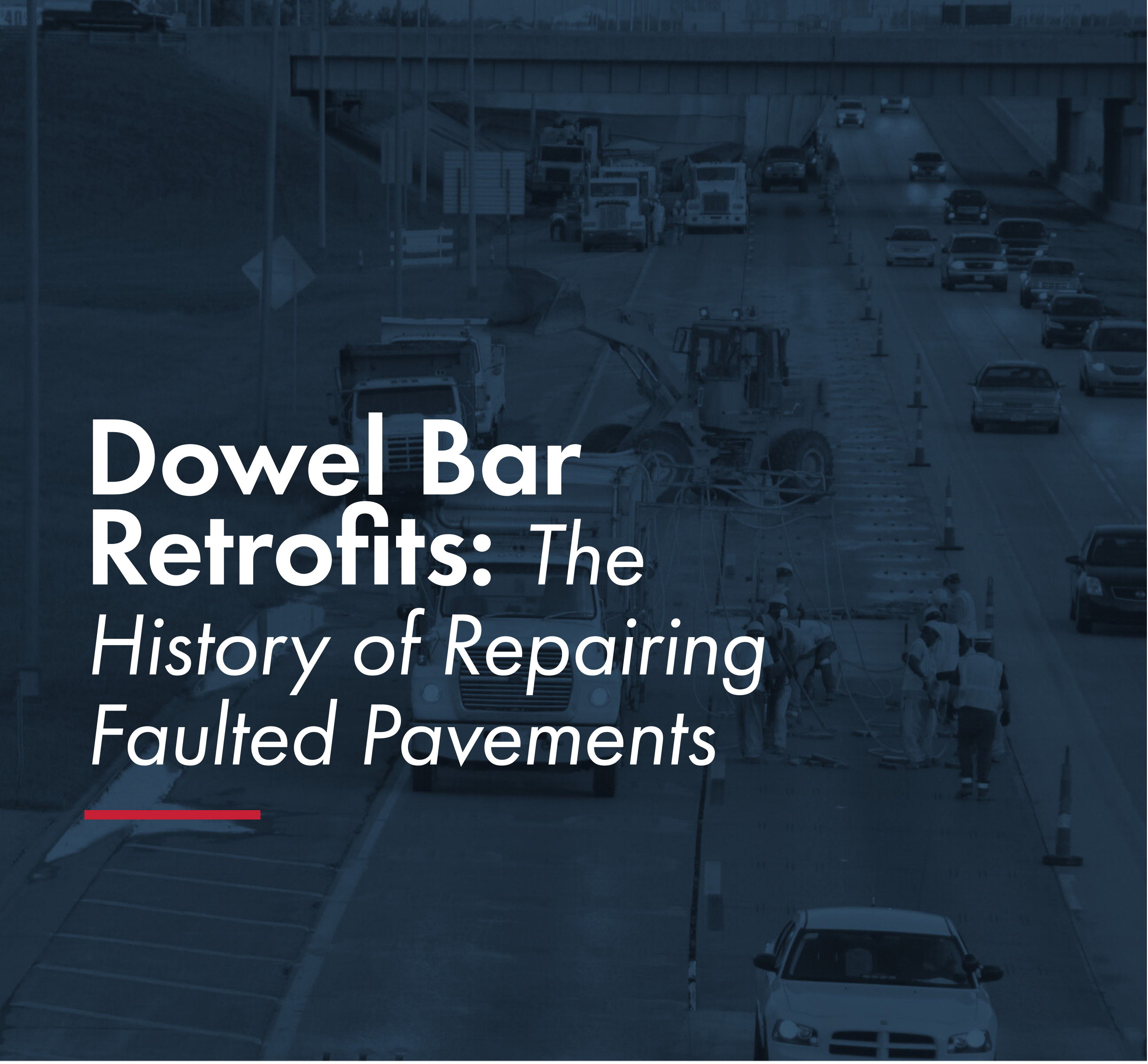

Dowel Bar Retrofits: *The History of Repairing Faulted Pavements*

America's highway network was created in the 1950s, kicking off decades of long-lasting service by concrete pavements. However, one unforeseen structural issue arose that needed to be addressed: due to a lack of effective load transfer between concrete slabs, faulting occurred. A cost-effective solution in the form of dowel bar retrofit—a pavement preservation technique still in use today—was developed.

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AMERICA'S HIGHWAY NETWORK WAS CREATED IN THE 1950s, and it did not take long for an unforeseen structural issue to arise. When concrete slabs lack effective load transfer, individual slabs tend to move vertically as heavy vehicles travel from one slab to the next. In many cases this vertical displacement would leave one slab higher than the other—a phenomenon known as faulting. By the 1970s, it was clear an affordable solution was needed.

That solution was dowel bar retrofit (DBR), a concrete pavement preservation (CPP) technique that restores load transfer across joints and cracks. By linking slabs, the traffic load is shared, preventing differential vertical movement of the slabs at the joints and cracks, thereby eliminating the formation of faults or step offs.

