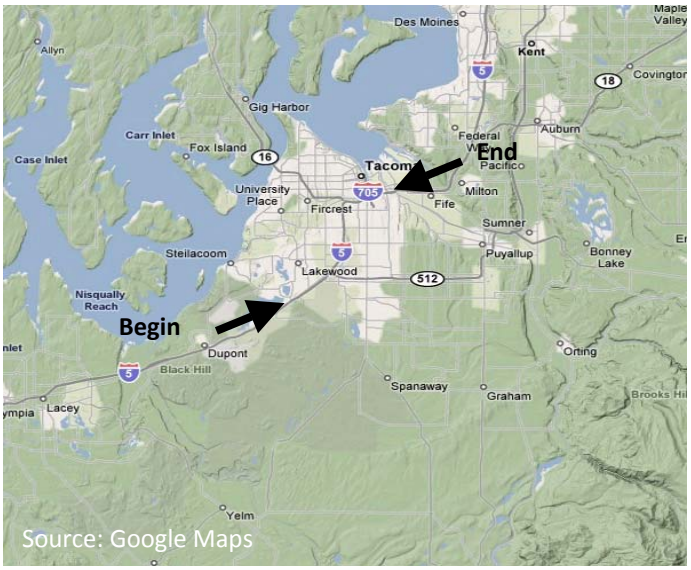
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – NORTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1998	1,752,000	730,000	0.18	295		5	0	0
1999	1,788,500	748,250	0.13	275		3	0	1
2000	1,825,000	755,550	0.09	149		2	0	0
2001	1,533,000	587,650	0.10	175	0.10	2	0	0
2002	1,569,500	594,950	0.09	168	0.03	3	0	0
2003	1,569,500	584,000	0.07	159	0.01	3	0	0
2004	1,679,000	616,850	0.08	160		3	0	0
2005	1,715,500	624,150	0.12	169	0.05	2	1	0
2006	1,825,000	652,548	0.09	164	0.06	2	1	0
Cumulative	15,257,000	5,893,948						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

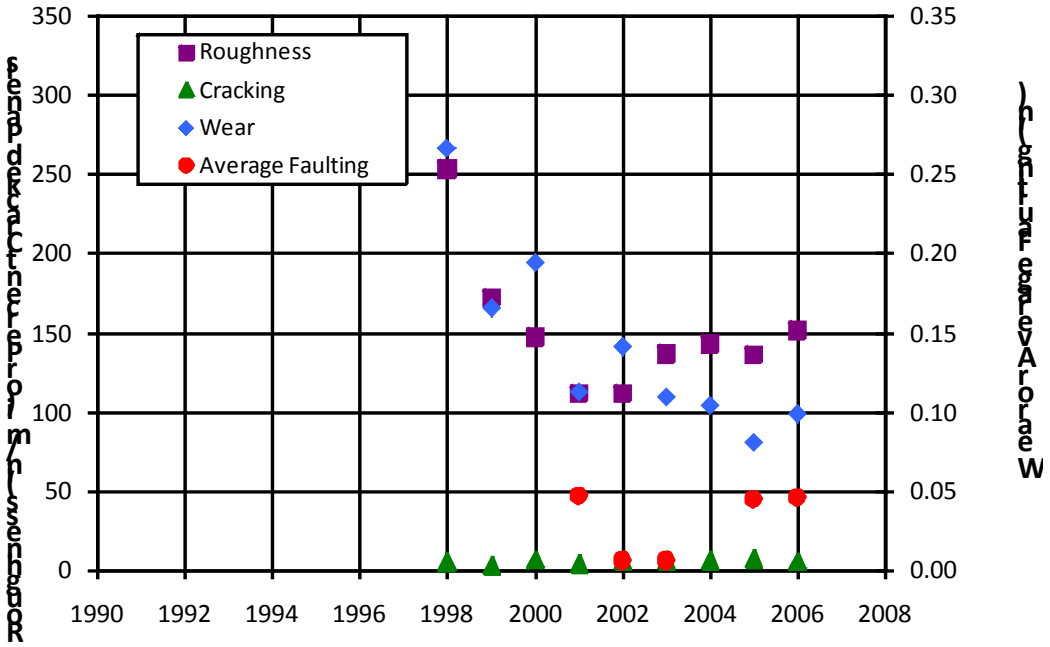
PROJECT DETAILS	
SR:	5
Project title:	Gravelly Lake I/C Vic to Puyallup R Br
Project limits:	MP 124.19 to MP 135.19
Direction:	NB & SB
Contract number:	5712
Original construction:	1959
Year of DBR:	1998
Age at DBR (yr):	39
2007 DBR Age (yr):	9
Lane miles DBR:	9.36
Lane miles grinding:	9.36
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	3 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	117



[1] Coarse = A1-A3; Fine = A4-A7

[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

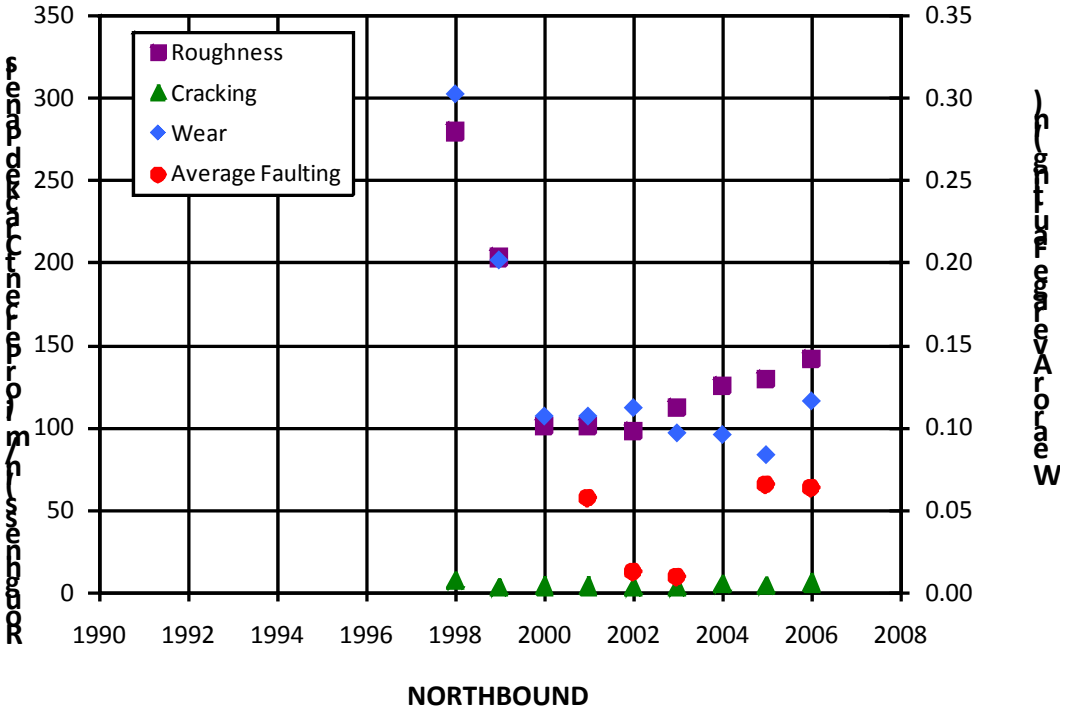
PAVEMENT CONDITION – SOUTHBOUND								
					Avg.	No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1998	4,964,000	1,053,025	0.27	253		5	0	0
1999	5,037,000	1,065,800	0.17	172		3	0	0
2000	4,854,500	1,019,719	0.19	147		5	1	1
2001	4,745,000	990,063	0.11	112	0.05	4	0	0
2002	4,818,000	983,219	0.14	112	0.01	5	0	1
2003	4,965,000	1,000,100	0.11	136	0.01	5	1	0
2004	4,965,000	961,775	0.10	143		5	0	1
2005	5,000,500	973,181	0.08	136	0.05	2	5	0
2006	5,000,500	973,181	0.10	152	0.05	1	4	0
Cumulative	44,347,500	9,020,063						



SOUTHBOUND

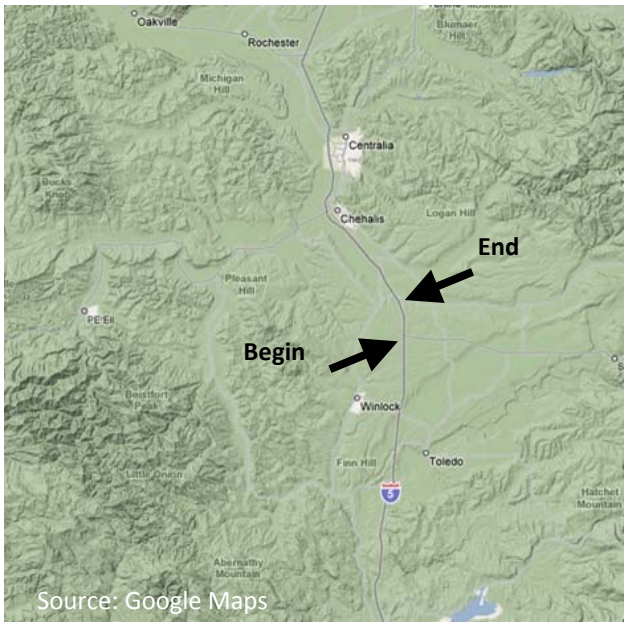
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – NORTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1998	4,964,000	1,053,025	0.30	280		7	0	0
1999	5,037,000	1,065,800	0.20	203		2	0	1
2000	4,854,500	1,019,719	0.11	101		2	0	1
2001	4,745,000	990,063	0.11	98	0.06	2	0	1
2002	4,818,000	983,219	0.10	112	0.01	1	1	1
2003	4,965,000	1,000,100	0.10	125	0.01	3	1	1
2004	4,965,000	961,775	0.08	129		3	0	1
2005	5,000,500	973,181	0.12	142	0.07	4	0	1
2006	5,000,500	973,181	0.15	158	0.06	9	0	1
Cumulative	44,347,500	9,020,063						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	SR 508 to Thurston County Line
Project limits:	MP 70.67 to MP 85.51
Direction:	NB & SB
Contract number:	5827
Original construction:	1970
Year of DBR:	1999
Age at DBR (yr):	29
2007 DBR Age (yr):	8
Lane miles DBR:	1.33
Lane miles grinding:	None
PCC thickness:	9 inches
Base type:	ATB[4]
Base thickness:	6 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	172



Notes: Dowel bar retrofit lane 1 beneath existing HMA overlay and subsealing This project was excluded from the dowel bar retrofit performance analysis due to placement of the HMA overlay.

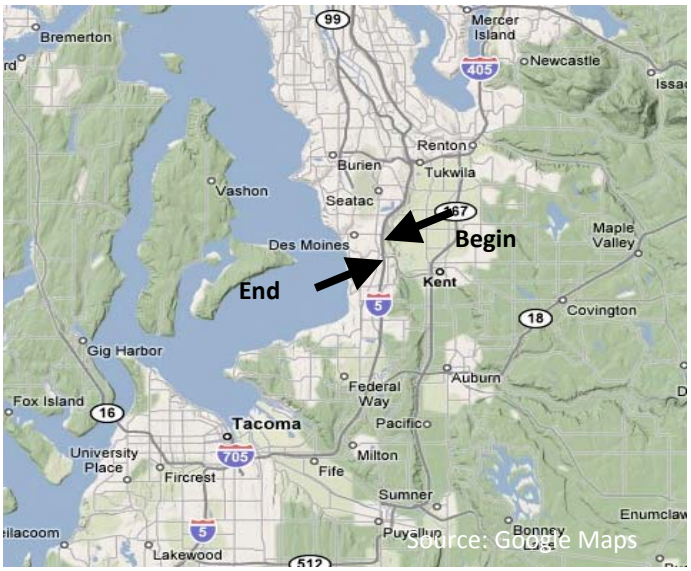
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/oi/9712/AFI-pubreturn.pdf
[4] Asphalt treated base

PROJECT DETAILS	
SR:	5
Project title:	Stanwood/Bryant Signing & Pavement Grinding
Project limits:	MP 211.73 to MP 215.04
Direction:	NB
Contract number:	5926
Original construction:	1959
Year of DBR:	2000
Age at DBR (yr):	41
2007 DBR Age (yr):	7
Lane miles DBR:	0.07
Lane miles grinding:	0.07
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	10 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	175

Notes: Rehabilitation for weigh-in-motion site
This project was excluded from the dowel bar retrofit performance analysis due to weigh-in-motion site.

[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/oi/9712/AFI-pubreturn.pdf

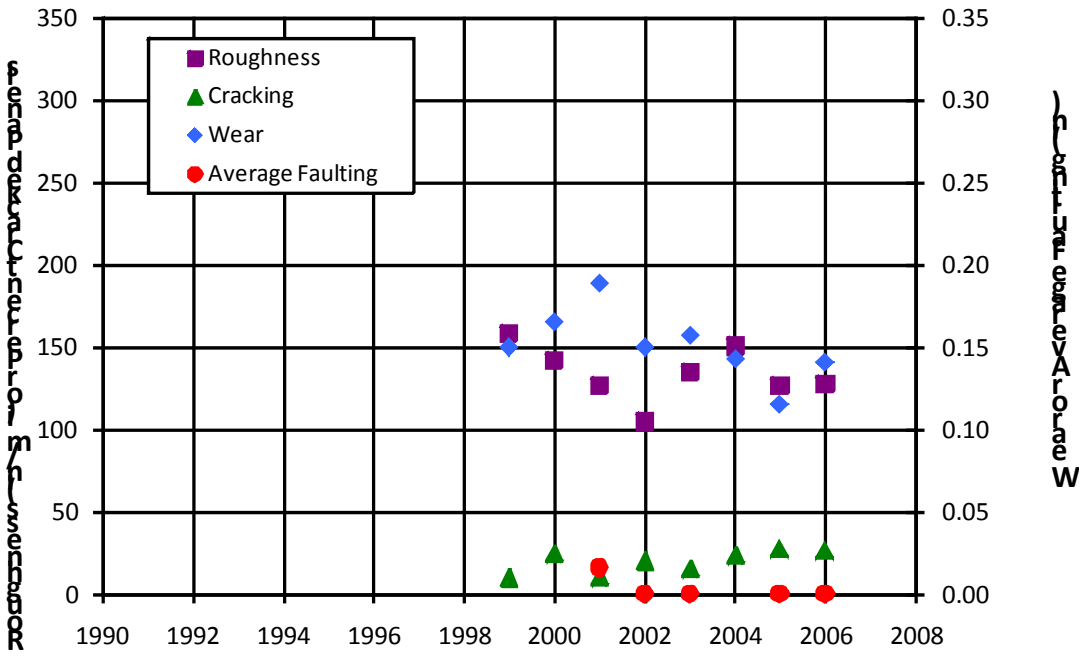
PROJECT DETAILS	
SR:	5
Project title:	Pierce County Line to Tukwila I/C Stage 2S
Project limits:	MP 148.9 to MP 149.76
Direction:	SB
Contract number:	5968
Original construction:	1962
Year of DBR:	1999
Age at DBR (yr):	37
2007 DBR Age (yr):	8
Lane miles DBR:	0.96
Lane miles grinding:	19.00
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	148



[1] Coarse = A1-A3; Fine = A4-A7

[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
1999	4,927,500	918,431	0.15	158		9.2	0	0.6
2000	5,073,500	943,981	0.17	142		21.8	3	0
2001	5,110,000	937,594	0.19	127	0.02	10	0	0
2002	5,657,500	1,028,844	0.15	105	0.00	19.2	0	1
2003	5,621,000	1,019,719	0.16	135	0.00	15.6	0	0
2004	5,657,500	1,023,369	0.14	151		23.6	0	0
2005	5,767,000	1,045,269	0.12	127	0.00	24.8	2.2	0.6
2006	5,694,000	1,027,019	0.14	128	0.00	22	1.8	3.2
Cumulative	43,508,000	7,944,226						



