PUTTING RESEARCH TO WORK

BRIEF

The Search for Quicker, More Reliable Testing for Aggregate Durability

Wisconsin DOT projects use approximately 11 million tons of aggregate per year as unbound pavement base courses, in bituminous and portland cement concrete pavements, and in structural concretes for bridges, box culverts and retaining walls. Selecting durable aggregates is critical, since if the aggregate deteriorates, the pavement or structure may require premature repair or replacement.

WisDOT uses a number of tests to ensure that durable aggregate is used in its projects. Standard tests include evaluation of gradation, plasticity, resistance to abrasion (impact), soundness, and freezing and thawing resistance.

What's the Problem?

WisDOT's tests have been in use for well over 50 years and have generally served the department well. However, the tests were developed when high-quality natural sources of aggregate were abundant, and the use of industrial byproducts and recycled/reclaimed materials in pavement was nonexistent. In addition, some of the tests have been kept in use in the name of tradition and simplicity rather than being replaced as the industry's understanding of the science of aggregate durability has improved.

Research Objectives

Researchers sought to improve the effectiveness and cost-efficiency of WisDOT's aggregate durability testing protocol by identifying tests that embrace recent advances in the understanding and testing of aggregate durability. Specific objectives included:

- Develop a testing program to address unbound, bituminous concrete and portland cement concrete pavement and structural elements.
- Identify a more efficient, cost-effective and scientifically valid test procedure to replace the Sodium Sulfate Soundness Test (AASHTO T 104) that WisDOT has used since 1960 to measure aggregate durability. Concerns are growing about this test's reliability, repeatability, and ability to predict durability performance and simulate field conditions. In addition, this test cannot be used with recycled concrete aggregates.
- Identify additional tests that can provide repeatable results.

Methodology

First, researchers conducted a literature review to assess the state of the practice for durability testing of natural and recycled material aggregate, and interviewed sources at FHWA, the National Center for Asphalt Technology at Auburn University, and the University of Texas at Austin.

Next, researchers developed a laboratory testing program to evaluate nine tests identified in the literature search; the tests were selected based on their precision, efficiency and predictive capabilities. For comparison, researchers used the same aggregates to evaluate WisDOT's current durability tests.

Seventy-four aggregate samples representing the full range of aggregate available in Wisconsin were collected for the laboratory testing program. Among the aggregates tested were glacial deposits of gravel, ledge rocks from different geologic groups, recycled aggregate stockpiles, and blast furnace slag. Based on vacuum-saturated specific gravity and absorption tests, 30 aggregates were selected for further analysis at Virginia Tech and 30 for analysis at Virginia Transportation Research Council facilities.

Investigator

"Use of the proto cols recommended in this study would significantly reduce WisDOT's testing times and costs."

–Richard Weyers
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Researchers recommend that WisDOT add the Micro-Deval test to its aggregate testing protocols to measure abrasion resistance. The test uses equipment shown above in a WisDOT lab.

Results

Test results indicated that WisDOT's aggregate testing protocol could be reduced substantially by eliminating many of the testing requirements for aggregates that have a vacuum-saturated absorption of less than 2%. Researchers proposed several specific modifications to WisDOT's protocol, including:

- Replacing the Sodium Sulfate Soundness Test with the Unconfined Freezing and Thawing test (CSA A23.2-24A), a Canadian test that offers better precision and better correlation with field performance.
- Using specific gravity and absorption tests ASTM C 127 and C 128 to help determine aggregate freeze/thaw durability. Tests for the specific gravity and absorption characteristics of aggregates have long been used to help determine batch quantities for concrete, but in recent years these tests have also been used to predict freeze/thaw durability. Results from these tests are more straight-forward and repeatable than results provided by the Sodium Sulfate Soundness Test.
- Adding the Micro-Deval test (AASHTO T-327; "Resistance of Coarse Aggregate Degradation by Abrasion in the Micro-Deval Apparatus") to the protocol to evaluate the abrasion resistance of aggregate. This test more accurately models the degradation that occurs during handling and mixing.

Figures 8.1, 8.2 and 8.3 of the final report present flow charts depicting test protocols for unbound, concrete and bituminous aggregates that would greatly reduce the amount of aggregate durability testing required by WisDOT. Vacuum-saturated absorption testing, the Micro-Deval Test, and the L.A. Abrasion Test (ASTM C 131-01; a measure of aggregate strength) are built into all three protocols.

Implementation and Benefits

Improved testing efficiencies identified in this project could reduce aggregate testing time for WisDOT and consultants, resulting in considerable cost savings for the department and taxpayers. As an initial implementation activity, WisDOT plans to begin using the Micro-Deval Test and vacuum-saturated absorption testing as recommended by researchers. The Sodium Sulfate Soundness Test may be abandoned if future test results correlate well with data from this study. The test protocols diagrammed in the final report will be used as starting points for developing an improved WisDOT protocol.

This brief summarizes Project 0092-02-03, "Investigation of Testing Methods to Determine Long-Term Durability of Wisconsin Aggregate Resources Including Natural Materials, Industrial By-Products, and Recycled/Reclaimed Materials," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research, Development & Technology Transfer Program, 4802 Sheboygan Ave., Madison, WI 53707.

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Project Manager

"This study's recommendations are a good starting point for developing a more effective, efficient protocol."

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