

# technotes

“tech notes” is an effort by the HQ Materials Laboratory to share design and construction technology gained from projects completed by WSDOT. This issue is from the Pavements Division discussing dowel bar retrofit.

## Dowel Bar Retrofit

### Background

In 1992, WSDOT constructed a test section to determine the appropriateness of dowel bar retrofit (DBR) and diamond grinding to restore the functionality of the concrete pavement as well as to provide a smooth riding surface. Due to the success of the test section, the first large-scale DBR project was constructed on Interstate 90 (Snoqualmie Pass vicinity) in 1993. Since that time, WSDOT has rehabilitated over 300 miles of existing concrete pavement by dowel bar retrofitting followed by diamond grinding. It is estimated that over the next 20 years an additional 300 lane-miles of concrete pavement may require DBR.

Based on the performance of the test section it is anticipated that dowel bar retrofit will extend the life of the concrete pavement by 10 to 15 years.

### Costs

The average construction costs for DBR is approximately \$450,000 (2006 dollars) per lane mile (includes all costs – PE, construction, traffic control, etc). The typical cost of a four-inch asphalt overlay, which is the minimum recommended overlay depth for rehabilitating a faulted concrete pavement, is approximately \$525,000 per lane mile (includes all costs). DBR is considered cost effective since it is only applied to the faulted lane while an asphalt overlay would be required on all lanes, shoulders, ramps, ramp tapers, etc.

### When to consider a DBR?

In addition “trigger” values for concrete rehabilitation and reconstruction have been developed. The current philosophy for the trigger values are as follows (Note – slab cracking is defined as the percent of panels that are cracked into 3 or more pieces):

- If average joint faulting is  $< 1/8$  inch and slab cracking is  $\leq 10$  percent – do nothing.
- If average joint faulting is  $\geq 1/8$  inch and  $< 1/2$  inch and slab cracking  $\leq 10$  percent – dowel bar retrofit.
- If average joint faulting is  $\geq 1/2$  inch, slab cracking  $\leq 10$  percent, and ADT  $\leq 50,000$  – dowel bar retrofit. This criterion is established due to life cycle cost analysis in low ADT locations.
- If average joint faulting is  $\geq 1/2$  inch, slab cracking  $\leq 10$  percent, and ADT  $> 50,000$  – reconstruct. This criterion is established due to life cycle cost analysis in high ADT locations.
- If cracking is  $> 10$  percent – reconstruction.



Photo 1. Joint faulting.



Photo 2. Slot cutting (gang saw).



Photo 3. Removing slot.



Photo 4. Slot cleaning with pressurized water.



Photo 5. Slots cut to avoid longitudinal crack with accidental punchout through bottom of slot.

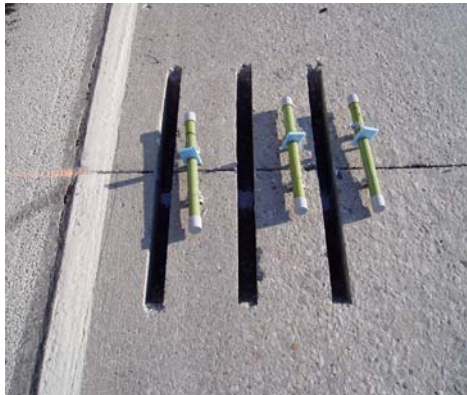


Photo 5. Assembled dowel bars.



Photo 6. Caulking placement.

### DBR construction process

The construction process for a DBR consists of seven primary stages. The following will briefly discuss these stages along with issues associated with this processes. Please refer to 5-01 of the WSDOT Standard Specifications for tother items related to Cement Concrete Pavement Rehabilitation.

#### 1. Cutting Slots

Saw cut slots must 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 the roadway surface. The alignment of saw cuts must be parallel to the roadway centerline, regardless of transverse joint skew. Dowel bar slots placed perpendicular to skewed joints will cause joint lock up and lead to pavement cracking. Saw cuts that are too deep will contribute to corner cracks when traffic loads are applied. Physical measurements of the depth can be made and should be done as dowel bar chairs dimensions sometimes vary from what is specified. Slots should be aligned to miss existing longitudinal cracks since slots that intersect longitudinal cracks will fail. The failure mechanism is typically the debonding of the concrete patching material from the walls of the saw cut slot. Shifting slots, three to four inches one way or another, will prevent this problem and still provide the required load transfer.