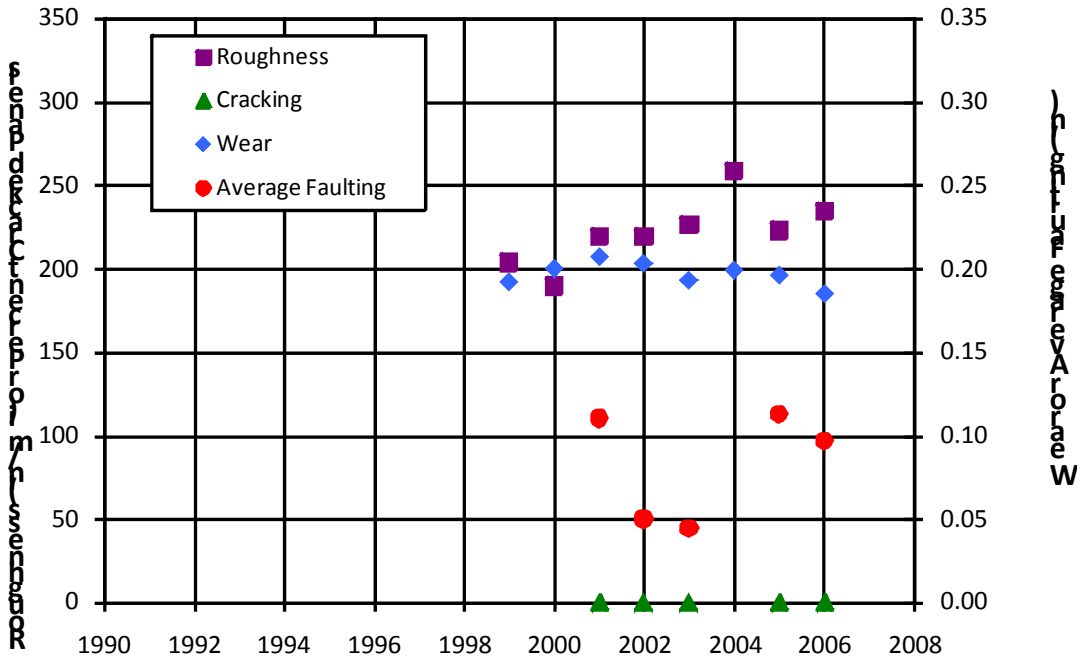
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Pierce Co Line to Tukwila HOV Lane & ITS - Stage 3
Project limits:	MP 143.22 to MP 148.88
Direction:	SB
Contract number:	5981
Original construction:	1962
Year of DBR:	1999
Age at DBR (yr):	37
2007 DBR Age (yr):	8
Lane miles DBR:	6.80
Lane miles grinding:	6.80
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	148

[1] Coarse = A1-A3; Fine = A4-A7

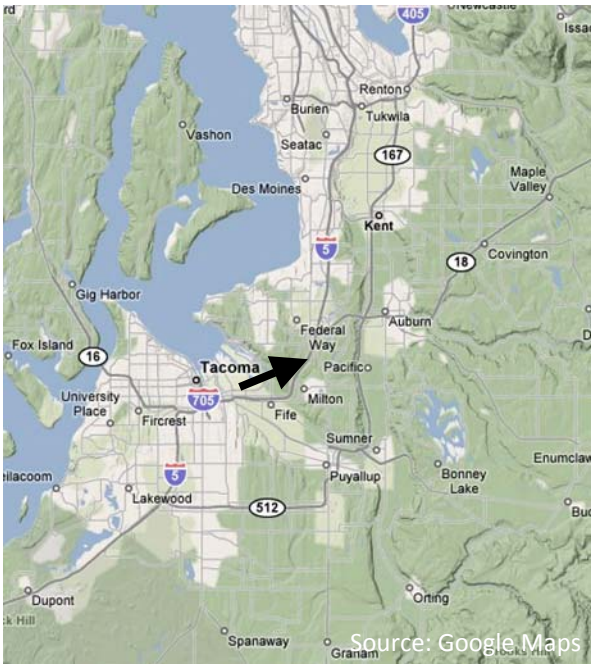
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION								
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/ mi)	Avg. Fault (in)	No. Cracked Slabs[3] Low/ Trans.	Med./ Long.	High/ Multi.
2000	5,073,500	943,981	0.20	189		13	0	0
2001	5,110,000	937,594	0.21	219	0.11	11	1	0
2002	5,657,500	1,028,844	0.20	219	0.05	15	1	0
2003	5,621,000	1,019,719	0.19	226	0.04	14	1	0
2004	5,657,500	1,023,369	0.20	258		10	1	0
2005	5,767,000	1,045,269	0.20	223	0.11	12	0	1
2006	5,694,000	1,027,019	0.18	234	0.10	12	0	1
Cumulative	38,580,500	7,025,795						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Federal Way SB Weigh Station WIM
Project limits:	MP 140.43 to MP 142.83
Direction:	SB
Contract number:	6025
Original construction:	1962
Year of DBR:	2000
Age at DBR (yr):	38
2007 DBR Age (yr):	7
Lane miles DBR:	0.08
Lane miles grinding:	0.42
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	148



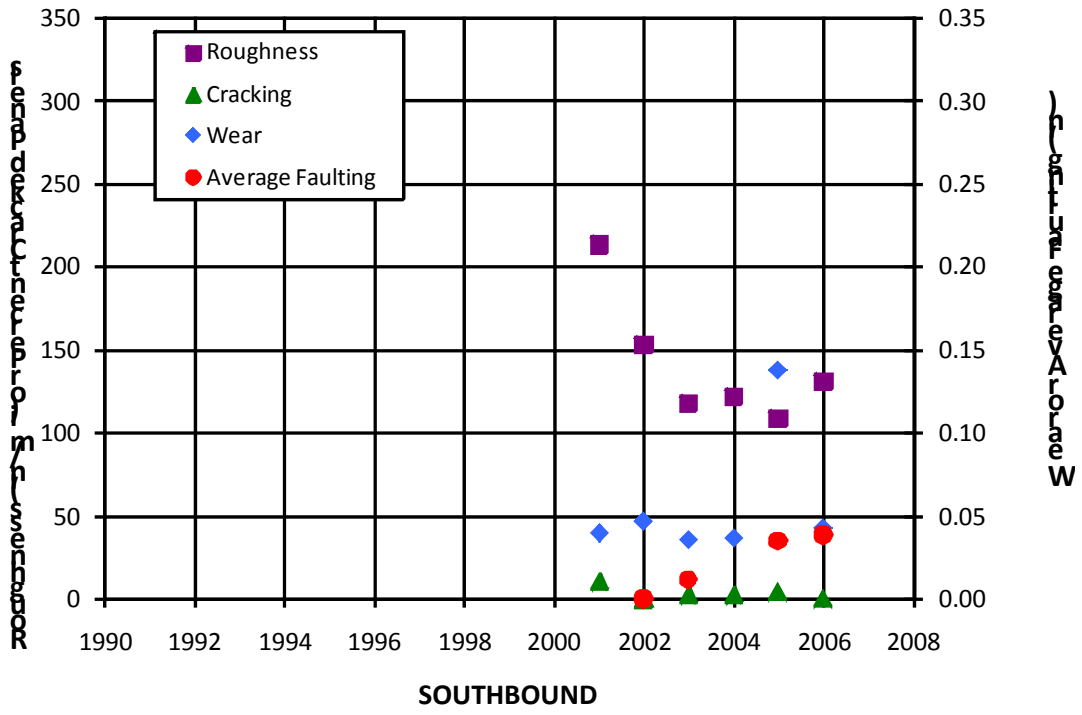
Notes: Rehabilitation for weigh-in-motion site
This project was excluded from the dowel bar retrofit performance analysis due to weigh-in-motion site.

[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PROJECT DETAILS	
SR:	5
Project title:	Nooksack R to Blaine/Dakota Cr Br Vic to SR 543
Project limits:	MP 263.46 to MP 263.49
	MP 273.93 to MP 275.25
Direction:	NB & SB
Contract number:	6334
Original construction:	1966
Year of DBR:	2001
Age at DBR (yr):	35
2007 DBR Age (yr):	6
Lane miles DBR:	2.10
Lane miles grinding:	5.28
PCC thickness:	9 inches
Base type:	CTB[5]
Base thickness:	4 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	261

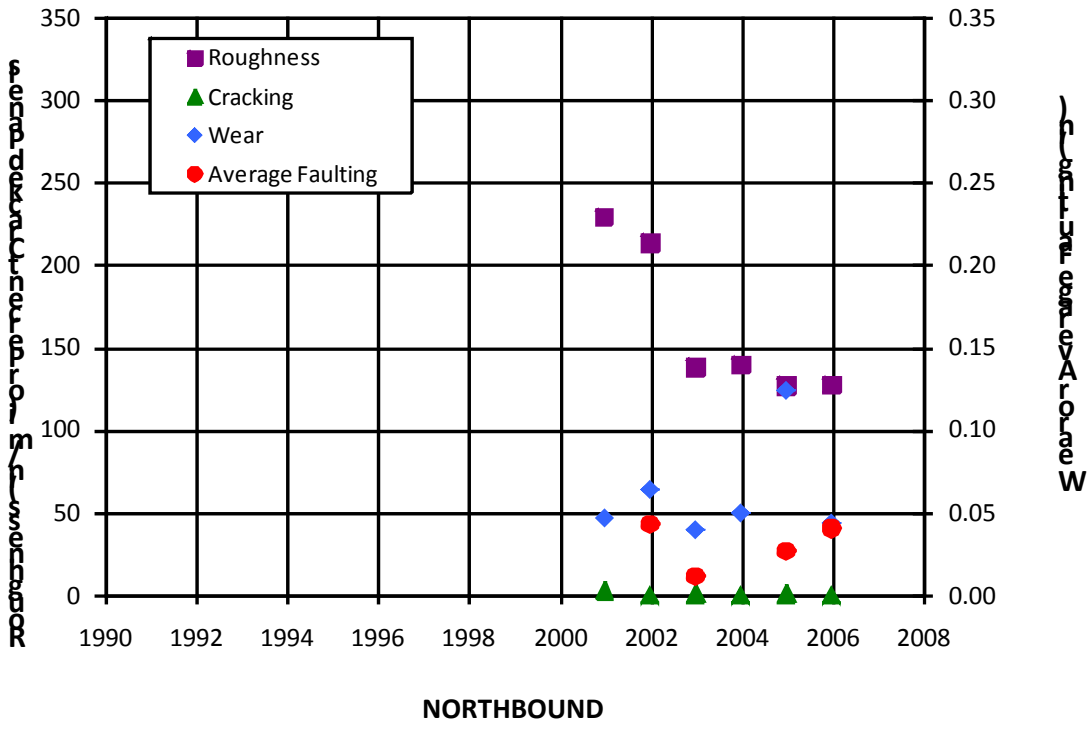
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf
[5] Cement treated base

PAVEMENT CONDITION - SOUTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2001	438,000	168,813	0.04	213		10	0	0
2002	401,500	150,563	0.05	153	0.00	0	0	0
2003	401,500	150,563	0.04	118	0.01	2	0	0
2004	438,000	157,863	0.04	122		2	0	0
2005	438,000	157,863	0.14	109	0.04	4	0	0
2006	474,500	176,113	0.04	131	0.04	1	0	0
Cumulative	2,591,500	961,778						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – NORTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2001	438,000	168,813	0.05	229		2	0	0
2002	401,500	150,563	0.06	213	0.04	0	0	0
2003	401,500	150,563	0.04	138	0.01	0	0	0
2004	438,000	157,863	0.05	139		0	0	0
2005	438,000	157,863	0.12	127	0.03	1	0	0
2006	474,500	176,113	0.04	127	0.04	0	0	0
Cumulative	2,591,500	961,778						

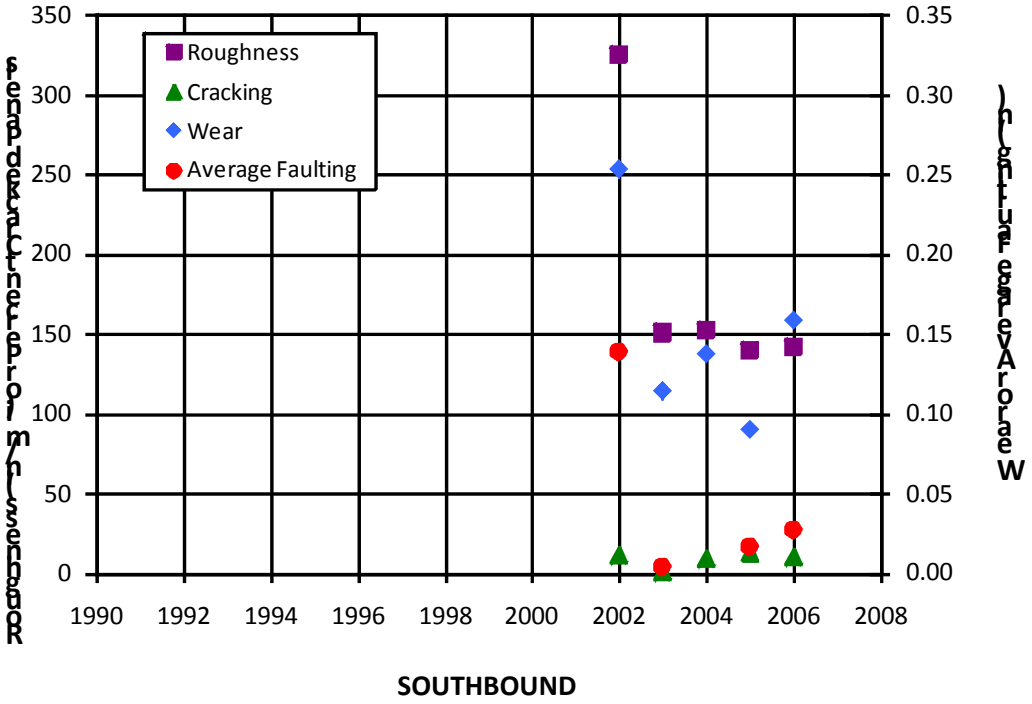


PROJECT DETAILS	
SR:	5
Project title:	36th St Vic to SR 542 Vic
Project limits:	MP 252.14 to MP 255.44
Direction:	NB & SB
Contract number:	6473
Original construction:	1961
Year of DBR:	2002
Age at DBR (yr):	41
2007 DBR Age (yr):	5
Lane miles DBR:	5.44
Lane miles grinding:	12.00
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	291

