LATEX MODIFIED CONCRETE
For Bridge Deck Overlays

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Outline

• Bridge Deck Preservation
• Ohio Data and projects
• What is Latex Modified Concrete (LMC)?
• Important Criteria to Consider with Overlay Selection
• Achieving a Quality LMC Overlay
• Cost Comparison
• Very Early Strength Latex Modified Concrete (VESLMC)
Bridge Deck Preservation

KEYS TO BRIDGE DECK LONGEVITY INCLUDE:

• Resources applied into preservation treatments
• Timing of applications
• Right treatment- Correct Project Scope is Important
• One of those treatment options is:

  “The right wearing surface at the right time”
Bridge Deck Preservation

- 2\textsuperscript{nd} / 3\textsuperscript{rd} Generation Overlays are viable
- It is cost effective to attain a minimum of 75 years of service life from bridge deck
- By placing Latex Modified Concrete Overlays on Hydrodemolition prepared bridge deck surfaces, 75 years of service life or more can be achieved
Bridge Deck Preservation
Dense Deck Overlays

• Latex Modified Concrete (LMC)
• Superplasticized Dense Concrete (SDC)
• Microsilica Concrete (MSC)
• Low Slump Concrete (LSC) – not used in Ohio

“What is the right choice in Ohio?”
### OHIO DATA from 2009

<table>
<thead>
<tr>
<th>Wearing Surface</th>
<th># Bridges</th>
<th>Avg Age per Bridge</th>
<th>Deck Area (SF)</th>
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</thead>
<tbody>
<tr>
<td>LMC</td>
<td>957</td>
<td>20.98</td>
<td>12360010</td>
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<tr>
<td>MSC</td>
<td>1612</td>
<td>10.95</td>
<td>19671475</td>
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<tr>
<td>SDC</td>
<td>569</td>
<td>18.31</td>
<td>7607614</td>
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### OHIO DATA from 2009

<table>
<thead>
<tr>
<th>Wearing Surface</th>
<th>CS 1 # Bridges</th>
<th>Avg Age</th>
<th>CS 2 # Bridges</th>
<th>Avg Age</th>
<th>CS 3 # Bridges</th>
<th>Avg Age</th>
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</thead>
<tbody>
<tr>
<td>LMC</td>
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<td>17.53</td>
<td>349</td>
<td>22.13</td>
<td>72</td>
<td>25.9</td>
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<tr>
<td>MSC</td>
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<td>735</td>
<td>13.23</td>
<td>37</td>
<td>11.03</td>
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<tr>
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<td>17.16</td>
<td>264</td>
<td>19.24</td>
<td>15</td>
<td>18.58</td>
</tr>
</tbody>
</table>
Fast Track Hydro Projects in Ohio

- IS 71 over Miami River Valley (Jeremiah Morrow Bridge) – 24,000 SY LMC
  Phase 1 in 2014, Phase 2 in 2016
- IS 71 over IS 670 in Columbus, OH – 8000 SY VESLMC
  Phase 1 in fall 2014, Phase 2 in spring 2015
- IS 70 over Railroad in Columbus, OH – 2000 SY VESLMC
  Fall 2012
- District 7 (Sidney) – 10 bridges in past two years using LMC or VESLMC
- Cuyahoga County – 3000 SY in progress (LMC)
Ohio Specification Supplemental Specification 848

848.05 Latex Modified Concrete Materials
848.08 Mixers – Continuous Mobile for Latex Modified Concrete
848.13 Proportioning and Mixing of Latex Modified Concrete
848.18 Removal of Existing Concrete Overlays
848.19 Removal of Existing Concrete Overlay, Variable Thickness
848.28 Curing Application LMC Overlays
848.42 Method of Measurement
848.43 Basis of Payment
Designer Notes
What is Latex?
What is LMC?

- Concrete mix specifically designed as thin bonded overlay
- Designed in late 1960’s by Dow Chemical Company
- Hydraulic cement and aggregates combined at time of mixing with latex emulsion
- Part of mixing water replaced with latex emulsion (24.5 gals/cu yd)
- Volumetrically mixed at site in mobile mixer for placement
Latex Emulsion

- Suspension of tiny (.2 micron diam.) styrene-butadiene polymer particles in water
- 50% polymer solids (24.5 gals/cu yd)
- Typical LMC formulation contains 15% latex solids as a percent of cement solids.
- Styrene-butadiene polymers known for their hydrophobicity or excellent water resistance.
- Polymer particles coalesce or fuse together when in intimate contact to form highly waterproof polymer film.
- Essentially waterproofs concrete.
# Latex Concrete Mix Design

- Type 1 (7 bags) 658 Lbs/CY
- Fine Aggregate (Sand) 1470 - 1785 Lbs/CY
- Course Aggregate (# 8’s) 1176 - 1456 Lbs/CY
- Latex Emulsion 24.5 Gal/CY
- Water/Cement Ratio Maximum 0.40
- Air % (non-entrained) 0 to 7 %
- Slump - Workability 3 to 7 In (measured 4 to 5 minutes after discharged)
- Strength Req. (5 Days) 3000 PSI
- Strength Req. (28 Days) 4000 PSI
- Mix Temperature 50 to 85 Degrees
Important Criteria to Consider with an Overlay

- Strength and Flexibility
- Adhesion / Bond
- Permeability
- Durability
- Construction Practices and Site Conditions
Strength and Flexibility

- All overlay types can achieve acceptable compressive strength
- Higher compressive strength not necessarily better
- Lower elastic modulus promotes more flexible overlay
- Flexibility minimizes stresses
- 15% latex (based on cement solids) reduces elastic modulus 15%
- LMC flexural strengths 50% higher than conventional concrete
Adhesion / Bond

