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THE USE OF COMPLEX MODULUS TO CHARACTERIZE THE PERFORMANCE OF ASPHALT MIXTURES AND PAVEMENTS IN FLORIDA

PROBLEM STATEMENT

Traditionally, pavement design procedures in the United States have been based on empirical equations derived from the AASHO Road Test. That test was conducted between 1958 and 1960, with a limited number of pavement sections at one location, Ottawa, Illinois, and with modest traffic levels compared with those of today. It is now well-accepted that pavement design should include expected traffic growth, materials, seasonal variations in materials and climatic conditions, and soil and moisture conditions. As such, pavement designs for today's conditions are projected far beyond the inference space of the original data from the AASHO Road Test. To meet current demands on pavements, the American Association of State and Highway Transportation Officials (AASHTO) Joint Task Force on Pavements in 1996 sponsored the development of a new mechanistic-empirical design guide for new and rehabilitated pavements. The results from this multi-year research effort culminated in the new AASHTO 2002 Guide for Mechanistic-Empirical (M-E) Design and Analysis.

The M-E pavement design guide uses mechanistic-empirical numerical models to analyze input data for traffic, climate, materials, and proposed structure. The estimation of damage accumulation over the service life of the new pavement is based on empirical rutting and cracking performance equations, which require the complex modulus as an input parameter. The complex modulus is dependent upon temperature and loading frequency, and thus allows for a more accurate representation of traffic load effects on pavements. Asphalt mixture creep and flow properties associated with the performance of mixtures can also potentially be obtained from the complex modulus. This new AASHTO 2002 pavement design guide provides significant potential benefits over previous pavement design guides in achieving cost-effective pavement designs and rehabilitation strategies. As a first-step for implementing the AASHTO 2002 pavement design guide in Florida, complex modulus capabilities for Florida need to be investigated, and the use of the complex modulus for materials common to Florida evaluated. This will allow for compliance with the new AASHTO pavement design standards and more cost-effective rehabilitation and pavement designs for Florida.

OBJECTIVES

The overall objectives of this research project were to develop complex modulus testing and interpretation capabilities for Florida, and to evaluate the new AASHTO 2002 predictive dynamic complex modulus equation for Florida mixtures. Complex modulus testing can be performed under triaxial, tensile, or torsional loading conditions. In order to perform a comprehensive evaluation of the complex modulus, the following objectives were identified:

- Develop triaxial dynamic complex modulus testing capabilities in Florida.
- Develop a system for obtaining dynamic complex modulus from the Superpave Indirect Tension Test.
- Develop testing and interpretation protocols for torsional shear dynamic complex modulus testing capabilities in Florida.

- Evaluate how well dynamic complex modulus predictive relationships in the new AASHTO 2002 Pavement Design Guide worked for Florida mixtures.
- Evaluate methods that could be used to obtain fracture and creep compliance properties from dynamic complex modulus testing.
- Evaluate potential relationships between rutting performance and the dynamic complex modulus.
- Perform a fundamental evaluation of the phase angle in the dynamic complex modulus test. In particular, various testing and material effects that may affect the phase angle were identified.
- Evaluate the effects of aggregate size distribution in asphalt mixtures on the dynamic complex modulus.
- Develop a performance test database for Florida mixtures.

FINDINGS AND CONCLUSIONS

In this project, dynamic complex modulus testing and interpretation capabilities were developed for Florida under three different modes of loading, namely, compression, torsion, and tension. The results from this project showed that the proposed predictive equation for dynamic modulus in the new AASHTO 2002 Pavement Design Guide appeared to work well for Florida mixtures. Potential relationships between the dynamic complex modulus and the rutting performance of mixtures were evaluated. No discernable relationship between dynamic complex modulus and rutting was established for mixtures of varying gradations and aggregate structure. Methods that can be used to obtain creep properties from dynamic complex modulus measurements as input into the Florida Hot Mix Asphalt Fracture Mechanics Model were evaluated. For the range of frequencies typically employed in dynamic complex modulus testing, it may not be possible to obtain creep compliance parameters accurately from dynamic measurements. However, an approach was developed for determining creep compliance parameters accurately from a combination of dynamic complex modulus and static creep tests. The effects of aggregate size distributions on the dynamic complex modulus were evaluated. A significant effect of gradation was found on dynamic complex modulus measurements.

In conclusion, the dynamic complex modulus generally should not be used to determine rutting or fracture resistance of mixtures. The primary use for the dynamic complex modulus test is to determine the stiffness of mixtures for purposes of determining the response to traffic loading, as per the new AASHTO 2002 flexible pavement design guide.

BENEFITS

This project is the first step towards implementing the new 2002 AASHTO Pavement Design Guide in Florida. It resulted in the following: (1) development of testing and interpretation procedures for dynamic complex modulus testing under triaxial compression, torsional shear, and tensile loading conditions, (2) verification of the AASHTO 2002 Pavement Design Guide predictive modulus relationship for Florida mixtures, (3) evaluation of potential relationships between dynamic complex modulus and pavement rutting and cracking performance, (4) development of testing and interpretation methods for obtaining creep parameters from a combination of dynamic complex modulus testing and static creep testing, and (5) development of a dynamic complex modulus database consisting over 30 mixtures from the field and the laboratory that are typical to Florida. The results from this research project promote compliance with the new AASHTO pavement design standards and will lead to more cost-effective rehabilitation and pavement designs in Florida.

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