Concrete pavement preservation, also known as concrete pavement restoration (CPR), is a series of engineered techniques developed more than 60 years ago to rehabilitate concrete pavement. A viable alternative to costly asphalt overlays, CPP targets and repairs areas of distress in otherwise structurally sound concrete pavement. The techniques can be used to renew deteriorated highways and can rehabilitate city streets constructed of concrete. Minimally disruptive, CPP is designed to be performed in small work areas and at off-peak hours. Best of all, CPP procedures offer repair solutions that often last for decades.

DBR involves placing steel bars in slots to link adjoining slabs, helping to reduce faulting, pumping and corner breaks in portland cement concrete pavement (PCCP). When properly constructed, DBR retrofitted pavements will last more than 20 years.

DBR is a good choice on pavements with the following qualities.

- Pavements that exhibit load transfer below 60%.
- Surfaces with joint and crack faulting between 1/8 and 3/4 inches.
- Surfaces with transverse cracks that are reasonably tight with minimal spalling.
- Pavements that were constructed as non-doweled jointed pavements, to prevent future faulting.

Let's look at the evolution of DBR and examples of the method as an effective CPP technique.

How DBR Works

1
Cut slots. (Typically, two to four slots are cut across a joint or crack, parallel to the centerline in the primary wheel paths.)

2
Remove existing concrete from slots and clean slots of all debris.

3
Place caulking compound at all joints/cracks.

4
Place the dowel bar assemblies in slots. Assemblies include the bars (typically steel), end caps, coreboard and chair.

5
Finish and properly cure the patching material.

6
Diamond grind the pavement surface to remove excess patch material and remove existing faults.

7
Seal cracks and reseal transverse joints.

Georgia Paves the Way for DBR

By the 1970s, it was clear the undoweled, jointed plain concrete pavement (JPCP) used when interstates were first constructed in the mid-20th century was not sufficient to accomplish load transfer between panels. Over time, the pavements started to experience faulting. A cost-effective rehabilitation was needed to minimize the effect of faulting.

Georgia was a DBR pioneer in the United States. By 1970, there were roughly 900 centerline miles of concrete pavement on the state road system in Georgia. Approximately 500 miles were built between 1960 and 1970 during the early years of the interstate highway construction era. It became evident that there were significant problems with the early performance of these concrete pavements, specifically with joint faulting and slab cracking. Although maintenance was being done on the pavements, it was more reactive than proactive and lacked a systematic process. Georgia Department of Transportation (GDOT) management became concerned that concrete pavement planned for future interstate projects would not be feasible.

DBR Research Begins In Georgia

In 1970, an in-house research project was initiated by GDOT to determine the extent, severity and causes of the performance issues, with the goal of preventing deterioration in future PCCP projects. A system was developed to document the condition of every mile of concrete pavement on the interstate and major state routes on an annual basis. The faulting and cracking then were related to the structural design features of the projects, as well as the accumulated truck traffic. This initial research effort clearly showed that truck traffic, erodible bases, water intrusion through the joints and the lack of load transfer in the joints were interrelated with the performance of the concrete pavement.

To address lack of load transfer, GDOT added dowel bars as a standard design detail in the mid-1970s for new PCCPs. However, none of the existing CPP activities studied in the 1970s addressed the lack of effective load transfer in existing pavements except through stabilization of the slab using undersealing techniques.

It was believed that the effectiveness of CPP could be extended if load transfer could be added at the joints. In 1977, the Federal Highway Administration (FHWA) published a report with conceptual proposals for two load transfer devices to address this need. GDOT initiated a research project in 1980 to evaluate the two FHWA devices, along with others.

Alternative Load Transfer Devices

For concrete pavements to truly be long-term effective, they require load transfer across transverse joints to avoid joint faulting. Though DBR is now commonly accepted as the most effective technique for retrofit load transfer, the performance of many other devices was studied. The findings were summarized in a WSDOT study by Linda Pierce and Stephen Muench, then graduate assistant and assistant professor (respectively) with the University of Washington.

» FIGURE EIGHT DEVICE
The Figure Eight Device is a single piece cylindrical metal shell that looks like the number eight. A 4-inch diameter hole is cored, two per wheelpath, over the center of the transverse joint, and the device is epoxied to the walls of the core hole. The center and side indentations of the device are filled with foam to keep out debris.

» VEE DEVICE
The Vee Device consists of a ¼-inch-thick steel plate bent into the shape of a "V." Installation of the Vee Device requires two core holes per device, which results in increased costs due to increased coring rates and increased use of patching material. For the study, four (two per wheel path) Vee Devices were installed at the transverse joint or crack.

» DOUBLE VEE DEVICE
The Double Vee Device consists of two Vee Devices placed back-to-back and reduced in size to accommodate installation into a 6-inch core hole. Core holes, typically two per wheel path, are centered over the transverse joint or crack. The device is compressed and inserted into the core hole. Similar to the Vee Device, the center section is filled with foam to keep out debris, and the outside of the steel section is padded with foam to allow for expansion and contraction.

