Unbonded PCC Overlay, Thin Concrete, and 60-year Concrete Performance at MnROAD

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Tom Burnham, P.E.
Minnesota Department of Transportation
Why Study PCC Overlays?

Becoming more popular in Minnesota

- More competitive on first cost basis
- Federal stimulus money
- Mn/DOT Innovation Funding

- Very good performance from “thicker” unbonded concrete overlays and whitetoppings

*Interest in thinner PCC overlays*
Unbonded PCC Overlays

- Used over distressed PCC pavements requiring additional structural capacity
- Thickness
  - “Standard” or most common > 7.5”
  - “Thin” < 7”
- Interlayer
  - To prevent reflective cracking and provide “cushioning” between rigid layers
    > PASSRC (Permeable Asphalt Stabilized Stress Relief Course)
    > Dense graded HMA (new)
    > Milled HMA (existing composite pavement)
    > Fabric (new to Minnesota)
# MnROAD Test Cells

<table>
<thead>
<tr>
<th>Cell</th>
<th>Thickness (in)</th>
<th>Panel size (ft)</th>
<th>Interlayer Type</th>
<th>Year built</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>4</td>
<td>(D) 15 x 14, (P) 15 x 13</td>
<td>1” PASSRC</td>
<td>2008</td>
</tr>
<tr>
<td>205</td>
<td>4</td>
<td>(D) 15 x 14, (P) 15 x 13</td>
<td>1” PASSRC</td>
<td>2008</td>
</tr>
<tr>
<td>305</td>
<td>5</td>
<td>(D) 15 x 14, (P) 15 x 13</td>
<td>1” PASSRC</td>
<td>2008</td>
</tr>
<tr>
<td>405</td>
<td>5</td>
<td>(D) 15 x 14, (P) 15 x 13</td>
<td>1” PASSRC</td>
<td>2008</td>
</tr>
<tr>
<td>505</td>
<td>5</td>
<td>6 x 6.5, 6 x 7.5 Drv, 6 x 6, 6 x 7 Pass</td>
<td>Fabric</td>
<td>2011</td>
</tr>
<tr>
<td>605</td>
<td>5</td>
<td>6 x 6.5, 6 x 7.5 Drv, 6 x 6, 6 x 7 Pass</td>
<td>Fabric</td>
<td>2011</td>
</tr>
</tbody>
</table>

**Mainline = I-94 traffic**
Mainline Traffic History

- Driving Lane
- Passing Lane

CEASLs
0 500,000 1,000,000 1,500,000 2,000,000 2,500,000 3,000,000
02/09 04/09 06/09 08/09 10/09 12/09 02/10 04/10 06/10 08/10 10/10 12/10 02/11 04/11 06/11
MnROAD Test Cells 105-405

- Other Design Details:
  - Unsealed joints
  - Wick drains @ 100 ft spacing
  - 14 year old joints vs broken joints
4” Thick Test Cells 105-205

- Early performance = poor (as expected)
  - More than 80% of 4” thick panels cracked within 2 years
  - Cause: Excessive curling of large thin slabs
  - Cracking did not coincide with underlying PCC cracks
  - Replaced in 2011 with Cells 505 and 605
4” Thick Test Cells 105-205

CELL 5
200 - 250 ft

DRV

PAS

TRAFFIC
5” Thick Test Cells 305-405

- Early Performance = fair to good
  - 40% of 5” thick panels cracked within 2 years
  - Less cracking over non-broken joints
  - Recently retrofit plate dowels across several cracks
MnROAD Test Cells 505-605

- Design Details:
  - 5” thick with smaller panels (6’ x 7.5’ largest size)
  - Non-woven fabric interlayer
  - Wick drains (enclosed) @ 50 ft spacing
  - 4” thick RCC shoulders
Thin PCC Pavements

- Used for city streets and lower volume county roads
- Thickness
  - Mn/DOT minimum currently 7”
  - “Thin” < 7”
- Good performance from MnROAD Phase 1

6” thick sections on Low Volume Road

*Interest in “How Thin Can You Go?”*
## MnROAD Test Cells

<table>
<thead>
<tr>
<th>Cell</th>
<th>Thickness (in)</th>
<th>Panel size (ft)</th>
<th>Dowel Type</th>
<th>Year built</th>
</tr>
</thead>
<tbody>
<tr>
<td>513a</td>
<td>5</td>
<td>15 x 12</td>
<td>3/8” Plate</td>
<td>2008</td>
</tr>
<tr>
<td>513b</td>
<td>5</td>
<td>12 x 12</td>
<td>3/8” Plate</td>
<td>2008</td>
</tr>
<tr>
<td>113a</td>
<td>5</td>
<td>12 x 12</td>
<td>1” Round</td>
<td>2008</td>
</tr>
<tr>
<td>113b</td>
<td>5</td>
<td>15 x 12</td>
<td>1” Round</td>
<td>2008</td>
</tr>
<tr>
<td>213</td>
<td>5.5</td>
<td>15 x 12</td>
<td>1” Round</td>
<td>2008</td>
</tr>
<tr>
<td>313</td>
<td>6</td>
<td>15 x 12</td>
<td>1” Round</td>
<td>2008</td>
</tr>
<tr>
<td>413</td>
<td>6.5</td>
<td>15 x 12</td>
<td>1” Round</td>
<td>2008</td>
</tr>
</tbody>
</table>

- CL 5 base
- Unsealed joints
- No drains

**Mainline = I-94 traffic**
Plate Dowels

- 3/8” thick, 12” long, tapered width
- Long history of use in industrial floors
- First application on interstate highway
- Donated by PNA, Inc.
Mainline Traffic History
# Distress Survey History

<table>
<thead>
<tr>
<th>Date</th>
<th>513</th>
<th>113</th>
<th>213</th>
<th>313</th>
<th>413</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/17/2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/21/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/28/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- **Driving Lane**
- **Passing Lane**

Survey results:
- No distress
Test Cells 113, 213 & 513

- Transverse cracks across both lanes after 1.5 million CESALs
- Onset of fatigue cracking in driving lane
- Cause: Excessive pumping of base material
- Punch-out type failures in sensor areas
- Longitudinal cracking in passing lane
Failure in Sensor Areas

- Concentration of embedded lead wires and supports
- Full-depth repairs in August 2011
First Cracking Detected
History of Pumping in Thin Cells
Joint Load Transfer Efficiency

Driving Lane - Before Joint

- Cell 513a
- 513b
- 113a
- 113b
- 213
- 313
- 413
Joint Deflections

Driving Lane - Before Joint

- Deflection (microns)
- Dates: 3/28/09 to 4/17/11

Legend:
- Cell 513a
- 513b
- 113a
- 113b
- 213
- 313
- 413
Corner Panel Deflections
Thin PCC Performance Trends

- Cells < 6 inches thick survived over 1.5 million CESALS before cracking
  - Rapidly deteriorating due to pumping

- Cells > 6 inches thick have much greater capacity
  - No distresses in 6.5 inch section

Note that panel sizes, dowel sizes, and unsealed joints are important variables that need to be considered in such analysis.
60 year Design Test Cell 53

- Built to Mn/DOT High Performance Concrete specifications (12” thick)
- Built on MnROAD Low Volume Road loop
- Designed to compare dynamic strain and deflection measurements with MnROAD 5 and 10 year design test cells
- Built with 3 inch thick PCC shoulders
  - 7.5 ft L x 10ft W panels
MnROAD Test Cell 53

- 3” thick shoulder performance = Poor
  - Cracking due to frost heave alone?
  - Little safety factor from heavy loads
Winter’s Coming!

Questions?