- Most important factor in success of overlay
- Overlay acts as monolithic section
- LMC provides bond greater than base concrete or overlay
- S-B polymers are excellent adhesives (chemical bond)
- Hydro’d surface provides added degree of bond for superior mechanical interlock
- Poor site prep can lead to premature debonding (failures)
Permeability and Durability

- Overlay material needs to minimize ingress of water and salt to the deck.
- LMC and MSC physically block capillary structure
- LMC gives a reduced porosity
- Impermeability of SDC or LSC based on density of mix
- LMC has good wear resistance capabilities (Kuhlman)
Construction Practices and Site Conditions

- All overlays will be subject to construction issues that can cause failure
- Deck cleanliness and preparation are critical
- Surface evaporation
- LMC has minimal shrinkage characteristics
- Traffic Loading
Achieving a Quality LMC Overlay

- Fulfilling mix design and specification requirements
- Superior bridge deck preparation
- Detailed installation procedures
- Proper curing of the overlay
SELECTIVE REMOVAL
Cure Durations

- Type I Cement LMC Mix = 48 hours wet / 48 hours dry
- Type III Cement LMC Mix = 24 hours wet / 24 hours dry
- Rapid Setting LMC Mix = 3 hour wet = 2,500 psi
LATEX MODIFIED CONCRETE
For Bridge Deck Overlays

What’s it Cost?
What’s it Cost?

• Most important question is:
  “What is the impact of material choice on life-cycle cost?”

• If LMC historically gets 25 years of life vs, MSC, 15 years of life:
  “Cost differential is offset by the added years of service life”

• While LMC will have an initial cost higher than MSC, the life of the material will make it cheaper from an annual cost
What’s it Cost?

• EXAMPLE:

  1000 SY bridge, assuming scarification and hydro are the same regardless of material selection for overlay.

  Using (Missouri) historical data where LMC installation cost is $25 per SY higher than MSC:

  Initial cost for LMC = $110 x 1000 SY = $110,000
  Initial cost for MSC = $85 x 1000 SY = $85,000
What’s it Cost?

- Using life expectancy of the various materials:
  - Over 25 years, average cost of LMC = $4400 per year
  - Over 15 years, average cost of MSC = $5667 per year
- As an annual cost, LMC will be cheaper in the long run due to the longer life expectancy.
LATEX MODIFIED CONCRETE
For Bridge Deck Overlays

Very Early Strength Latex Modified Concrete (VESLMC)
Very Early Strength Latex Modified Concrete (VESLMC)

- Add very early strength hydraulic / portland cement to LMC mix
- Achieves compressive strengths over 2,500 psi in 3 hours
- Provides same benefits as LMC overlays
- Used on projects in US since 1991
- Very impervious to chemicals that deteriorate conventional concrete
- Bonds well with hydro’d substrate
- Gets through plastic state very quickly
VESLMC Mix Design

- Mix Design per Cu Yd
  - Class of Concrete = VES (CTS Rapid Set Cement)
  - W/C Ratio = 0.42 (maximum)
  - Air = 0% to 7% (Defoamer may be allowed as needed)
  - 7 Bag Mix with Rapid Setting Cement (658 pounds)
  - Fine Aggregate = 1501 Pounds
  - Coarse Aggregate (#8) = 1170 Pounds
  - 154 Pounds Water (18.48 Gals)
  - Latex (Styron/Dow Modifier A) = 206 Pounds (24.5 Gals)
Research has shown in comparing high early strength overlay options:

VESLMC is –
* More durable
* Less prone to shrinkage problems
* More resistant to chloride ion penetration
* Higher cement cost more than offset by the reduced cost of traffic control

VESLMC found to perform as well as, or better than, conventional LMC overlays
Ohio Research

- Report on High Early Strength Concrete Overlays, 2007
- Approach to Brent-Spence Bridge Project
- LMC RS* was only mix able to achieve 2 hour flexural strength requirement
  *(product not selected for project)
Additional Benefits of VESLMC Overlays

• Reduces inconvenience to traffic
• Lowers road user costs
• Provides ideal accelerated construction method to preserve bridge deck
• Typically used on weekend and overnight projects
• 25+ years of additional service life expected
## TYPICAL WEEKEND SCHEDULE  (Example)

### Friday
- 9:00 pm to 10:00 pm - Close roadway.
- 10:00 pm to 12:00 am - Milling
- 12:00 am - Hydrodemolition

### Saturday
- 12:00 am to 12:00 pm - Hydrodemolition & clean-up
- 12:00 pm to 12:00 am - VESLMC prep and pour

### Sunday
- 12:00 am to 4:00 am - Cure VESLMC overlay
- 4:00 am to 12:00 pm - Clean up work area
- 12:00 pm to 2:00 pm - Open roadway
Powhite Parkway, Richmond, VA - Record 421 CY of VESLMC in a single weekend
TYPICAL NIGHTTIME SCHEDULE (Example)

- 7:00 PM  Close traffic lanes
- 8:00 PM  Milling operation
- 9:00 PM  Hydro and cleanup
- 12:00 AM Prep of deck
- 2:00 AM  Pour VESLMC
- 3:00 AM  Curing
- 6:00 AM  Clean-up and open to traffic
Overnight work,
I-64 in Kentucky
Summary

- LMC has withstood the test of time – over 25 year life
- Provides many of the key characteristics desirable for overlay construction
- Life-cycle costs can prove LMC to be a more cost effective option
- The use of VESLMC is the ideal choice for expedited construction
Special Acknowledgements

• Mike Sprinkel, Virginia Transportation Research Council
• Peter Doty, Dow Reichhold Specialty Latex
• BASF Manual for Placement of Latex Modified Concrete
• Lou Kuhlman, Dow Chemical
Latex Modified Concrete for Bridge Deck Overlays

THE END

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