» MINIATURE I-BEAM
The Miniature I-Beam is installed in the same manner as dowel bar retrofit.

» GEORGIA SPLIT PIPE DEVICE
The Georgia Split Pipe Device was developed by GDOT and consists of two sides of a split pipe that are epoxied to either side of a 4-inch diameter core hole centered over the transverse joint or crack. The top and bottom circular plates, which are allowed to slip over the top ends of the two halves of the split pipe during slab expansion, rest on the top and bottom edges of the two split pipe pieces. Once tightened, the four bolts and the epoxy bond between the split pipe pieces and the concrete core hole surfaces provide the load transfer from one slab to the next.

» FREYSSINET CONNECTOR
The connector consists of two symmetrical cast iron half shells, a steel key that slides into a housing machined in the half-shells, and a central elastomeric sleeve that bonds the half shells and makes the unit watertight. The connector (total of four per joint or crack) is placed into a core hole centered over the joint or crack.

A load transfer retrofit test area on I-75 had been rehabilitated in 1976 by GDOT maintenance forces, but significant increases in levels of faulting were measured by 1980. The goal of the new research project was to develop construction procedures for adding load transfer to existing pavements and to evaluate the effectiveness of the methods. In 1981, various load transfer devices were placed by maintenance forces in a total of 461 joints on I-75 between Atlanta and Macon; additional installations were done in 1982.

Devices placed were the Georgia Split Pipe, the Figure Eight Device used in experiments in France, the Vee Device published in the 1977 FHWA report, the Double Vee Device developed at the University of Illinois (and sold under the trade name of LTD plus), and dowel bars. To test the dowel bars, the slots for the dowels originally were to be cut with a specially built roto mill mandrel, but a field trial showed that there was too much damage to the joints and the slots were cut instead with closely spaced single saw cuts and the fins were removed with crowbars. Core holes were drilled for the placement of the other devices.

Patching materials used on the project included three types of fast-setting grouts, polymer concrete and plain fast-setting concrete. The number and spacing of the various devices and dowel bars also were variables in the project.

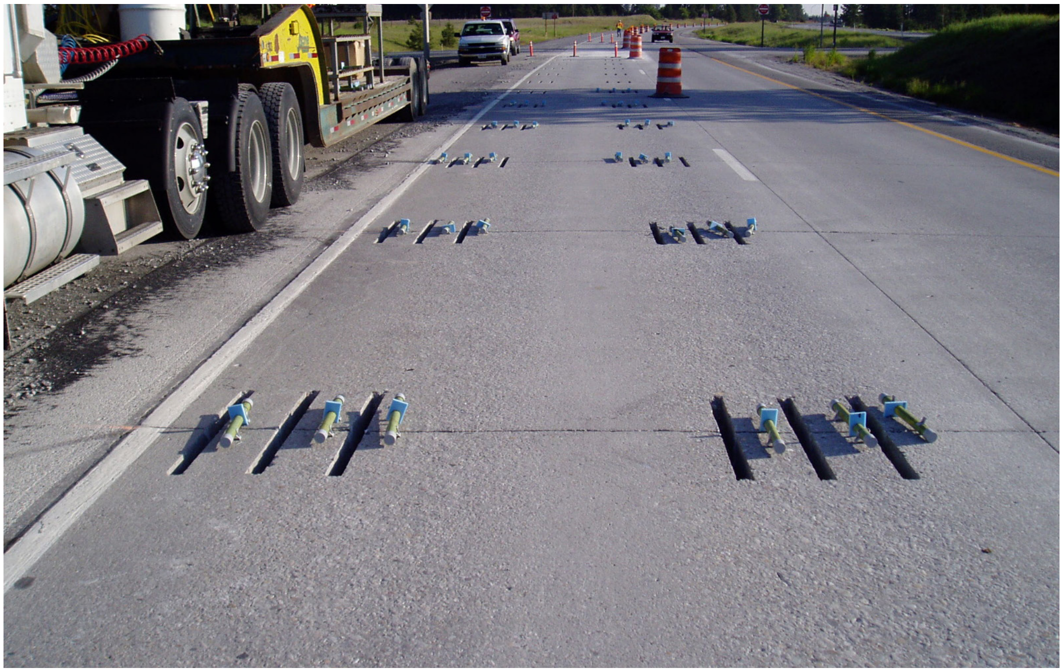
Research Shows DBR Establishes Load Transfer to Existing Joints

Performance evaluations were made in January 1982, September 1982, and March 1983. Static weight and Dynaflect load transfer measurements were made, along with horizontal joint movement measurements, faulting measurements, slab cracking, and visual observations of the load transfer devices for bond failures and spalling and cracking of the patching materials.

