PREDICTION OF THERMAL CRACKING BY COMBINING EXPERIMENTAL AND ANALYTICAL CREEP COMPLIANCE DATA

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In the newly-released Mechanistic-Empirical Pavement Design Guide (MEPDG), creep compliance, D(t) is required for the characterization of the linear viscoelastic (LVE) behavior of asphalt concrete (AC) mixtures needed for predicting thermal cracking in flexible pavements. For that application in particular, D(t) needs to measured using the indirect tensile mode as outlined in AASHTO T322. On the other hand, dynamic modulus (|E*|) measured in the uniaxial mode is needed for prediction of rutting and longitudinal cracking. The simple performance tester, developed based on recommendations from NCHRP 9-29, can be used to measure |E*| but not D(t) in the IDT mode. Thus, for designers wishing to use the MEPDG for design and analysis of pavements would thus need a testing machine other than the simple performance tester. This encumbers additional resources and burdens on highway agencies and industry in implementing the MEPDG.

It is known that the material behavior of AC mixture can be considered as linear viscoelastic at very low temperatures and fast cooling rates. It is also known that the LVE material response can be characterized by a number of material functions including creep compliance (D(t)), relaxation modulus (E(t)) and complex modulus (E*). Several interconversion techniques have been used in obtaining one LVE function from the other. These techniques, however, are only valid for uniaxial stress modes and not bi-axial as the case in IDT. For Level 3, MEPDG analysis, default D(t) values empirically derived from volumetric material properties through nationally calibrated coefficients, are used. This introduces error in thermal cracking predictions and is not as reliable as using measured D(t) for the particular AC mix used in the design. It is thus worth investigating whether obtaining mix specific D(t) in IDT mode from uniaxial E* through approximate numerical /analytical interconversions yields predictions with higher accuracy than using Level 3 inputs.

In this paper, some of the existing methods of interconversion between the complex modulus and creep compliance are reviewed. Laboratory tests data on AC mixtures are used to measure both uniaxial E* and D(t) in IDT mode for several Superpave HMA mixtures. A comparison study on thermal cracking prediction using measured and inter-converted D(t) from E* is carried out using the MEPDG software. A statistical analysis is then applied to the resulting predictions to evaluate the results. The main contribution of this study is not the development of a new experimental or analytical method of determining D(t) itself, but rather the demonstration of the feasibility of using interconversion techniques experimental E* data, and statistical tools to evaluate the quality of thermal cracking predictions using the MEPDG.

Reference

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