Acknowledgments

• 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
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>
<th></th>
<th>Control</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cement</strong></td>
<td>457</td>
<td>457</td>
</tr>
<tr>
<td><strong>Fly ash</strong></td>
<td>114</td>
<td>114</td>
</tr>
<tr>
<td><strong>Coarse</strong></td>
<td>1672</td>
<td>1672</td>
</tr>
<tr>
<td><strong>Int.</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Fine</strong></td>
<td>1376</td>
<td>897</td>
</tr>
<tr>
<td><strong>LWFA</strong></td>
<td>0</td>
<td>309</td>
</tr>
<tr>
<td><strong>H2O</strong></td>
<td>246</td>
<td>246</td>
</tr>
<tr>
<td><strong>Air</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3865</td>
<td>3696</td>
</tr>
<tr>
<td>Test</td>
<td>Age (day)</td>
<td>CC</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------</td>
<td>--------</td>
</tr>
<tr>
<td>Compressive Strength (psi)</td>
<td>7</td>
<td>4200</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>5470</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>6230</td>
</tr>
<tr>
<td>Splitting Tensile Strength (psi)</td>
<td>7</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>325</td>
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<tr>
<td></td>
<td>90</td>
<td>315</td>
</tr>
<tr>
<td>Modulus of Elasticity (psi)</td>
<td>7</td>
<td>4100</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>4600</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>5530</td>
</tr>
<tr>
<td>Surface Resistivity (kΩ.cm)</td>
<td>7</td>
<td>10.6</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>25.7</td>
</tr>
</tbody>
</table>
Maturity Washington

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

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

<table>
<thead>
<tr>
<th>Traffic direction</th>
<th>Existing pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 ft.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>10 ft.</td>
<td></td>
</tr>
<tr>
<td>5 ft.</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>D</td>
</tr>
<tr>
<td>13 ft.</td>
<td></td>
</tr>
<tr>
<td>6 ft.</td>
<td>Widened lane</td>
</tr>
<tr>
<td>2 ft.</td>
<td>Shoulder</td>
</tr>
</tbody>
</table>

#### Data acquisition system
- **Thermocouples**
- **Moisture sensors**

#### Pavement section view
- **6 in. PCC overlay**
  - 1 in.
  - 2.5 in.
  - 4 in.
  - 5.5 in.

#### Cross-section view for each sensor tree
Collecting Samples, Washington County
Sensor Installation, 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

Date
Temperature Data, Washington County

Comparing the IC and NC Temp

![Graph showing temperature data over time]
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
Washington County, Sept
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

Help?

• Guide Specification