[1] Coarse = A1-A3; Fine = A4-A7

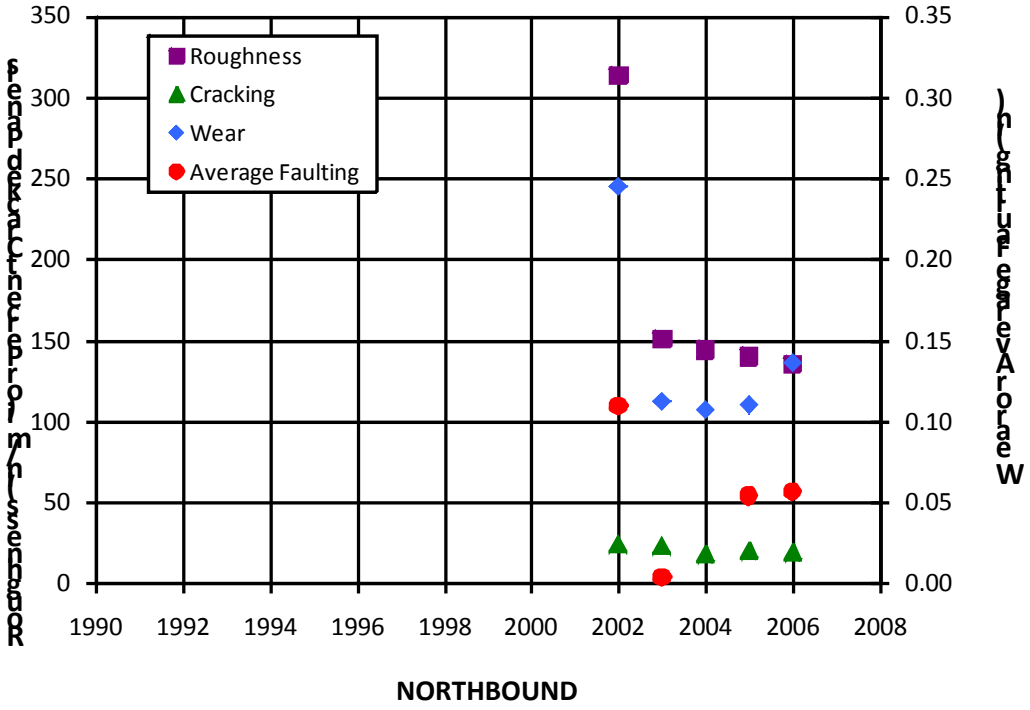
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION - SOUTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2002	2,117,000	796,613	0.25	325	0.14	9	2	1
2003	2,226,500	818,513	0.11	151	0.00	1	0	0
2004	2,336,000	851,363	0.14	153	-	9	0	0
2005	2,409,000	865,963	0.09	139	0.02	6	7	1
2006	2,555,000	917,063	0.16	142	0.03	4	7	0
Cumulative	11,643,500	4,249,515						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION - NORTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2002	2,117,000	796,613	0.25	313	0.11	21	2	1
2003	2,226,500	818,513	0.11	151	0.00	8	9	7
2004	2,336,000	851,363	0.11	144	-	17	1	1
2005	2,409,000	865,963	0.11	140	0.05	16	2	2
2006	2,555,000	917,063	0.14	135	0.06	15	2	2
Cumulative	11,643,500	4,249,515						

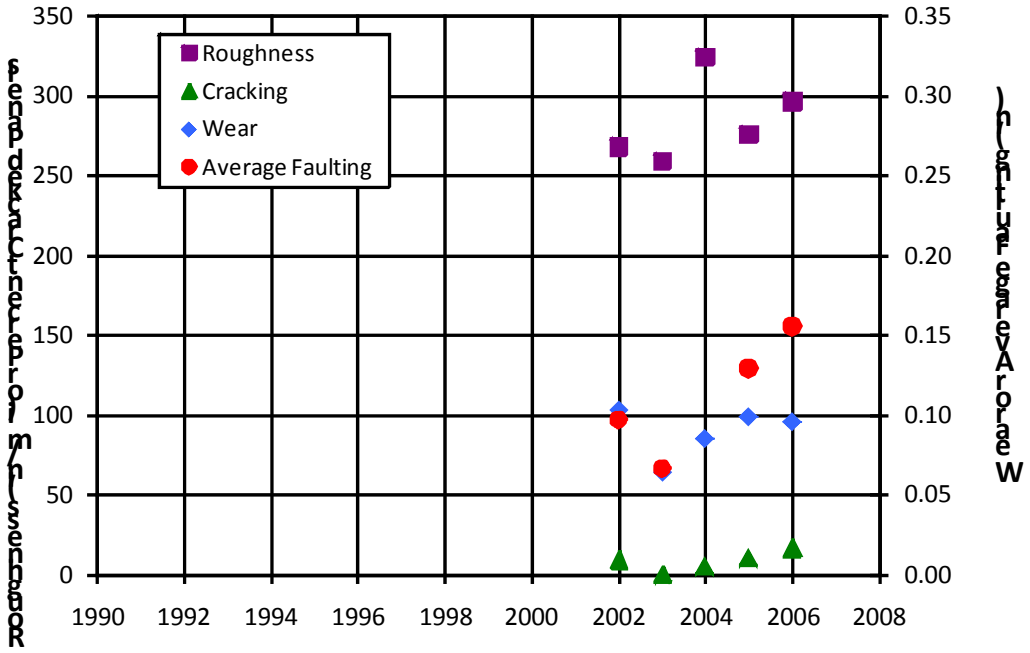


[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Vic 300th Ave to Starbird Rd
Project limits:	MP 216.00 to MP 217.75
Direction:	SB
Contract number:	6520
Original construction:	1976
Year of DBR:	2002
Age at DBR (yr):	26
2007 DBR Age (yr):	5
Lane miles DBR:	3.75
Lane miles grinding:	3.75
PCC thickness:	9 inches
Base type:	ATB[4]
Base thickness:	5.4 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	175

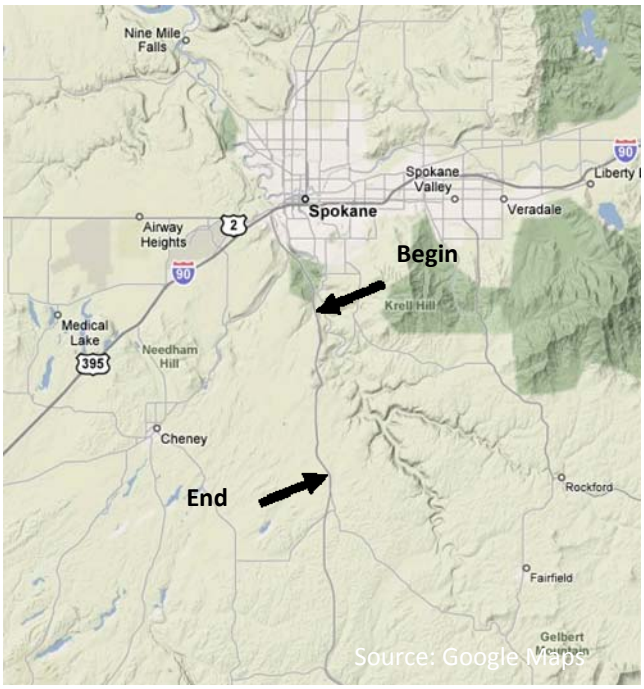
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf
[4] Asphalt treated base

PAVEMENT CONDITION								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2002	3,139,000	902,767	0.10	268	0.10	8	1	0
2003	3,248,500	821,250	0.06	259	0.07	0	0	0
2004	3,285,000	826,117	0.09	324		5	0	0
2005	3,248,500	821,250	0.10	276	0.13	1	9	0
2006	3,321,500	838,283	0.10	296	0.16	1	15	0
Cumulative	16,242,500	4,209,667						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

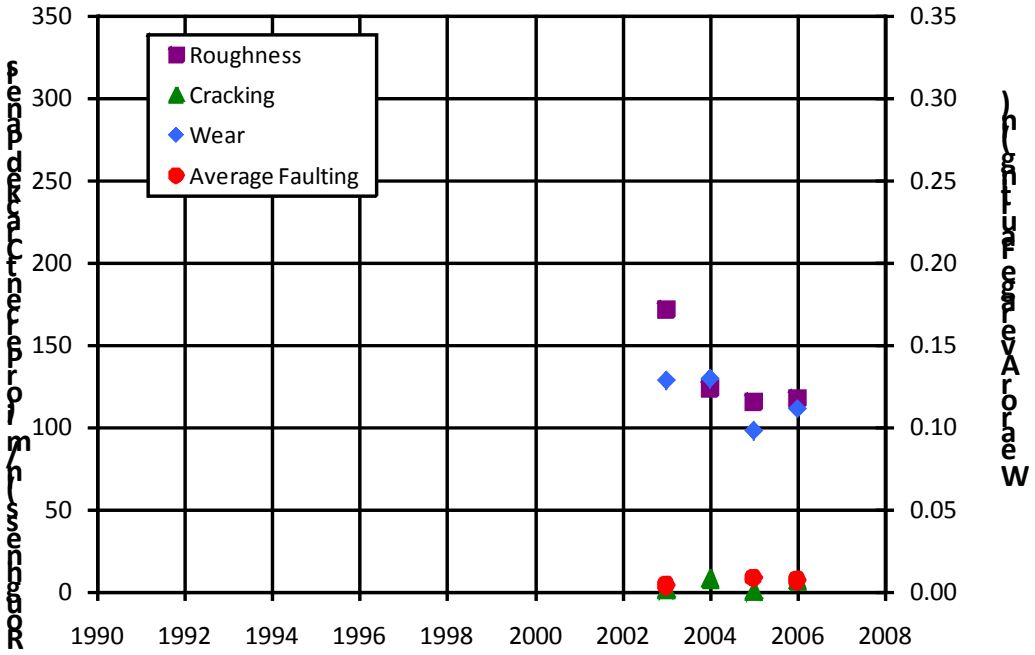
PROJECT DETAILS	
SR:	195
Project title:	Cornwall Road to Excelsior Drive
Project limits:	MP 80.27 to MP 95.95
Direction:	SB
Contract number:	6529
Original construction:	1959
Year of DBR:	2003
Age at DBR (yr):	44
2007 DBR Age (yr):	4
Lane miles DBR:	7.53
Lane miles grinding:	7.53
PCC thickness:	8 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	1232



[1] Coarse = A1-A3; Fine = A4-A7

[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

PAVEMENT CONDITION								
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	No. Cracked Slabs[3]		
						Low/ Trans.	Med./ Long.	High/ Multi.
2003	328,500	108,953	0.13	171	0.00	2	0	0
2004	350,400	117,074	0.13	124		8	0	0
2005	310,250	105,759	0.10	116	0.01	0	0	0
2006	317,550	108,314	0.11	118	0.01	2	5	0
Cumulative	1,306,700	440,100						



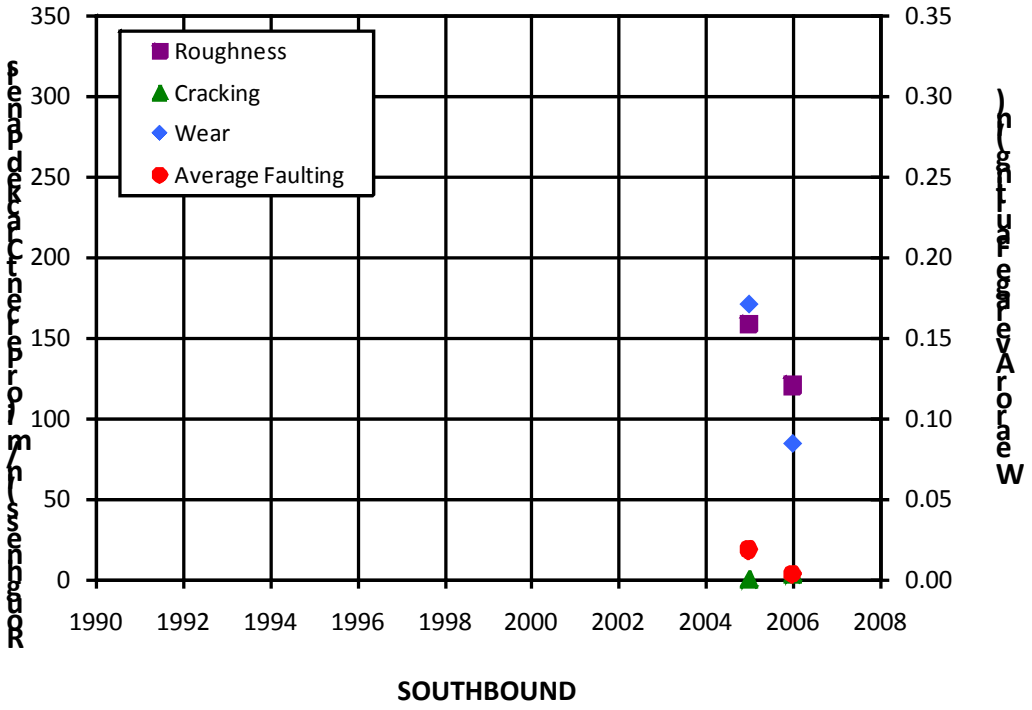
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Federal Way - S 317th St HOV Direct Access
Project limits:	MP 143.25 to MP 144.74
Direction:	NB & SB
Contract number:	6757
Original construction:	1962
Year of DBR:	2005
Age at DBR (yr):	43
2007 DBR Age (yr):	2
Lane miles DBR:	2.86
Lane miles grinding:	2.98
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	117

[1] Coarse = A1-A3; Fine = A4-A7

[2] http://www4.ncdc.noaa.gov/oi/9712/AFI-pubreturn.pdf

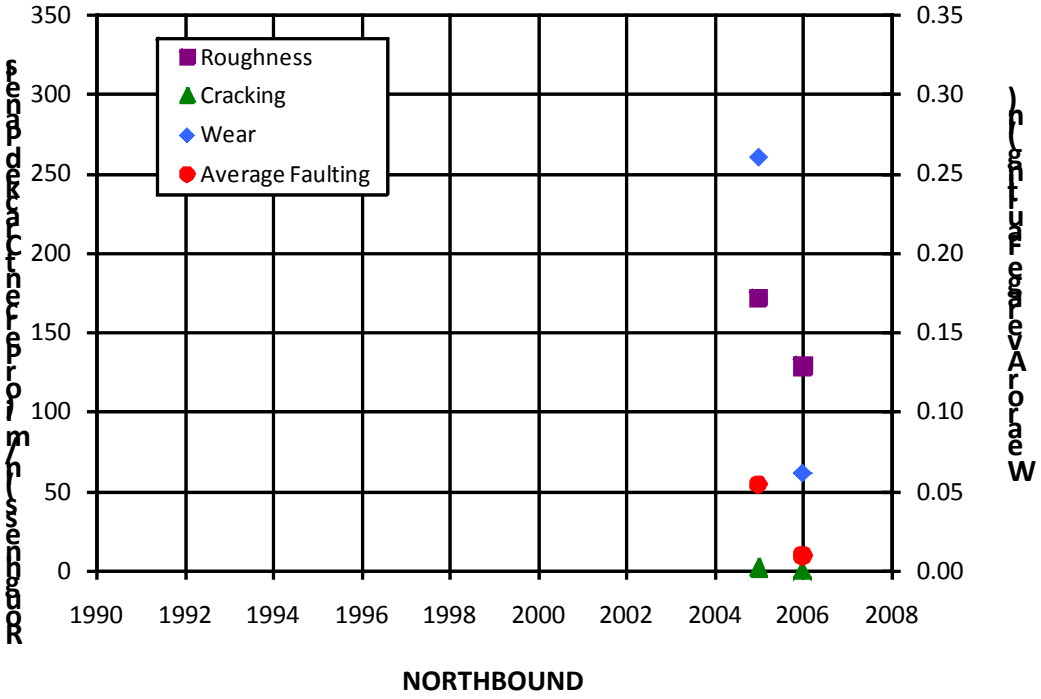
PAVEMENT CONDITION – SOUTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2005	4,854,500	878,281	0.17	158	0.20	0	0	0
2006	4,818,000	869,156	0.08	121	0.00	1	2	0
Cumulative	9,672,500	1,747,437						



SOUTHBOUND

[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION - NORTHBOUND								
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	No. Cracked Slabs[3]		
						Low/ Trans.	Med./ Long.	High/ Multi.
2005	4,854,500	878,281	0.26	171	0.05	1	1	0
2006	4,818,000	869,156	0.06	129	0.01	0	0	0
Cumulative	9,672,500	1,747,437						



