Bridge Preservation / Decks

Better Assessment in the use of Polymer Technology for Bridge Deck Overlays

NATIONAL BRIDGE PRESERVATION PARTNERSHIP CONFERENCE 2014
Goals
Maximizing the Life-Cycle Potential of a Concrete Bridge Deck

• How material related distresses contribute to early age bridge deck failure
• Triggers for the use of various polymer bridge deck overlay systems
• Assessing bridge deck condition
• Potential failure mechanisms of bridge deck overlay systems
Contribution to Early Age Bridge Deck Failure

EARLY TRIGGER: Plastic shrinkage, thermal cracking, drying shrinkage etc...

Water, penetrating through these cracks, is the most important substance that is involved in virtually every form of concrete deterioration-freezing-thawing damage, reinforcement corrosion, alkali-aggregate reactions, dissolution, sulfate attack and carbonation (Cody, 1994).
Materials-Related Distress (MRD)
Crystalline Growth Pressure Development

CHEMICAL MECHANISMS

- Alkali–Silica Reactivity (ASR)
- Alkali–Carbonate Reactivity (ACR)
- External Sulfate Attack (ESA)
- Internal Sulfate Attack (ISA)
- Delayed Ettringite Formation (DEF)
Carbonation

The lowering of PH levels in concrete around the reinforcing steel compromises the passive protective layer around the steel thus increasing corrosion potential.
Common Uses of Polymer Technology for Bridge Deck Overlays

Thin-Bonded, Multi-Layer, Polymer Overlay
Common Types: Modified Polyester, LM Epoxy, MMA, Urethane
Polyester Polymer Concrete – PPC
New bridge decks with a 1.75in avg. cover should show signs of chloride-induced corrosion (chloride ion content equals 1lb/yd³ [0.63 kg/m³]) as follows when the average chloride application rate is moderate:

- 13 years when no protection treatment is used
- 25 years when a polymer sealer is maintained
- 77 years when a polymer overlay is maintained
What about Epoxy Coated Rebar?

The Bottom Line

Evaluations of ECR in approximately 250 concrete samples from 18 bridge decks across Virginia indicate that the epoxy coating debonds from the reinforcement in as little as 4 years and long before chlorides arrive at the level of the reinforcement. Assuming a debonded coating will provide for little additional service life, ECR should not be used to extend the service life of bridges in Virginia.
Thin-Bonded, Multi-Layer, Polymer Overlay

Trigger for use: Deck is still in good-excellent condition with <5% spalled, debonded or patched, minimal chloride contamination & > 250 psi strength of substrate (deck concrete)
Poor Condition for Thin Polymer (MLS)

“Once the deck deteriorates and requires patching on more than 5% of the deck, the overlay will most likely perform well for only a few years.”

(Investigations of Failures of Epoxy Polymer Overlays in Missouri / Nov 2007)
Polymer Resin Binder - ASTM D-638

The flexibility and strength of the polymer resin binder should demonstrate:

- The ability of the resin binder to retain aggregate through shear stresses and abrasion in extreme temperatures
- Thermal compatibility of the HFST system with the pavement
Potential Failure Mechanisms
Polymer Overlay Systems

- Thermal incompatibility with deck substrate
- Poor surface preparation
- Poor deck condition
- Improper mix ratio
Polyester Polymer Concrete
<table>
<thead>
<tr>
<th>Property</th>
<th>Polyester Concrete</th>
<th>Portland Cement (8 sk)</th>
<th>Latex-mod. Concrete</th>
<th>Silica-fume concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive Strength, psi</td>
<td>8,000</td>
<td>7,000</td>
<td>7 - 9,000</td>
<td>7 - 10,000</td>
</tr>
<tr>
<td>24 hr. Early Strength</td>
<td>4,000</td>
<td>1500</td>
<td>1500</td>
<td>2500</td>
</tr>
<tr>
<td>Return to Service</td>
<td>2 - 4 hours</td>
<td>3 - 7 days</td>
<td>3 - 7 days</td>
<td>2 - 4 days</td>
</tr>
<tr>
<td>Modulus (E), x10^6 psi</td>
<td>1 - 2</td>
<td>3 - 5</td>
<td>3 - 4</td>
<td>3-5</td>
</tr>
<tr>
<td>Flexural, psi</td>
<td>2,200</td>
<td>800</td>
<td>900</td>
<td>1,100</td>
</tr>
<tr>
<td>Abrasion, gms</td>
<td>1 - 2</td>
<td>10 - 20</td>
<td>10 - 20</td>
<td>10 - 20</td>
</tr>
<tr>
<td>RCP, coulombs</td>
<td>0 - 300</td>
<td>1,000 - 3,000</td>
<td>500 - 1,000</td>
<td>500 - 1000</td>
</tr>
</tbody>
</table>
Overlay or Deck Replacement

TRIGGER: PPC, LMC, MSC, Low Slump, Rapid Set Overlay

Polyester Polymer Concrete
• Impermeable
• Low Life Cycle Cost
• High Abrasion Resistance
• High Impact Resistance
• Some Structural Capacity

High Performance Concrete
• Low Permeability
• Low Life Cycle Cost
• More Prone to Cracking
• Structural Capacity