ABSTRACT

Asgari, Alireza, Ph.D., Purdue University, December 2003. Evaluation of Concrete Pavement Service Life Using 3d Nonlinear Finite Elemnet Analysis And Nonlinear Fatigue Damage Model. Major Professor: Elisa Sotelino.

Current design procedures for concrete pavements do not account for several factors can influence their service life. In this work, these factors are investigated and the findings are integrated into a procedure for better predicting long-term performance of concrete pavements. To achieve this, sophisticated finite element techniques are employed and parametric studies are performed. The findings are then integrated into a nonlinear procedure for damage accumulation.

In the development of a comprehensive 3D Finite Element (FE) model several issues are studied including geometry of the model, mesh refinement, element selection, interaction between pavement components, and loading simulation. The developed model is then used in a number of parametric studies to investigate the effect of soil conditions, subbase and slab thickness, and slab length and stiffness on the developed stresses. Among other findings, it is established that for a given slab length, increasing the slab thickness beyond a certain limit is not justifiable.

The developed FE model is also used to investigate the behavior of skewed concrete pavement slabs under several loading conditions. In particular, the crack patterns obtained from the FE analyses are compared to those observed in an actual skewed concrete pavement. It is found that the developed FE model is able to

successfully predict the cause and orientation of the failure of the studied pavement section.

An investigation of various existing fatigue equations is also carried out and a software tool is developed to perform both linear and nonlinear damage accumulation calculations. A case study of an actual pavement section on Interstate 70, which has failed prematurely, is created using the previously developed finite element techniques. The resulting stresses from the finite element analyses under various loading conditions are used in the damage analysis of the pavement section. It is predicted that, irrespective of how the damage is accumulated; the case study pavement should have failed at an early age. Nonlinear damage accumulation predicted that the failure would occur at an earlier age than did linear damage accumulation, which is consistent with the observed behavior of the pavement section.