#### 2. Removing Existing Concrete from Slots

Jackhammers weighing 30 pounds or less must be used to break loose the concrete from the slots. Jackhammers must not be used vertically to the plane of the concrete pavement because punch through can happen. Many contractors have used 15-pound jackhammer to level the bottom of the slot. Leveling the bottom of the slot will help ensure that the dowel bar will meet alignment tolerances.

#### 3. Cleaning Slots

All exposed surfaces and cracks in the slot must be sand blasted and cleaned to bare concrete to remove slurry, parting compound, or other foreign materials prior to installation of the dowel. If water is present, more than one attempt at cleaning the slot may be necessary since slurry residue is redistributed to the bottom or sides of the slots by sandblasting or compressed air. Protection to the public from sand blasting debris should be provided. A physical check of the slots cleanliness (using a tool such as a scraper) should be made to ensure no slurry residue remains on the sides of slots. Dirt and debris is easily reintroduced to the slot during dowel bar and concrete patching material placement so concrete debris, and slurry residue should be cleaned to a minimum of four feet from the slots.

#### 4. Silicone Sealant in Slots

Prior to placement of the dowel bar and concrete patching material, the transverse joint or crack must be caulked at the bottom and sides of the slot to prevent any patching material from entering the joint/

crack at the bottom or sides of the slot. The caulking filler must not be placed any farther than ½ inch outside either side of the joint or crack.

### 5. Dowel Bar Placement

The epoxy coating on dowel bars must be free of nicks and abrasions prior to use. The dowel bars must be lightly coated with a parting compound prior to placement and positioned 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 should hold the dowel bar tightly in place during placement of the concrete patching material. The chairs placed on the dowel bars should be strong enough to allow full support of the dowel bar.

A ¾ inch thick foam insert (closed cell foam with plastic or poster board faced material) must be placed at the middle of the dowel to maintain the transverse joint. The foam insert must fit tightly around the dowel, the bottom and the edges of the slot, and be a minimum of 1½ inch below the existing concrete surface. If for any reason the foam insert shifts during placement of the concrete patching material, the work should be rejected and redone at the Contractor's expense. The foam core insert, positioned on the dowel bar, is used to ensure that a joint is formed directly in line with the existing joint and to allow for the expansion of the concrete patching material. Care must be given to ensure the core foam insert extends beneath the dowel bar to the bottom of the slot; otherwise, separation of the joint is not obtained.

End caps must allow at least ¼ inch of movement at each end of the bar. Dowel bar assemblies must be carefully placed into the slots, according to the required tolerances.

### 6. Placement of Concrete Patching Material

Patching material should be consolidated with a one inch or less diameter vibrator. Concrete patching material should be placed in a manner that does not cause the movement of the dowel bar within the slot and should not be dumped onto the slots. The patching material on the surface of the dowel bar slots should not be overworked, causing segregation and leaving the fine material on the surface. Placing the concrete patching material on the surface adjacent to the slot and shoving it towards the slot allows the least movement. The patching material must be left ⅛ inch to ¼ inch high and not finished flush with the existing concrete surface.

The joint must be maintained by saw cutting the surface with a hand pushed single blade saw. The cut width must be 3/16 to 5/16 inch and the depth 1½ inch and must be sawed within 24 hours after placement of the concrete patching material.

### 7. Diamond Grinding.

Smoothness restoration should be completed via diamond grinding. Pavement grinding should begin within 10 working days of placing dowel bar retrofit patching materials (this minimizes traveler



Photo 7. Dowel bar placement in slot.



Photo 8. Placing grout in slot.



Photo 9. Consolidating grout in slot.



Photo 10. Grinding pavement after retrofit.



Photo 11. Grinding pavement after retrofit.



Photo 12. Slurry processing plant.



Photo 13. Retrofit lanes after grinding.

complaints of surface roughness). Diamond grinding cuts into the concrete aggregate to improve the surface and ride. Performance has shown that when a milling machine is used to restore the pavement ride, an unacceptable riding surface results within three to five years and has been shown to cause joint and crack spalling.

*8. Slurry Removal*

Removal of the grinding residue from the roadway surface should occur immediately after grinding. Slurry must not be allowed to drain across open traffic lanes and shoulders. Slurry must 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 removed off site. Whether concrete slurry removal is allowed on site or off site, the contractor should be made aware that they are responsible for all costs.

**Closing**

Load transfer increases a pavements structural capacity and decreases stresses in pavement. To increase the efficiency of load transfer at faulted transverse cracks and joints in concrete pavements the best available option is the DBR process. This process ties the slabs together allowing for even distribution of the load across the joint. Using the DBR process with a diamond grind finish eliminates faulted joints and restores ride and safety to a condition suitable for the traveling public.

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