Using HIPERPAV to Monitor Uncontrolled Cracking Risk

Airport Pavement Design and Construction Workshop
October 23, 2019

By Sabrina I. Garber
High PERformance Concrete PAVing

- FHWA-sponsored software
- Systems Approach simulation
  - Environment,
  - Materials,
  - Pavement Design, and
  - Construction Factors
- A quality control tool for everyone
What does HIPERPAV do?

The first 72 hours are critical!

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**Scenario #1**
Cracking should not occur

**Scenario #2**
Cracking may occur
When should you use it?

- **Preconstruction**
  - Plan the design and alternatives

- **Construction**
  - Plan for the right construction methods

- **Post Construction**
  - Identify if there was an increased risk
How does it apply to airport paving?

- **P-501 Temperature Requirements**
  - 501-4.7 c. Temperature management program
    - Prior to the start of paving operation for each day of paving, the **Contractor shall provide the Engineer** with a **Temperature Management Program** for the concrete to be placed to assure that uncontrolled cracking is avoided.
      1) Anticipated tensile strains in the fresh concrete as related to heating and cooling of the concrete material.
      2) Anticipated weather conditions such as ambient temperatures, wind velocity, and relative humidity; and anticipated evaporation rate using Figure 11-8, PCA, Design and Control of Concrete Mixtures.
      3) Anticipated timing of initial sawing of joint.
      4) Anticipated number and type of saws to be used.
Factors affecting PCC Temperature

- Heat Conduction to/from the subbase
- Solar Radiation
- Overcast Conditions
- Irradiation
- Convection
- Heat of Hydration
How does HIPERPAV work?

• In the past, many individual models have been developed to address pavement behavior.

• HIPERPAV uses a **Systems Approach** to unify all the models into one useful tool.

• The **Systems Approach** integrates:
  – Design parameters
  – Material properties
  – Environmental conditions
  – Construction activities
Axial + Curling + Shrinkage = Total

Systems Approach
Critical Stresses

- Tension
- Compression

"Critical Stress"
What does HIPERPAV look like?
How do you use HIPERPAV?
How do you use HIPERPAV?
How do you use HIPERPAV?
How do you use HIPERPAV?
How do you use HIPERPAV?
Building Strategies

Advanced View

Simplified View
Geometry

Reliability Level (%): 90

Geometry
- New Slab Thickness: 10 inches
- New Slab Width: 12 ft
- Transverse Joint Spacing: 15 ft

Slab Support
- Base Material: Asphalt Concrete Subbase (Rough)
- Subbase Thickness: 6 inches
Cement Type: Type I
Aggregate Type: Siliceous Gravel
Admixtures (ASTM C494 Type): None
Fly Ash Class: Class F (CaO ≤ 7%)

Water: 215
Cement (Type I): 479
Fly Ash: 102
GGBF Slag: 0
Silica Fume: 0
Total: 4000

Water to Cement Ratio is 0.45
Water to Cementitious Ratio is 0.37

PCC 28-Day Strength
Strength Type: Splitting Tensile
28-Day Strength: 520 psi
Building Strategies

Cement Type: Type I
Aggregate Type: Siliceous Gravel
Admixtures (ASTM C494 Type): None
Fly Ash Class: Class F (CaO ≤ 7%)

Batch Proportions

<table>
<thead>
<tr>
<th>Constituent</th>
<th>lb/yd³</th>
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<tbody>
<tr>
<td>Coarse Aggregate</td>
<td>1854</td>
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<tr>
<td>Fine Aggregate</td>
<td>1349</td>
</tr>
<tr>
<td>Water</td>
<td>216</td>
</tr>
<tr>
<td>Cement (Type I)</td>
<td>479</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>102</td>
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<tr>
<td>GGBF Slag</td>
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PCC 28-Day Strength

Strength Type: Splitting Tensile
28-Day Strength: 520 psi
Initial Conditions

- Initial PCC Mix Temperature: 75 °F
- Initial Support Layer Temperature: 70 °F
- Base is moist
- Base is dry

Strength for Opening to Traffic:
- Display strength for opening to traffic?
  - Strength: 350 psi
  - Strength Type: Splitting Tensile
## Early-Age Construction

### Initial Conditions
- Initial PCC Mix Temperature: 75 °F
- Initial Support Layer Temperature: 70 °F

### Curing Method
- **Curing Method:** Single Coat Liquid Curing Compound
- **Age Curing Applied:** 0 hours
- **Age Curing Removed:** 72 hours

- **No Sawing**
  - Skip Sawcutting every: 2nd joint
  - Sawing Age of Skipped Joints: 24 hours

- **Strength for Opening to Traffic**
  - **Display strength for opening to traffic?**
    - Strength: 350 psi
    - Strength Type: Splitting Tensile
Sawcutting (Skipping sawcutting is not recommended)

- Saw at Optimum Time (Early-Entry "Green" Sawcutting)
- User-Defined Sawing Age: 7 hours
- No Sawing
- Skip Sawcutting every: 2nd joint
- Sawing Age of Skipped Joints: 24 hours

Strength Type: Splitting Tensile
Early-Age Construction

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Strength for Opening to Traffic
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Cracking Risk

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<tr>
<th>Slab Width</th>
<th>Stress to Strength Ratio (%)</th>
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<tbody>
<tr>
<td>12 ft</td>
<td>40</td>
</tr>
<tr>
<td>15 ft</td>
<td>50</td>
</tr>
<tr>
<td>18 ft</td>
<td>60</td>
</tr>
<tr>
<td>21 ft</td>
<td>70</td>
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<td>24 ft</td>
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<td>27 ft</td>
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<td>36 ft</td>
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<td>39 ft</td>
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<tr>
<td>42 ft</td>
<td>100</td>
</tr>
<tr>
<td>45 ft</td>
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Types of analyses

• Evaluate affects of climatic conditions
• Evaluate joint spacing
• Evaluate different subbases
• Evaluate different mix designs
• Evaluate base temperatures, moisture conditions
• Evaluate curing methods
Estimated Climatic Conditions

Downloaded/Interpolated Climatic Conditions
Recap: What is HIPERPAV?

- High **PE**Rformance Concrete **PA**Ving

- FHWA-sponsored software

- Systems Approach simulation
  - Environment,
  - Materials,
  - Pavement Design, and
  - Construction Factors

- Another tool for quality control
How do I get HIPERPAV?

www.HIPERPAV.com

Or google HIPERPAV 3.3 for the latest version that includes the automatic climatic download feature