Research Project

01-1B

Capsule

Technology Transfer Program

LTRC

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Tomography Imaging & Computational Technology for the Characterization of Asphalt Concrete

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LTRC

Louisiana Transportation Research Center

Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

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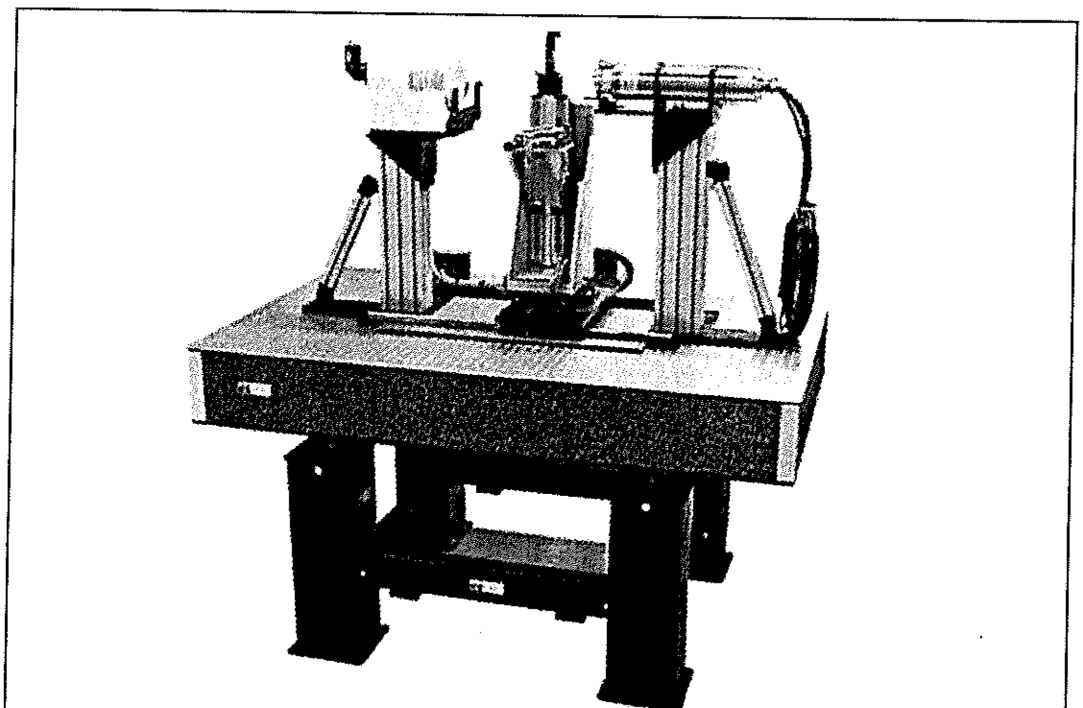
Problem

Superpave asphalt mix design procedures have been widely adopted by state transportation agencies, including LaDOTD. However, a limitation of these design procedures is their failure to account for the structural complexity of an asphalt pavement.

Asphalt mixtures are comprised of aggregates, asphalt binder, and air voids. The aggregate skeleton structure, the binder stiffness, and the void distribution are important factors that affect the properties of the mixture.

Advanced imaging technologies and high-performance computational techniques have provided a feasible means for evaluating the three-dimensional (3D) structure of asphalt pavements and simulating their response to various loading conditions. The results of these material characterization and simulation techniques must be correlated with performance-related data.



Tomography Imaging Equipment

Objective

X-ray tomography image analysis is a technique for obtaining a "stack" of sectional images quickly and non-destructively. These images can be used to reconstruct true 3D representations of an asphalt pavement and permit measurement of void size distribution, void connectivity, and orientation of particle contacts.

The variability of asphalt mixture properties is mainly determined by aggregate properties and gradation. Aggregates exhibit great variability in mineral composition, shape, surface roughness, and surface texture. In practice, these properties are described qualitatively. Through numerical representation of the aggregate, quantitative descriptors of form and shape may be derived.

X-ray tomography imaging and high-performance computational techniques will be used to evaluate aggregate and asphalt mixture properties, and a correlation between the internal structure of asphalt pavements and their performance will be determined.

Description

In phase 1 of this research, image-based evaluation methods will be used to quantify performance-related aggregate characteristics. A correlation will be established between these characteristics and currently specified properties such as Fine Aggregate Angularity and Aggregate Shape Index.

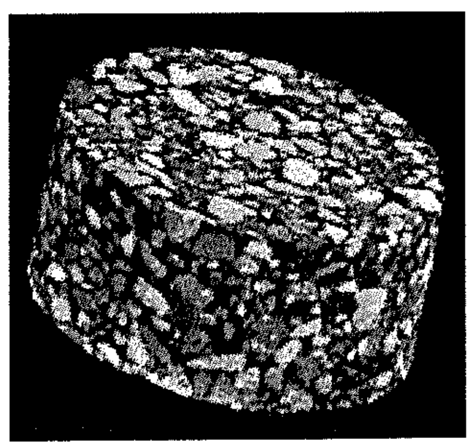
In phase 2 of this research, the effect of aggregate characteristics on mixture properties will be evaluated. An analytical technique, known as the discrete element method, will be adapted to simulate compaction of particles with any shape, surface roughness, or surface texture. A method to reconstruct the 3D structure of an asphalt mixture from tomography images for direct finite element simulation will be used to evaluate the stress concentration and strain localization effects of loading on different mixtures. The relationship between permeability and void distribution/connectivity will also be investigated.

In phase 3 of this research, the sensitivity of asphalt pavement mechanistic responses to aggregate and asphalt mixture characteristics will be evaluated. The Simple Shear Tester (SST) and the Asphalt Pavement Analyzer (APA) are currently used to evaluate the rutting and fatigue properties of asphalt mixtures.

The SST and APA test data will be correlated with actual performance data obtained from LTRC's Accelerated Loading Facility (ALF). An analytical relationship between the SST, APA, and ALF data will be established using computational technology.

Implementation Potential

The proposed research will help DOTD establish performance-related specifications for aggregate used in asphalt pavements by providing a more detailed analysis of particle shape. Aggregate properties that affect design of asphalt mixtures will be recommended for specification. New methods to compute performance-related parameters of asphalt mixtures will be developed. These computational methods will establish numerical relations among results from SST, APA, and ALF tests. Improved methodologies for mix design and performance evaluation may be directly implemented through the use of a user-friendly software package that will be developed.



Visualization of an Asphalt Concrete Specimen