LMC Overlays For Bridge Deck Preservation

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INTRODUCTION

• The number one cause of bridge deterioration is corrosion.
• In 2004 FHWA reported $10.5 billion spent for repairs.
• Latex-Modified Concrete (LMC) Overlays have been used since 1969 to repair, protect and preserve decks.
INTRODUCTION

• LMC overlays are usually placed on bridge decks to reduce infiltration of water and chloride ions and improve skid resistance, ride quality, and surface appearance.

• The construction of conventional LMC overlays has become increasingly difficult in recent years because of traffic congestion.

• Lanes cannot be closed for extended periods because of traffic concerns.
Need for Rapid Overlays

• Contractors are often forced to work at night and on weekends and during cooler weather to accommodate traffic.
• Most of the conventional overlay materials can not be used under these conditions.
• LMC prepared with a very early hardening cement has been used to construct rapid concrete overlays (LMC-VE) on bridge decks in Virginia since 1997.
Need for Rapid Overlays

• In 2009 a new very early hardening polymer modified cement was used to construct rapid overlays (PMCC-VE) on bridge decks in Missouri.

• The PMCC-VE overlays are constructed and cured the same way as LMC-VE overlays with the exception that the polymer is in the cement rather than being added as a liquid.

• VDOT constructed its first PMCC-VE overlay in November 2010.
Purpose of Presentation

- Compare the properties and performance of LMC, LMC-VE and PMCC-VE overlays.
- The presentation covers the VDOT experience as follows:
  LMC: 41 years
  LMC-VE: 13 years
  PMCC-VE: < 1 year
Results

• Construction
• Mixture proportions
• Compressive strength
• Permeability to chloride ion
• Shrinkage
• Bond Strength
• Costs
• Conclusions
• Recommendations
Construction of LMC Overlays

- Close lane for 7 days or more
- Install concrete barriers and other traffic control
- Mill deck surface
- Patch deck (if done prior to overlay placement)
- Cure patches
- Shot blast surface
- Wet surface
- Place overlay
- Cure overlay 48 hours wet and 48 hours dry
- Remove concrete barriers and other traffic control
- Open lane
Construction of LMC-VE & PMCC-VE Overlays Using 8 Hour Lane Closures

- Patching phase
  - Close lane at 9 pm
  - Mill deck surface
  - Patch deck
  - Cure patches
  - Open lane at 5 am

- Overlay Phase
  - Close lane at 9 pm
  - Shot blast surface
  - Wet surface
  - Place overlay
  - Cure overlay 3 hours
  - Open lane at 5 am
Construction of LMC-VE & PMCC-VE Overlays Using Weekend Lane Closures

- **Patching Phase**
  - Close lane at 9 pm
  - Mill deck surface
  - Patch deck
  - Cure patches
  - Open lane at 5 am (may be done during weekend closure)

- **Overlay Phase**
  - Close lane at 9 pm Friday
  - Shot blast surface
  - Wet surface
  - Place overlay
  - Cure overlay 3 – 24 hours
  - Open lane at 5 am Monday (may open earlier)
LMC-VE Overlay Construction at Night, 1998
LMC-VE Overlay Curing
PMCC-VE Overlay Over Muddy Creek, 11-19-10
## LMC, LMC-VE and PMCC-VE Concrete Specifications

<table>
<thead>
<tr>
<th>Property</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>PMCC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump, inches</td>
<td>4 - 6</td>
<td>4 - 6</td>
<td>5 - 9</td>
</tr>
<tr>
<td>Air, Percent</td>
<td>3 - 7</td>
<td>3 - 7</td>
<td>3 - 6</td>
</tr>
<tr>
<td>Lab. CS @ 2 hr, psi</td>
<td>-</td>
<td>&gt; 2500</td>
<td>&gt; 2500</td>
</tr>
<tr>
<td>Field CS @ traf., psi</td>
<td>≥ 3500</td>
<td>≥ 2500</td>
<td>≥ 2500</td>
</tr>
<tr>
<td>Lab. CS @ 1 day, psi</td>
<td>-</td>
<td>≥ 3500</td>
<td>≥ 3500</td>
</tr>
<tr>
<td>Lab. Comp. Str. @ 28 days, psi</td>
<td>≥ 3500</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lab. Perm. @ 28 days, coulombs</td>
<td>-</td>
<td>-</td>
<td>≤ 1000</td>
</tr>
</tbody>
</table>
VE Cement Specifications

• Cement shall be approximately 1/3 calcium sulfoaluminate and 2/3 dicalcium silicate or other hydraulic cement that will provide a Latex-Modified Concrete that meets the physical requirements for LMC-VE as indicated in this special provision.

