Pavement Recycling

An Effective Reuse of Resources

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High volumes of heavy traffic combine with the elements to exact a substantial toll on the nation's highways. The implementation of findings from research on pavement recycling, however, can increase the service life of roads and can reduce the costs and environmental impacts of paving.

In 2011, the Virginia Department of Transportation (DOT) addressed the deterioration on a 3.7-mile section of Interstate 81 with pavement recycling. The techniques involved a series of processes to reuse the materials from the asphalt pavement during the rehabilitation or reconstruction. The benefits included reductions in the consumption of raw materials, in the greenhouse gas emissions, and in the costs of preservation, maintenance, and rehabilitation (*1*).

Problem

Mostly built in the late 1960s, Interstate 81 in Virginia carries a high percentage of truck traffic—20 to 35 percent. Virginia DOT has maintained the driving surface routinely by patching deteriorated sections and by milling and replacing surface layers. These treatments, however, do not address structural deterioration and, as a result, do not always provide long-term solutions.

Fatigue cracking in the two southbound lanes of Interstate 81 near Staunton had allowed water to seep into the base layers and to weaken the pavement structure. This compromised the original foundation of compacted aggregate and clayey soil, which no longer provided a stable base for the asphalt layers.

In addition, the asphalt layers within the pavement structure had debonded and no longer served as a monolithic structure to support the high volumes of traffic. The right lane was in worse condition than the left lane, because the right lane carries most of the nearly 6,500 trucks that use this stretch of Interstate 81 every day.

Years of surface repairs had addressed only the symptoms of the deterioration and had masked the structural problems. Virginia DOT needed to find a cost-effective rehabilitation strategy to address the causes of the deterioration.

PHOTO: VIRGINIA DOT

Cold in-place recycling on Interstate 81, Virginia.

Photo: Virginia DOT

Full-depth reclamation on Interstate 81.

Solution

Virginia DOT reconstructed the deteriorated section of Interstate 81 with three pavement recycling processes:

- Cold in-place recycling,
- Cold central-plant recycling, and
- Full-depth reclamation.

Virginia DOT determined that these techniques would best alleviate the causes of the deterioration, require less construction time, be better for the environment, and prove cost-effective. This became the first Interstate rehabilitation project to use the three pavement-recycling methods together.

Different treatments were applied to the right and left lanes because the location and extent of the deterioration were not the same. In the right lane, the deterioration consisted of debonded asphalt layers and fatigue cracking that extended throughout the bound layers. The deterioration in the left passing lane also included debonded asphalt layers and cracking that originated from within the bound layers and progressed to the surface. As the project began, Virginia DOT initiated a study to document the construction processes and the early pavement performance after construction.

Pavement Recycling

Virginia DOT's contractor completed construction on the right lane using full-depth reclamation and cold central-plant recycling. The full-depth reclamation pulverized, stabilized, and compacted in place the bound layers and a predetermined portion of the unbound materials (see photo, above).

