Project Summary

Texas Department of Transportation

0-1707: Long-Term Research on Bituminous Coarse Aggregate

Background

Three key areas were addressed in Project 0-1707:

- a review and upgrade of the surface aggregate classification system associated with the wet weather skid accident reduction program (WWARP),
- development of methods to assess aggregate to ensure better performance as part of the hot mix asphalt composite, and
- assessment and evaluation of use of the Hamburg wheel-tracking device (HWTD) as a means by which to assess aggregate durability.

What the Researchers Did

Researchers evaluated various lab test procedures that are used in the classification of aggregates as well as the field skid resistance performance of 27 sources (40 aggregates) of synthetic, sandstone, igneous, gravel, and carbonate aggregates. Researchers identified aggregate properties that affect mixture durability and the potential for the mixture to deform or rut under traffic, resulting in unsafe driving conditions.

Evaluation of shape, angularity, and texture gradients of aggregates using the aggregate imaging system (AIMS) proved superior to traditional physical tests in terms of assessing the properties of the aggregate with the goal of reducing the potential for plastic deformation. Such deformation manifests in wheel track rutting and is a safety issue. Image analysis can be used to assess the potential for aggregates to possess suitable characteristics for skid resistance. AIMS was selected based on its relative superior performance. It was not developed under Project 0-1707, but the analytical protocol supporting AIMS was enhanced and in a sensitivity analysis of some 40 aggregates it proved to be able to distinguish among aggregate shape, angularity, and textural properties to the degree that the impact of various aggregates in hot mix could be predicted based on AIMS analysis.

The use of AIMS was extended and was incorporated into an elastic-viscoplastic-plastic continuum model of a hot mix asphalt (HMA) capable of predicting performance under load under different climatic conditions. The model incorporates aggregate shape, form, and textural properties based on AIMS analysis with a Drucker-Prager yield surface that is modified to capture the influence of stress path direction on the material response. Parameters that reflect the directional distribution of aggregate particles in the asphalt matrix and damage density in the microstructure are also included in the model. The level of microstructural damage is concentrated primarily in the asphalt mastic (asphalt binder plus mineral filler with aggregate finer than about 74 μm).

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The properties of this mixture component are characterized in this project by dynamic mechanical analysis (DMA).

Project 0-1707 evaluated the feasibility of implementing the Micro-Deval (MD) test in TxDOT's Aggregate Quality Monitoring Program (AQMP) for bituminous coarse aggregate. In particular, the research investigated the possibility of using this test as a project-level quality control tool. The project included review and analysis of TxDOT's materials and test lab's AQMP data as well as independent laboratory testing.

What They Found

As a result of activities conducted in this project, researchers reached the following conclusions.

1. Hard, durable aggregates characterized by greater than 80 percent acid insoluble residue or less than 8 percent MD loss provided excellent to very good skid resistance regardless of the aggregate residual polish value (RPV). The primary limitation in these test methods was found to be their ability to classify borderline aggregates into satisfactory and unsatisfactory categories.
2. The current aggregate classification system based on RPV and magnesium sulfate soundness (MSS) loss was found to be superior to any method that relies on a single lab test parameter. An alternative classification chart, based on RPV and percent MD loss and tentative boundaries that may be used to separate Class A and B material, was developed and presented.
3. AIMS proved to be able to distinguish among aggregate shape, angularity, and textural properties to the degree that the impact of various aggregates in hot mix could be predicted based on AIMS analysis. Aggregate performance predictions based on AIMS were evaluated against widely accepted "torture" tests including the asphalt pavement analyzer (APA) and the HWTD with highly acceptable correlations.
4. The elastic-viscoplastic-plastic model of pavement performance was found to be highly sensitive to aggregate properties (as identified by AIMS) and was proven to be able to predict performance measured in laboratory repeated load plastic deformation testing as well as by "torture" tests such as the APA and the HWTD.
5. DMA can be used as a specification type test to assess the compatibility and relative performance potential of various binder-mineral filler combinations.

What This Means

An improved WWARP classification system was developed and is available for use based on residual polish value and magnesium sulfate soundness or Micro-Deval testing.

AIMS is a superior method by which to characterize aggregate properties that impact the performance of HMA. AIMS provides a fast, repeatable, and reliable evaluation of the angularity gradient, textural gradient, and form gradient of the total aggregate (course and fine) used in the asphalt composite.

Dynamic mechanical analysis provides an excellent, rapid, and repeatable assessment of the asphalt mastic and/or the asphalt mastic plus fine aggregate matrix. This assessment can be done in dry or wet (moisture-conditioned) systems. The DMA analysis defines the ability of the fine aggregate and/or mastic to resist crack damage and/or plastic deformation.

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