MODIFIED AGGREGATE TEST EXPEDITES SUPERPAVE

Kansas Department of Transportation's Field Test Saves Time and Money

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The Superpave® (Superior Performing Asphalt Pavements) design of hot-mix asphalt mixtures requires minimal coarse and fine aggregate angularities. This ensures a high degree of aggregate internal friction and rutting resistance.

Coarse aggregate angularity is defined by the percentage of weight that consists of aggregates larger than 4.75 mm and with one or more fractured faces. Fine aggregate angularity is defined by the percentage of air voids—or the U-value—in loosely compacted aggregates smaller than 2.36 mm; higher percentages of air voids indicate larger quantities of fractured faces.

Here is how one agency met the Superpave requirements as soon as they became available.

Problem

Until 1993, the Kansas Department of Transportation (KDOT) performed visual and microscopic examination of aggregate samples to determine the percentage of crushed material in the sand and gravel after crushing. However, evaluating fine aggregates with a microscope is time consuming and subjective—it is operator dependent—and requires shipping the sample to the KDOT laboratory in Topeka, Kansas. Clearly, a simple test method adaptable to field use that could determine aggregate acceptability and relate to mixture performance would yield economic benefits.

Solution

KDOT initiated a study to develop a replacement for the microscopic examination for fine aggregate; the test would have to differentiate samples of crushed material with slight contamination from blends of crushed and uncrushed material. In addition, the study sought to identify practical limits for good performance.

Modifications

The study led to a modification of the flow test, Procedure A of ASTM C 1252, Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading) only available in 1993 as the National Aggregate Association flow test. The modified test is called Kansas Test Method KT-50, Uncompacted Void Content of Fine Aggregate.

The ASTM test determines the bulk specific gravity, which requires a 24-hour soak of the aggregate, making the test unsuitable for field use. Because western Kansas aggregates tend to have low absorptions and similar specific gravity values, researchers hypothesized that using apparent specific gravity instead of bulk specific gravity would not affect the results.

In the modified test, aggregates in the calibrated cylinder are transferred to a volumetric flask and weighed. The volume of voids is determined by adding water and reweighing (Figure 1). The U-value was calculated by substituting the apparent specific gravity for bulk specific gravity in the ASTM standard's formula.

Tests

The study tested 54 samples of aggregates typically used in western Kansas. Microscopic examination determined the percentage of crushed material; the ASTM test and the Kansas modification determined the U-value. The bulk and apparent specific gravity values were measured using Kansas Test Method KT-6, Specific Gravity and Absorption of Aggregates.

Analysis of test results indicated that the KT-50 and the ASTM methods produced similar mean values. A one-way analysis of variance also revealed that the ASTM method and KT-50 tests produced statistically similar results for the 54 samples at a 95 percent confidence limit. Researchers concluded that

KT-50 provided results similar to the ASTM method and required less than 30 minutes for results once the field sample had been sieved.

The next step was to determine if there was a relationship between the KT-50 U-value and the percentage of angular and rounded material in the mixtures. Samples of very angular material mixed with differing amounts of very rounded material were tested to determine the U-values. A linear relationship was observed, although the slopes of the regression lines appeared to depend on the material.

The study also investigated whether the KT-50 method could detect the presence of contaminants, such as natural sand, silt, or clay. Known amounts of contaminants were mixed into the samples before testing. Results showed that the KT-50 test could differentiate crushed material from crushed material with varying amounts of contaminant.

Tests also were conducted to determine if the KT-50 U-values related to the Gyratory Elastic Plastic Index (GEPI), a measure of internal friction. Five percent asphalt cement by weight of the aggregate was mixed with samples that already had U-values determined by KT-50. Samples with different void contents were tested for GEPI in accordance with ASTM D3387, Standard Test Method for Compaction and Shear Properties of Bituminous Mixtures by Means of the U.S. Corps of Engineers Gyratory Testing Machine.

The results indicated that the GEPI values for mixtures with a U-value of 46 percent or more were as low as for a sample of 100 percent crushed gravel. Therefore, 46 percent was selected as the threshold for the U-value for crushed gravel as measured by KT-50.

Application

KDOT developed a special provision to the standard specification for crushed gravel based on the study results . The KT-50 method replaced microscopic evaluation in determining the percentage of crushed material, and 46 percent has been adopted as a minimum U-value for acceptance. Field experience and further laboratory testing to incorporate absorptive limestone has facilitated adoption and use in Superpave design.

Benefits

The adoption of KT-50 and the ability to test fine aggregate in the field since 1993 has saved time and effort—the method takes an estimated three hours of employee time less per test compared with the ASTM test method. This shortens the time to results by two days, not counting transportation time. At the current testing volume, the use of KT-50 results in annual savings of 1,900 hours or about $26,000.

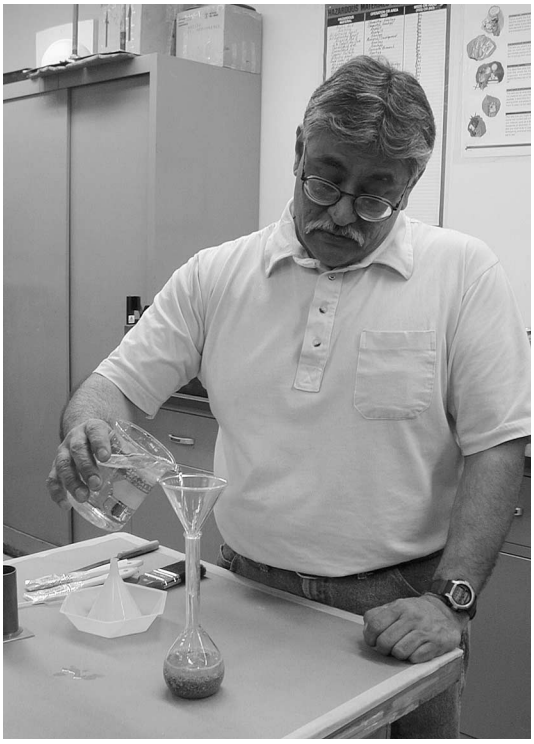

FIGURE 1 KT-50 is a simple method for determining the U-value or percentage of air voids in loosely compacted fine aggregates; the test can be performed in the field.

The test also eliminated the costs associated with transporting samples to the laboratory, and the shorter testing time has expedited mix design development and project construction. In addition, the adoption of KT-50 has reduced tensions between contractors and inspectors, since trained personnel anywhere can perform the test.

The KT-50 test has proved timely, reliable, and reproducible. The net gain for KDOT is the savings in time and costs, expedited construction, and easier implementation of Superpave. Although developed specifically for western Kansas aggregates, the method applies to combinations including absorptive limestone and is used statewide in Superpave design.

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Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC 20418 (telephone 202-334-2952, e-mail gjayapra@nas.edu).