UNR Releases 3D-Move Analysis Software

The University of Nevada, Reno (UNR) has released new software for analysis of asphalt pavements. The new analytical model, called 3D-Move, uses a continuum-based finite-layer approach to compute pavement responses. The 3D-Move model can account for important pavement response factors such as moving loads, three dimensional contact stress distributions (normal and shear) of any shape, and viscoelastic material characterization for the pavement layers.

The finite-layer approach adopted in the 3D-Move treats each pavement layer as a continuum and uses the Fourier transform technique; therefore, it can handle complex surface loadings such as multiple loads and non-uniform tire pavement contact stress distribution. Since the tire imprint can be of any shape, this approach is suitable to analyze tire imprints, including those generated by wide-base tires (Siddharthan et al. 1998; 2000; 2002).

The finite-layer method is much more computationally efficient than the moving load models based on the finite element method (Huhtala and Pihlajamaki 1992; Al-Qadi and Wang 2009). This is because often the pavements are horizontally layered, and pavement responses are required only at a few selected locations. For such problems the finite layer approach of 3D-Move is ideally suited. Since rate-dependant material properties (viscoelastic) can be accommodated by the approach, it is an ideal tool to model the behavior of asphalt concrete (AC) layer and also to study pavement response as a function of vehicle speed. Frequency-domain solutions are adopted in 3D-Move, which enables the direct use of the frequency sweep test data of AC mixtures in the analysis.

Many field calibration efforts (e.g. Penn State University test track, MnRoad and UNR Off-road Vehicle study) that compared a variety of independently-measured pavement responses (stresses, strains, and displacements) with those computed have been reported in the literature (Siddharthan et al. 2002, 2005). These verification studies have validated the applicability and versatility of the 3D-Move.

The software is available as a free download at http://www.arc.unr.edu/Software.html. This is a Windows®-based program that enables the user to analyze pavement response under a variety of vehicle loading conditions. To illustrate the capability of the current version 1.1 of the program, important features of the program have been highlighted below.

Selected Features of 3D-Move Analysis

Axle Configuration and Contact Pressure Distribution
One of the important inputs to 3D-Move Analysis is the pavement contact stress distribution. It is customary to assume simpler contact stress distributions, for example, circular or elliptical loaded areas with uniform vertical stress. However, the pavement contact stress distributions are non-uniform and more complex. There are six types of loading considered in the 3D-Move Analysis.

Type 1: Pre-Defined Load Cases (Uniform/Non-Uniform Contact Pressure Distribution)

The nine load cases included under this option represent many widely-used field cases. User cannot modify the axle configuration and contact pressure distribution of any of the load cases.
Type 2: User-Selected Pre-Defined Axle/Tire Configuration (Uniform Contact Pressure Distribution)

Here, the user can specify axle configuration and three types of contact pressure distribution (Circle, Ellipse and Rectangle).

Type 3: User-Selected Tire Configuration and Contact Pressure Distribution from Database (Non-Uniform Contact Pressure Distribution)

In this case, VRSPTA (de Beer and Fisher (1997)) and Kistler MODULUS (Sime and Ashmore (1999)) databases which have reported measured contact pressure distributions for many single tires are used. A variety of tire types that include single and wide base tires under a tire pressure range of 220 – 1000 kPa and a tire load range of 26 – 106 kN are considered in both databases. The user can specify the axle configuration, which can vary from a single axle, single tire to a tridem axle, dual tire configuration. For a specified axle configuration and tire load, a contact pressure distribution can be generated from the available databases.
Type 4: Semi-Trailer Truck Including Vehicle Dynamics
(Uniform / Non-Uniform Contact Pressure Distribution)

Under this option, the load distribution on the various tires of the 18-wheel tractor-semitrailer during normal highway traffic and during braking is initially computed. Braking causes the vehicle to decelerate and the loads to transfer to the front of the vehicle. The resulting axle load can be higher or lower than the initial static load, depending on the location of the axle. Once the load distribution among the axles of the semitrailer is evaluated, the contact pressure distribution can be assigned (Uniform or Non-Uniform).

Type 5: Special Non-Highway Vehicles
(Uniform Contact Pressure Distribution)

Under this option, two non-highway vehicles (an end dump truck and forklift) are included. Different manufacturers are presented for each vehicle. User can select an appropriate axle configuration and tire load from a database of manufacturer's specifications. Uniform contact pressure distribution is the only option available.
Type 6: User-Input Tire Configuration and Contact Pressure Distribution
(Uniform / Non-Uniform Contact Pressure Distribution)

This option is entirely open to the user to define the contact pressure distributions. Contact may be uniform or non-uniform.

Characterization of Asphalt Materials

The asphalt layer material can be characterized as a linear elastic material or as a viscoelastic material. The dynamic modulus, \(|E^*|\), is required for the viscoelastic analysis. \(|E^*|\) can be input in three ways:

**Dynamic Modulus Lab Data**
Asphalt material properties can be specified using the dynamic modulus lab data. The 3D-Move Analysis incorporates the master curve, which enables the input of dynamic modulus at any selected pavement temperature in the analysis. It uses an optimization tool which is independent of Microsoft Excel to construct the master curve from the lab data.

**Witczak Model**
In this version of 3D-Move Analysis, the Witczak model is included to calculate the frequency-dependent dynamic modulus based on the gradation and binder properties of the mixture.

**User Defined Materials Properties**
A set of data of \(|E^*|\) as function of frequency can be specified by the user. Other input variables (Poisson’s and Damping ratios) can be either specified as constants or as a function of frequency.

Output

An important component of the analysis package is the user-friendly documentation and portability of the results to other platforms. The 3D-Move Analysis output can be viewed using Text Mode, Tabular Mode, or Graphical Mode.

**Graphical Mode**
*(Available only for dynamic analysis.)*
References:


