POISSION'S RATIO AND TEMPERATURE GRADIENT ADJUSTMENTS

INTRODUCTION

This section of this study will provide information about the background and objectives of the work undertaken to complete the calibration of Poission's ratio and temperature gradient.

Background

Poisson ratio for concrete has received relatively little attention in literature. In its hardened state, the Poisson ratio normally varies between 0.15-0.25. [1]

Poisson Ratio

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. The expression for the Poisson's ratio as a function of time is presented in equation 1 and the shape of the curve is based on the curve presented in reference 2. The shape of equation 1can be seen in figure 1. An alternate model for the shape of the Poisson ratio as a function of time (as proposed by GERMANN Instruments, Inc. is also plotted on figure 1.[3] The shape of the later curve, however, does not incorporate the sudden change in phase, which the concrete undergoes during setting and its transition from liquid to solid, as presented by equation 1. Therefore, equation 1 intuitively seems more reasonable.

$$v(t) = -0.05 \cdot \ln(t + 1.11) + 0.425 \leq 0.42 \qquad \text{………………} \ (\mathbf{1})$$

Where:

t = concrete age after setting (hours).

The effect of varying the Poisson's ratio with time on the estimated edge curling can be observed in figure 2. The increased Poisson ratio at early time, increases the edge deflections to some extent. From figure 2, it can be concluded that the change in Poisson's ratio significantly affects the predicted edge deflection, and the incorporation of this model in HIPERPAV is justified.

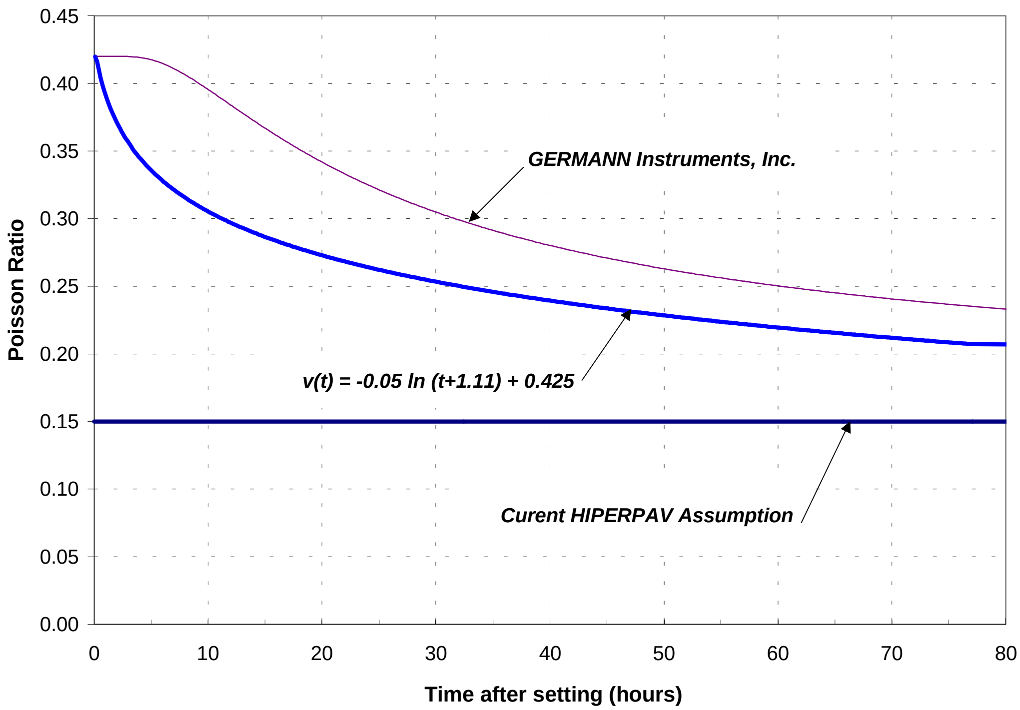

Figure 1. Poisson's ratio as a function of time.

