Rapid Repair Materials, Deck Sealing and Other Techniques for Bridge Deck Preservation

2010 Southeast Bridge Preservation Partnership Meeting

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Virginia Transportation Research Council
Bridge Deck Preservation Techniques

- Overlays
- Patching
- Joint repairs
- Filling cracks in concrete
- Sealing concrete
Overlays

- Multiple Layer Epoxy Overlays
- Hydraulic Cement Concrete Overlays
Multiple Layer Epoxy Overlays

3 hour cure time (depends on temperature)

2 layers of epoxy and broadcasted aggregate, 0.25-in thick
(Refer to VDOT Special Provision for Epoxy Concrete Overlays)

Shot blasting surface  
Placing epoxy prior to broadcasting aggregate
Construction of Epoxy Overlays

Phase 1
• Close lane at 9 pm
• Shot blast surface
• Patch deck
• Construct/test epoxy patches
• Cure patches
• Open lane at 5 am

Phase 2
• Close lane at 9 pm
• Shot blast surface
• Place layer 1
• Place layer 2
• Cure overlay 3 hours
• Open lane at 5 am

Weekend lane closures can be more productive.
Rapid Concrete Overlay Options

Hydraulic Cement Concrete Overlays

24 hour cure time (early repair)
- 15% latex and type III cement (LMC-HE)
- 7% silica fume and type I/II cement (SF)

3 hour cure time (very early repair)
- 15% latex and calcium sulfoaluminate and dicalcium silicate cement (LMC-VE)
<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Close lane at 9 pm</td>
<td>• Close lane at 9 pm</td>
</tr>
<tr>
<td>• Mill deck surface</td>
<td>• Shot blast surface</td>
</tr>
<tr>
<td>• Patch deck</td>
<td>• Wet surface</td>
</tr>
<tr>
<td>• Cure patches</td>
<td>• Place overlay</td>
</tr>
<tr>
<td>• Open lane at 5 am</td>
<td>• Cure overlay 3 hours</td>
</tr>
<tr>
<td></td>
<td>• Open lane at 5 am</td>
</tr>
</tbody>
</table>

Weekend lane closures are preferred for LMC-VE and required for silica fume and LMC-HE overlays.
Concrete removal and surface preparation

Milling rapidly removes the old surface

Shot blasting cleans and prepares the surface
Construction of LMC-VE Overlays

Placing and consolidating the overlay. Fogging to minimize cracking.

Wet burlap and polyethylene cure overlay
<table>
<thead>
<tr>
<th>Mixture</th>
<th>LMC</th>
<th>LMC-HE</th>
<th>SF</th>
<th>LMC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cure Time</td>
<td>3 day</td>
<td>24 hr</td>
<td>24 hr</td>
<td>3 hr</td>
</tr>
<tr>
<td>Cement</td>
<td>I/II</td>
<td>III</td>
<td>I/II</td>
<td>Rapid Set</td>
</tr>
<tr>
<td>Cement</td>
<td>658</td>
<td>815</td>
<td>658</td>
<td>658</td>
</tr>
<tr>
<td>Silica Fume</td>
<td>0</td>
<td>0</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>Fine agg.</td>
<td>1571</td>
<td>1402</td>
<td>1269</td>
<td>1600</td>
</tr>
<tr>
<td>Coarse agg.</td>
<td>1234</td>
<td>1142</td>
<td>1516</td>
<td>1168</td>
</tr>
<tr>
<td>Latex (48%)</td>
<td>205</td>
<td>218</td>
<td>0</td>
<td>205</td>
</tr>
<tr>
<td>Water</td>
<td>137</td>
<td>164</td>
<td>282</td>
<td>137</td>
</tr>
<tr>
<td>Air, per cent</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>
### Average Compressive Strength, lb/in²