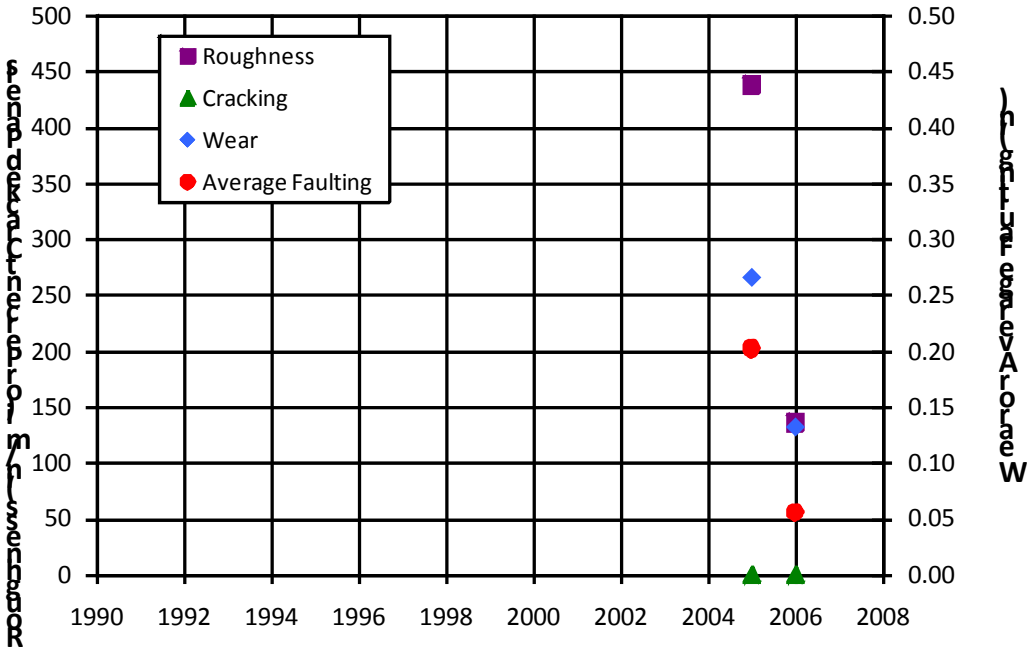
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	Pierce Co Line to Tukwila I/C HOV - Stage 4
Project limits:	MP 139.06 to MP 144.75
Direction:	NB & SB
Contract number:	6883
Original construction:	1962
DBR construction:	2005
Age at DBR (yr):	43
2007 DBR Age (yr):	2
Lane miles DBR:	15.24
Lane miles grinding:	27.75
DBR Contractor:	Unknown
Grinding Contractor:	Unknown
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	117

[1] Coarse = A1-A3; Fine = A4-A7

[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

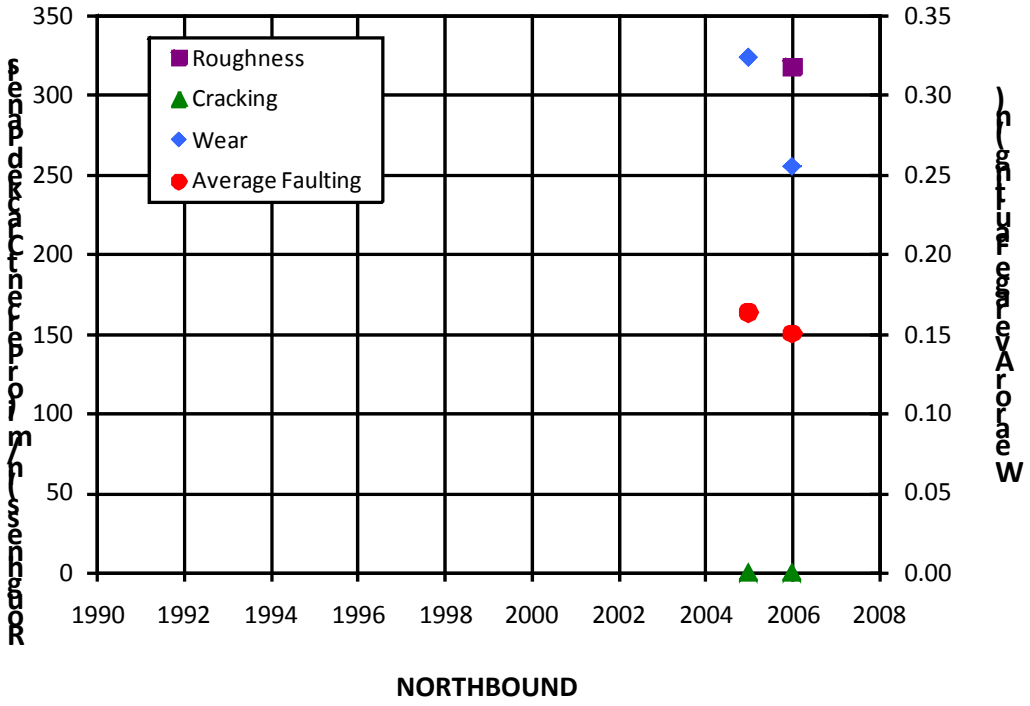
PAVEMENT CONDITION - SOUTHBOUND								
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	No. Cracked Slabs[3]		
						Low/ Trans.	Med./ Long.	High/ Multi.
2005	5,365,500	969,988	0.27	438	0.20	0	0	0
2006	5,402,000	973,638	0.13	136	0.06	0	0	0
Cumulative	10,767,500	1,943,626						



SOUTHBOUND

[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION - NORTHBOUND								
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	No. Cracked Slabs[3]		
						Low/ Trans.	Med./ Long.	High/ Multi.
2005	5,365,500	969,988	0.32	358	0.16	0	0	0
2006	5,402,000	973,638	0.26	318	0.15	0	0	0
Cumulative	10,767,500	1,943,626						



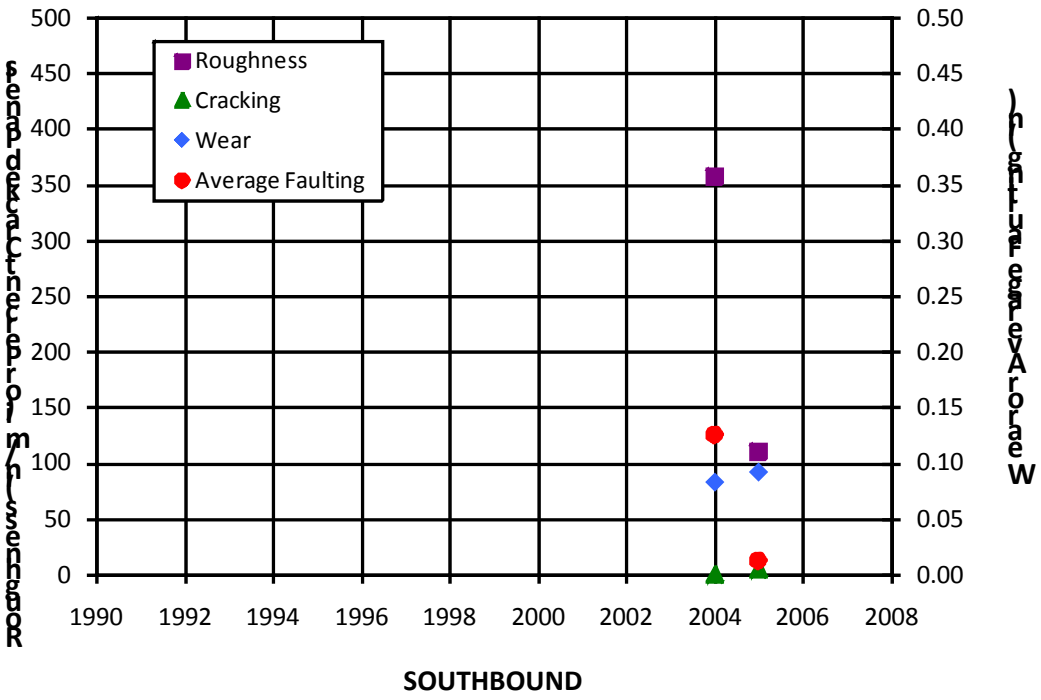
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	205
Project title:	SR 500 to I-5 PCCP Rehabilitation and DBR
Project limits:	MP 31.36 to MP 37.73
Direction:	NB & SB
Contract number:	6916
Original construction:	1976
Year of DBR:	2004
Age at DBR (yr):	28
2007 DBR Age (yr):	3
Lane miles DBR:	13.63
Lane miles grinding:	25.48
PCC thickness:	9 inches
Base type:	ATB[4]
Base thickness:	4 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	249

Notes: Retrofitted a 4 ft tied and doweled shoulder, both directions

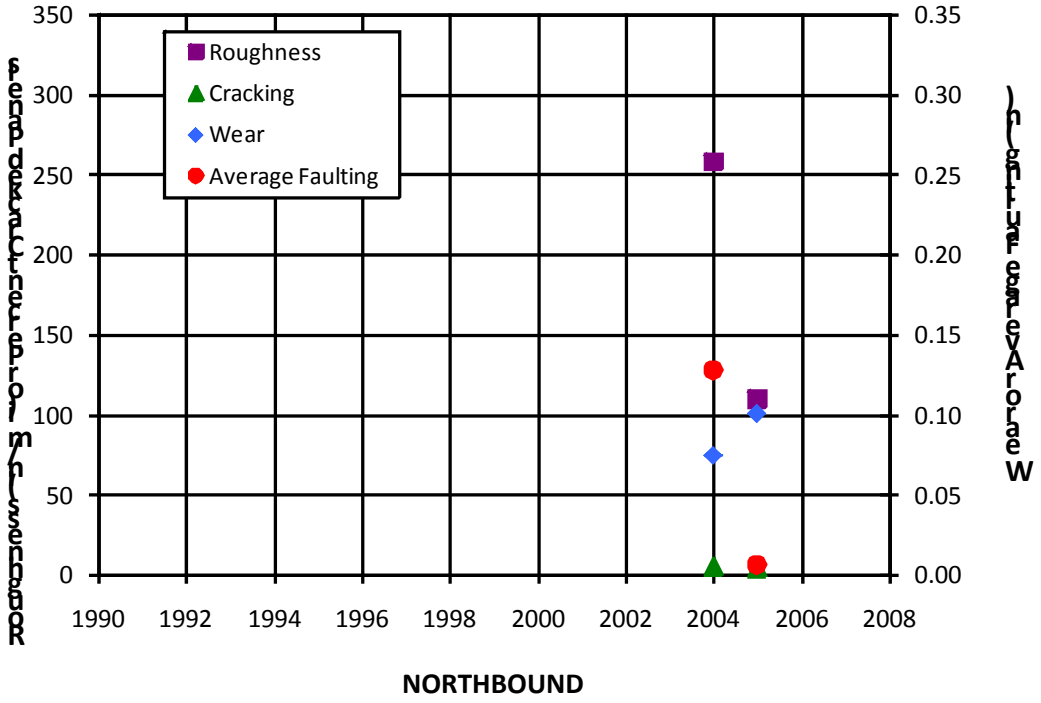
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/oi/9712/AFI-pubreturn.pdf
[4] Asphalt treated base

PAVEMENT CONDITION - SOUTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2005	1,825,000	613,200	0.08	357	0.13	0	0	0
2006	1,825,000	613,200	0.09	110	0.01	1	3	0
Cumulative	3,650,000	1,226,400						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – NORTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2005	1,825,000	613,200	0.08	258	0.13	4	1	0
2006	1,825,000	613,200	0.10	110	0.01	3	2	0
Cumulative	3,650,000	1,226,400						



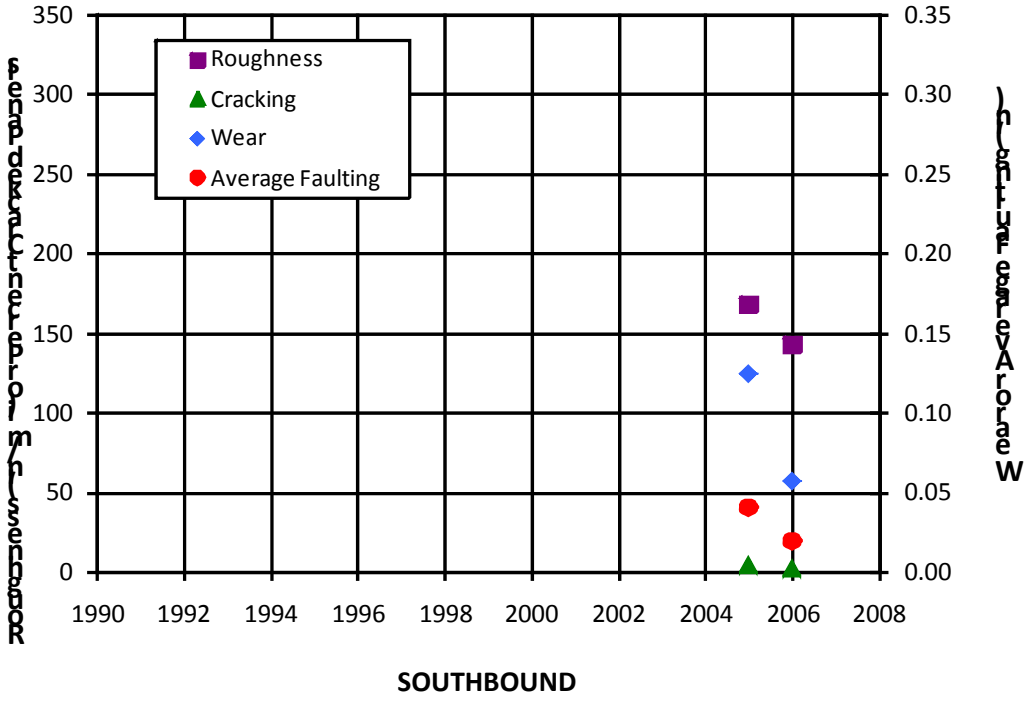
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	5
Project title:	I-205 to N. Fork Lewis R Br PCCP Rehabilitation
Project limits:	MP 7.98 to MP 20.08
Direction:	NB & SB
Contract number:	7084
Original construction:	
Year of DBR:	2005
Age at DBR (yr):	2005
2007 DBR Age (yr):	2
Lane miles DBR:	16.88
Lane miles grinding:	16.88
PCC thickness:	9 inches
Base type:	ATB[4]
Base thickness:	6 inches
Subgrade[1]:	Fine
Shoulder type:	HMA
Freezing Index[2]:	249

Notes: Subsealing prior to dowel bar retrofit

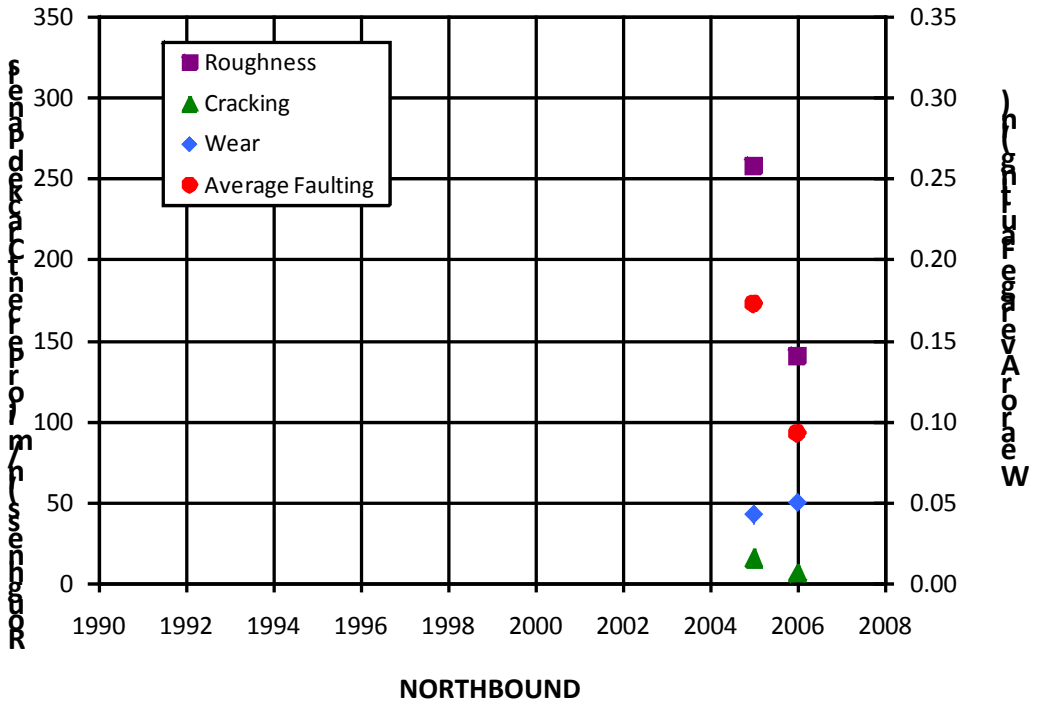
[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf
[4] Asphalt treated base