The results from the test installations showed that dowel bars were the best solution to establishing load transfer to existing joints. Around the same time Georgia began considering DBR, multiple states began testing ways to reduce joint faulting in existing concrete pavements by retrofitting transverse joints with mechanical devices. Taken together, test results indicated that DBR offered the most reliable means of restoring load transfer, nearly doubling pavement life compared to pavement that was not retrofitted.

Optimal dimensions for dowels and slots began to be identified and researchers found three dowels should be placed in the outside wheel path and two dowels in the inside wheel path. The WSDOT study also stated that dowels in the inside wheel path could possibly be eliminated once long-term performance data became available. Study results recommended that joints with large slab movements should be stabilized prior to placing dowels. The specifications and methods developed for concrete pavement restoration during this time still are used today by GDOT and other DOTs around the country.

The pavement industry was instrumental in developing and improving equipment for restoration and was a willing participant in the numerous experimental procedures that were used to improve techniques. GDOT took into account the many recommendations from the industry during this time to improve the process and participated in field trials to evaluate the recommendations. The results made implementing DBR possible on a production basis.

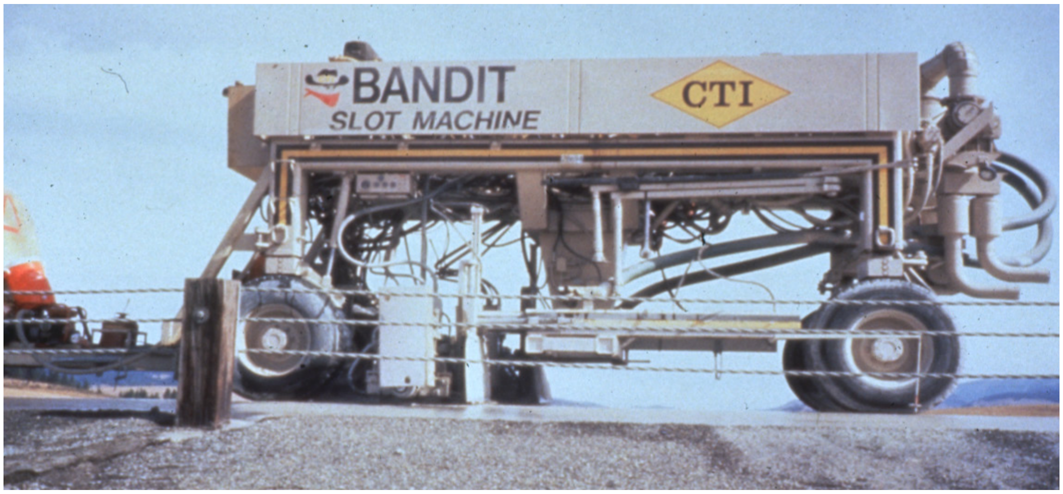


Washington Continues DBR Research

In 1991, Newt Jackson, Washington State Department of Transportation (WSDOT) Pavements Engineer at the time, initiated a research program with the help of then Research Engineer Linda Pierce—Principal of NCE as of this writing—to determine whether DBR could be used in Washington to reduce faulting.

After multiple tests showed DBR to be an effective pavement preservation technique, Jackson recognized the need for DBR to be done on the project level, which would require a device that was more efficient and effective in making sure the slots were all completed quickly, easily and with the appropriate alignment. Jackson challenged contractors and suppliers to develop a gang-saw type of equipment to create slots using one cut per joint location.

Concrete Textures Inc. retrofitted an existing machine with sawblades, installed them at the correct spacing, and demonstrated the machine could install DBR quickly and accurately on long stretches of road. This machine provided an option for large-scale pavement preservation using DBR.



New Tech Allows Increased DBR Use

The first high-production, large-scale DBR project was constructed in 1993 by the WSDOT.[1]

In Washington, JPCP constructed prior to the 1990s did not contain dowel bars across the transverse joints. As such, a significant number of pavements aged 30 or more years had developed transverse joint faulting. With sufficient funding unavailable to reconstruct the faulted and rough concrete pavements, WSDOT decided in 1993 to begin its first full-scale DBR project for a severely faulted concrete pavement.

WSDOT's DBR repair also included diamond grinding of the entire project length, full-depth replacement of concrete panels with two or more cracks, partial-depth spall repair, crack sealing, and resealing transverse and longitudinal joints. The project used specially designed machines that allowed for the placement of thousands of dowels in a single day.

1 Puerto Rico was a trailblazer for DBR as well, though it did not conduct specific projects to determine DBR's effectiveness. DBR has been used in the U.S. territory since 1980 and used routinely since 1983.

Research Proves DBR Effectiveness

Between 1993 and 2006, research was conducted by Pierce, as well as Stephen T. Muench, Assistant Professor, and Joe P. Mahoney, Professor—both of the University of Washington—to evaluate the effectiveness of DBR in Washington.

In the study, road roughness and wear were examined on pavements repaired with the DBR method in Washington between 1993 and 2007. The average age of the existing pavements prior to DBR was 32 years (with a range of 17 to 46 years), and the average in-service age of the DBR was nine years (with a range of one to 14 years).