<table>
<thead>
<tr>
<th>Mixture</th>
<th>LMC</th>
<th>LMC-HE</th>
<th>SF</th>
<th>LMC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cure Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 day</td>
<td>3 day</td>
<td>24 hr</td>
<td>24 hr</td>
<td>3 hr</td>
</tr>
<tr>
<td>3 hr.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3510</td>
</tr>
<tr>
<td>4 hr.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3810</td>
</tr>
<tr>
<td>5 hr.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4070</td>
</tr>
<tr>
<td>24 hr.</td>
<td>1810</td>
<td>3600</td>
<td>2520</td>
<td>5440</td>
</tr>
<tr>
<td>7 day</td>
<td>3360</td>
<td>4940</td>
<td>5310</td>
<td>6290</td>
</tr>
<tr>
<td>28 day</td>
<td>4630</td>
<td>5700</td>
<td>7250</td>
<td>6710</td>
</tr>
</tbody>
</table>
LMC Compressive Strength

Comparative Strength vs. Age

- Rte. 33 EBL
- Rte. 33 WBL
- Rte. 620 WBL
- LMC
- LMC-HE
Effect of temperature on LMC-VE strength

Strength vs. Age

Strength (psi x 1000)

Time (hours)

SB 1 #1 @ 23°C (73°F), SB 1 #2 @ 18°C (65°F), SB 1 #3 @ 13°C (55°F), SB 1 #4 @ 10°C (50°F), SB 1 #5 @ 8°C (45°F), SB 1 #6 @ 4°C (40°F), SB 1 #7 @ 2°C (35°F), SB 2 #1 @ 23°C (73°F), SB 2 #2 @ 2°C (35°F)
Length change of LMC-VE and LMC-K specimens at 170 days is approximately 0.02 percent as compared to 0.06 percent for specimens of the other overlays.
<table>
<thead>
<tr>
<th>Age</th>
<th>LMC-VE</th>
<th>LMC</th>
<th>SFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 day</td>
<td>300 - 1400</td>
<td>1500 - 2560</td>
<td>950 - 2330</td>
</tr>
<tr>
<td>1 year</td>
<td>0 - 10</td>
<td>200 - 2060</td>
<td>590 - 1280</td>
</tr>
<tr>
<td>3 year</td>
<td>-</td>
<td>300 - 710</td>
<td>520 - 1460</td>
</tr>
<tr>
<td>5 year</td>
<td>-</td>
<td>450 - 500</td>
<td>780 - 910</td>
</tr>
<tr>
<td>9 year</td>
<td>0 - 60</td>
<td>100 - 400</td>
<td>-</td>
</tr>
<tr>
<td>Age</td>
<td>LMC-VE</td>
<td>LMC</td>
<td>SFC</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>1-6 months</td>
<td>153 - 276</td>
<td>114 - 260</td>
<td>145 - 305</td>
</tr>
<tr>
<td>3- 5 years</td>
<td>-</td>
<td>200 - 310</td>
<td>145 - 275</td>
</tr>
<tr>
<td>9-10 years</td>
<td>176 - 301</td>
<td>246 - 296</td>
<td>251 - 293</td>
</tr>
</tbody>
</table>

Test results are primarily for failures in the concrete deck below the bond interface.
### Cost of Rapid HCC Overlays

<table>
<thead>
<tr>
<th>Mixture</th>
<th>LMC-VE</th>
<th>LMC</th>
<th>SFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlay</td>
<td>90</td>
<td>83</td>
<td>75</td>
</tr>
<tr>
<td>Misc.</td>
<td>32</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Traffic</td>
<td>28</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>159</td>
<td>151</td>
</tr>
</tbody>
</table>

**Overlay Cost, $/yd² (from 2006-2009 bids)**

LMC-VE overlay placed in 2006 on I64 over Rivanna River. 5000 yd² overlay placed over 2 extended weekends saved approximately $519,000 in user costs.
User Costs

• Road user cost calculations for I64 over Rivanna River for LMC-VE and LMC Overlay options were computed by Michael Fontaine of VTRC.

• Costs are based on the methodology described in the Texas Transportation Institute Urban Mobility Report (Schrank and Lomax, 2007, TTI).

• The report provides default values for time and vehicle occupancy.