PAVEMENT CONDITION - SOUTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg. Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2005	5,000,500	1,425,933	0.12	168	0.04	1	4	0
2006	5,110,000	1,447,225	0.06	143	0.02	1	1	0
Cumulative	10,110,500	2,873,158						



[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PAVEMENT CONDITION – NORTHBOUND								
						No. Cracked Slabs[3]		
Year	Trucks	Annual ESAL	Wear (in)	IRI (in/mi)	Avg./ Fault (in)	Low/ Trans.	Med./ Long.	High/ Multi.
2005	5,000,500	1,425,933	0.12	168	0.04	1	4	0
2006	5,110,000	1,447,225	0.06	143	0.02	1	1	0
Cumulative	10,110,500	2,873,158						



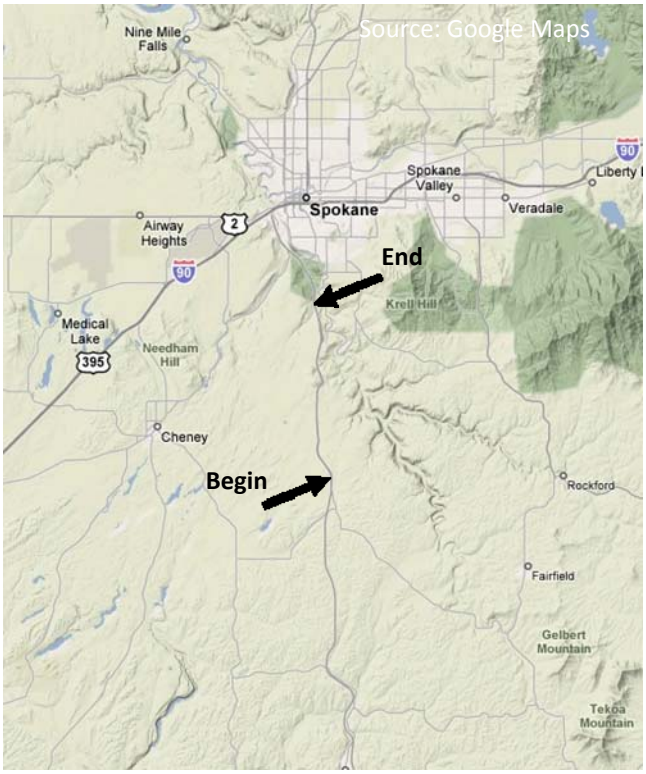
[3] 1992 to 2003: low = one crack; medium = two cracks; high = > three or more cracks per panel
2004 to 2006: low = transverse, medium = longitudinal, high = Multiple cracked slab

PROJECT DETAILS	
SR:	82
Project title:	Yakima to Prosser WIM
Project limits:	MP 40.32 to MP 84.08
Direction:	EB
Contract number:	7130
Original construction:	1982
DBR construction:	2007
Age at DBR (yr):	25
2007 DBR Age (yr):	0
Lane miles DBR:	0.08
Lane miles grinding:	0.08
PCC thickness:	9 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	661

Notes: Rehabilitation for weigh-in-motion site
This project was excluded from the dowel bar retrofit performance analysis due to weigh-in-motion site and constructed after 2006.

[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/oi/9712/AFI-pubreturn.pdf

PROJECT DETAILS	
SR:	195
Project title:	Cornwall Road to Hatch Road
Project limits:	MP 80.96 to MP 91.18
Direction:	NB
Contract number:	7293
Original construction:	1967
DBR construction:	2007
Age at DBR (yr):	40
2007 DBR Age (yr):	0
Lane miles DBR:	6.05
Lane miles grinding:	7.76
PCC thickness:	8 inches
Base type:	Untreated
Base thickness:	9 inches
Subgrade[1]:	Coarse
Shoulder type:	HMA
Freezing Index[2]:	1232



Note: Subsealing prior to dowel bar retrofit
This project was excluded from the dowel bar retrofit performance analysis due to constructed after 2006.

[1] Coarse = A1-A3; Fine = A4-A7
[2] http://www4.ncdc.noaa.gov/ol/9712/AFI-pubreturn.pdf

APPENDIX E. ADDITIONAL DISTRESS IMAGES

The following illustrates distresses noted on the dowel bar retrofit projects in Washington State. Pavement images were obtained from WSDOT 2006 annual condition data survey and illustrate the surface of the full roadway width (fog line to skip stripe). In some instances, images where pasted together to more fully illustrate the extent of the distress.

Figures E-1 and E-2 depict the typical performance of perpendicular and skewed, respectively, transverse joints that have been dowel bar retrofitted. The majority of dowel bar retrofitted transverse joints in Washington State have no noticeable distress.

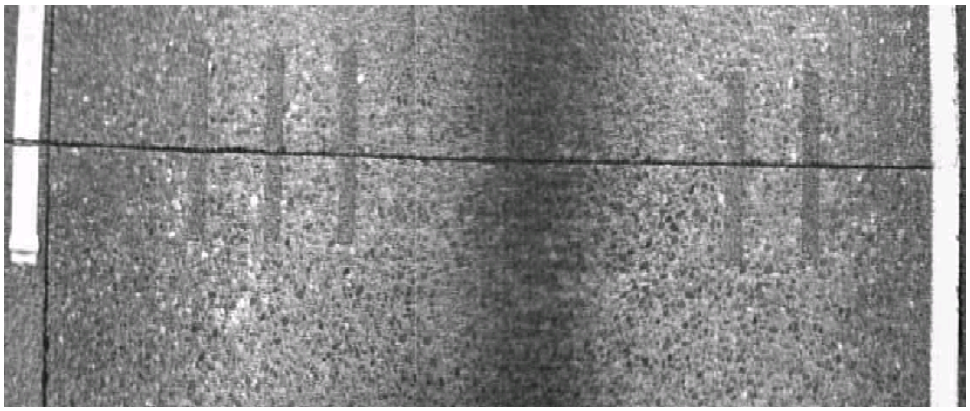


Figure E-1 No distress – perpendicular joint

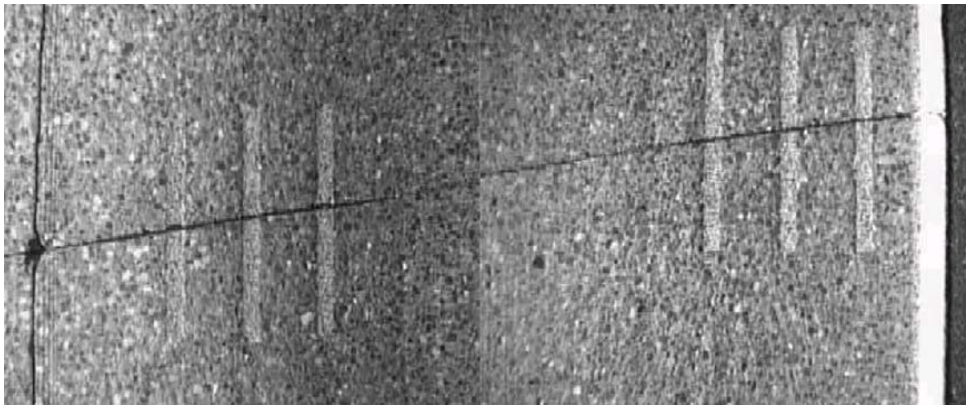


Figure E-2 No distress – skewed joint

Figure E-3 was captured on the I-82 project, where the contract allowed for sawing and resealing of the transverse joint only over the width of the dowel bar retrofitted slots. Based on the observations of this one project, this practice appears to be performing well.

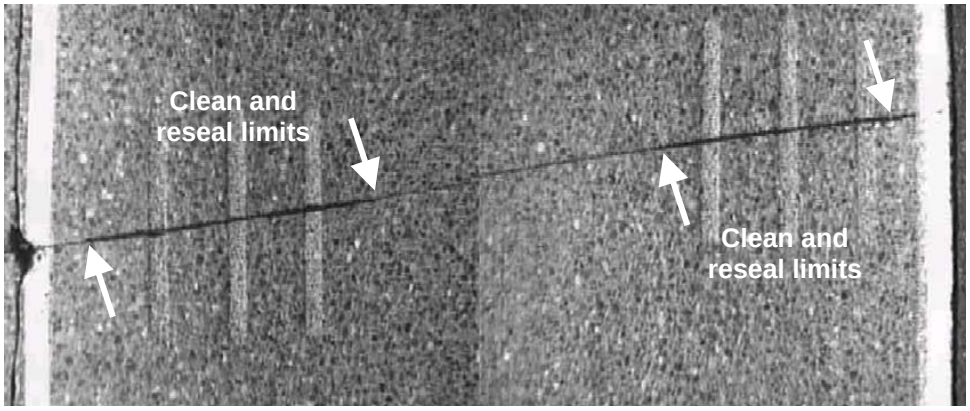


Figure E-3 Clean and reseal joint only over dowel bar slots.

Figure E-4 illustrates where the foam core board was either not properly centered over the transverse joint or more likely, the foam core board was displaced during placement of the patching material. In addition, on this project (I-5, Contract 5712, Gravelly Lake Interchange Vicinity to Puyallup River Bridge), the requirement to saw and seal the transverse joint after dowel bar retrofit was removed due to budgetary constraints. Based on a visual survey of dowel bar slot condition, this project had a high percentage of slots that were cracked and/or spalled, as compared to other projects with similar traffic volumes and dowel bar retrofit age. The presence of slot distress can not be completely explained by the lack of sawcutting and sealing the transverse joint after dowel bar retrofit, however, sawcutting and sealing is considered to be a low cost item that does provide some benefit and it is recommended that this item not be deleted from the construction requirements.

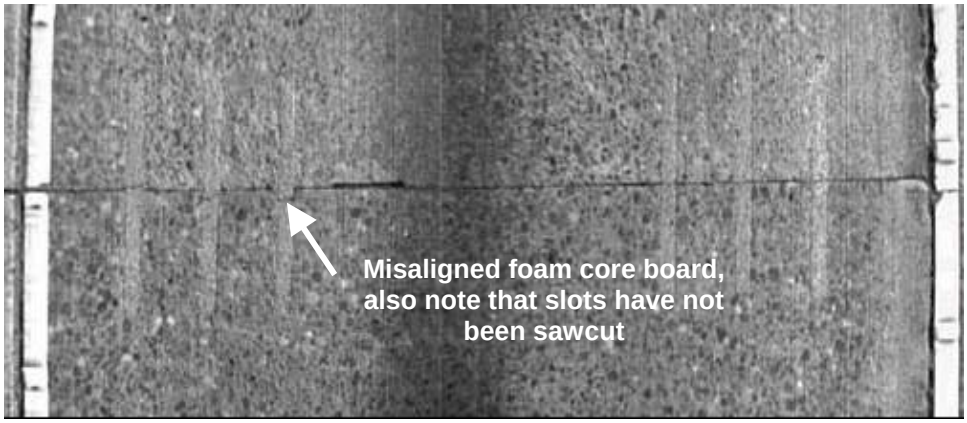


Figure E-4 Misaligned foam core board.

Figure E-5 illustrates the typical performance of an existing transverse crack that has been dowel bar retrofitted.

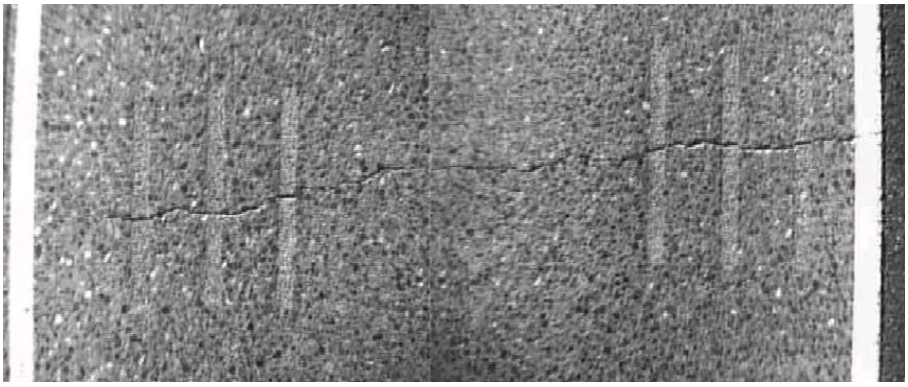


Figure E-5 Dowel bar retrofit of existing transverse crack.

Figure E-6 shows a transverse crack (note the narrow width of sawed joint) that is functioning as the working joint (joint more than likely sawed to late during original construction) that has been dowel bar retrofitted. The transverse crack is located within approximately one to two feet of the transverse joint. The Contractor sawcut the dowel bar slot over both the joint and the working crack, however, it is not clear if the dowel bar assembly was centered over the transverse crack, over the transverse joint or over both the joint and crack. In this case, it would be best to center the dowel bar assembly over the transverse crack (Figure E-7). In general, dowel bar retrofit of working cracks has performed well in Washington State.

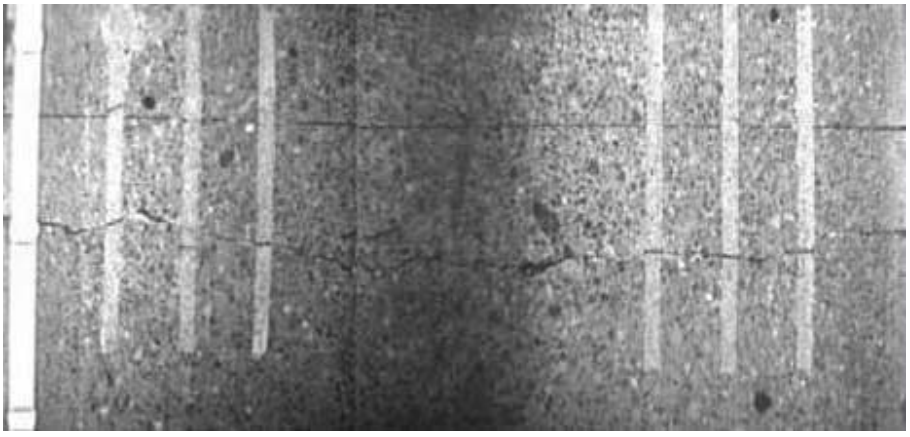


Figure E-6 Dowel bar retrofitted transverse crack and joint.

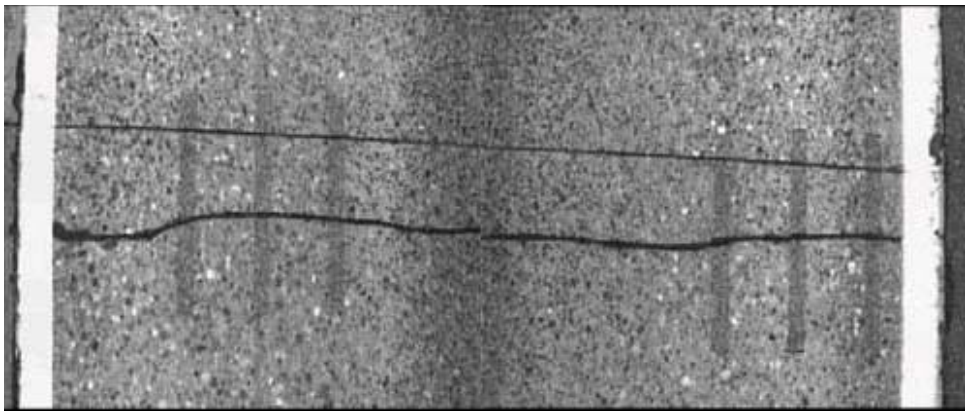


Figure E-7 Dowel bar retrofit of working crack.

