FHWA Mobile Concrete Laboratory

US 58
Concrete Overlay
Open House
August 23, 2012
Mission

- **Tech Transfer to SHA’s**
  - Field demos on active projects
  - Equipment loan
  - Training of staff
  - Conferences and workshops

- **Focus currently on:**
  - Nondestructive/In-situ Tests
  - Long Life Pavements/Bridges
  - MEPDG / DARWin-ME
  - QA/QC
Technology

- Conventional QC Tests
- Nondestructive/In-situ Tests
- Durability Related Tests
MCL Testing on the Unbonded Overlay Section
MCL at the RTE 58 Plant Site

MCL’s Objectives

• Characterize the materials
• Showcase new technologies
• Level 1 materials inputs for DARWin-ME
• Data for potential use in a QA workshop on concrete paving
Testing at the Plant

<table>
<thead>
<tr>
<th>Thursday (N)</th>
<th>Friday (N)</th>
<th>Tuesday (D)</th>
<th>Thursday (D)</th>
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<tbody>
<tr>
<td>7/5/12</td>
<td>7/6/12</td>
<td>7/10/12</td>
<td>7/12/12</td>
</tr>
<tr>
<td>Production</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Sample 1</td>
<td>X</td>
<td>X</td>
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<td>Sample 2</td>
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- Slump, unit weight, air content and Temperature
- Calorimeter / Heat Signature
- Specimens for Coefficient of Thermal Expansion
- Specimens for Surface Resistivity Measurement
- Specimens for Rapid Chloride Permeability Testing
## Testing at the Plant

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<td>X *</td>
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<td>X</td>
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- Strength
- * Maturity
- * Darwin-ME
- * Flex vs. Comp
Testing at the Plant

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- Strength
- AVA Testing
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<tr>
<th></th>
<th>Friday</th>
<th>Sunday</th>
<th>Tuesday</th>
<th>Wednesday</th>
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<tbody>
<tr>
<td>HIPERPAV</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>MIT Scan T2</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Maturity</td>
<td>X, X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Fresh Concrete Properties – Slump

Slump, in

Sample ID

1-1 1-2 1-3 2-1 2-2 2-3 3-1 3-2 4-1

Slump, in

1/2 1 1 1/2 2 3 3 1/2 3 3 1/2 3 3 1/2 3 1/2 1 1/2 1/2 0

Slump, Average Slump, Max Slump

0 1/2 1 1 1/2 2 3 3 1/2 3 3 1/2 3 1/2 1 1/2 1/2 0
Slump Loss with Time
Fresh Concrete Properties – Unit Weight

![Graph showing unit weight data](image-url)

- **Unit Weight, pcf**
- **Mixture Design**
- **Lower Limit**
- **Upper Limit**

The graph displays the unit weight variation over different mixture design stages.
**Fresh Concrete Properties – Air Content**

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Air Content, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>5%</td>
</tr>
<tr>
<td>1-2</td>
<td>5%</td>
</tr>
<tr>
<td>1-3</td>
<td>5%</td>
</tr>
<tr>
<td>2-1</td>
<td>7%</td>
</tr>
<tr>
<td>2-2</td>
<td>7%</td>
</tr>
<tr>
<td>2-3</td>
<td>7%</td>
</tr>
<tr>
<td>3-1</td>
<td>9%</td>
</tr>
<tr>
<td>3-2</td>
<td>9%</td>
</tr>
<tr>
<td>4-1</td>
<td>9%</td>
</tr>
</tbody>
</table>
Unit Weight vs. Air Content

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Unit Weight, pcf</th>
<th>Air Content, %</th>
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</thead>
<tbody>
<tr>
<td>1-1</td>
<td>141</td>
<td>2</td>
</tr>
<tr>
<td>1-2</td>
<td>142</td>
<td>3</td>
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<tr>
<td>1-3</td>
<td>139</td>
<td>4</td>
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<tr>
<td>2-1</td>
<td>143</td>
<td>5</td>
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<td>2-2</td>
<td>140</td>
<td>6</td>
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<td>2-3</td>
<td>144</td>
<td>7</td>
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<td>3-1</td>
<td>138</td>
<td>8</td>
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<tr>
<td>3-2</td>
<td>145</td>
<td>2</td>
</tr>
<tr>
<td>4-1</td>
<td>143</td>
<td>3</td>
</tr>
</tbody>
</table>

The graph shows the relationship between unit weight (Unit Weight) and air content (Air Content) for different sample IDs.
Compressive Strengths