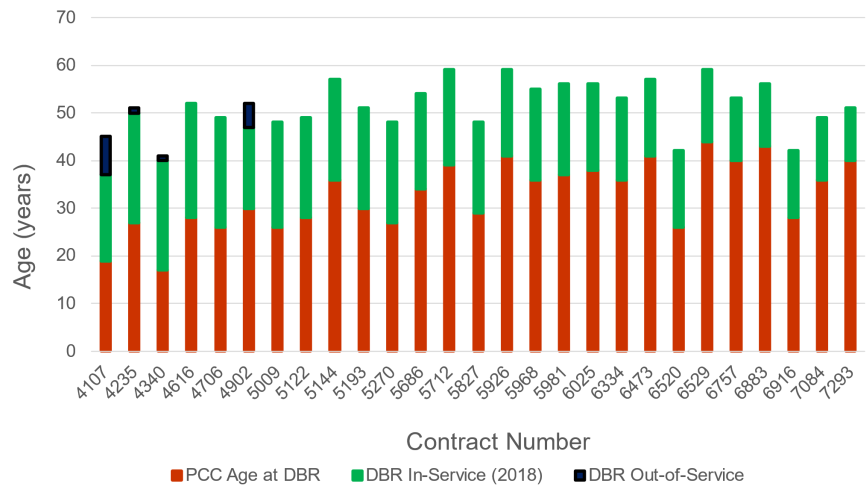
Based on the review of approximately 380,000 DBR slots, Pierce noted that cracking, spalling and debonding of the patching material was nearly non-existent, indicating superior construction and inspection practices leading to long-term performance.

"From the review of data collected, it was determined that Washington state has experienced very little DBR slot-related distress, with less than 3% of all DBR slot distress combined on any given project and typically less than 1% on all projects," said Pierce.

After reviewing DBR performance, it was found that five of the 21 projects examined showed superior longer-term performance as compared to all other DBR projects.

"The best results were found when DBR was performed prior to the development of significant faulting in the concrete," said Pierce. "Therefore, it can be concluded that applying DBR prior to significant fault development can result in improved, longer-term DBR performance."

Pavement Age vs. DBR Placement



The study found appropriate specifications and construction inspection processes are critical to the success of DBR projects, as well as contractors firmly establishing themselves in DBR construction techniques.

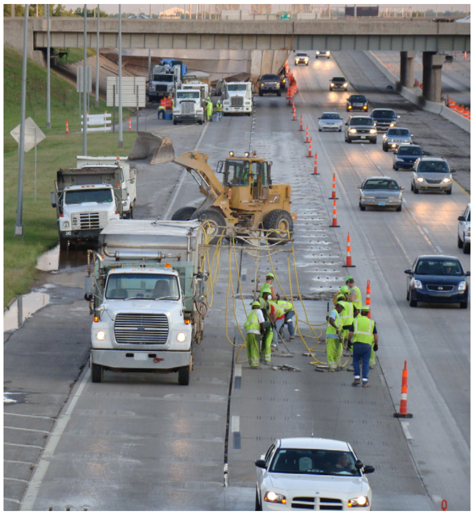
Since that time, WSDOT has rehabilitated more than 300 miles of existing concrete pavement by using more than 910,000 dowel bars followed by diamond grinding.

DBR Becomes Mainstream

Since those initial projects in Georgia and Washington proved the effectiveness of DBR as a CPP method in the United States, many states followed suit. Let's look at how states around the country implemented DBR for successful CPP.

Oklahoma: DBR Provides Smoother Travel Among Major Cities

With between 125,000 and 135,000 vehicles travelling each day, I-44 between I-40 and I-35 in Oklahoma City experienced wear and tear that needed to be addressed. A significant road repair project began in 2004 and was divided into five segments completed over a span of five years.



A physical survey conducted before work began revealed severe panel damage and faulted pavement on I-44. The road was in desperate need of repair; the transverse joint faulting was in the 1/4-inch to 3/8-inch range with isolated 1/2-inch to 5/8-inch faults and variable 1/4-inch to 3/4-inch faulting at the longitudinal joints.

Due to the high level of traffic and poor road conditions, a fast yet long-term solution was needed. DBR, diamond grinding, joint sealing, selective panel replacement and base repair were used on the project for all lanes in both directions.

The construction phases were as follows.

1. 2004: From the junction of SH-74 extending east to the Burlington Northern Santa Fe Railroad, just west of I-235.
2. 2005: From just west of Western Avenue extending east to Lincoln Boulevard.
3. 2007: Beginning at Lincoln Boulevard extending east to I-35.
4. 2008: Beginning at the Oklahoma River extending north to the Burlington Northern Santa Fe Bridge.
5. 2009: Repair of four lanes eastbound and westbound beginning at the Burlington Northern Santa Fe Bridge to the junction of SH-74.