• Assumptions include one of two lanes closed at Mile Marker 136, 16% trucks, and maximum queue of 3.6 miles between 6 and 7 pm, 2006 dollars.
<table>
<thead>
<tr>
<th>Option</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>LMC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane Closure</td>
<td>2 Weeks</td>
<td>2 Long Weekends</td>
<td>4 Weekends</td>
</tr>
<tr>
<td>Days, $</td>
<td>Days</td>
<td>Cost, $</td>
<td>Days</td>
</tr>
<tr>
<td>Weekday</td>
<td>10</td>
<td>648,730</td>
<td>2</td>
</tr>
<tr>
<td>Saturday</td>
<td>2</td>
<td>3,854</td>
<td>2</td>
</tr>
<tr>
<td>Sunday</td>
<td>2</td>
<td>2,656</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>655,240</td>
<td>6</td>
</tr>
<tr>
<td>Savings</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

Construction cost= $750,000 for 5,000 yd2 overlay.
Bridge Deck Preservation Techniques

- Overlays
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Patching

- Refer to List 31, HCC Patching Materials, VDOT website: materials/app_lists for products that achieve 2500 psi comp. strength in ≤ 2 hours.
- Patch geometry and temperature affect strength development rate
- Concrete removal takes majority of time
- Patch geometry affects removal time
- Manpower and equipment affect patching rate
Patching

Sawcut perimeter 1 inch deep

Remove concrete using hammers weighing < 30 lbs
Patching

Place concrete into properly prepared cavity: saw cut perimeter, saturated surface dry surface, clearance under rebar, no rust on rebar

Consolidating concrete
Patching

Use Mobile mixer or ready mix when feasible.
Patching with prepackaged materials

Calibrated containers must be used to batch ingredients
White pigmented liquid membrane curing material is applied to surface of patches. Fewer, larger, **rectangular patches save time and money**: preferred to small, many sided patches.
Use patching materials with low shrinkage

Percent length change vs. age, ASTM C157
Curing time for patching materials

Hours required to obtain 2500 psi compressive strength at 4 Temperatures, F

<table>
<thead>
<tr>
<th>Temperature</th>
<th>40</th>
<th>55</th>
<th>72</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBC 1</td>
<td>5.0</td>
<td>1.7</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>SBC 2</td>
<td>3.6</td>
<td>2.2</td>
<td>1.5</td>
<td>0.6</td>
</tr>
<tr>
<td>SBC 3</td>
<td>6.2</td>
<td>3.4</td>
<td>2.9</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Bridge Deck Preservation Techniques

- Overlays
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Rapid Joint repair

Two component silicone mixed in the nozzle is used to caulk a joint rapidly.
Joint repair

Silicone is placed over backer rod to caulk a joint. (Section 212 VDOT Road and Bridge Specifications)
Bridge Deck Preservation Techniques

• Overlays
• Patching
• Joint repairs
• Filling cracks in concrete
• Sealing concrete
Filling cracks in concrete

- Materials include high molecular weight methacrylate, epoxy and urethane.
- Need to use materials with rapid cure but adequate pot life to penetrate cracks.
- Cure time affected by the condition of the concrete, temperature and relative humidity.
Filling cracks in concrete

- Apply material over deck surface with broom, squeegee or low pressure spray
- Apply sufficient material to fill cracks
- Broom excess material from valleys of texture before it gels
- Treat individual cracks with small batches
- Refer to VDOT Special Provision for Gravity Filled Polymer Crack Sealing and List 28 Polymers for Sealing Cracks, VDOT website: materials/approved_lists)
Bridge Deck Preservation Techniques

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- Sealing concrete
Sealing Concrete

• Water repellents such as silanes and siloxanes typically **cure faster**

• Pore blockers such as acrylics, linseed oil, epoxy, polyester, gum resin and urethane typically **cure slower**

• Cure time affected by the condition of the concrete, temperature and relative humidity
Sealing Concrete

• Apply sealer with broom, squeegee or low pressure spray
• Refer to List 30 Sealants, Stains and Coatings, VDOT website: materials/approved_lists)
• Additional information:
  Maine DOT approved products list, concrete sealers
  NCHRP Synthesis 209 Sealers for Portland Cement Concrete Highway Facilities
Conclusions

1. Successful rapid repairs include:
   - Overlays
   - Patching
   - Joint repair
   - Filling cracks in concrete
   - Sealing concrete

2. Use of rapid repairs can reduce user costs and increase or decrease construction costs.

3. Use of rapid repairs is increasing.
Rapid Repair Materials, Deck Sealing and Other Techniques for Bridge Deck Preservation

Thank You

Questions?