Use of HIPERPAV & Maturity Testing for Building Quality Concrete Pavements

Virginia Concrete Conference
Richmond, VA
March 8th, 2013

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What does **HIPERPAV** do?
- Compares early-age pavement stresses and strengths to determine if cracking is likely.

Why?
- To help minimize uncontrolled early-age cracking...
HIPERPAV uses a Systems Approach to unify several models into one tool that integrates:

- Design Parameters
- Material Properties
- Construction Activities
- Environmental Conditions
Environmental Influences

Overcast Conditions

Solar Radiation

Convection

Irradiation

Heat Conduction to/from the subbase

First 72 hours

HIPERPAV
Strength and Stress Comparison

Scenario #1

Scenario #2

Magnitude of Stress or Strength vs. Time since Construction

Strength

Critical Stress

Cracking
Analysis Screen
Risk Analysis

Warning! Stress begins to exceed strength at 6 AM.
Baseline Case

- I-35 bypass, Austin TX
- September 2003, mid-day paving
- 10” JPCP with 15’ joint spacing
- Unbound aggregate base
- Concrete Mix:
  - Type I with 18% F-Ash
  - 350psi tensile opening strength
- Early-entry saw with curing compound
Baseline Case
Baseline Case
Well, that’s nice…

But, what if the weather is not “ideal”?
Cold Front
Cold Front
What Now?
Maybe some Polyethylene Sheeting or Blankets?
Cold Front
Cold Front + Blankets
What happens if I have to open to traffic in 36 Hours?
Cold Front + Blankets
Cold Front + 36 hours of Blankets

(Blankets removed at 36 hours)
Is there another way?

What about a Fast-Track Mix?
Cold Front + Fast Track Mix
ROUTE 58 – Unbonded Section
What are typical uses?

- Predict responses in cold and hot weather paving
- Predict potential strength gain for tight closures and opening to traffic
- Determine optimal mix characteristics
- Determine effects of design parameters on stress development
  - Joint spacing, thickness, base type
- Forensic studies – crack development
State DOT Implementation

Ohio DOT
- Since 2005 included in specifications

Wisconsin DOT
- Since 2007 included in special provisions for numerous projects
- Customized software for WI materials

CALTRANS
- Include in updated specifications for 2010

Delaware DOT
- Since 2011 included in specifications
Maturity Method
What is the maturity method?
- Non destructive means to estimate in-place strength of concrete
- Strength is evaluated as a function of TIME and TEMPERATURE
- For a given mixture, concretes of the same maturity have the same strength
The concept of maturity is actually pretty simple.

More heat = More strength.

More time = More strength.

The Maturity Method simply combines both time and temperature into an index value.
Calculate the **Maturity Index** by either:

- **Nurse-Saul function**
  Maturity index - temperature-time factor (TTF)
  Simple math

- **Arrhenius equation**
  Maturity index - equivalent age \( (t_e) \)
  More complex math
Nurse-Saul function

Maturity is a function of the product of curing time and concrete temperature.

\[ M = \sum_{0}^{t} (T_c - T_o) \cdot \Delta t \]

Saul also introduced the “Maturity Rule”

Samples of the same mix at the same maturity has approximately the same strength whatever combination of time and temperature go to make up that maturity.
Maturity Method

Nurse-Saul Function

\[ M = \sum_{o}^{t} (T-T_o) \Delta t \]
Nurse-Saul Function (cont.)

What does this mean?

When $M_{\text{field}} = M_{\text{lab}}$, the two concretes are of the same strength...
Two Step Process:

1. Develop strength-maturity curve in the laboratory (this can be done in field too)
2. Measure time & temperature (maturity) in the field and estimate strength
1. Relate strength to maturity
   - Cast cylinders in lab, and instrument them
   - Break cylinders, and record maturity

   ➢ Build the “maturity curve”
1. Relate strength to maturity (cont.)

- Determine maturity value that corresponds with strength of interest…
2. Measure in-place maturity to estimate strength

- As soon as possible after concrete placement, instrument in-place concrete.
2. Measure in-place maturity to estimate strength

- Monitor maturity until it reaches the value corresponding to the strength of interest

- For critical operations, verify in-place strength (NDT, companion, etc)
Maturity Method

When the maturity reaches this value, we can reliably say that the in-place strength is 3000psi (ASTM C 1074)
Field Maturity
Maturity of the Pavement

Maturity of Standard Cured Cylinder

Time Savings

ROUTE 58
 Availability of technology?
 Wide variety of meters available
 All record temperature and convert to a maturity value
Case Study: North Central Expressway (US75), Dallas, TX

- $113M reconstruction
- Maturity implementation reduced pavement opening times from 7 to 4 days
- Maturity reduced bridge opening time from 21 to 8 days
- Traffic detouring time reduced by 60%
- Project opened almost one year ahead of schedule
Summary

- Maturity has been around for ½ century
- Simple procedure to estimate *in-place* strength
  - Temperature
  - Time
- Great tool for:
  - Early opening to traffic - *speed* construction
  - Reducing volume and *cost* of QC testing
  - *Safe* removal of shoring and/or protection
Summary

- Primary cautions:
  - Mixture variability
  - Moist curing (permit hydration)
  - Confirmation strength testing
Questions

Download software at:
www.hiperpav.com

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