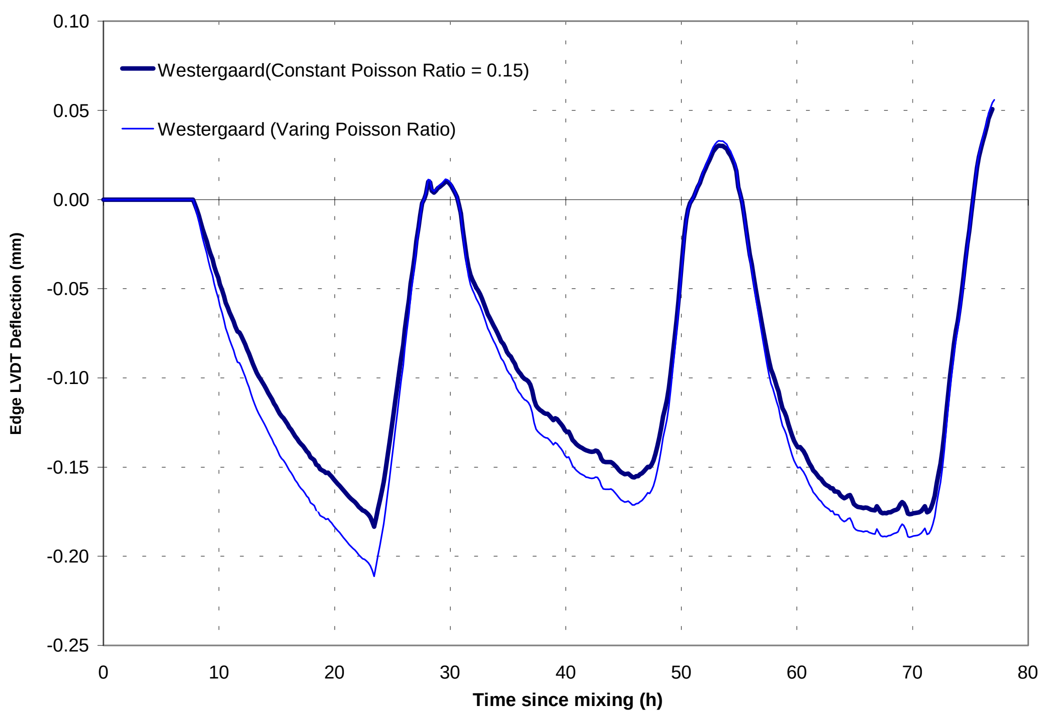

Figure 2. The effect of a time dependent Poisson's ratio on curling deflection predictions.

(*Note*: Creep effects has not been included at this stage of the analysis)

Temperature Gradient through Slab Depth

During the instrumentation of the site, 7 thermocouples, were placed at two locations. The readings from these thermo-couples were used to estimate the temperature differential between the bottom and the top of the pavement as required by equation 1. It is well known that the temperature gradient changes continually throughout the day and this was also observed by the thermo-couple readouts. The two darker lines in figure 3, provides an indication of the temparature gradient that exists during differnent times of the day.

Different approaches were taken to estimate the average top-to-bottom temperature gradient in the slab. The method that provide an acceptable estimate of the average gradient is one where a linear least-sum-of-the-square regression line is fitted through all the measured temperature readings. The average temperature gradient can then be 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.

For this instrumentation site, the top thermo-couple was also not installed at the top of the pavement, but rather 1.25 in from the top. After the linear regression was complete, the temperature at the top of the slab was estimated by extrapolating to the top of the slab. Figure 1 contains two examples of linear regressions performed in order to obtain an estimate of the average temperature gradient in the slab.

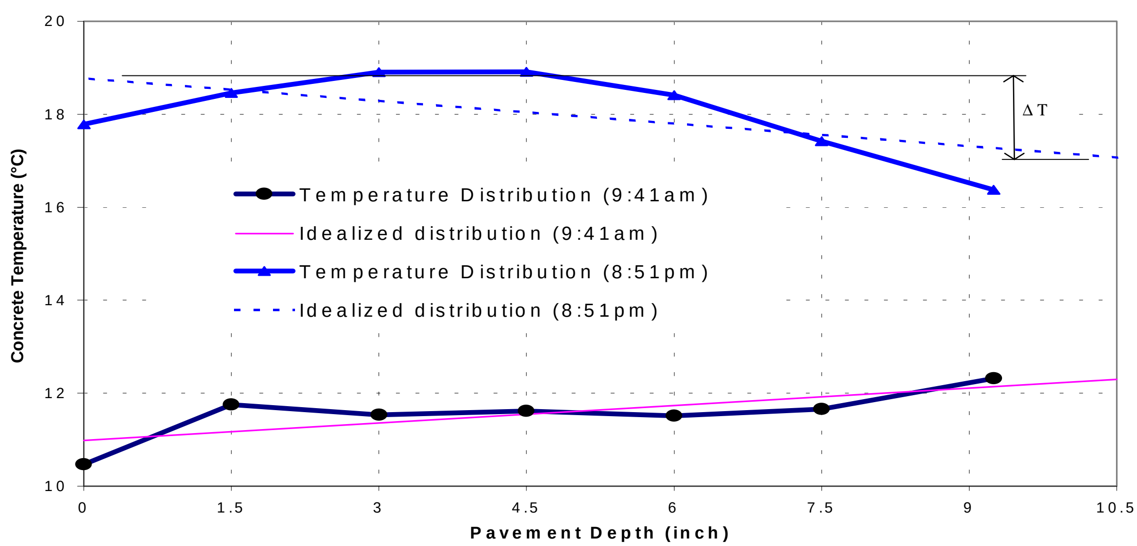

Figure 3. Practical idealization of the actual measured pavement temperatures.

The temperature gradient used in HIPERPAV is based on a datum of the temperature gradient at final set. The following equation, as used by HIPERPAV, was used to determine the temperature differential between the bottom and the top of the pavement for each time increment:

$$\Delta T = (T_{top,current} - T_{bottom,\ current}) - (T_{top,final\ set} - T_{bottom,\ final\ set})$$

REFERENCES

(1) Byfors, J., “Plain Concrete at Early Ages,” Swedish Cement and Concrete Research Institute,Stockholm, 1980.

(2) Paulini, P., and Gratl, N., “Stiffness Formation on Early Age Concrete”, Procedings of the International RILEM Symposium, Munich, E & FN Spon, Germany, October 1994.

(3) GERMANN Instruments, Inc., “4C-Temperature & Stress; Temperature and Stress simulation during hardening – User Manual,” GERMANN Instruments, Inc., Evanston, Illinois, 1998.