Figure E-8 shows a transverse crack that has been dowel bar retrofitted, but in this case the transverse crack is within four to five feet of the transverse joint. Due to the distance between the transverse joint and transverse crack, it can be assumed that the transverse joint is functioning as intended. What is interesting to note, is that a longitudinal crack has developed between the transverse crack and transverse joint.

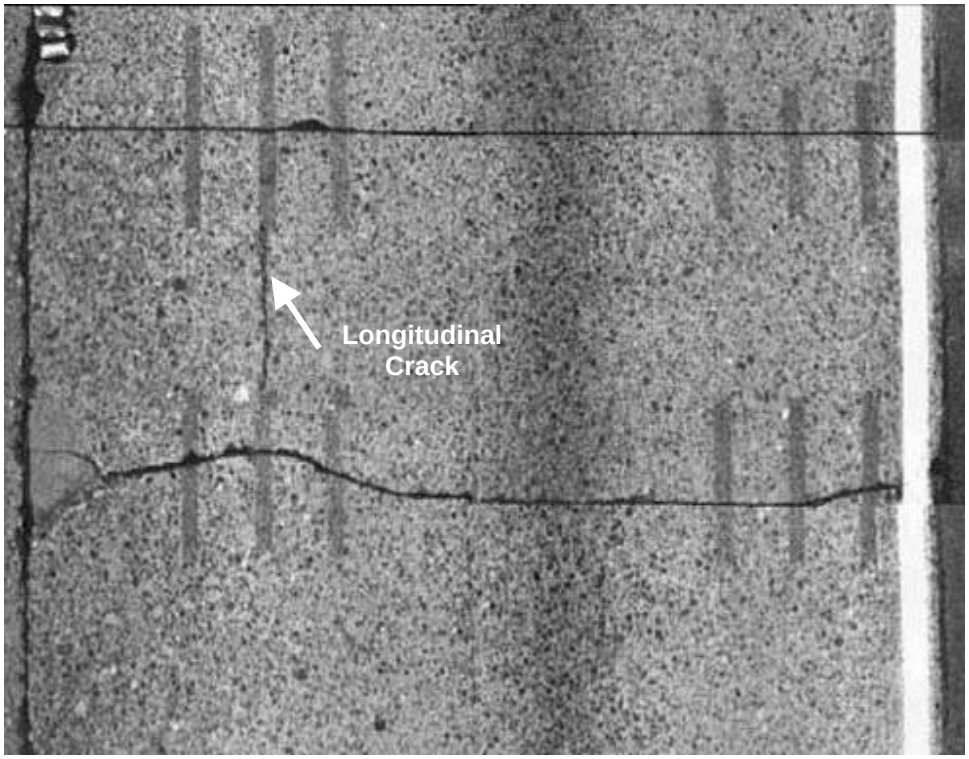


Figure E-8 Dowel bar retrofitted transverse crack and longitudinal crack.

Figure E-9 is an image of a transverse crack that developed after (note narrow opening of transverse crack) dowel bar retrofit. It is standard WSDOT practice to dowel bar retrofit all transverse cracks, therefore, since this crack was not dowel bar retrofitted, it can safely assumed that the crack occurred after dowel bar retrofit.

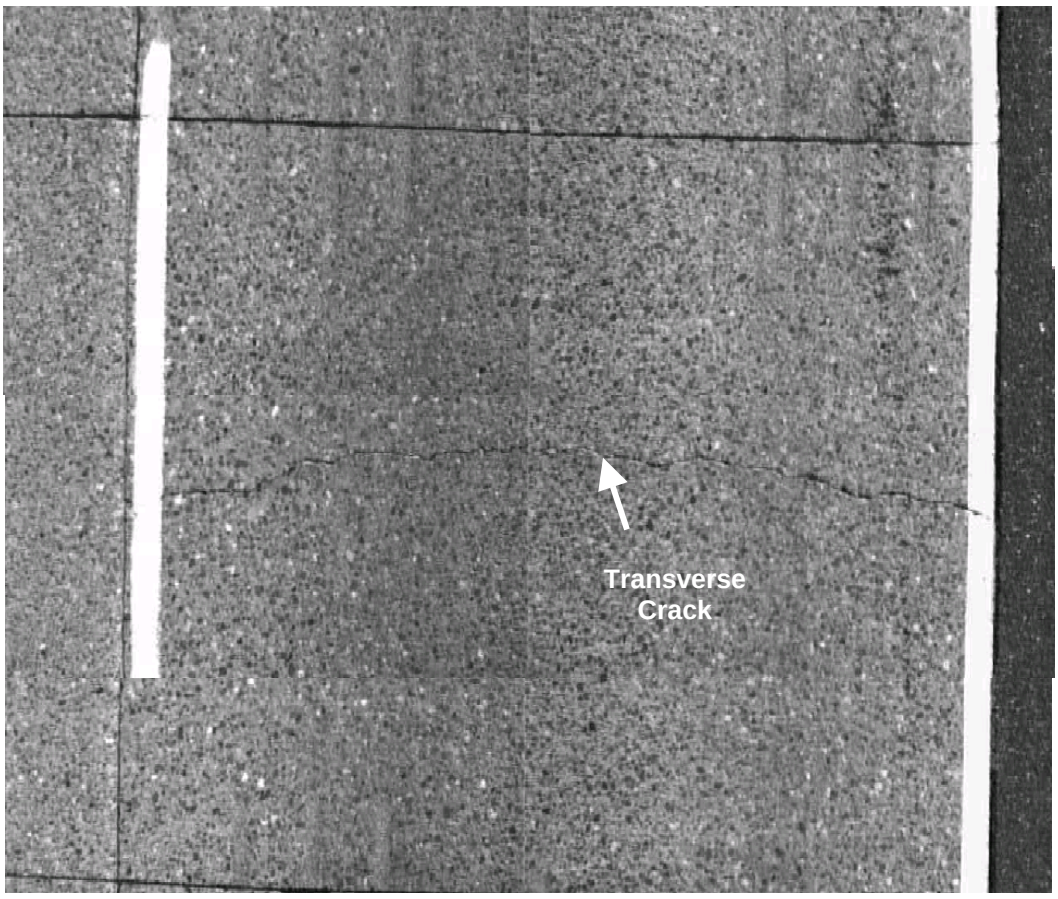


Figure E-9 Transverse crack after dowel bar retrofit.

Figure E-10 shows an existing corner crack (note width of crack) that was dowel bar retrofitted. Slot failure, both cracking within the slot and slot debonding has occurred. It has been noted that many existing corner cracks only occur on one panel, following dowel bar retrofit; the adjacent panel develops a corner crack. In this case, it may have been better to either not retrofit the slot that intersects the crack or conduct a panel replacement to repair the corner crack. The latter becomes a very expensive option and it should be evaluated by each agency to determine the consequences of dowel bar retrofitting at a lower cost, but higher potential of noted distress versus the cost of a panel replacement.

Figure E-10 Pre existing corner crack.

Figure E-11 shows a corner crack that developed after dowel bar retrofit (note tightness of the crack). This distress more commonly occurs in the right wheel path, but has been known to occur in the left wheel path as shown in Figure E-11.

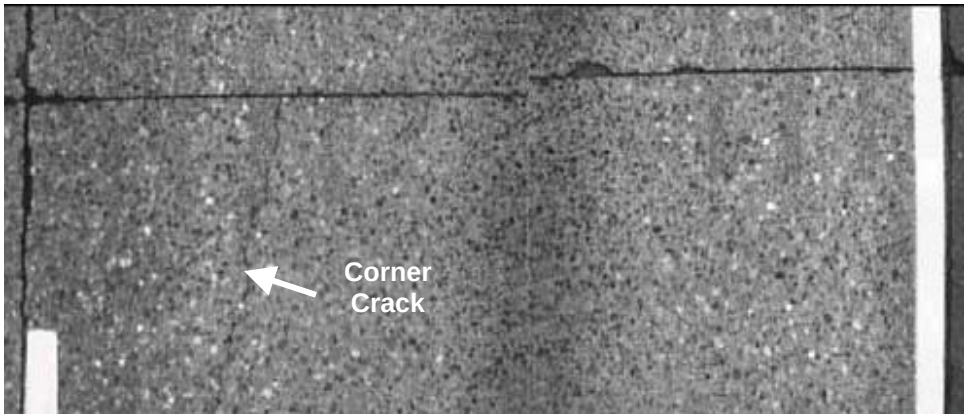


Figure E-11 Corner crack after dowel bar retrofit.

Figure E-12 shows an example of a pre-existing longitudinal crack that was sealed during the dowel bar retrofit project. The crack appears to intersect the dowel bar slot at both of the transverse joints; however, there does not appear to be any additional distress in the dowel bar slot due to the presence of the longitudinal crack (which is not typical). It is advised, based on performance in Washington State, that dowel bar slots not be located at the intersection of a longitudinal crack. Distress associated with the dowel bar slot and longitudinal crack is described further below.

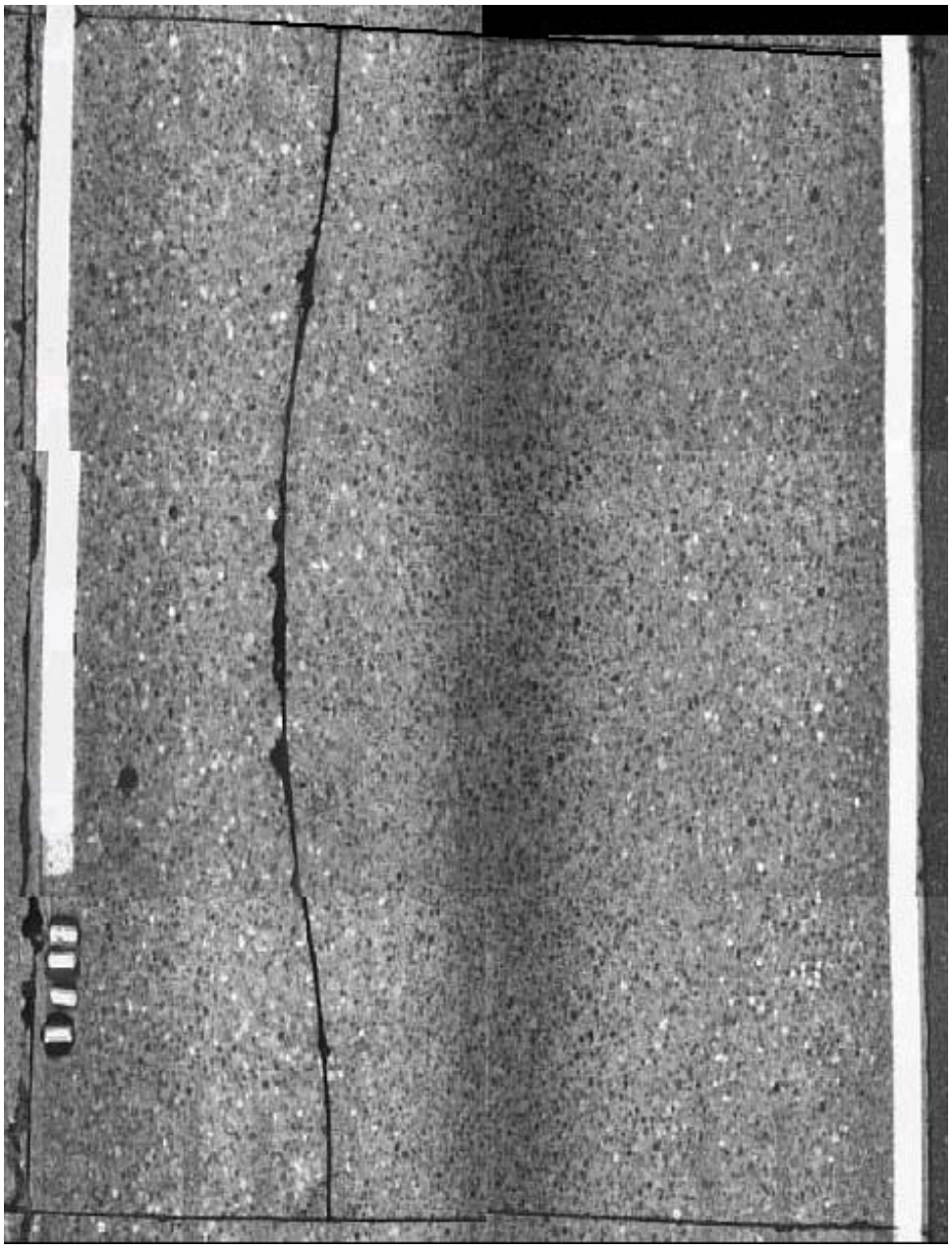


Figure E-12 Pre existing longitudinal crack.

Figure E-13 shows an example of a longitudinal crack that developed after dowel bar retrofit. The tightness of the longitudinal crack and the fact that it has not been sealed (which is standard WSDOT practice for rehabilitation projects) identifies this crack as occurring after dowel bar retrofit. In this case, the longitudinal crack intersects a dowel bar slot at both transverse joints. Newly developed longitudinal cracks can occur due to propagation of cracks

from adjacent panels or due to stress concentration within the newly dowel bar retrofitted panel.

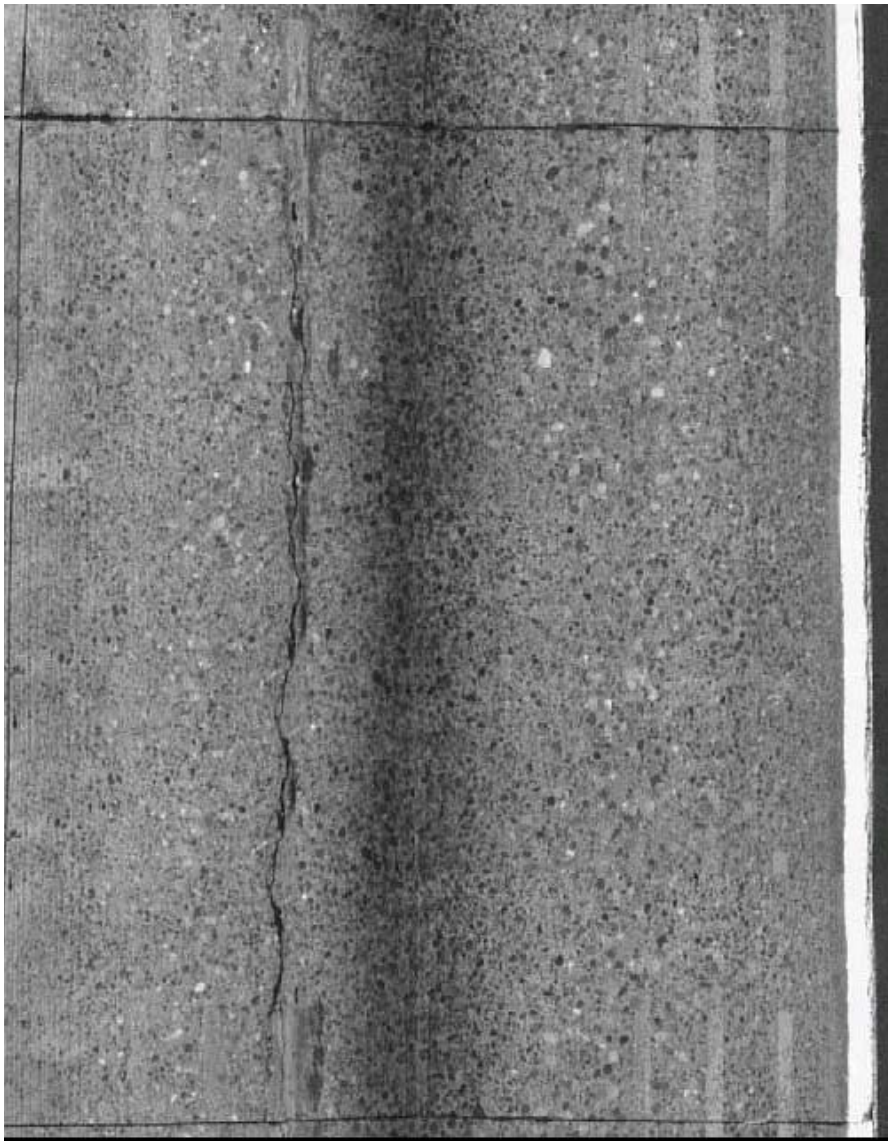


Figure E-13 Longitudinal crack after dowel bar retrofit.