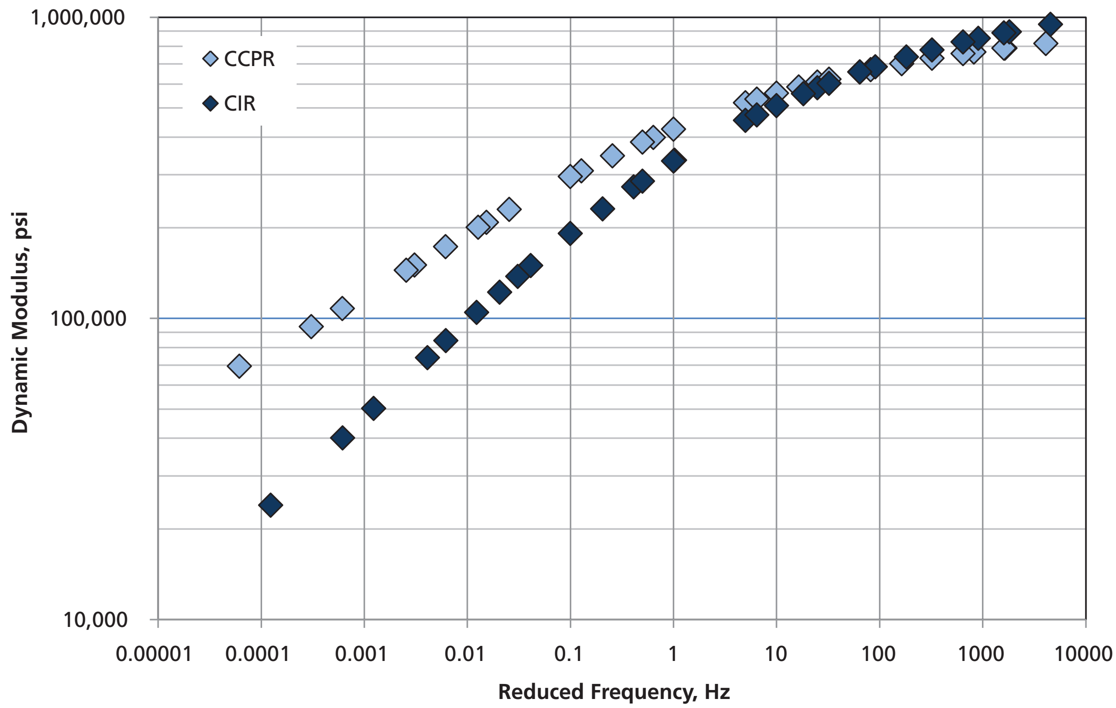
These steps corrected severe structural deficiencies and defects deep within the pavement's substructure. In this project, the full-depth reclamation stabilized materials 12 to 22 inches below the surface. A combination of lime kiln dust and hydraulic cement served as the stabilizing agent.

Cold central-plant recycling processed the asphalt milled from the roadway's top layers at a mobile plant near the project. After the processing (see photo, below), the contractor applied traditional paving practices to place the recycled material in two layers totaling 6 to 8 inches, depending on the location. The layers of recycled material were paved on top of the base materials placed during the full-depth reclamation process. The cold central-plant recycling material used foamed asphalt and hydraulic cement as the recycling agents.

Photo: Virginia DOT

Cold central-plant recycling.

FIGURE 1 Dynamic modulus master curve for cold in-place recycling (CIR) and cold central-plant recycling (CCPR) materials from the Interstate 81 project (reference temperature = 21.1°C).



Because the left lane had less underlying deterioration, cold in-place recycling was specified to rehabilitate only the top layers. In the cold in-place recycling process, a portion of the asphalt pavement layers was pulverized, stabilized, and repaved in place (see photo, page 52). The cold in-place recycling was completed in three days—the contractor milled off the top 2 inches of pavement and recycled the next 5 inches. Foamed asphalt and hydraulic cement were used as recycling agents.

The driving surface of both lanes received a new multicourse asphalt overlay. In the right lane, the asphalt overlay had a thickness of 4 inches for the first 2,150 feet of the project and a thickness of 6 inches for the remainder of the lane, to level the 8-inch and 6-inch sections of material from the cold central-plant recycling. The asphalt overlay for the left lane was 4 inches thick. The thicker asphalt overlay in the right lane was designed for the truck traffic.

Project Explores Properties of Recycled Pavement Materials

More information is needed about the material properties of cold in-place recycling and full-depth reclamation asphalt mixtures, particularly to account for the ways that the stabilized base layers contribute to the performance of the pavement structures. The AASHTOWare Pavement ME Design program, for example, provides little guidance for cold in-place recycling and full-depth reclamation products.

The National Cooperative Highway Research Program (NCHRP) therefore has initiated Project 9-51 to determine the material properties and to propose associated test methods and distress models for predicting the performance of pavement layers prepared with cold in-place recycling and full-depth reclamation materials. The University of Maryland–College Park is conducting the project through a series of laboratory and field experiments, with support from the Virginia Transportation Research Council; Brian Diefenderfer is coprincipal investigator for the project.