"The original pavement, built in 1976, has served the public well over the years and with the improvements made to the roadway through this project, we may see another decade or two of service. The concrete pavement preservation techniques used in this project do more than just cover the problem for a few years. Combined with the long life of the original pavement, the work performed by the contractor will give the taxpayers a great value for their money," said Brent Burwell, Executive Director of the Oklahoma/Arkansas Chapter of the American Concrete Pavement Association (ACPA).

The total cost of all five projects was $11.3 million. The result for taxpayers is a smooth road that is expected to last more than 15 years.

Minnesota: Thinner Dowel Bars Repair Thin Concrete

In 2016, Minnesota's Olmsted County Transportation Division initiated a CPP project on County Highway 22. The existing roadway consisted of an 8-inch bituminous base with a 6.5-inch concrete overlay. There were no dowel bars in the slab and some of the concrete pavement was experiencing faulting on a non-erodible base. The county elected to restore load transfer using DBR.

"Olmsted County used dowel bars in two other projects—one in 2000 and one in 2004—and those are performing well," said Scott Holmes, Transportation Supervisor of Construction & Traffic with Olmsted County Public Works.

To accommodate the thinner-than-usual slab depth of 6.5 inches on Highway 22, the county used 1-inch diameter dowel bars rather than the usual 1.5-inch dowels. Dowels with a 1-inch diameter have proven performance and are well suited for thinner concrete pavement sections. Their smaller size allows for the necessary concrete cover to accomplish effective load transfer at the pavement joints. This procedure is particularly applicable in municipal and county roadway networks where un-dowelled, thin sections of concrete pavements have been used for years and are now in need of additional load transfer.

Smaller dowels have the additional benefit of requiring fewer materials to produce, achieving cost savings while providing the same level of performance for low volume roads.

By September 2016, the Olmsted County project was complete with pavement grinding, joint sealing and pavement marking. A total of 26,882 dowels were used and 72,558 square yards of grinding took place.

End users of the finished road noticed the improvement right away, with one citizen emailing the county to say, "I just want to congratulate the county and especially the Diamond [Surface Inc.] crew for the work on 37th Street. That company had the manpower, and the equipment, that got the job done in a[n] exceptional manner without undue disruption of traffic."

As an added benefit, the project led to a new product being widely available. When dowels are placed in new pavement, they are either inserted using an automatic dowel inserter or they are positioned prior to the pour and held in place using dowel baskets. When used as a retrofit during CPP, dowels must be fitted with expansion caps and seated in chairs to keep them from moving during the backfill operation.

The molds and tooling required to manufacture expansion caps and chairs for 1" dowel bar retrofit units did not exist at the time the Olmsted County project bid. However, through coordination between the contractor and the material suppliers, the components were designed, manufactured and delivered on schedule for the Olmsted County job and resources are now in place to produce the dowel bar units for future projects. This improvement in product availability means there is now another tool in the toolbox for owners to use when fixing their thin section, lower volume concrete roadways.

South Dakota: DBR is the Right Solution for the Job

Watertown, South Dakota, is a quaint town of approximately 20,000 inhabitants. Located in the northeast area of the state, US 212 is a two-lane concrete pavement that goes through Watertown. In South Dakota, there are more than 2,050 two-lane miles of concrete pavement and 25% (488 miles) are constructed without dowel bars and have no load transfer other than aggregate interlock.

After 17 years of service, US 212 from Watertown east to the intersection of SD 15 needed timely repair. The original construction occurred in 1984 and the existing road was badly faulted approximately ¾ inches at every transverse joint due to the lack of dowel bars. The project used grinding, joint sealing and DBR for the 16.6 miles of repair. Other methods considered included an overlay with asphalt as well as concrete repair and an under seal.

The South Dakota Department of Transportation (SDDOT) had been successfully using DBR since 1994 with minimal failures on similar projects and the existing pavement appeared to be an excellent CPP with DBR candidate, as evidenced by the minimal faulting with heavy truck usage and the superior aggregate quality.

In total, the project consisted of 5,801 transverse joints spaced 15 feet apart and 291,957 square yards of grinding. Traffic control was a challenge as the team needed to maintain two-way traffic using 24-hour flagging and a pilot car. At night, there were message boards and lighted stations to facilitate diamond grinding.

The 129-day project was completed for $2,665,912. The result for the public was a smooth, safe and long-lasting roadway delivered at an economical cost.

Utah: County Executes Largest DBR Project in the State

Box Elder County, located at the northwestern point in Utah, is home to 45,000 residents. Totaling 19 miles, this CPP project took place on I-84 from SR-83 to SR-103 and involved four lanes and shoulders in each direction. The Utah Department of Transportation (UDOT) carefully considered a variety of options to repair the 20-year-old concrete pavement, but selected CPP based on its proven longevity. Although CPP is an accepted method in many areas of the United States, this was one of the first times that the method was used in Utah. Further, it was the largest DBR project ever constructed in Utah to date.