• Cement shall be approximately 1/3 calcium sulfoaluminate and 2/3 dicalcium silicate and admixtures or other hydraulic cement that will provide a Polymer-Modified Cement Concrete that meets the physical requirements for PMCC-VE as indicated in this special provision.
## Typical Mixture Proportions, lb/yd³

<table>
<thead>
<tr>
<th>Mixture</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>PMCC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Type</td>
<td>I/II</td>
<td>VE</td>
<td>VE</td>
</tr>
<tr>
<td>Cement</td>
<td>658</td>
<td>658</td>
<td>611</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>1571</td>
<td>1600</td>
<td>1620</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>1234</td>
<td>1168</td>
<td>1487</td>
</tr>
<tr>
<td>Latex</td>
<td>205</td>
<td>205</td>
<td>-</td>
</tr>
<tr>
<td>Water (w/c ≤ 0.40)</td>
<td>137</td>
<td>137</td>
<td>244</td>
</tr>
<tr>
<td>Air, per cent</td>
<td>3 to 7</td>
<td>3 to 7</td>
<td>3 to 6</td>
</tr>
<tr>
<td>Slump, in</td>
<td>4 to 6</td>
<td>4 to 6</td>
<td>5 to 9</td>
</tr>
</tbody>
</table>
## Average Compressive Strength and Modulus, psi

<table>
<thead>
<tr>
<th>Age</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>PMCC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 hour</td>
<td>-</td>
<td>3660</td>
<td>5210</td>
</tr>
<tr>
<td>1 day</td>
<td>1810</td>
<td>5570</td>
<td>6500</td>
</tr>
<tr>
<td>7 day</td>
<td>5400</td>
<td>6470</td>
<td>7610</td>
</tr>
<tr>
<td>28 day</td>
<td>5990</td>
<td>6980</td>
<td>8370</td>
</tr>
<tr>
<td>28 day Modulus</td>
<td>3,290,000</td>
<td>3,140,000</td>
<td>4,070,000</td>
</tr>
</tbody>
</table>
## Permeability to Chloride Ion, Coulombs

<table>
<thead>
<tr>
<th>Age</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>PMCC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 day</td>
<td>1500 - 2560</td>
<td>300 - 1400</td>
<td>645</td>
</tr>
<tr>
<td>1 year</td>
<td>200 - 2060</td>
<td>0 - 10</td>
<td>-</td>
</tr>
<tr>
<td>3 year</td>
<td>300 - 710</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5 year</td>
<td>450 - 500</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9 year</td>
<td>100 - 400</td>
<td>0 - 60</td>
<td>-</td>
</tr>
</tbody>
</table>
Drying Shrinkage, ASTM C157

LENGTH CHANGE RESULTS FOR LMC

Percent of Change

Time in Days

0 20 40 60 80 100 120 140 160 180

1 - LMC-VE Dry
2 - Type K Dry
3 - Roanoke I/II Dry
4 - Roanoke Type III Dry
1 - LMC-VE Wet
2 - Type K Wet
3 - Roanoke Type I/II Wet
4 - Roanoke Type III Wet
Drying Shrinkage

Length change (ASTM C157) of LMC-VE specimens at 170 days is approximately 0.02 percent as compared to 0.06 percent for specimens of LMC.
## Bond Strength, psi

<table>
<thead>
<tr>
<th>Age</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>PMCC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-6 months</td>
<td>114 - 260</td>
<td>153 - 276</td>
<td>-</td>
</tr>
<tr>
<td>3-5 years</td>
<td>200 - 310</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9-10 years</td>
<td>246 - 296</td>
<td>176 - 301</td>
<td>-</td>
</tr>
</tbody>
</table>

Test results are primarily for failures in the concrete deck below the bond interface.
## Cost of Overlays 2006-2009 ($/yd2)

<table>
<thead>
<tr>
<th>Mixture</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>PMCC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlay</td>
<td>83</td>
<td>90</td>
<td>&lt; 90</td>
</tr>
<tr>
<td>Misc.</td>
<td>32</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Traffic</td>
<td>44</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>159</td>
<td>150</td>
<td>&lt; 150</td>
</tr>
</tbody>
</table>
I64 Over Rivanna River, 2006
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.
## User Costs, I64 over Rivanna River

<table>
<thead>
<tr>
<th>Option</th>
<th>LMC</th>
<th>LMC-VE</th>
<th>LMC-VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closure</td>
<td>2 Weeks</td>
<td>2 Weekends +Mon</td>
<td>4 Weekends</td>
</tr>
<tr>
<td>Days, $</td>
<td>Days, Cost, $</td>
<td>Days, Cost, $</td>
<td>Days, Cost, $</td>
</tr>
<tr>
<td>Weekday</td>
<td>10 648,730</td>
<td>2 129,746</td>
<td>0 0</td>
</tr>
<tr>
<td>Saturday</td>
<td>2 3,854</td>
<td>2 3,854</td>
<td>4 7,708</td>
</tr>
<tr>
<td>Sunday</td>
<td>2 2,656</td>
<td>2 2,656</td>
<td>4 5,312</td>
</tr>
<tr>
<td>Total</td>
<td>14 655,240</td>
<td>6 136,256</td>
<td>8 13,020</td>
</tr>
<tr>
<td>Savings</td>
<td>- 0</td>
<td>- 518,984</td>
<td>- 642,220</td>
</tr>
</tbody>
</table>

Construction cost = $750,000 for 5,000 yd2 overlay.
Conclusions

1. LMC overlays have very low to low permeability to chloride ion and good to excellent bond strength and perform well.
2. LMC-VE overlays are performing as well or better than LMC overlays.
3. LMC-VE overlays are typically used for situations in which lane closures cause major traffic congestion.
4. The higher cost of materials for LMC-VE overlays can be offset by lower costs for traffic control.
Conclusions

5. Including user cost savings LMC-VE overlays are even more cost effective and supportive of a sustainable environment.

6. PMCC-VE overlays are performing as well as LMC-VE overlays based on short term experience.
Recommendations

1. DOT s should continue to use LMC and LMC-VE overlays.
2. DOT s should try the new PMCC-VE overlay introduced in 2009.
References


Thank You.

QUESTIONS?