Stress Analysis of Jointed Concrete Pavements

Recently, Portland cement concrete has gradually been recognized as an alternative pavement material in our highway pavement community due to its high rigidity and superior bearing capability as compared to asphalt concrete. The ultimate goal of this thesis research is to develop a new concrete pavement design procedure suitable for Taiwan's special climatic characteristics and dramatically increasing traffic loadings. Since analyzing the structural responses of pavements under a variety of loading conditions is the most crucial component when developing a mechanistic-based design procedure, this study mainly focuses on the stress analysis of jointed concrete pavements.

The ILLI-SLAB finite element (F.E.) program was used to analyze the critical bending stresses of concrete pavements under various critical loading (edge, interior, and corner) and thermal curling conditions. Based on the principles of dimensional analysis, the dominating mechanistic variables were carefully identified and verified. The resulting ILLI-SLAB stresses were compared to theoretical Westergaard solutions to develop adjustment (multiplication) factors. A new regression technique (Projection Pursuit Regression) was utilized to develop prediction models to account for these theoretical differences and to instantly estimate the critical bending stresses of a jointed concrete pavement.

The scope of this study includes:

1. To analyze the corner stress of a finite slab subjected to the individual and combination effects of a single wheel load and a linear temperature differential, and also to develop prediction models for corner stresses.
2. To expand the findings to different gear configurations, a widened outer lane, a tied concrete shoulder, and a second bonded or unbonded layer. To investigate the structural response (stress) of each case located at the slab interior, edge, and corner. Prediction models for the critical bending stresses were also developed.

The research findings can be practically used for various design and analysis of jointed concrete pavements based on theoretical considerations. Not only can the use of these stress prediction models avoid the possibility of obtaining incorrect results due to the improper use of the F.E. model, but it can also reduce the complicated computation time significantly. Furthermore, the critical bending stresses can be conveniently, accurately, and the best of all --- instantly calculated through the use of these stress prediction models. The research findings can be used as a part of any mechanistic-based design procedure for jointed concrete pavements as well.