SLAB CURLING MODEL VALIDATION

INTRODUCTION

This section of this technical memorandum will provide information about the background and objectives of the work undertaken to complete the calibration of the HIPERPAV curling model on one of the instrumented test slabs. The scope of the calibration analysis is outlined at the end of this section.

Background

The curling model adopted in HIPERPAV is based on the classic model developed by Westergaard, which was developed to predict the deflections, strains, and stresses in a rigid pavement due to variations of temperature. As the stresses that develop due to curling alone, cannot be measured directly, the calibration of the curling model will be based on estimating the curling deflections.

Objectives

The objective of this document is documentation of the validation for the curling model encompassed in HIPERPAV.

Curling Model

Many parameters of the curling stress equations are time dependent and have to be determined for each time step, including: Poisson's ratio, temperature differential over the slab depth, and modulus of elasticity.

Poisson's Ratio

Poisson's ratio for concrete has received relatively little attention in literature. In its hardened state, the Poisson's ratio normally varies between 0.15-0. Initially in HIPERPAV, a constant value of 0.15 for the Poisson's ratio is assumed. However, during the hydration period the concrete mix undergoes a gradual phase change; from plastic to a rigid consistency. At the plastic state, the fresh concrete mix is very compressible, and the Poisson's ratio has been found to be between 0.4 and 0.45. During the change in phase, the Poisson's ratio has to gradually change between its near-liquid value to that of hardened concrete.

Temperature Gradient through Slab Depth

It is well known that the temperature gradient changes continually throughout the day and this was also observed by the thermo-couple readouts.

A linear least-sum-of-the-square regression line is fitted through all the measured temperature readings. This provided an acceptable estimate of the average gradient. The average temperature gradient then was estimated by interpolating the top and bottom slab temperatures from the linear regression line. This is the method that was used during the calibration of this project.

Modulus of Elasticity

As the magnitude of corner curling is affected by the stiffness of the concrete at the time step under consideration, it is critical to obtain an accurate estimate of the modulus of elasticity of the pavement. The pavement is loaded by thermal stresses as soon as setting of the slab occurs and creep effects, therefore, influence the buildup of the modulus of elasticity significantly.

To estimate the modulus of elasticity for each of the field measured time steps, a curve was fit through the modulus of elasticity of the concrete pavement. Through the adiabatic testing procedure, the hydration shape and time parameters, were determined for the concrete mix design used during this project. Based on the hydration shape and time parameters obtained from the adiabatic testing, the pavement modulus of elasticity was very well predicted by the current HIPERPAV subroutine.

Presentation of Curling Displacements Results – Texas Slab 2 and 3

Based on the curling model encompassed in HIPERPAV and the various input parameters collected for each slab, the curling movement of the slab edge was predicted. Figures 1and 2 present the predicted edge deflection together with the measured corner deflection for slabs 2 and 3 in Texas. From these figures it can be concluded that the HIPERPAV curling model accurately predicted the deflection of slabs 2 and 3 in Texas. For other slab deflections, please refer to reference 1.

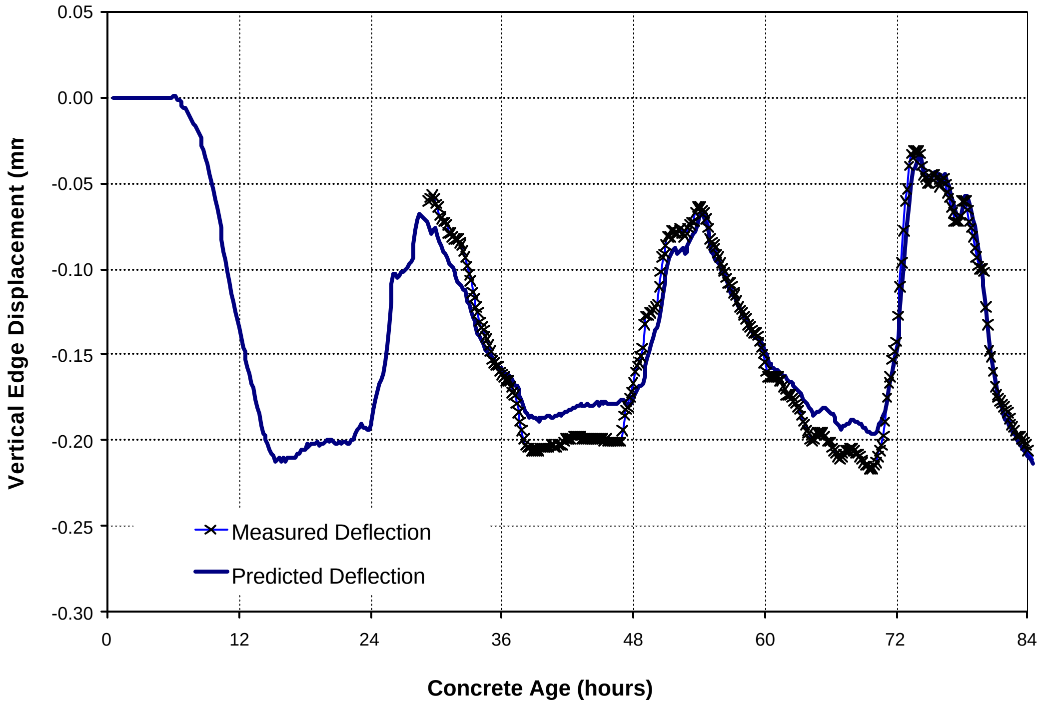

Figure 1. Predicted edge deflection as compared to the measured corner deflection (Texas: Slab 2).

Summary of the coefficient of determination (R2)

Table 1 contains all the R^2-values that were obtained. In most cases the vertical deflections were well predicted by the curling model contained in HIPERPAV and only in a few cases were low R^2-values obtained. In the cases where low R^2-values were obtained the measured deflections exhibited behavior that is probably not only caused by temperature gradients throughout the depth of the pavement.

Table 1. Allocation of calibration or validation for all the instrumented slabs .

	Modulus of Elasticity	Curling Model
Arizona		
Slab 1	**0.85**	**0.70**
Slab 3	**0.91**	**0.90**
Slab 6	**0.92**	**0.36**
Nebraska		
Slab 2	**0.94**	**-**
Minnesota		
Slab 1	**0.99**	**0.82**
Slab 4	**0.93**	**0.51**
North Carolina		
Slab 2	**0.98**	**0.93**
Slab 3	**0.97**	**0.95**
Texas		
Slab 2	**0.98**	**0.93**
Slab 3	**0.98**	**0.97**

REFERENCES

(1) Technical Memorandum No. 18, Modulus of Elasticity Validation