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LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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LRRB PROJECT COST:
$93,969

Long recycling trains may not be practical for FDR projects on urban and suburban streets, but FDR done with unconnected pieces of machinery is still cost-effective in those settings.

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Full-Depth Reclamation a Cost-Effective, Durable Option for Roadways

Using laboratory testing and computer simulations, researchers showed that FDR is a superior method for rehabilitating urban and suburban roadways, outperforming traditional mill and overlay in cost and durability over a 35-year period. FDR can be tested and modeled with the same tools as regular asphalt mixtures. The study now puts FDR performance-based specifications within reach.

What Was the Need?

Full-depth reclamation (FDR) of asphalt pavement is often used on rural roadways to reduce costs for materials and hauling. With FDR, road builders use trains of recycling equipment to pulverize, lift, grind, remix and repave asphalt in a single pass. The old asphalt materials being used in the new mix never leave the site. This recycling puts less demand on petroleum sources, reduces reliance on the diminishing resource of new aggregate and demonstrates commitment to green initiatives.

FDR, however, has yet to be adopted widely by city and county public works departments. One reason may be the challenge of using trains of equipment on urban and suburban roads that feature manholes, curbs and driveways. In addition, the standard method of rehabilitating asphalt pavement on local roads—by milling off a few inches and laying down a new overlay—costs less in the short term than does FDR.

Yet Minnesota municipalities like Shoreview in the Twin Cities area have employed FDR effectively by using individual machinery units—rather than long, connected recycling trains—to rubblize and reclaim most of the asphalt on-site. These local jurisdictions consider FDR an excellent long-term solution to rehabilitation needs. The research described here was undertaken to encourage wider acceptance of FDR in urban and suburban settings.

What Was Our Goal?

Investigators aimed to provide evidence of cost-effectiveness, guidelines for FDR project selection and, ultimately, performance-based specifications. Guidelines would also include testing protocols for determining mechanical properties of FDR mixes, procedures for analyzing the life-cycle costs of FDR versus conventional rehabilitation strategies, and ways to use the MnPAVE computer program to determine long-term performance expectations for FDR.

What Did We Do?

Investigators pulled samples of existing asphalt pavement from an FDR construction site in Victoria, Minnesota, before and after emulsion was added and created four asphalt mixtures. One mix was a site sample with emulsion added on-site and compacted in the lab; the other three were dry mixes from the field mixed and compacted in the lab with various versions of the field emulsion. One lab mixture used the same emulsion as was used in the field. A second lab mixture added cementitious materials to the emulsion. The third lab mixture added a graphite nanoplatelet (GNP) material to the mixture. Investigators also pulled compacted samples from the field to compare field compaction to lab compaction.

Samples were tested for creep and for dynamic modulus at two curing times. Mechanical properties from the tests were used in MnPAVE simulations and in life-cycle cost

continued

"This research helps us translate full-depth reclamation projects in Shoreview into hard cost-benefit, return on investment numbers. It validates what we've been doing and gives cities what they need to justify the cost of using full-depth reclamation in urban settings."

—Mark Maloney,
Public Works Director,
City of Shoreview

"These results provide tools to assess the feasibility of using full-depth reclamation. Before, all we had was anecdotal information. Now we have laboratory-testing methods that are very accurate and easy to use to obtain the mechanistic properties of FDR mixtures."

—Mihai Marasteanu,
Professor, University of Minnesota Department of Civil, Environmental, and Geo-Engineering

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Compacting and smoothing pavement is one of the last steps in FDR of urban and suburban roads. FDR has been shown to be more cost-effective than standard mill-and-overlay approaches.

analysis. Because MnPAVE addresses rutting and fatigue cracking, investigators also calculated thermal stress in the models to determine each mixture's critical cracking temperature. Results for potential performance and design life were then compared to known results for traditional mill-and-overlay mixtures.

What Did We Learn?

The study showed that FDR mixes can be effectively tested for creep, dynamic modulus and critical cracking temperature using the standard mechanical testing methods that are applied to conventional asphalt. Tested properties can be used in MnPAVE's pavement design software in the same way as regular asphalt properties can.

Laboratory results showed that additives provide mixed benefits. As curing times increase for mixes with cement and graphite additives, dynamic modulus and tensile strength performance improve. However, cement additives result in reduced performance life, reduced crack resistance (because of reduced critical cracking temperatures) and slightly higher initial costs when compared with standard FDR mixes. GNP additives also reduce performance life, but resist cracking better than does standard FDR. These GNP mixtures are the most expensive of the tested mixtures and are not as cost-effective as standard FDR. Samples of FDR compacted in the laboratory show better mechanical properties than samples compacted in the field, suggesting that field compaction methods could be improved.

Life-cycle cost analysis showed that based on MnDOT standards, FDR is more cost-effective over a 35-year period than is mill and overlay. Because the analysis did not include road user costs associated with rehabilitation activities, the cost-effectiveness of FDR, already better than that for traditional pavement rehabilitation, is understated. Mill and overlay must be redone every 18 years, causing more road user inconvenience and cost than the longer-lasting FDR.

This research was not able to provide actionable preliminary guidelines for project selection. The study did, however, provide one of the two necessary sets of information for development of performance-based specifications for FDR projects.

What's Next?

This study validates the assertion that FDR is a viable and cost-effective option for urban and suburban asphalt pavement rehabilitation. As the second step in developing final, performance-based specifications for FDR, it will be necessary to gather and analyze historical data on FDR.

This Technical Summary pertains to the LRRB-produced Report 2016-37, "Full Depth Reclamation (FDR) for Suburban/Urban and Local Roads Application," published December 2016. The full report can be accessed at mndot.gov/research/TS/2016/201637.pdf.