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Modeling of Dowel Jointed Rigid Airfield Pavement under Thermal Gradients and Dynamic Loads

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Abstract

Concrete pavements have been widely used for constructing runways, taxiways, and apron areas at airports. The aviation industry has responded to increased demand for air travel by developing longer, wider, and heavier aircraft with increasing numbers of wheels to support the aircraft while in ground operation. Many researchers developed their models based on the finite element method (FEM) for the analysis of jointed concrete pavement. Despite the notable improvement, important considerations were overlooked. These simplifications may affect the results of the developed models and make them unrealistic. Sensitivity studies were conducted in this study to investigate the effect of the loading parameters on the load transfer efficiency (LTE) indictors where concept of LTE is fundamental in airfield design procedures. Development of the three-dimensional computational model was guided by a set of technical requirements, all of which were met in the final model with using the finite element code ABAQUS (6.13). The effect of main gear loading magnitudes in different wheel configurations combined with positive and negative thermal gradients was investigated. The verification process was presented to increases the confidence in the model results. Understanding the response of rigid airfield pavement under such circumstances is important developing a new pavement design procedure, as well as implementing a suitable remedial measure for existing pavements. The results obtained that utilizing a dynamic load allows studying the fatigue cycles that pavement can be subjected under different wheel configurations. This allows examining the cycles of tension-compression due to wheel loading which may reduce the strength of the concrete and develop more fatigue damage than considering a static load imposed only in one direction, i.e. no stress reversal is involved. Moreover, the change in the thermal gradient from positive to negative significantly changed the slab curvature shape. The critical case in the stress was found in the combination of the wheel load and the positive thermal gradient.

Key words: Finite Element Modeling; Dynamic Loads; Thermal Gradients; Airfield; Jointed Concrete Pavement; Load Transfer Efficiency.

1. Introduction

The function of airport pavements is to provide a firm support to accommodate satisfactorily trafficking aircraft loads throughout its operational life. Pavement design procedures are developed to fulfill the above criteria (AC 150/5320-6E, 2009). Rigid pavements are complex structural systems that consist of numerous different concrete slabs where longitudinal and transverse joints are supplied between them, which may or may not include dowel bars. Dowel bars connect the slabs also transfer the applied loading across the joint mainly by shear. The concept of load transfer is straightforward: when the load is applied to a concrete slab, stresses and deflections are decreased if a fraction of this load is transmitted to an adjoining slab. Load transfer is essential to the FAA pavement design procedure. Load transfer is a complicated phenomenon that varies with concrete material, age, environmental conditions, as thermal gradient, shrinkage and moisture content, quality of construction, magnitude and configuration of the wheel load, and the way of jointing [1, 2]. In 1926, Westergaard developed a response model for rigid pavement of a slabs-on-grade applied by wheel loading and simulating the paving layer as a thin, infinite or semi-infinite plate based on a bed of springs [3]. It was suggested that a 25 % of the load transfers to the adjacent slab was an appropriate design value for

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