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TECHNICAL SUMMARY

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PROJECT COST:
$140,000

The Hamburg wheel track test assesses an asphalt mixture's rutting resistance and may be used in BMD.

Balanced Mix Design Complements Volumetrics, Emerges as Promising Procedure

Researchers developed and tested a complementary process to current volumetric procedures for asphalt mixture design and validation. In the balanced mix design process, volumetrically designed asphalt pavement mixtures undergo performance testing to evaluate and optimize binder content for crack and rut resistance.

What Was the Need?

Typically, asphalt pavement mix design identifies ratios of asphalt binder to aggregate content and air voids. These volumetric design approaches became more complex as state transportation agencies adopted Superpave specifications in the 1990s. Superpave design focused on material selection, aggregate structure, binder content and moisture sensitivity testing, but no practical performance testing.

When the principal Superpave performance testing protocol proved too expensive for widespread adoption, states developed individual procedures for validating volumetric designs. As a result, design and performance testing methods continued to vary among agencies. More recent trends in materials and practices have further complicated volumetric design processes, including the use of polymer additives to improve low- and high-temperature binder performance, variability in new binder properties due to changing oil refining methods, and the use of recycled asphalt pavement and shingles and the aged binders they add to mixtures. Volumetric design and testing protocols account individually for binder and aggregate characteristics, but not for the properties of the composite blend of ingredients within asphalt mixtures.

MnDOT asphalt engineers have become interested in balanced mix design (BMD), an alternate approach that couples performance testing with volumetric testing. BMD emphasizes testing of entire asphalt mixtures for cracking, rutting and other performance characteristics to account for variations in mixture performance due to binder quality from refining processes or recycled content.

What Was Our Goal?

The goal of this project was to develop a BMD approach for MnDOT. Researchers could then evaluate materials from Minnesota asphalt pavement projects, comparing MnDOT's volumetric design to a BMD approach.

What Did We Do?

A literature review identified the state of the practice of BMD among agencies throughout the country. The findings suggested that volumetric mix design remains standard, though many agencies augment procedures with mechanical performance tests that typically focus on moisture damage and rut resistance. Unlike Minnesota, few states test for cracking resistance.

Based on the findings from the literature review, researchers and members of the Technical Advisory Panel developed a BMD plan to determine how asphalt content impacts performance. According to the plan, researchers would conduct performance tests on

continued

"The push to increase our use of recycled asphalt pavement makes BMD really attractive because it tests the entire mix—the binder, aggregates and recycled asphalt pavement."

—Dave Van Deusen, Research Operations Engineer, MnDOT Office of Materials and Road Research

"Unlike many states that show an interest in BMD, MnDOT has taken a rigorous approach toward implementing more performance-based measurements in mix design."

—Dave Newcomb, Division Head, Materials and Pavement Division, Texas Transportation Institute

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A well-built pavement begins with a well-designed asphalt mixture. MnDOT is rigorously examining the BMD approach, which ensures quality through performance testing.

a volumetrically developed mix, adjusting the asphalt content based on test results and repeating the tests after each adjustment.

MnDOT provided the research team with four Minnesota mixtures for two traffic levels: carbonate, limestone aggregate for the lower traffic loading level and igneous, granite aggregate for the heavier traffic level. Tests included a widely used rutting test, MnDOT's crack resistance test and two alternative crack resistance tests.

The research team evaluated the proposed BMD procedure, described cracking test variability and recommended optimum asphalt contents for BMD and volumetric designs.

What Did We Learn?

Performance tests and BMD effectively distinguished the influence of asphalt content and traffic and aggregate variables on rut resistance and crack resistance in the four MnDOT mixtures.

Three crack resistance tests were selected: the disk-shaped compact tension (DCT) test used by MnDOT, the Illinois flexibility index test (I-FIT) and the indirect tension asphalt cracking test (IDEAL-CT). These performance tests demonstrated that mixtures with granite aggregates resist cracking better than the mixtures with limestone; granite suits MnDOT's use in higher loading pavement designs.

MnDOT's DCT test evaluates low-temperature cracking effectively, but requires temperature control and conditioning. Because a 48-hour lead time is needed for the test, the DCT is most suitable for testing initial mix designs. The IDEAL-CT, developed in the mid-2000s, requires no cutting, drilling, gluing or instrumentation. Although sample preparation time is four hours (for conditioning and compaction), the time to run the test itself is very short, which may make it suitable for daily quality assurance use in sampling asphalt produced during construction.

In three of the mixes, BMD resulted in higher asphalt content than the initial volumetric designs. However, investigators cautioned that only a limited number of mixes were evaluated in this study and the finding may not apply in general.

Researchers recommend targeting asphalt content for BMD at a level that meets minimum crack resistance requirements plus 0.4 percent and that meets minimum rut resistance requirements. Additional work is required to refine threshold criteria for the performance tests.

What's Next?

MnDOT will continue studying BMD and testing performance against a greater number of paving projects and asphalt mixtures around the state to further evaluate cracking and rutting criteria. Binder tolerance levels of 0.4 percent may be examined to determine if 0.3 percent is a cost-effective target for asphalt content.

The IDEAL-CT, which itself warrants further study for failure criteria, may be used to examine asphalt content during mix production, examining how sensitive tests are to normal operating variations. Ultimately, MnDOT engineers hope to pilot a small number of pavement projects that will be required to meet BMD criteria.

This Technical Summary pertains to Report 2018-22, "Balanced Design of Asphalt Mixtures," published June 2018. The full report can be accessed at mndot.gov/research/reports/2018/201822.pdf.