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>7 Day</th>
<th>28 Day</th>
<th>56 Day</th>
<th>28 Day Strength Requirement</th>
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</thead>
<tbody>
<tr>
<td>1-1</td>
<td>3500</td>
<td>5500</td>
<td></td>
<td>3000 PSI</td>
</tr>
<tr>
<td>2-1</td>
<td>3700</td>
<td>4800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-1</td>
<td>3600</td>
<td>5000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Heat Signature

- Optimize Mixture materials and proportions
- Identify potential adverse interactions
- Troubleshoot field problems
- Screen and QC Raw Materials
- Reduce overtime to perform set times
- Compare Competitive Materials
Calorimetry / Heat Signature
Laboratory Maturity
Maturity Curve

Maturity Curve - Standard Cured Cylinders

Compressive Strength, PSI

Maturity, °C-Hrs

Specimens Cast on 7/6/12

2000 °C-Hrs
Field Maturity
Field Maturity

Maturity of the Pavement

Maturity of Standard Cured Cylinder

Time Savings ~ 16 hrs

Field (7/6/12)
Field (7/7/12)
Lab (7/6/12)
Concrete Permeability Tests

RCPT

SR Meter

Concrete’s ability to resist chloride ion penetration
Surface Resistivity

Surface Resistivity, KOhm-cm

Sample ID

28 Days

Low

Moderate

High

1-1 1-2 1-3 2-1 2-2 2-3 3-1 3-2 4-1
What does HIPERPAV do?

Compares early-age pavement strengths and stresses to determine if cracking is likely...
HIPERPAV

7/6/12 – 11:40 p.m.

7/8/12 – 9:00 p.m.

7/10/12 – 6:50 a.m.
DARWin-ME Inputs

- Modulus of Elasticity
- Poissons Ratio
- Compressive Strength
- Flexural Strength
- Shrinkage Tests
- CTE

(7, 14, 28 and 90 days)
## Coefficient of Thermal Expansion

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Sample ID</th>
<th>Cast Date</th>
<th>Test Date</th>
<th>Age, Days</th>
<th>Microstrain/°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-1</td>
<td>7/5/2012</td>
<td>8/7/2012</td>
<td>33</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>2-1</td>
<td>7/6/2012</td>
<td>8/7/2012</td>
<td>32</td>
<td>4.9</td>
</tr>
<tr>
<td>3</td>
<td>3-1</td>
<td>7/10/2012</td>
<td>8/7/2012</td>
<td>28</td>
<td>5</td>
</tr>
</tbody>
</table>
Flexural vs. Compressive Strengths

\[ y = -0.1583x^2 + 198.12x - 57541 \]

\[ R^2 = 0.9724 \]
Innovative MCL Equipment

MIT Scan 2

MIT Scan T2

Tensile Bond Strength

Microwave W/C

Ultrasonic tomography
MIT Scan T2

- A faster, cheaper and non-destructive method to measure pavement thickness
y = 1.0308x - 9.0521
R² = 0.9968
MIT Scan 2

- Magnetic tomography technology
- Designed specifically for measuring dowel bar position and alignment
A method to evaluate dowel bar:

- Horizontal and vertical alignment
- Depth
- Side shift
- Spacing

A means to predict joint performance
Problem Joints

Typical Joint
MIRA-Ultrasonic Pulse Echo

1 pair per measurement

45 pair per measurement
MIRA – Defect Detection

- Delamination
- Pavement Base Interface
- Poor consolidation/voids
Pull-off Test

- Measure the **bond strength** between layers of two materials or the **tensile strength** of surface concrete

![Diagram of Pull-off Test]

- Tensile Force
- Overlay
- 50 mm (2.0 in.)
- ≥10 mm (0.5 in.)
Pull-off Test

Measures the weakest of:

- Tensile strength of existing concrete
- Interfacial bond between layers
- Tensile strength of overlay
Pull-off Test Procedure

- Drilling core with alignment system
- Prepare the Surface
- Apply epoxy to the surface of the core
- Glue the push pin to the core
Pull-off Procedure

- Attach loading apparatus to the steel disk
- Tensile load applied to the disk
Summary

- Compressive strengths met the project specification requirement
- Heat signature curves - very consistent
- 28 day Surface Resistivity – consistency between samples and in moderate category
Summary

- Maturity – Time Savings for early opening to traffic or construction operations

- HIPERPAV – very little risk of cracking

- Coefficient of Thermal Expansion – consistent results
Contacts

Interested in our services?

Contact either:

- FHWA Division Office
- FHWA Resource Center
- Mobile Concrete Laboratory

Directly

- Gary Crawford (202) 366-1286
- Jim Grove (515) 294-5988
- Jagan Gudimettla (202) 366-1335
QUESTIONS?

WWW.FHWA.DOT.GOV