ABSTRACT

DEVELOPMENT OF A NEW SOLUTION FOR VISCOELASTIC WAVE PROPAGATION OF PAVEMENT STRUCTURES AND ITS USE IN DYNAMIC BACKCALCULATION

By

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August 23, 2013, 3:00 pm – 5:00 pm
3546 Engineering Building

Due to the viscoelastic nature of asphalt materials and the dynamic nature of pavement structures, it is important to consider both effects simultaneously in modeling of asphalt pavements. In this study, a new computational algorithm, namely ViscoWave, has been developed and implemented for modeling the pavement dynamics and viscoelasticity under an impact load generated by a Falling Weight Deflectometer (FWD). The primary advantage of the proposed solution over some of the existing solutions is that it uses continuous integral transforms (Laplace and Hankel transforms) that are more appropriate for the FWD time histories whose signal characteristics are transient, nonperiodic, and truncated.

Prior to the mathematical formulation of the developed algorithm, the fundamental properties of a viscoelastic material and the theory of uniaxial viscoelasticity are reviewed. Then, the theory of linear, uniaxial viscoelasticity is extended to multi-axial viscoelasticity. The multi-axial theory of viscoelasticity is, in turn, applied to develop a methodology for analyzing the laboratory Indirect Tensile (IDT) test data.

The theoretical development of ViscoWave follows similar steps to those used for the development of the spectral element method. However, in place of the discrete transforms adopted in the spectral element method, ViscoWave utilizes the continuous integral transforms (namely Laplace and Hankel transforms) that are more appropriate for transient, nonperiodic signals. The theory behind ViscoWave was verified by comparing the ViscoWave simulation results to other existing solutions such as the Finite Element Analysis (FEA) and spectral element method.

To backcalculate the pavement layer parameters, two of the well known unconstrained optimization algorithms (Gauss-Newton and Levenberg-Marquardt methods) were adopted for use with ViscoWave. The backcalculation was conducted using both theoretically-generated and field-obtained FWD time histories. The results indicate that ViscoWave has great potential for modeling the viscoelastic and dynamic effects of a pavement structure under an impact load.