Considerations for Nonlinear Analyses of Pavement Foundation Geomaterials in the Finite Element Modeling of Flexible Pavements

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Flexible pavements are most commonly used for low to medium volume roads with significant usage also found in high volume Interstate highways and runways, taxiways, and aprons of major hub airfields subjected to heavy aircraft gear/wheel loads. As the demand for applied wheel loads and number of load applications increases, it becomes very important to properly characterize the behavior of subgrade soils and unbound aggregate layers as the foundations of the layered pavement structure. Previous laboratory studies have shown that the resilient responses of pavement foundation geomaterials, i.e., coarse-grained unbound granular material used in untreated base/subbase courses and fine-grained soils of a prepared subgrade, follow nonlinear, stress-dependent behavior under repeated traffic loading. Unbound granular materials exhibit stress hardening, whereas, fine-grained soils show stress softening type behavior. A finite element (FE) type analysis needs to be employed to model such nonlinear resilient behavior and more realistically predict pavement responses for a mechanistic pavement analysis.

Many general-purpose finite element programs, such as ABAQUS™, ANSYS™, and ADINA™, have been used to predict the pavement response under various traffic load conditions while not considering accurately pavement foundation geomaterial characteristics of unbound aggregate base/subbase and subgrade soil layers. This paper will describe the recent pavement FE modeling research efforts focused on using both the specific purpose axisymmetric and also general-purpose three-dimensional (3D) FE programs for flexible pavement analyses. To properly characterize the resilient response of pavement foundations, stress dependent modulus models have been properly programmed in a *User Material Subroutine* in the commercial general-purpose finite element program ABAQUS™. For the convergence of the geomaterial models, a direct secant stiffness approach is successfully employed in nonlinear iteration schemes. Results obtained from both axisymmetric and 3D FE nonlinear analyses will be compared for different meshes, including use of infinite elements, for predicting critical pavement responses. Important conclusions will be drawn on the need and the future recommended use of proper characterization of the nonlinear, stress-dependent geomaterial behavior using the FE solution technique.

Keywords: Pavement foundations, flexible pavements, nonlinear finite element analysis