The methods selected included DBR, diamond grinding, full- and partial-depth repair, slab jacking and joint resealing. In total, the project included 4,753 square yards of full-depth repair; 686,086 lineal feet of joint and crack resealing; 447,138 square yards of diamond grinding; and 102,774 dowel bar retrofits.

Safety was of major importance as the four-lane highway became two lanes during construction. The work zone traffic volume was 10,300 vehicles per day with 33% of those being heavy trucks. Multiple Concrete Enterprises, Inc., assigned a full time, 24-hour public information representative to ensure effective communication with the driving public by providing flyers and frequent website updates related to construction activities, lane closures and overall project progress.

The project began in September 2006 and was completed a year later, two weeks ahead of schedule. Despite many challenges, including the aggressive schedule, traffic control and availability of subcontractors, the repairs resulted in significantly more years of extra pavement life for the owner. In addition, the average smoothness before CPP was 14-inches per mile; after CPP, the index was 1.4-inches per mile—a nearly 90% improvement.

The I-84 project is a solid example of what can be done to an old, un-doweled concrete pavement that is rehabilitated before the deterioration becomes too severe.

Texas: DBR Repairs Busy Main Street

When the city of Baytown, Texas, faced ride quality and drainage issues on a heavily traveled main street in 2015, the city's Public Works and Engineering Department needed to find a cost-effective repair strategy.

Installed in the 1980s, North Main Street is a concrete road that serves as a major right-of-way, with two lanes in each direction and a turn lane. It also is a truck route that serves nearby industrial areas. The aggregate used in the original construction was river rock, an exceptionally hard material. Measurements from hardness tests on the aggregates were an 8 on the Mohs scale of mineral hardness; in comparison, diamonds measure a 10. Some of the roadway's ride quality issues were due to the wearing away of the cement paste layer and consequent exposure of the hard rock.

On the section of street in need of repair, Pavement Condition Index (PCI) measurements averaged 43, with four sections being in the low 20s to mid-30s. The PCI scale is based on a 100-point range, with 0 representing the worst conditions and 100 representing the best.

Reconstruction was considered, but with an estimated cost between $12 million and $13 million, the city didn't have adequate funding for a project of that scope, said Kevin Harvill, Assistant Director of Baytown Public Works. Through word of mouth, Harvill's team learned about CPP.

For a pavement to be a good candidate for CPP, it should show an adequate level of structural integrity. Prior to project inception, the extent and severity of distresses should be analyzed so proper repair methods can be determined. The types of deterioration to look for include poor ride quality, cracked slabs, corner breaks, base pumping, faulting at transverse or longitudinal joints and joint sealant failure. For long-term repairs, chemistry problems such as alkali silica reaction should be considered prior to project design.

"One of the keys to success on the North Main Street project was the timely application of CPP treatments before the pavement deteriorated to the point where the repair cost would outweigh the benefits. CPP typically works best when applied before excessive cracking and spalling manifest due to long-term neglect," said John Roberts, Executive Director of the International Grooving & Grinding Association (IGGA).

Because the public works department had no experience with a CPP program, one of the first steps was to meet with experts to learn more. Harvill and his team consulted with states that have performed or overseen CPP projects and took online training classes through the Iowa State University's National Concrete Pavement Technology Center. They also consulted with IGGA, which serves as a technical resource for pavement preservation and restoration.

During project planning, IGGA experts and Baytown officials inspected the roadway, confirming the pavement showed adequate structural integrity and was a good candidate for CPP. They then worked together to develop specifications, gleaning insights from states with detailed specifications already in place.

"In addition to helping us refine the specs, IGGA assisted us in determining when to bid the project as well as identified contractors across a larger geographic area," said Harvill. Highway contractor Interstate Improvement Inc., based in Faribault, Minn., was selected to perform grinding, cross-stitching and DBRs because of their extensive experience with CPP. Nathan Sirek, project manager with Interstate Improvement, visited Baytown and consulted with department officials before work commenced.

"On city streets, public access and aging utilities generally lead us to less invasive repairs, such as cross-stitching and dowl bar retrofits," said Sirek. "These are also low-cost alternatives to full concrete replacement. Partnering with Baytown's Public Works and Engineering Department to identify and implement the proper repair for each distressed area was the key to a successful project."

Construction began in 2020 and was completed in the spring of 2021. The city replaced approximately 20% of the road surface, with CCP work including the following.

- Full-depth panel replacement.
- Dowel bar retrofit (using 300 dowel bars) for transverse cracks.
- Cross-stitching (using 2,500 deformed rebars) for longitudinal cracks and joints.
- Replacing and resetting manholes.
- Approximately 47,000 square yards of diamond grinding, removing approximately 1/8 to 1/4 inches of material.
- Crack repair and sealing.

Diamond grinding the extremely hard river rock aggregates originally used to construct North Main Street proved to be especially challenging.

"The combination of hard exposed aggregates, manholes and/or valve boxes to grind around, and intersections with cross-slopes requiring daylight grinding made the project time-consuming. Plus, the location of the pavement within city limits made it desirable to create an aesthetically pleasing surface in addition to the goal of improving ride quality," said Sirek.

