Innovations in Concrete Pavement; Activities at CP Tech Center

Hamed Sadati, PhD
Why Do We Exist?

The purpose of the center is to unite agencies, industry and researchers to advance concrete pavement technology.
What Do We Do?

• We research
• We solve problems
• We write
• We teach
• We demonstrate

• In all things concrete pavements
Staff

- Dr. Peter Taylor PE  Director
- Steve Tritsch PE  Assoc. Director
- Gordon Smith PE  Assoc. Director
- John Adam  Program manager
- Dr. Hamed Sadati  Engineer
- Dr. Yifeng Ling  Post Doc
- Jeremy McIntyre  Lab
- Sharon Prochnow  Contracts Manager
- Denise Wagner  Admin
- Numerous consultants
Funding Model

• Operational fund (~15% of 2018 budget)
  - Sponsorships from industry and IA DOT

• Competitively won contracts (remainder)
  - FHWA Cooperative agreement
  - FHWA IDIQs
  - NCHRP
  - State DOT research
  - Transportation pooled funds
Who Is Our Audience?

- State and local agencies through NC2
- Industry through the trade associations

32 States
+ IL Tollway & MB
Engagement

• American Concrete Institute
• AASHTO
• Transportation Research Board
• Cement Sustainability Initiative (CSI)
• ASTM
Training

- Overlays
- Preservation
- Performance engineered mixtures
- Real time smoothness
- Internal curing
- Asset management

29 States + Ontario + Manitoba + TRB & NRMCA/PCA/ACPA
Research

- Internal curing
- Performance engineered mixtures
- Penetrating sealants
- Salt scaling
- Air void systems
- Fiber reinforced overlays
- Joint spacing

- Vibration?
- Sliver spalls in airfields?
Performance Engineered Mixtures

- What do we want?
- How do we measure it?
- Limits?
- Specification language
- Payment issues
- Education
- Implementation
Training and Testing

- **Super Air Meter (SAM)**
  - Air void characteristics of concrete

- **Surface Resistivity**
  - Rapid permeability measurement

- **Box Test**

- **V-Kelly**
  - Measurement of workability

- **Calorimetry**
- **Maturity**
- **Sorptivity**
- **Strength Development**
- **Oxychloride formation, microwave w/c...**
Mobile Labs: FHWA or CP Tech
Internal Curing in Pavements

Data Credit:

Dr. Peter C. Taylor
Dr. Halil Ceylan
Dr. Yang Zhang
Amin Daghighi, PhD Student
Acknowledgement

• Iowa DOT and IHRB
• County Engineers
  • Lee Bjerke
  • Jacob Thorius
• Lightweight Fine Aggregate donated by Buildex
• Contractors: Strebb, Croell
Purpose of the Work

- To perform a full-scale field demonstration of internal curing in pavements
- Demonstrate constructability
- Assess benefits in the field
  - Cracking risk
  - Ride
- Monitor performance
Internal Curing

Why?

- To maintain uniformly distributed moisture content
- Reduce gradients
- Promote hydration

Internal Curing

Curling and warping

- Lower temperature gradient and CTE
- Lower moisture gradient
- Lower MoE

Maximum vertical movement, inch

<table>
<thead>
<tr>
<th></th>
<th>CC</th>
<th>IC</th>
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<tbody>
<tr>
<td>Panel length 8ft</td>
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<td>0.1</td>
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<tr>
<td>Panel length 12 ft</td>
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<td>0.1</td>
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This Project

• Build two sections ¼ mile long in
  • Washington Co
  • Winneshiek Co
• Only change to mixtures was replace 35% by volume of fine aggregate with LWFA from MO
• LWFA had to be soaked for 48 hours then drain for 12
## Mixture Proportions

Washington Co, pcy

<table>
<thead>
<tr>
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<th>Control</th>
<th>Test</th>
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<tbody>
<tr>
<td>Cement</td>
<td>457</td>
<td>457</td>
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<tr>
<td>Fly ash</td>
<td>114</td>
<td>114</td>
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<tr>
<td>Coarse</td>
<td>1672</td>
<td>1672</td>
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<tr>
<td>Int.</td>
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<td>0</td>
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<tr>
<td>Fine</td>
<td>1376</td>
<td>897</td>
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<tr>
<td>LWFA</td>
<td>0</td>
<td>309</td>
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<tr>
<td>H2O</td>
<td>246</td>
<td>246</td>
</tr>
<tr>
<td>Air</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
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<td>3696</td>
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# Lab Data Washington

