CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6617: Revamping Aggregate Property Requirements for Portland Cement Concrete

Background

Current Texas Department of Transportation (TxDOT) procedures for evaluating coarse aggregate for portland cement concrete (PCC) have been in place for over 39 years. Item 421 in the TxDOT "Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges" describes the tests and test limits that must be met by aggregates before they can be approved for use in PCC applications. The intention of Item 421 is to ensure that only strong, durable aggregates are used in concrete so that the life of concrete is not cut short by common distress mechanisms which ultimately lead to costly repairs and replacements.

The ultimate aim of this research project was to examine how more coarse aggregate sources could be utilized in PCC without affecting the quality of the concrete produced.

What the Researchers Did

In order to correlate performance with test results, the research team is in the process of collecting coarse aggregates from more than 50 sources and fine aggregates from more than 35 sources used by TxDOT. Aggregates tested represent a variety of mineralogies and geographic locations in Texas. Fine aggregates tested also include both natural sands and manufactured sands.

Coarse aggregate tests that were performed include the Micro-Deval test (Tex-461-A), Los Angeles abrasion and impact test (Tex-410-A), magnesium sulfate soundness test (Tex-411-A), British aggregate crushing value test (BS 812 Part 110), British aggregate impact value test (BS 812 Part 112), specific gravity and absorption test (Tex-403-A), flat and elongated particles test (Tex-280-F), Aggregate Imaging System (AIMS 2.0), and thermal conductivity test (using Mathis TCi equipment). Fine aggregate tests that were performed include the Micro-Deval test (ASTM D 7428), specific gravity and absorption test (Tex-403-A), Aggregate Imaging and System (AIMS 2.0), flakiness sieve (developed by Rogers and Gorman [2008]), acid insoluble residue test (Tex-612-J), Grace methylene blue test (developed by W.R. Grace Co.), organic impurities test (Tex-408-A), and sand equivalent test (Tex 203-F). Because the field performance history of an aggregate was not always readily available, researchers also performed a variety of concrete tests in an attempt to correlate results with aggregate tests. Concrete tests that were performed include compressive strength, flexural strength, modulus of elasticity, and coefficient of thermal expansion.

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What They Found

Conclusions from the research include new findings and confirmation of previously obtained knowledge on the impact of aggregate characteristics on the performance of PCC. Key findings can be discussed that are crucial to the importance of this research.

The accuracy of the AIMS and the Camsizer was evaluated by comparing the results of each test. It was observed that excellent correlations exist between the two systems, even though the mathematical formulas for evaluating the fine aggregate characteristics are not the same. The Camsizer can evaluate the characteristics of fine aggregates by measuring sphericity and angularity, and it can also perform a gradation analysis of fine aggregate. However, the size of the sample was found to play an important role in obtaining accurate results. The Grace methylene blue test correlated poorly with the sand equivalent test. This raises questions and concerns about the method of determination between the Grace method and sand equivalent test. The non-approved fine aggregates were compared with the approved fine aggregates; it was found that the non-approved fine aggregate produced higher strength mortar than some of the approved fine aggregates.

Moderate correlations were found between the mechanical properties of coarse aggregate and concrete. These correlations were used to select the most applicable test methods for qualifying aggregate; these test methods became the basis for recommendations for coarse aggregate testing. Testing with the aggregate impact value apparatus provided the strongest correlation between aggregate performance and mechanical strength testing of concrete. However, test results from the conventional test apparatus could be influenced by operator execution. The aggregate impact value apparatus was successfully modified to eliminate potential variability from the operator. A more rapid approach to determining the coefficient of thermal expansion of an aggregate was investigated and determined to be feasible. However, the requirement that the aggregate being tested have uniform lithology is a major limitation of the approach. The causes of distress for many of the field sites investigated were a combination of many factors. However, improved inspection during construction, combined with a better understanding by construction workers of the implications actions could have for a construction project, could potentially reduce problems.

What This Means

The findings of the project should be made known to TxDOT personnel for considerations in future specification book publications. Not all aggregates may be applicable for all construction purposes; however, most aggregates had adequate mechanical performance in PCC to allow for utilization in some applications.

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