For information on NCHRP Project 9-51, visit http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3164, or contact Senior Program Officer Ed Harrigan, eharrigan@nas.edu.

Performance Testing

Virginia DOT researchers collected samples of the recycled materials during and after construction and tested the gradation, indirect tensile strength, resilient modulus, dynamic modulus, and rutting resistance with repeated-load permanent deformation.

Results from the indirect tensile strength and resilient modulus testing indicated that the recycled materials from the cold central-plant recycling and the cold in-place recycling processes would perform similarly (*2*). Dynamic modulus testing revealed that the material from the cold central-plant recycling process was stiffer at higher temperatures, as indicated by the left side of the dynamic modulus master curve shown in Figure 1 (above) (*3*).

Rut depth and ride quality were measured periodically from five to 34 months after construction, as was the structural capacity, with falling weight deflectometer tests. Throughout the evaluation period, rut depths were less than 0.1 inch, and the ride quality, measured in terms of the International Roughness

Index, was excellent, according to Virginia DOT criteria, at approximately 45 to 55 inches per mile (*4*). The structural capacity of the pavement increased during the first year after construction; this also had occurred on earlier Virginia DOT recycling projects and may be attributable to the curing of the recycled material (*5*).

Instrumented Load Testing

Instrumenting Interstate 81 during construction was not feasible; therefore, in 2012, Virginia DOT secured three track sections at the National Center for Asphalt Technology (NCAT) in Auburn, Alabama, for trafficking. Data from these sections will help Virginia DOT determine the effects of millions of load passes. The data also will help in developing performance-prediction models to complete the designs with pavement recycling within a mechanistic–empirical framework.

All three NCAT track sections incorporated cold central-plant recycling materials produced with millings from the Interstate 81 project. Full-depth reclamation was incorporated into one of the NCAT track sections by stabilizing the aggregate and subgrade material with hydraulic cement.

The three NCAT sections received 10 million equivalent single-axle loads (ESALs) during the two-year test cycle. In comparison, the Interstate 81 section has received approximately 8 million ESALs since construction in 2011.

Results from the NCAT test sections confirmed that the performance of the recycled design was excellent—no deterioration was observed in any of the three sections after 10 million ESALs. The data further validated the Interstate 81 findings and have allowed Virginia DOT to quantify the pavement's response to the truck loading. Virginia DOT plans to continue the testing at NCAT during the 2015 track cycle and to apply another 10 million ESALs to the recycled sections.

Benefits and Implementation

The Interstate 81 pavement recycling project cost approximately $10 million. Virginia DOT had estimated that an equivalent project using conventional construction practices would have cost approximately $16 million. The pavement recycling and the unique traffic management plan enabled Virginia DOT to reduce costs and to complete the reconstruction work in approximately eight months.

Previous studies have shown that pavement recycling is beneficial in rehabilitating lower-volume roadways (*1*), and agencies' experience had centered on these kinds of roads. This perpetuated the idea that recycling was not suitable for higher-volume highways. Virginia DOT's Interstate 81 and track studies at NCAT have shown that these recycling processes can be successful on roadways with higher truck volumes.

Virginia DOT gained confidence and experience with pavement recycling on Interstate 81 and with the NCAT track studies. As a result, the agency has developed specifications and is pursuing pavement recycling projects.

Paving the Way with Research

Virginia DOT's I-81 pavement recycling project was selected as one of 16 "high-value research projects" for 2015 by the Research Advisory Committee of the American Association of State Highway and Transportation Officials (AASHTO). The project was a top-10 finalist in 2012 for America's Transportation Awards, sponsored by AASHTO, the American Automobile Association, and the U.S. Chamber of Commerce, and earned the 2012 Recycling Award for Cold In-Place Recycling from the Asphalt Recycling and Reclaiming Association and *Roads & Bridges* magazine.

A video produced by Virginia DOT about the I-81 pavement-recycling project is available at www.youtube.com/watch?v=FF0JQub86E0&list=UU2bzenYbUHlh6S2v6gonuvw.

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Suggestions for Research Pays Off topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2956; gjayaprakash@nas.edu).