<table>
<thead>
<tr>
<th>Test</th>
<th>Age (day)</th>
<th>CC</th>
<th>IC</th>
<th>Average</th>
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<tbody>
<tr>
<td><strong>Compressive Strength (psi)</strong></td>
<td>7</td>
<td>4200</td>
<td>4810</td>
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<td></td>
<td>28</td>
<td>5470</td>
<td>6015</td>
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<td></td>
<td>90</td>
<td>6230</td>
<td>7100</td>
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<tr>
<td><strong>Splitting Tensile Strength (psi)</strong></td>
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<td>320</td>
<td>320</td>
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<tr>
<td></td>
<td>28</td>
<td>325</td>
<td>380</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>315</td>
<td>440</td>
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<tr>
<td><strong>Modulus of Elasticity (psi)</strong></td>
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<td>4100</td>
<td>4410</td>
<td></td>
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<tr>
<td></td>
<td>28</td>
<td>4600</td>
<td>5090</td>
<td></td>
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<tr>
<td></td>
<td>90</td>
<td>5530</td>
<td>5460</td>
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<tr>
<td><strong>Surface Resistivity (kΩ.cm)</strong></td>
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<td>10.6</td>
<td>7.6</td>
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<tr>
<td></td>
<td>28</td>
<td>12</td>
<td>10.5</td>
<td></td>
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<tr>
<td></td>
<td>90</td>
<td>25.7</td>
<td>24.1</td>
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Maturity Washington

\[ CS_{CC} = 1871 \times \ln(\text{Maturity Index}) - 9752 \]
\[ R^2 = 0.990 \]

\[ CS_{ICC} = 2040 \times \ln(\text{Maturity Index}) - 10959 \]
\[ R^2 = 0.998 \]
Sensor Instrumentation Plan

- At each site, two slabs were instrumented
- Each slab had 2 sensor trees
Sensors

- Meter ECH2O 5TE moisture sensors
- Omega HSTC-TT-20S thermocouple
Washington County Control Site

Data acquisition system
- Thermocouples
- Moisture sensors

Traffic direction

Existing pavement

6 in. PCC overlay
- 1 in.
- 2.5 in.
- 4 in.
- 5.5 in.

Cross-section view for each sensor tree

Pavement section view

6 ft.
Widened lane

2 ft.
Shoulder

10 ft.

5 ft.

13 ft.

1 ft.

A

B

C

D

Traffic direction

12 ft.
Washington County
Constructability

• Storing and moisture conditioning the LWFA was not trivial
• IC mixture observed to be a little more “pastey”
• Otherwise no noticeable issues
Temperature Data, Washington County

Comparing IC and NC Temp

- IC-O-1
- NC-O-1
Temperature Data, Washington County

Comparing the IC and NC Temp

- IC-O-5.5
- NC-O-5.5

Temperature (C)

6/27/2018 0:00 7/1/2018 0:00 7/5/2018 0:00 7/9/2018 0:00

28
Temperature Data, Washington County

• The deeper sensors in the pavement, show 2 to 3 Celsius Degrees higher temperature for IC than NC in the first two weeks

• After the second week, the IC section shows equal temperature with the NC section
Moisture Data, Washington County

Control Section Site 5TE Moisture

Internal Curing Section Site 5TE Moisture
Costs

- LWFA ~$3.00 / cy
- Delivery ~$8.00 / cy
- Handling ~$4.00 / cy

- Life cycle benefits still being assessed – previous projects have been positive
Where Next?

- Monitor warping through the seasons
- Super absorbent polymer (SAP)
Warping

• Using LIDAR

• Measure when it is
  • Hot and cold
  • Wet and dry
Warping
Guide Specification for Internally Curing Concrete
November 2017

Sponsored by
Federal Highway Administration
Transportation Pooled Fund TPF-5(286)
(Part of InTrans Project 13-482)
Publications
Future Publications

- Cement Stabilized Materials (PCA)
- Cellular Concrete (PCA)
- Concrete Trails (NRMCA)
- IMCP
Summary

• We believe that our model is effective
  – A small core of engaged professionals
  – A broad network of expert consultants
  – Collaboration with many organizations

• We aim to be
  – A resource to anyone building and owning concrete pavements
  – A clearing house of expertise
  – The go-to name for people with questions
Thank you for helping us make a difference