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MnPAVE Flexible - Odemark's Equivalent Thickness Method

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MnPAVE Flexible [1] is Minnesota's pavement design method for flexible (asphalt) pavements. The layered-elastic analysis method used in MnPAVE Flexible, WESLEA [2] has a limit of five layers, and pavement responses can only be simulated in the top four layers. In order to simulate additional asphalt or aggregate layers (or sublayers), Odemark's Equivalent Thickness method [3] is employed. This method combines two layers with different moduli (E) and/or Poisson's ratios (μ) into a single layer which has the same modulus and Poisson's ratio as one of the original layers. In MnPAVE Flexible version 6.403 the Poisson's ratios of the original sublayers are assumed to be equal. When the modulus of the second layer is changed to that of the first, its thickness is adjusted so that it has the same stiffness as the original thickness and modulus combination. This process can be repeated to add a third sublayer.

Asphalt Layers

In MnPAVE Flexible, the fatigue cracking performance model is based on simulated tensile strain at the bottom of the asphalt layer. Therefore, the modulus of the new combined layer is the same as that of the bottom sublayer (Equation 1).

Aggregate Layers

For stress and strains in aggregate base and subbase layers, the critical location is near the top of the layer. Therefore, the modulus of the new combined layer is the same as that of the top sublayer (Equation 2).

Geogrid Simulation

Recent Minnesota Department of Transportation reports [4], [5] indicate that geogrid in a pavement aggregate layer can increase the effective modulus of that layer. A geogrid option has been implemented in the Research version of MnPAVE Flexible 6.403. In this version, "Geogrid" can be selected for an aggregate base or subbase layer. Once selected, an effective geogrid modulus can be entered. This converts the bottom 1 inch of the layer to a special sublayer with the effective geogrid modulus. Simulations are conducted on a combined layer with equivalent thickness calculated by Equation 2.

$$H_{Eq} = H_B + H_T \left[\frac{E_T(1-\mu_B^2)}{E_B(1-\mu_T^2)}\right]^{1/3} \quad (1)$$

$$H_{Eq} = H_T + H_B \left[\frac{E_B(1-\mu_T^2)}{E_T(1-\mu_B^2)}\right]^{1/3} \quad (2)$$

Where:

H_B = Thickness of bottom sublayer
E_B = Modulus of bottom sublayer
μ_B = Poisson's ratio of bottom sublayer
H_T = Thickness of top sublayer
E_T = Modulus of top sublayer
μ_T = Poisson's ratio of top sublayer

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1. MnPAVE Flexible: MnDOT Flexible Pavement Design, Minnesota Department of Transportation web site, http://www.dot.state.mn.us/app/mnpave
2. Van Cauwelaert, F.J., Lequeux, Delaunnois, "Computer Programs for the Determination of Stresses and Displacements in Four-Layered Systems", WES Research Contract DAJA45-86-M-0483, U.S. Army Waterways Experiment Station, Vicksburg, MI, 1986.
3. Ullidtz, P. (1987). Pavement Analysis, Elsevier Science, New York, NY, p. 47.
4. Siekmeier, J. and Casanova, J., "Geogrid Reinforced Aggregate Base Stiffness for Mechanistic Pavement Design", Minnesota Department of Transportation Report MN/RC 2016-24, July 2016.
5. Siekmeier, J., "Performance Specification for Geogrid Reinforced Aggregate Base", Minnesota Department of Transportation Report MN/RC 2018-30, October 2018.