Joint opening Model for JCP Using Demec Readings

INTRODUCTION

Many components of the pavement (ie. material properties (CTE_c), dimensions and structural restraint (slab-base friction F_i)) have to be quantified to determine the stresses and strains in the concrete pavement. Using the Demec data, these parameters will be calibrated and validated.

OBJECTIVE

Calibrate the concrete pavement joint opening model using the experimental Demec readings recorded in TX, NC, AZ, NE and MN.

DEMEC DATA

After the concrete set and the joints were cut in the field, Demec points were epoxied to the concrete slab (figure 1).
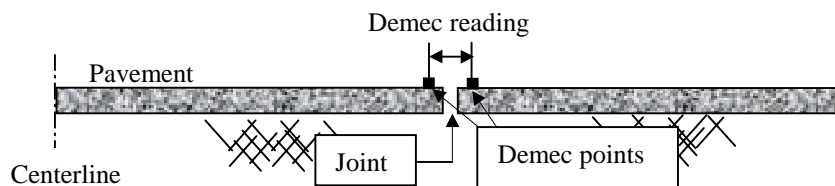

Figure 1. Schematic of Demec point placement on instrumented slabs.

Then for approximately the next 5 days, Demec readings were taken. These Demec readings are a measure of pavement movement and can show whether the pavement has cracked or not. Concrete temperature was recorded at the time the Demec measurements were taken. To analyze the Demec data, two temperature dependent scenarios are used. Case I and II show what happens when there is a crack and $+\Delta T$ or $-\Delta T$ (figures 2 and 3) and Case III and IV demonstrate what happens when there is no crack and $+\Delta T$ or $-\Delta T$ (figures 4 and 5).
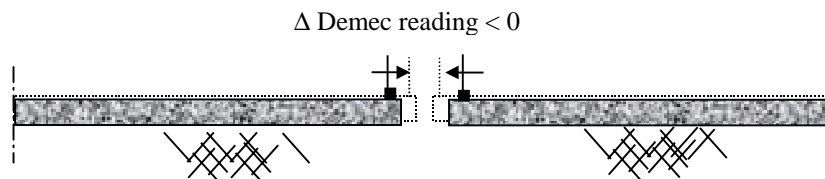

Figure 2. Case I of Demec data analysis for $+\Delta T$, Δ Demec reading < 0.
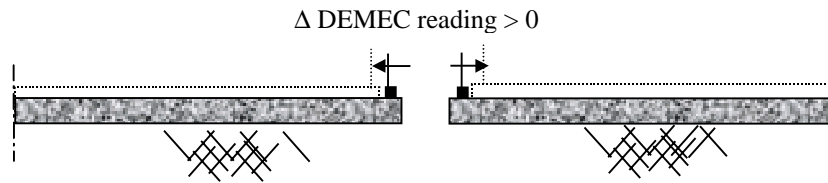**Case I:** $+\Delta T$ (ex. Temp = 10 $\rightarrow$ 15 °C) and crack at joint.

Figure 3. Case II of Demec data analysis (-ΔT and crack at the joint) Δ Demec reading > 0.
Case II: - ΔT (ex. Temp = 15 → 10 °C) and crack at joint.

In figure 2, there is a +ΔT, so the concrete is expanding from the centerline. This means that the change in Demec readings is less than zero; the crack is closing. The opposite happens when there is a negative change in temperature. The concrete shrinks towards the fixed center line, so the Demec reading increases. However, Case I and II are no longer valid there is no crack at the joint. The no crack cases (III and IV) are shown in figures 4 and 5.
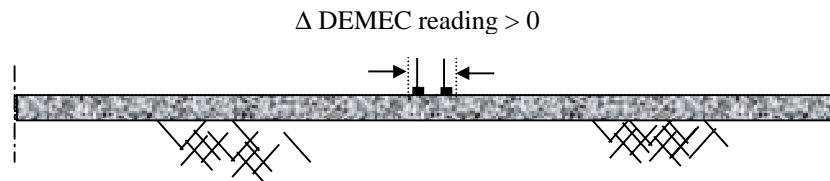

Figure 4. Case III of DEMEC data analysis (+ΔT and no crack at the joint) Δ Demec reading > 0.
Case III: +ΔT (ex. Temp = 10 → 15 °C) and no crack at joint.
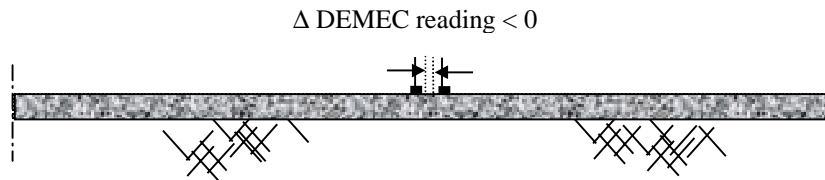

Figure 5. Case IV of Demec data analysis (-ΔT and no crack at the joint) Δ Demec reading < 0.
Case IV: -ΔT (ex. Temp = 15 → 10 °C) and no crack at joint.

When no crack forms at the sawed construction joint, a + ΔT causes the Δ Demec reading to increase (expansion), as depicted in figure 4. For a –ΔT, the Δ Demec reading is less than zero because the concrete is contracting (figure 5).

Theory Behind Demec Data Analysis

To analyze the Demec data, the JCP Stress Analysis spreadsheet created by the contractor was used. The theory behind the stress, strain and joint opening calculations is described reference 1.

Input Parameters to Theoretical Joint Opening, Stress and Strain Analysis

Input to the theoretical joint opening program that analyzes the stresses and strains in the pavement are discussed in details in reference 2.

The friction force between the pavement and the sub-base was measured experimentally in the field. The procedure used was described in detail in reference 3).

Arizona Demec Data

The comparisons between theoretical and experimental joint openings vs. Δ Temperature for Arizona slabs 1 is shown in figure 6. The comparison for other slabs are shown in reference 2.
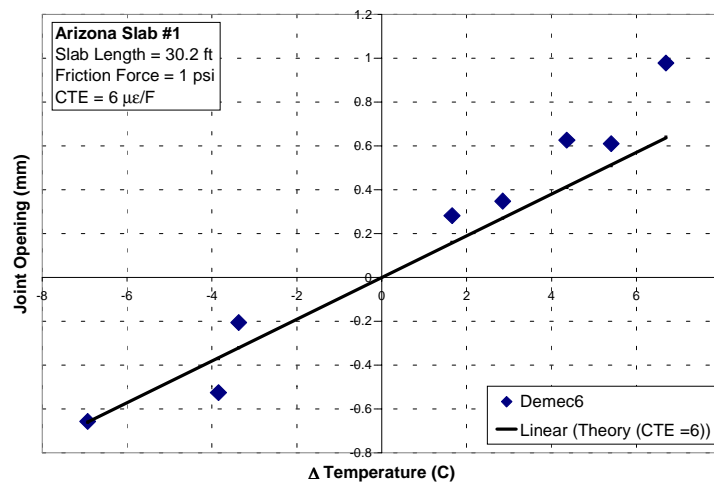

Figure 6. Comparison between theoretical and experimental joint opening for AZ slab #1 Demec 6.

This study proves that the theoretical JCP model to predict joint opening is valid and can be applied to the experimental data.

REFERENCES

(1)   One-Dimensional Model for Analysis of CRC Pavement Growth. Xin, D, D. G. Zollinger and R. W. James.

(2)   Technical Memorandum No. 20, Joint Opening Model for JCP Using Demec Readings.

(3)   Technical Memorandum No. 8, Field Instrumentation Details and Data Collected – Texas Construction Site.