Figure E-14 illustrates a typical distress when the longitudinal crack intersects the dowel bar retrofit slot. This image shows late stage distress development where the loss of patching material has occurred. Typically distress progresses via debonding of patching material from the sides of the slot (longitudinal crack propagates through patching material) or cracking within the patching material or both. Over time and traffic, the material spalls or breaks loose from the dowel bar slot. Total loss of the patching material has been noted in several instances in

Washington State. Therefore, it is recommended that longitudinal cracks be avoided when dowel bar retrofitting transverse joints and cracks.

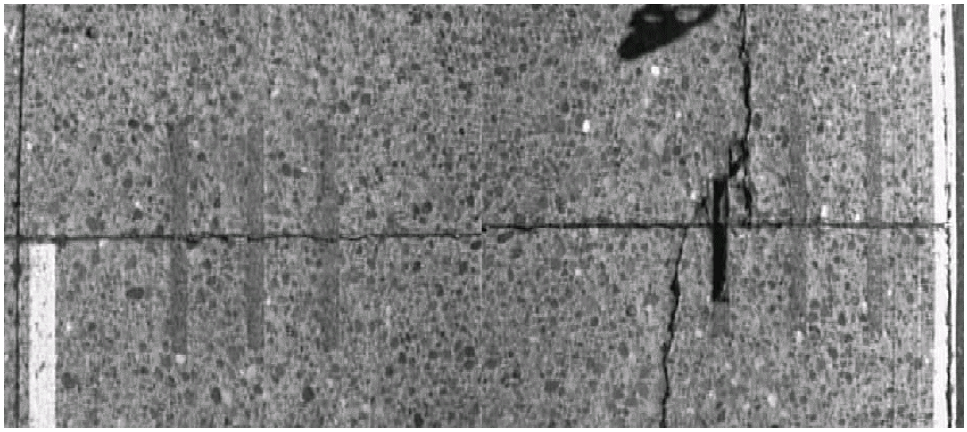


Figure E-14 Failure of dowel bar slot over existing longitudinal crack.

Figure E-15 illustrates the presence of a longitudinal crack (top panel) and the propagation into an adjacent slab (bottom panel). As part of the dowel bar retrofit project, the longitudinal crack in the upper panel was sealed. In addition, the dowel bar retrofit slots were either adjusted to miss the longitudinal crack or the location of the crack did not intersect with the specified dowel bar retrofit locations. However, neither sealing the crack nor missing the dowel bar retrofit slot will guarantee that the crack will not propagate to adjacent panels. Certainly, replacing all panels with longitudinal cracks will eliminate the potential of crack propagation; however, due to funding limitations this practice is not practical. An agency should decide the cost effectiveness and potential benefits of dowel bar retrofitting panels with longitudinal cracks and accepting crack propagation versus the higher cost, but minimal performance issues with panel replacements.

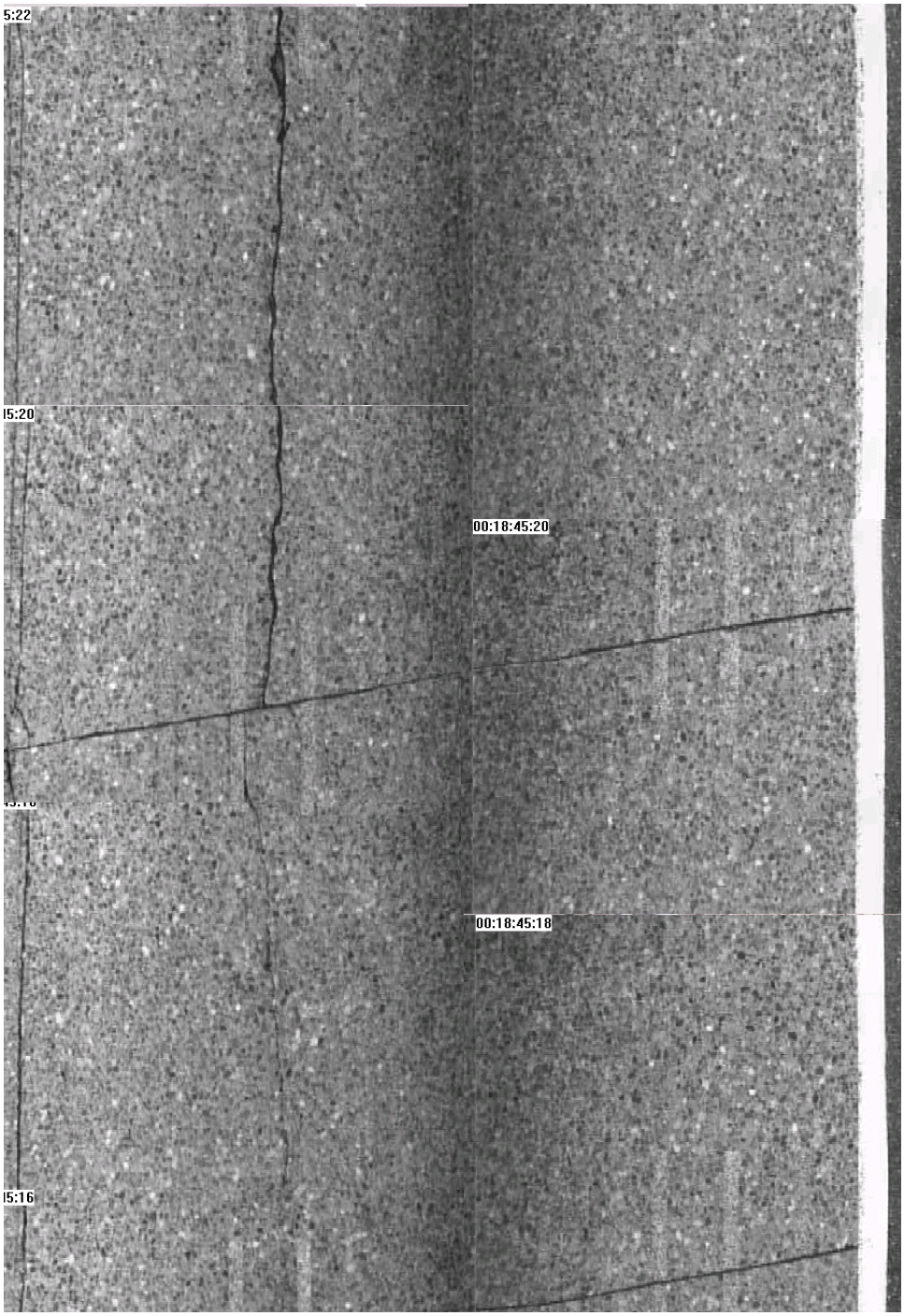


Figure E-15 Existing sealed longitudinal crack (top panel) and longitudinal crack after dowel bar retrofit (lower panel).

Figure E-16 illustrates a situation where the longitudinal crack would intersect a dowel bar retrofit slot. In this instance, the slot was cut but the existing concrete between the saw cuts was not removed. The saw cuts should be sealed with epoxy. The other option would be to shift

the dowel bar slots to the left or right to avoid the longitudinal crack. The latter may be more difficult to accomplish, especially when a full-width gang saw is used for cutting the dowel bar retrofit slots. The practice of sawcutting but not removing the existing concrete within the dowel bar slot has provided good performance in Washington State.

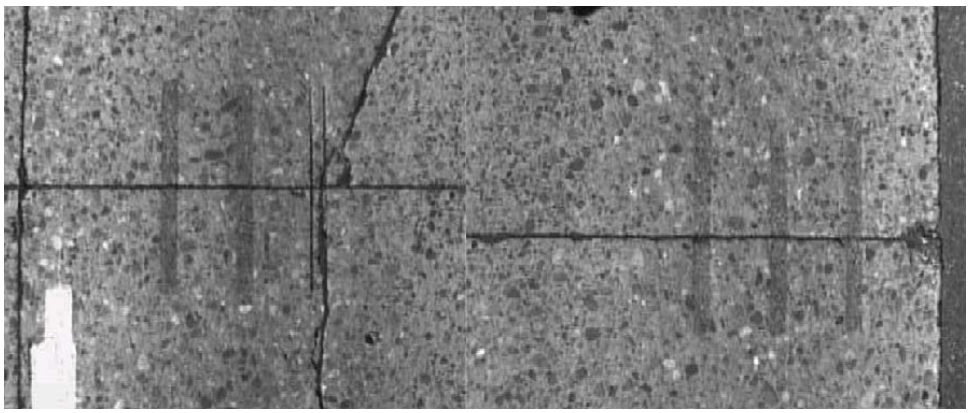


Figure E-16 Slots sawed by not removed to avoid longitudinal crack.

The image shown in Figure E-17, certainly is not typical, but demonstrates the vast array of potential opportunities for dowel bar retrofit. In this case, a large corner crack was dowel bar retrofitted. This project was dowel bar retrofitted more than 10 years and appears to be performing satisfactorily (no additional cracking or slot failure at the top of the corner crack). Distress has occurred (severe spalling that has been patched with HMA by Maintenance) in the dowel bar retrofit slot where the corner crack intersects the transverse joint and connects with the longitudinal crack in the adjacent panel.

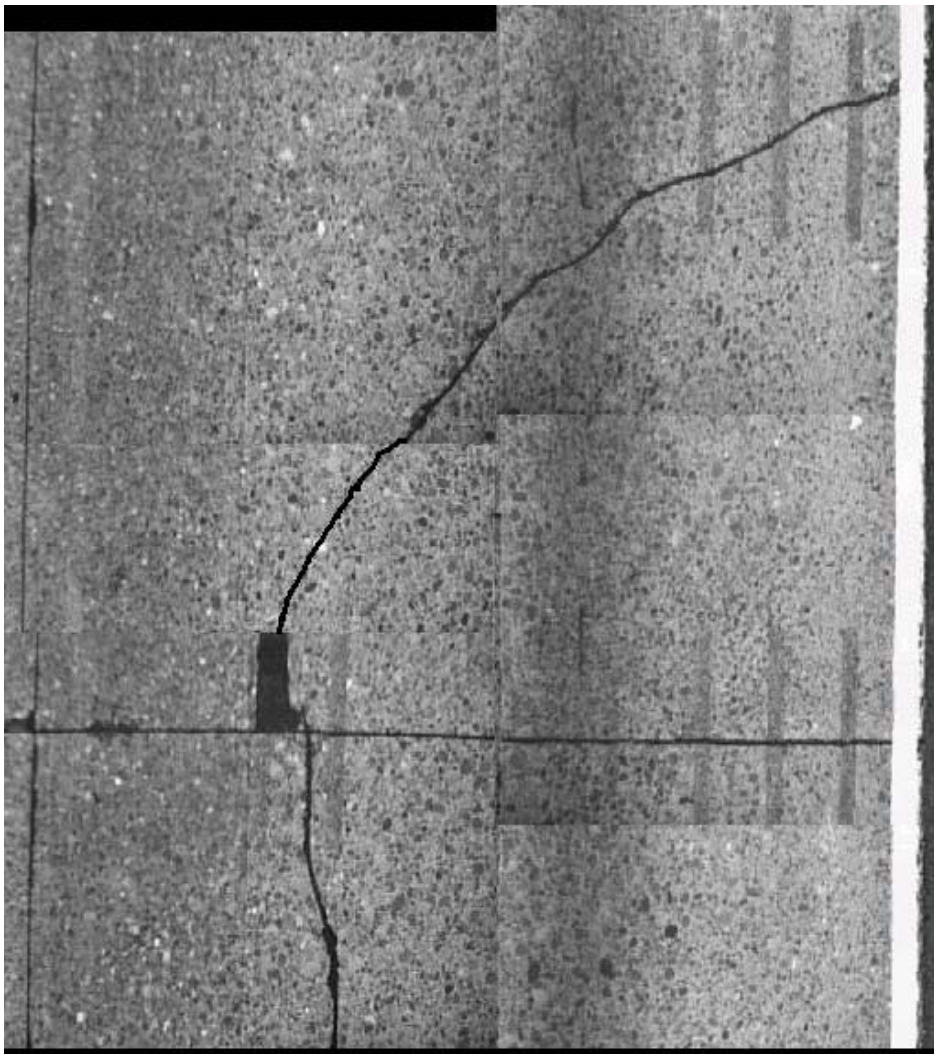


Figure E-17 Dowel bar retrofit of existing longitudinal to transverse crack.

Figures E-18 through E-20 illustrates locations where a spall repair was conducted in conjunction with dowel bar retrofit. In Figures E-18 and E-19, the spall appears to have been simply filled while placing the patching material in the dowel bar retrofit slot. It can be noted that the shape of the spall repair is irregular indicating that a saw cut was not conducted to define the extent of the spalled area. Ideally, spalled areas should be saw cut, as shown in Figure E-20, prior to placement of patching material. It is interesting to note, that in all three instances, the spall repair is not performing poorly, cracking is present regardless of the spall repair technique.

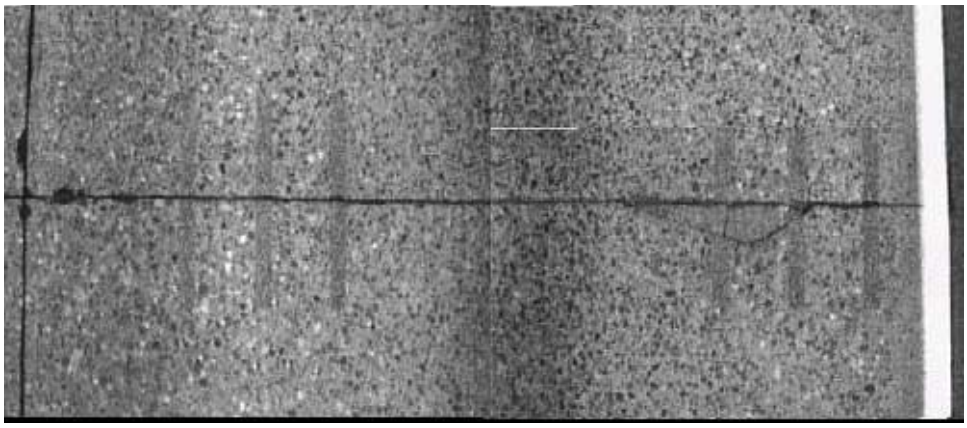


Figure E-18 Distressed spall repair with dowel bar retrofit.

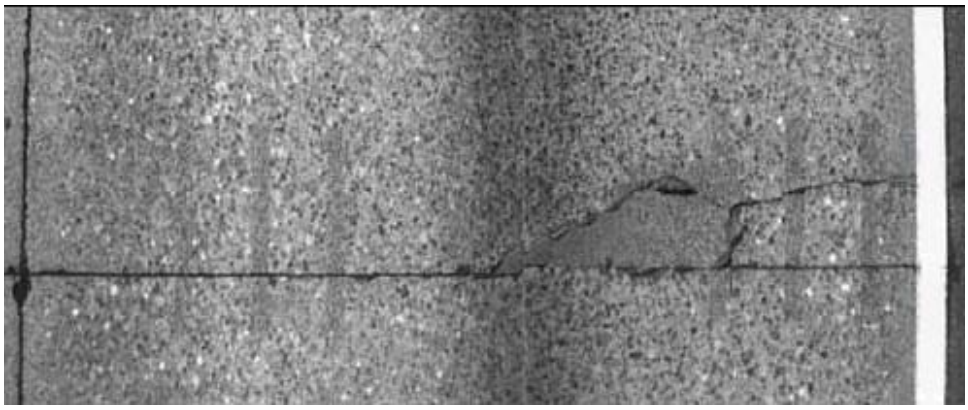


Figure E-19 Spall repair with dowel bar retrofit.

