Generating a 3D model for evaluating the joint opening effects on load transfer efficiency in concrete pavements, using Abaqus

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Abstract
A 3D FE model is generated by ABAQUS for evaluating the effects of joint opening on load transfer efficiency in concrete pavements. The modeling method details are presented as well. For dowel and concrete modeling, C3D8R elements are used. The dowel-concrete interaction is simulated by hard contact model. The model consists of two concrete slab connected at transverse joint using steel dowels. Various amounts of joint opening are evaluated and after loading the slabs, load transfer efficiency is measured. The obtained results show that as the amount of joint opening increases due to slab contraction, the load transfer efficiency decreases.
Keywords: concrete pavement, load transfer efficiency, finite element, ABAQUS.

1. INTRODUCTION

A vast majority of the nation's highways and roads are made of jointed concrete pavement. Jointed plane concrete pavements (JPCP) are in wide use because of their durability, their ability to overcome subgrade weakness, and difficult climate conditions. JPCPs consist of Portland cement concrete slabs supported by one or several foundation layers. When a load is applied to a concrete slab, bending stresses are developed, and the load is transferred and distributed over the foundation layers. Joints are introduced in concrete pavements to control transverse and/or longitudinal cracking that occur due to restrained deformations caused by moisture and temperature variations in the slabs [1].

All plain concrete pavements should be constructed with closely spaced contraction joints. Dowels or aggregate interlocks may be used for load transfer across the joints. The practice of using dowels or not using dowels varies among the states. Dowels are used most frequently in the southern states, aggregate interlocks in the western and southwestern states, and both are used in other states. Depending on the type of aggregate, climate, and prior experience, joint spacing between 4.6 and 9.1 m have been used. However, as the joint spacing increases, the aggregate interlock decreases, and there is also an increased risk f cracking. Based on the results of a performance survey, Nussbaum and Lokken (1978) recommended maximum joint spacing of 6.1 m for doweled joints and 4.6 m for undoweled joints [2].

As a wheel load is applied near a transverse doweled joint in a PCC pavement, both loaded and unloaded slab deflect since a portion of the load applied to the loaded slab is transferred to the unloaded one through the dowel bars. As a result of the presence of load transfer devices, deflections and stresses in the loaded slabs may be significantly less than those induced in slab with free edge. The magnitude of reduction in stress and deflections by a joint depends on its load transfer efficiency. The term load transfer efficiency is used for expressing the ability of a joint to transmit part of the applied load on the loaded slab to the adjacent unloaded one [3].

Equation 1 is the most common measure for load transfer efficiency:

$$\mathrm{LTE} = \frac{d_u}{d_l} \qquad (1)$$