Effects of Slab Temperature Profiles on Use of Falling Weight Deflectometer Data to Monitor Joint Performance and Detect Voids

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The primary objective of this research effort is to determine if temperature gradients affect the ability to use falling weight deflectometer (FWD) testing to monitor pavement joint performance and detect voids under the corners of the slab. A field investigation was performed at the Minnesota Road Research System test facility to meet this objective. It was found that gradients can have an effect on the results of FWD testing for rigid pavements. Although the load transfer efficiencies measured for doweled slabs were not found to be affected by slab temperature or temperature gradients (even when poor joint performance was exhibited), load transfer efficiencies measured for the undoweled slabs were greatly influenced by the presence of a gradient. There even appears to be a higher correlation between the gradient present at the time of testing and the average temperature of the slab for the pavement designs and environmental conditions included in this study. Gradients present at the time of testing also affect the ability to detect voids beneath the slab. Large positive gradients produced negative void parameters (indicating that a void was not present), whereas large negative gradients produced large positive void parameters (indicating that a void was present). This study found that loss of support under the slab could be identified even when the joints were locked if gradients were not present. On the basis of these findings, it is important to determine the complete temperature profile throughout the depth of the slab at the time of testing so that this information can be considered when the deflection data are interpreted.

With the aging of the highway infrastructure, pavement engineers must find a reliable means to assess the condition of their pavement networks. The most commonly used method to assess the condition of a portland cement concrete (PCC) pavement is falling weight deflectometer (FWD) testing. FWD testing is commonly performed to characterize joint performance and to determine if voids are present under the corners of the slab. Pavement structural design parameters and climatic conditions both affect the pavement response to applied loads (including FWD test loads). Temperature factors must be considered from two different perspectives: uniform changes in temperature and gradients that exist through the thickness of the slab. The primary focus of this research effort is to determine if temperature gradients affect the ability to use FWD testing to monitor joint performance and detect voids under the corners of the slab. A field investigation was performed at the Minnesota Road Research System (MnROAD) test facility to meet this objective. A description of the study and a discussion of the analysis are provided following a brief historical review.

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HISTORICAL REVIEW

A historical review is provided on previous work pertaining to characterizing the effects of the slab temperature profile on use of FWD data to evaluate joint performance and detect voids under the slab. The method used to quantify joint performance and to detect voids throughout this study is established also.

Evaluation of Joint Efficiency

The joint performance for this study was quantified by dividing the deflection under the load plate and 152 mm (6 in.) away from the joint by the deflection measured 152 mm away from the joint on the unloaded side (see Equation 1). The load transfer efficiency (LTE) can be corrected for slab bending by using deflection data collected at midpanel. The LTE is multiplied by the deflection measured under the load at midpanel divided by the deflection 305 mm (12 in.) from the center of the applied load [see Equations 2 and 3 (*1*)]. The correction factor accounts for the fact that deflections are being measured 152 mm away from the joint and not directly at the joint. Khazanovich and Gotlif found the effects of bending to be minimal except in the case of very low slab stiffness [radius of relative stiffness less than 750 mm (30 in.)] (*2*). The radius of relative stiffness ranged between 145 cm and 81 cm (57 in. and 32 in.) for this study. Because of the large range in the radius of relative stiffness values for the test sections evaluated in this study, a correction factor for bending was used when the LTE was calculated (Equation 3).

$$\text{LTE} = \left[\frac{\delta_{ul}}{\delta_l}\right] \times 100\% \tag{1}$$

where

LTE = deflection LTE (%),
δ_{ul} = deflection on unloaded side 152 mm away from joint or crack when testing in wheelpath adjacent to joint, and
δ_l = deflection on loaded side 152 mm away from joint or crack when testing in wheelpath adjacent to joint.