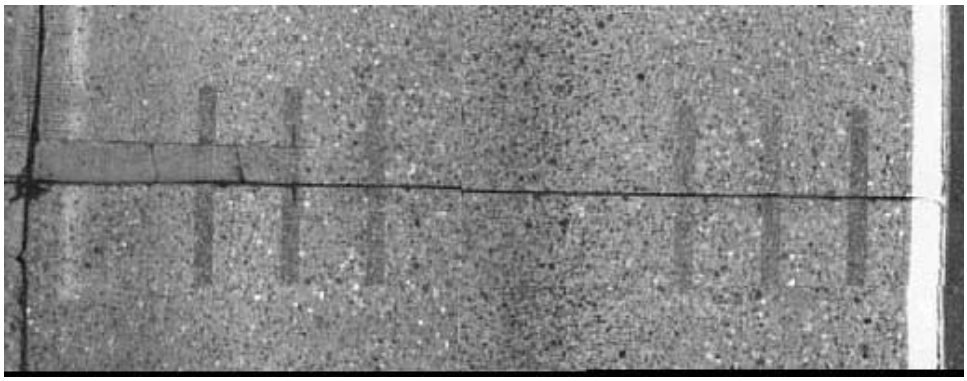


Figure E-20 Distressed spall repair with dowel bar retrofit.

Figure E-21 illustrates cracking that has occurred, more than likely, due to saw cutting the dowel bar slot to deep or by using heavy jackhammers. When the concrete is removed in a slot that has been saw cut to deep, the dowel bar will not be placed at the neutral axis, which can

lead to high stresses and lead to slot or panel cracking. In addition, a deeper saw cut can result in the jackhammer causing cracking in the bottom of the dowel bar slot, due to insufficient thickness between the bottom of the slot and the bottom of the concrete panel. Cracking in the bottom of the slot becomes an issue since the patching material can enter into the crack and lead to joint lockup and cracking. In Washington State, this type of cracking is a very rare occurrence; however, on one project on I-90, the Contractor requested and was allowed to use a 60 pound jackhammer for dowel bar slot removal. This resulted in the jackhammer punching through the bottom of the slot, once realized the Contractor was directed to use 30 pound jackhammers.

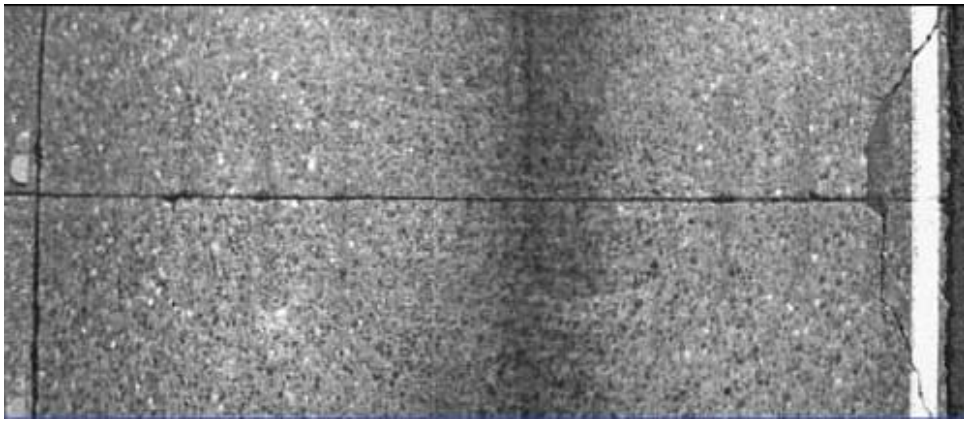


Figure E- 21 Joint lockup due to sawing and/or jackhammering to deep.

Figures E-22 and E-23 shows cracking within the dowel bar slot, which is more than likely caused by shrinkage. This distress occurs infrequently in Washington State.

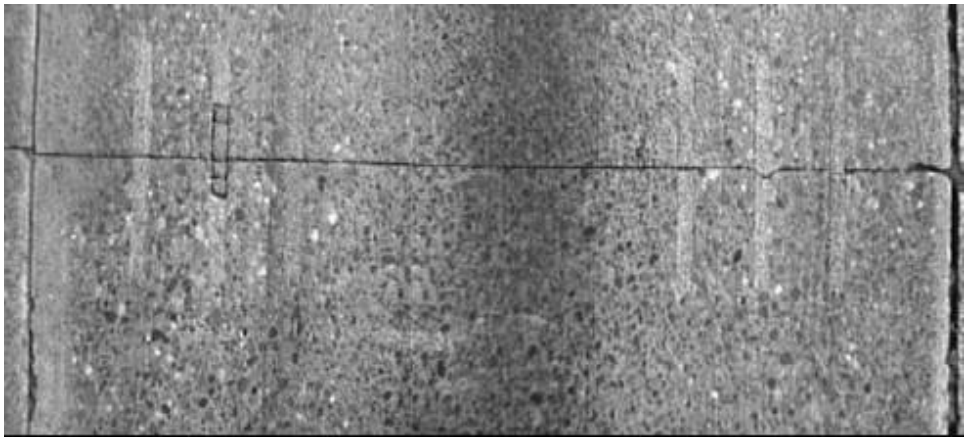


Figure E-22 Low severity cracking within dowel bar slot.

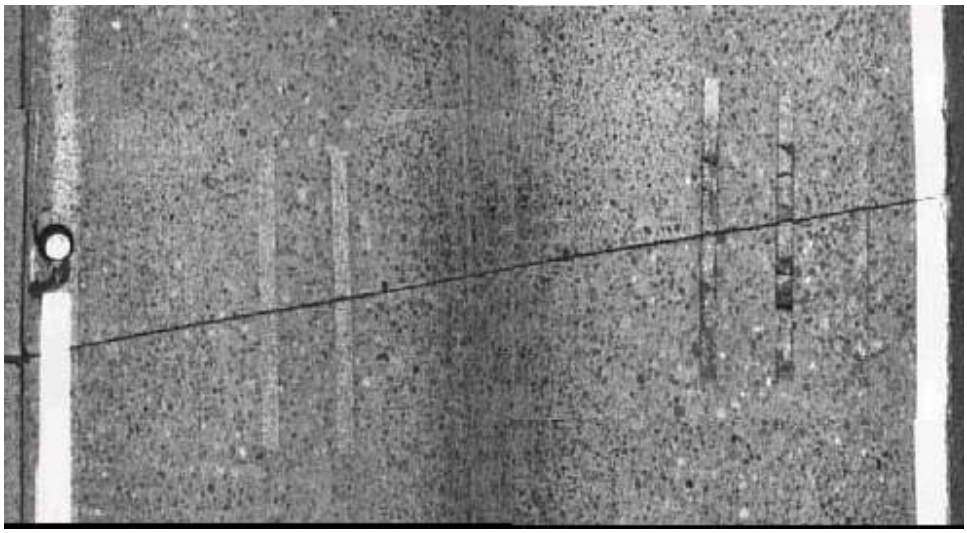


Figure E-23 High severity cracking within dowel bar slot.

Figures E-24 and E-25 illustrate dowel bar retrofit slot spalling. Spalling has been noted on very few dowel bar retrofit slots in Washington State. Spalling can occur due to poor consolidation, misaligned foam core board and advanced stages of cracking which causes a portion of the patching material to become dislodged from the dowel bar retrofit slot. Spalling can be minimized by following approved construction practices.

Figure E-24 Low severity spalling within dowel bar slot.

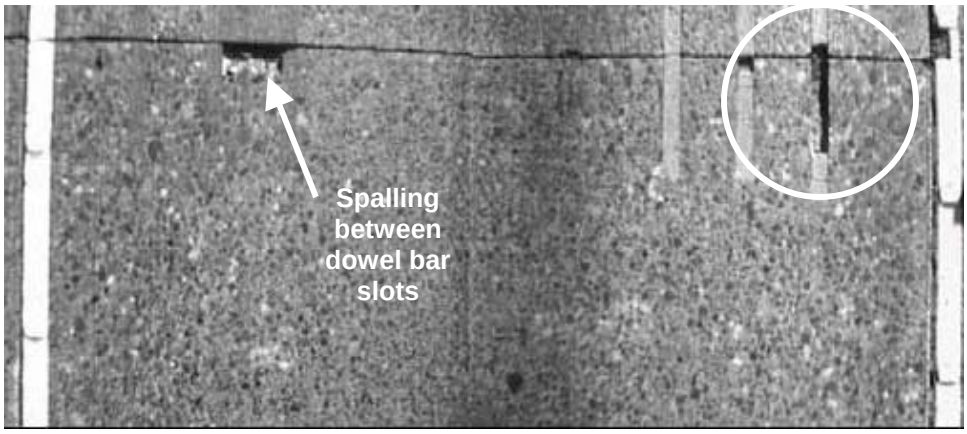


Figure E-25 High severity spalling within dowel bar slot.

Figure E-26 Illustrates debonding of the patching material from the sides of the dowel bar retrofit slot. Debonding is typically due to poor adhesion of the patching material to the sides of the dowel bar retrofit slots. This is typically due to the presence of fine material (saw residue and debris) on the sides of the dowel bar retrofit slot that were not adequately removed during the cleaning process. The dowel bar retrofit slot is considered to be clean when no residue exists on the sides of the dowel bar retrofit slot.

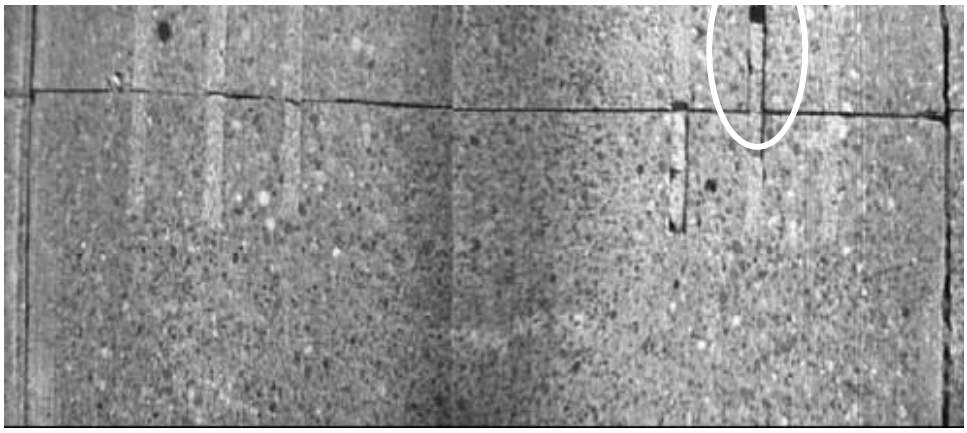


Figure E-26 Debonding of dowel bar slot.

Figure E-27 illustrates typical distress on many of the panels of I-90 westbound over Snoqualmie Pass. There are several notable issues related to this roadway section:

- One of the oldest sections of existing concrete pavement,
- Compared to other sections, had some of the worst pavement condition (faulting, roughness and percent of cracked panels) prior to dowel bar retrofit,

- Is subjected to high truck traffic loadings and
- Is subjected to a high number of freeze-thaw cycles.

Though not expected, considering the existing conditions, it makes sense that this roadway is showing the highest percent of cracked panels of all dowel bar retrofit sections.

Figure E-27 illustrates an existing transverse crack that was dowel bar retrofitted, with the development of a new longitudinal crack. The longitudinal crack may be propagation of longitudinal cracking from adjacent panels or the development of a new crack (this section of I-90 has both). The development of longitudinal cracking in older (> 10 years) dowel bar retrofit projects is becoming a more common occurrence and is believe to be the primary factor of dowel bar retrofit failure. Though it must be pointed out, that longitudinal cracking does not appear to increase levels of roughness and may take years to propagate to adjacent slabs.

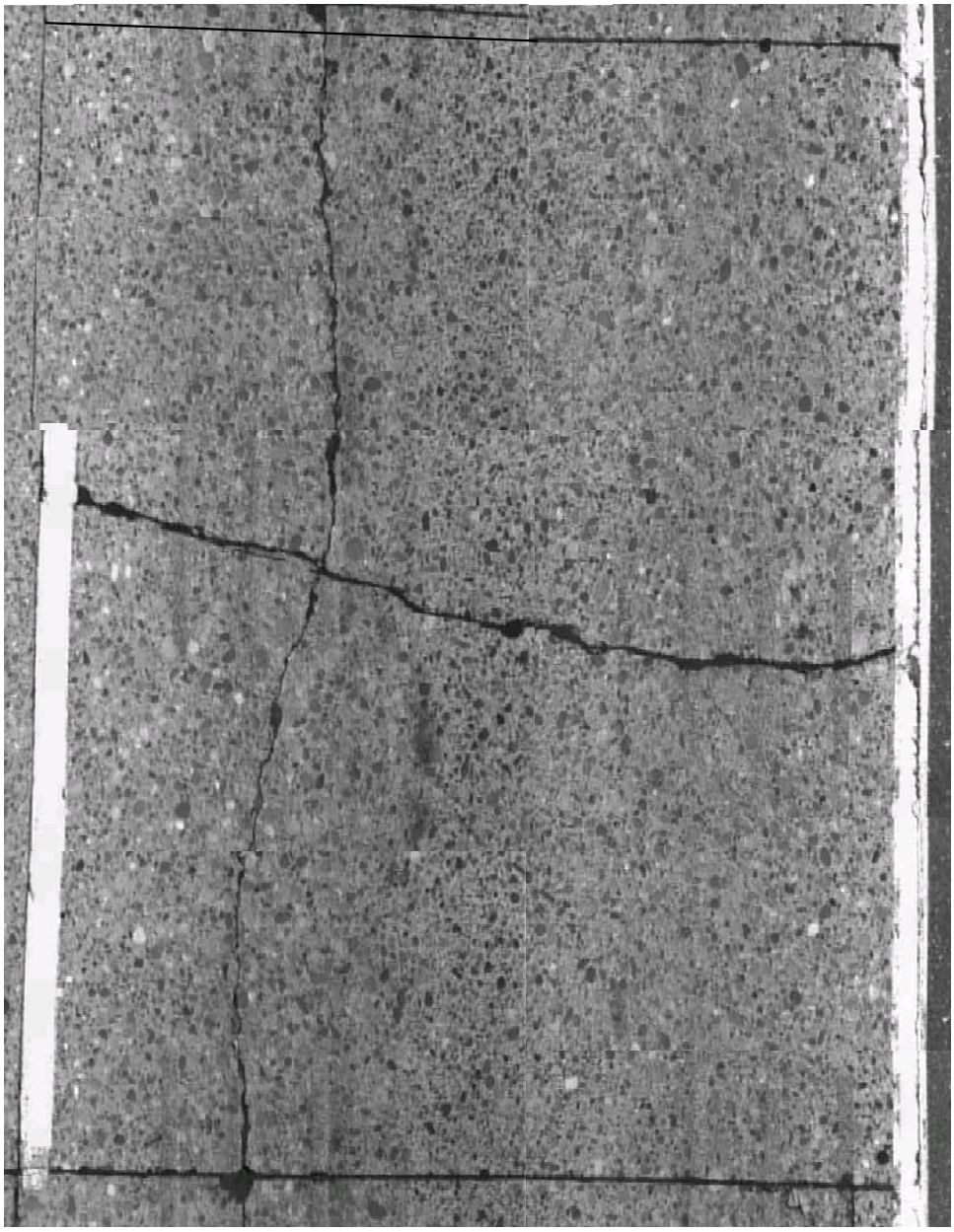


Figure E-27 Retrofitted transverse crack and new longitudinal crack.