Evaluation and Local Calibration of MEPDG EICM Model Using MnROAD Data

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Objectives

- Evaluate the modeling of thermal behavior in concrete and composite pavements by the Enhanced Integrated Climatic Model (EICM)
- Investigate benefits of thin AC overlays on thermal characteristics of PCC slabs using MnROAD Data
- Validate EICM predictions of thermal gradients through PCC slabs
- Investigate the effect of MEPDG user inputs for thermal conductivity of the PCC

MnROAD Data

Data Collection

- One year of hourly data from thermocouple "trees" in PCC and AC/PCC
- Only difference in pavements was the presence of AC layer

113	213	313	106	206
5"	5.5"	6"	2"64-34	2"64-34
			5"	5"
5"Cl 1 Stab Agg	5"Cl 1 Stab Agg	5"Cl 1 Stab Agg	6" Cl 1 Stab Agg	6" Cl 1 Stab Agg
5" Class 5	4.5" Class 5	4" Class 5	6" Class 5	6" Class 5
Clay	Clay	Clay	Clay	Clay
heavy turf	heavy turf	heavy turf	Mesabi 4.75 SuperP	Mesabi 4.75 SuperP
15'x12'	15'x12'	15'x12'	15'x12' 1" dowel	15'x12' no dowels
Oct 08	Oct 08	Oct 08		
Current	Current	Current	Oct 08 Current	Oct 08 Current

Figure 1. MnROAD Cells Used in Analysis

Data Filtering

- Subjected data to various tests to identify missing and insufficient data, sensor outliers, data subset outliers, etc.

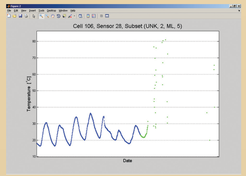

Figure 2. Example of Filtered Data

- Suspect data were flagged and excluded from analysis
- Screening allowed researchers to make comparisons with confidence

MnROAD Data Analysis – Thermal Gradients in PCC Layer

Effect of Albedo

- AC has higher surface temperature
- Greater overall temperature gradients in AC/PCC structure

Thermal Gradients in PCC Layer

- Larger thermal gradients in composite system does not equate to larger thermal gradient in PCC layer
- AC layer provides an insulating effect
- Gradients most pronounced in summer (see figure of 2-week detail)

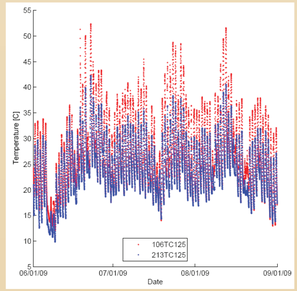

Figure 3. Surface Temperature – Albedo Effect

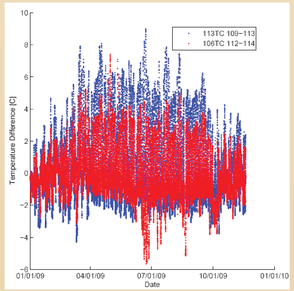

Figure 4. Thermal Gradients – Relative Depths

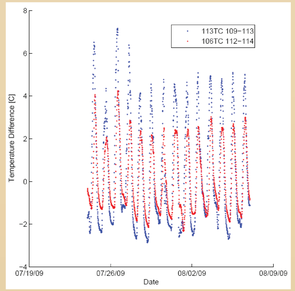

Figure 5. Thermal Gradients – Relative Depths

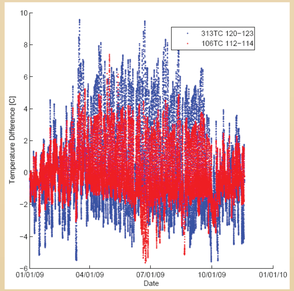

Figure 6. Thermal Gradients – Absolute Depths

Sensor Locations

- Thermocouple sensor depths were relative to 5" PCC slab
- Top sensors were 0.5" from top of PCC surface
- Bottom sensors were 1" above bottom of PCC layer
- Identical vertical distance of 3.5"
- A similar comparison (Fig. 6) was done using sensors at similar absolute depths to ensure that the difference in thermal gradients was due to AC layer, and not sensor positioning

Legend
Red – AC/PCC
Blue – PCC

MEPDG and EICM Sensitivity to Thermal Conductivity

- Measured and modeled data plotted on a cumulative frequency distribution chart
- Results indicated the EICM underestimated the temperature distributions in a PCC pavement with default k value, k = 1.25 BTU / hr-ft-°F
  - Unnecessarily high k value may contribute in part to underestimation
- k = 0.94 BTU / hr-ft-°F produced the closest match to measured values

AC	% Cracking
0.80	30.1
(default) 0.67	**20.0**
0.54	10.3

PCC	% Cracking
1.38	15.8
(default) 1.25	**20.0**
1.13	25.6
1.00	32.0
0.94	35.6
0.85	41.0

Figure 7. Effect of *k* on Transverse Cracking

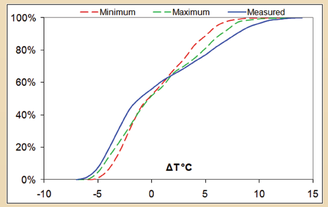

Figure 8a. July, k = 1.25 BTU / hr-ft-°F

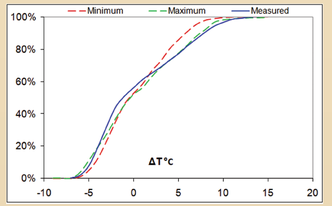

Figure 8b. July, k = 0.94 BTU / hr-ft -°F

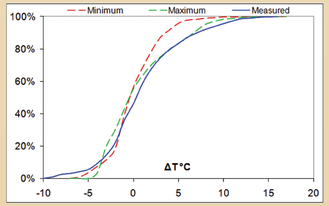

Figure 9a. March, k = 1.25 BTU / hr-ft-°F

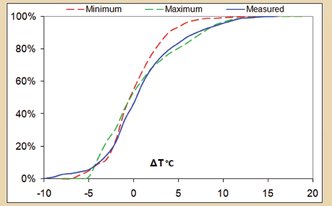

Figure 9b March, k = 0.94 BTU / hr-ft-°F

- Thermal conductivity (k-value) affects the temperature profile through a layer
- Input k-value influences performance predictions, especially in PCC slabs

EICM Predictions

- EICM qualitatively predicts thermal insulating effect
- Visible in cumulative frequency distributions comparing measured and modeled data
- Support the hypothesis that an AC layer significantly alters PCC layer temperature distributions

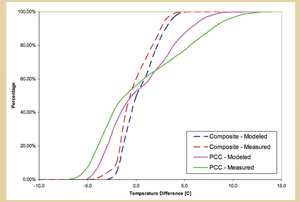

Figure 10. Thermal Gradients – Measured vs. Modeled

Conclusions

- AC surface produced markedly higher surface temperatures than PCC
- Despite higher surface temperatures, an AC overlay reduced thermal gradients in a PCC layer
- EICM simulations quantitatively reproduced the insulating effect, which may contribute to longevity and improved PCC performance
- Thermal property inputs can have significant effect on pavement performance predictions, and these inputs should be adjusted as part of a local calibration process
- EICM simulations produced temperature distributions smaller than the measured distributions when the MEPDG default k value was used (1.25 BTU / hr-ft-°F)
- Several k values were tested, the best agreement between measured and modeled data was k = 0.94 BTU / hr-ft-°F

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