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Parameter Analysis and Verification for Jointed Concrete Pavements

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Abstract:

Determination of critical structural responses in terms of stresses and deflections in a concrete slab is essential to mechanistic-based design as well as structural evaluation procedures. Two-dimensional (2-D, ILLI-SLAB) finite element models (FEM) have been successfully utilized to account for the effects of many practical pavement conditions more realistically than theoretical solutions based on infinite slab and full contact assumptions. With the introduction of three-dimensional (3-D, ABAQUS) FEM and all the promising features and results reported in the literature, its applications on pavement engineering become inevitable. Nevertheless, due to the required running time and complexity of the FEM, 3-D finite element analysis cannot be easily implemented as a part of design or structural evaluation procedure. Thus, the main objective of this study is to conduct in-depth parameter studies and verifications on 3-D finite element analysis of rigid pavements.

To study the effects of mesh fineness and element selection on the results of FEM runs of a single slab, a systematic analytical approach was utilized and implemented in a Visual Basic software package to generate the FEM input files, conduct the runs, as well as automatically summarize the results. Several guidelines in mesh fineness and the selection of various element types are subsequently recommended. The principles of dimensional analysis were utilized throughout this study. Besides the normalized load radius (a/ℓ), the normalized finite slab length (L/ℓ), and the normalized finite slab width (W/ℓ), an additional dominating dimensionless variable (h/a) defined as the ratio of slab thickness (h) and load radius (a) was identified and verified to have a substantial influence on ABAQUS runs using either 3-D shell or 3-D solid elements, in which ℓ is the radius of relative stiffness of the slab-subgrade system. This additional mechanistic variable can be used to account for the differences among various 2-D, 3-D FEM idealizations, and theoretical closed-form stress and deflection solutions.

Separate stress and deflection databases were developed using these dimensionless mechanistic variables. Example predictive models in terms of adjustment factors of critical stresses and deflections in a concrete slab are developed to illustrate their possible applications. The ultimate goal of this study is to bridge the gap among various FEM idealizations and closed-form solutions in order to develop a new mechanistic-based design and structural evaluation (backcalculation) procedure using the results of 3-D FEM analysis.

KEY WORDS:

Concrete (Rigid) Pavement, Stress Analysis, Pavement Backcalculation, Finite Element Model (FEM), Dimensional Analysis, Predictive Model, Projection Pursuit Regression.