Role of Zero Stress Temperature

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Outline

• What is Zero-Stress Temperature?
• Implication of Zero-Stress Temperature on Concrete Pavements.
• What effect does it have on Long-term performance of CRCP?
• Concluding Remarks.
Zero-Stress Temperature

- Setting Temperature
- Peak Curing Temperature
- Zero-Stress Temperature
Implications for Zero-Stress Temperature

• Early-Age Cracking: Higher ZST early age cracking tends to be at closer spacings – Poor Performance?
• % Steel: Higher ZST may also require higher % of steel to keep cracks tight
• MEPDG: Models used show that higher ZST result in wider cracks and higher number of punch-out distresses in CRCP.
• Texas CRCP ME Design Program: Minimal effect of ZST on punchouts in CRCP
• Long-Term Performance?
The diagram illustrates the relationship between concrete temperature, zero-stress temperature, and the percentage of steel required in construction. Larger ΔT’s, or temperature differences, result in higher tensile stress. Therefore, higher % steel may be needed to keep cracks tight.
MEPDG & Zero Stress Temp.

Crack Width Model:

\[ cw = \text{Max} \left( L \left( \varepsilon_{sh} + \alpha_{PCC} \Delta T \right) \left( \frac{c_2 f_\sigma}{E_{PCC}} \right) \right) 10000 \cdot \text{CC}, 0.001 \]

Crack Spacing

Punch-out Prediction
Past and Current Recommendations From Research

• Control Curing/Peak Temperature
  – Max Fresh Concrete Temperature
  – Placement Time
    • Afternoon vs. Morning
  – Pre-cooling – Lower Fresh Concrete Temperature
    • Chilled Water or Aggregates
    • Ice
    • Liquid Nitrogen

– Use of SCM’s
  • Use Class F Fly Ash between April – October

– Use of Set Retarding Admixtures
Long-Term Performance

• Crack Spacing and Width
• Distresses: Punchouts, Spalling, etc.
• Repairs
Variations of Concrete Temperature placed at Different Times of Day
Figure 10.28: Crack width (mm) vs. Time (Kohler, 2005)
Load Transfer Efficiency

Figure 29. Average load transfer efficiency at cracks versus crack spacing.
Long-Term Performance

Pavement Sections with Wide Crack Widths

Spalling Issues on pavements with SRG
Pavement Distress

- Large Surface Defects: 47%
- True Punchout: 14%
- Construction Joint: 21%
- Repair Joints: 18%

- Result of high CoTE Aggregates and finishing issues
- Result of inadequate joint repair methods
- Result of poor methods for joint construction
- Punchouts are generally result of edge pumping and loss of support

No Link to Zero-Stress Temperature
Concluding Remarks

• No strong correlations with Zero-Stress Temp and Long-term Performance.
• Small Crack Spacings and Large Crack Widths not linked to Pavement Performance.
• Other factors seem to have larger effect on long-term performance (i.e. CTE of Aggregate, Joint Construction Methods, etc.).
• Specifications geared to lowering Zero-Stress Temp not necessary.
Concluding Remarks

• Still need to use good concreting and construction practices to ensure long-term durability.
  – Low cementitious content mix designs
    • Reduced shrinkage
    • Lower peak curing temperature
  – Use of SCM’s (Class F and C fly ash, slag)
    • Lower Permeability
    • Lower Peak Curing Temperature
  – Optimized Graded Aggregate Mix Designs
    • Reduced Cement Content
    • Lower Shrinkage
    • Lower Peak Curing Temperature
  – Hot and Cold Weather Placement Techniques
  – Joint Construction Methods
  – Proper Curing Techniques
    • Timing of Application
    • Pavement Needs to be White
Questions?