The project was a success by all measures. Cost savings were enormous, with CPP treatments being completed for $2.2 million—less than 20% of the cost of reconstruction—saving the city approximately $10 million. PCI measurements improved to an average of 75 to 80. Not only were department officials pleased with the rideability of the finished road surface, but residents were as well.

The Many Advantages of DBR

Today, more than 8 million dowel bars have been installed internationally. DBR is recognized broadly as a highly effective solution for long-term pavement preservation.

*DBR Across the Nation**

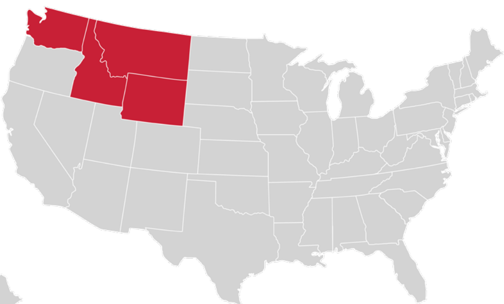
Here's where DBR use stands today.

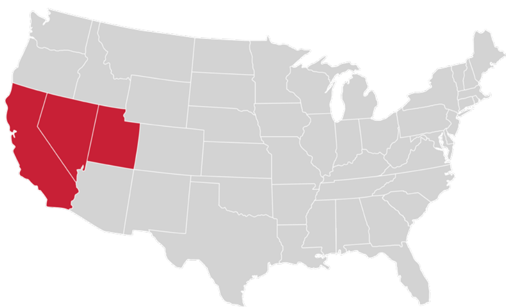
Washington: 910,000+ dowel bars

Idaho: 216,000+ dowel bars

Montana: 102,000 + dowel bars

Wyoming: 585,000+ dowel bars





California: 280,000+ dowel bars

Nevada: 151,000+ dowel bars

Utah: 574,000+ dowel bars

Kansas: 560,000+ dowel bars

Minnesota: 366,000+ dowel bars

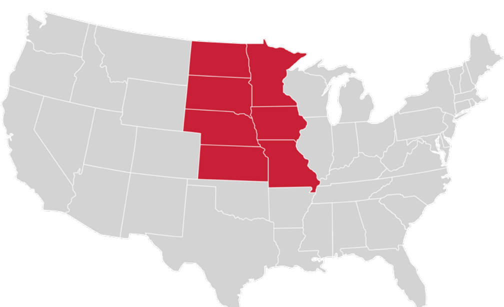
North Dakota: 574,000+ dowel bars

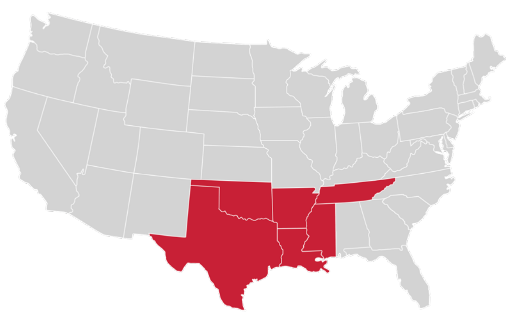
South Dakota: 457,000+ dowel bars

Nebraska: 563,000+ dowel bars

Missouri: 52,000+ dowel bars

Iowa: 157,000+ dowel bars





Oklahoma: 1,571,000+ dowel bars

Arkansas: 21,000+ dowel bars

Tennessee: 11,000+ dowel bars

* Available data collected by the IGGA as of 2017

DBR has a long lifespan, often more than 20 years. It also is environmentally friendly, maintaining the existing surface and conserving natural resources. Additionally, maintaining a light-colored surface by diamond grinding (a CPP technique that is commonly used with DBR) leads to improved nighttime visibility, reduced lighting requirements and reduced heat island effect.

Construction is easy with DBR as well, as its simple design process allows projects to be designed and advertised in a fraction of the time required for competitive processes. And projects can be completed during off-peak hours with short single lane closures. However, ensuring appropriate specifications and construction inspection processes are employed in all DBR projects is critical and contractors should be firmly established in DBR construction techniques.

DBR with diamond grinding improves the driver experience by increasing road smoothness and safety. In fact, diamond grinding has been proven to enhance surface friction and safety. In Wisconsin, researchers found the overall wet weather accident rate for diamond ground surfaces was only 57% of the rate for non-ground surfaces.

As more states seek ways to extend the life of aging concrete pavements, DBR has proven to be a go-to solution when long-lasting, cost-effective repairs are desired. «

Resources

Pierce, Linda M. and Muench, Stephen T. "Evaluation of Dowel Bar Retrofit for Long-Term Pavement Life in Washington State." WA-RD 727.1, May 2009.

Pierce, Linda M., Muench, Stephen T. and Mahoney, Joe P. "Long-Term Performance of Dowel Bar Retrofit in Washington State." November 2009.

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