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TECHNICAL SUMMARY

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TOTAL PROJECT COST:
$95,823

LRRB COST:
$47,912

Using the IDT test, investigators determined key material properties of SFDR cores including dynamic modulus, a key to effective performance modeling.

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Investigating the Performance Requirements of Stabilized Full-Depth Reclamation of Asphalt

Through material testing of core samples from north-central Minnesota asphalt pavements, investigators established that tested material properties could be used effectively in numerical models of stabilized full-depth reclamation projects. MnDOT can use readily available databases and MnPAVE to develop reliability-based projections for SFDR rutting behavior.

What Was the Need?

On-site reclamation of distressed asphalt pavement is an attractive option to reduce costs for materials and hauling. Stabilized full-depth reclamation goes a step further to grind up distressed asphalt pavement as well as some or all of the base, mix the reclaimed aggregate with new binder, lay it back down and compact it into a refreshed asphalt pavement base layer over which will be laid a thin top layer of new asphalt.

Minnesota has been employing SFDR for years. The technique eliminates deep cracks and other structure-based pavement problems that recur if only surface repairs are made. SFDR has consistently delivered a number of benefits, including reduced total cost, better frost performance, better ride quality, structural improvements with little change to roadway geometry and profile depth and width, fewer traffic interruptions and more. An effective SFDR rehabilitation also shows little rutting or low-temperature cracking.

The challenge of building reliable SFDR pavements is in designing mixes to suit variable base materials at individual sites. Little research has focused on mechanical properties of SFDR and how it performs in the field.

What Was Our Goal?

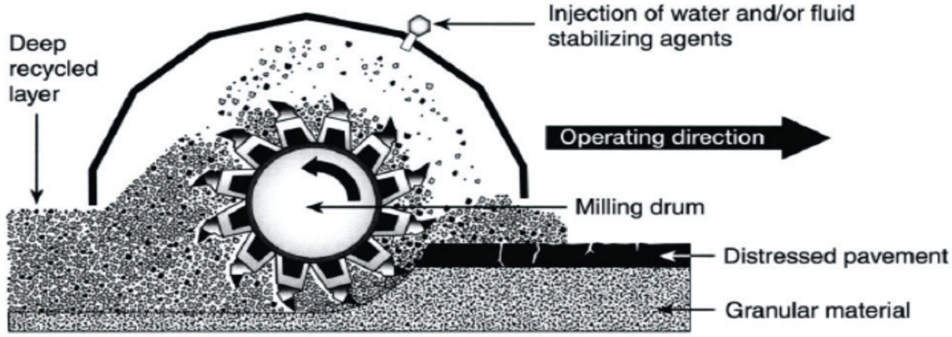
This research aimed to determine material properties for SFDR as a base layer for hot-mix asphalt roadways that avoid rutting and low-temperature cracking and achieve strong overall performance. These properties will help engineers design mixes to mitigate variation in field conditions and materials available for recycling.

What Did We Do?

Following a literature search and an investigation of Mechanistic Empirical Pavement Design Guide procedures, researchers determined that designers should model SFDR as a bound asphalt layer in MEPDG to best determine its performance qualities, an approach that requires material testing of existing pavement materials for dynamic modulus.

The research team ran material testing on cores from four sites on Trunk Highway 55 near Kensington and TH 65 near Mora in north-central Minnesota. Selected sites offered reclamations stabilized with a range of additives: cement, foamed asphalt and engineered emulsion. Results were used in numerical modeling—a method familiar to MnDOT—of pavement performance within MEPDG procedures and employed again in numerical modeling within MnPAVE for comparison. Finally, researchers conducted parametric analysis to identify improvements to SFDR mix designs and to propose design approaches based on design life or on reliability for MnDOT practice in the future.

continued



SFDR grinds a thick section of distressed asphalt pavement, mixes the material with water and stabilizers, then reissues the material as a bound asphalt pavement base layer over which a thinner layer of asphalt can be laid.

"The materials testing was interesting. The semi-circular bending test is not a good test for SFDR. We should continue to use the direct compact tension test. Dynamic modulus testing with the indirect tension method may be useful."

—Shongtao Dai,
Research Operations Engineer, MnDOT Office of Materials and Road Research

"We wanted to determine what material properties would achieve the pavement's desirable performance level. We can use MnPAVE to design a system for a given rut depth and get useful information on performance reliability."

—Jia-Liang Le,
Assistant Professor, University of Minnesota Department of Civil, Environmental and Geo-Engineering

What Did We Learn?

Materials Testing. Investigators measured creep, tensile strength and more using indirect tension testing. Then, because cores poorly suit conventional testing for dynamic modulus, the team used a simple adaption to IDT to measure dynamic modulus. For the measurement of fracture energy, researchers compared the semi-circular bending test to MnDOT's practice of using direct compact tension. Compared with the SCB test, the DCT test yields more consistent measurements. Samples from one of the four sites failed to offer enough dynamic modulus data for modeling.

Numerical Modeling. Modeling with MnPAVE was more successful than with MEPDG. With MnPAVE, researchers analyzed the three remaining sets of site samples; MEPDG, which requires a limited range of dynamic modulus values, allowed analysis of only one site. MnPAVE accommodates a more flexible range of dynamic modulus values, uses considerably less computational time and employs input parameters easily accessible in MnDOT climate and traffic databases. Investigators identified MnPAVE as the best option for parametric analysis.

Parametric Analysis. Researchers used traffic loading and dynamic modulus data for analyzing the three eligible sites and arrived at the following conclusions:

- Researchers don't yet understand how SFDR properties influence long-term pavement behavior well enough to determine desirable properties for each application. Numerical modeling is essential to gain such an understanding. It is expected that the SFDR performance and mix needs vary significantly from site to site.
- Material testing showed that emulsion-stabilized SFDR outperforms cement-stabilized pavements. Results on foamed-asphalt samples were inconclusive.
- MnDOT practice of determining fracture energy with DCT works more reliably than the SCB method used by researchers.
- This reliability-based design approach provides a complete assessment of rutting performance at traffic-loading levels.

What's Next?

Further research could more fully compare added stabilizers, including newer additives made with nanomaterials, which may further improve the cost-effectiveness of the FDR operation.

Milling depth remains a key interest. Milling to approximately the top 1 inch of aggregate base rather than the entire base will considerably change optimal additive levels. Given that existing pavement profiles can vary in terms of base thickness and asphalt thickness within 500 feet, variable milling depths or varying thickness of stabilized asphalt layers may be required for a durable reclamation.

This Technical Summary pertains to the LRRB-produced Report 2016-09, "Investigation of Performance Requirements of Full-Depth Reclamation Stabilization," published March 2016. The full report can be accessed at mndot.gov/research/TS/2016/201609.pdf.

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