Protective Coatings for Steel and Concrete Bridge Components

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Content from Two Research Studies

- KTC-16-03/SPR12-433-1F
  Thin Film Concrete Coatings

- KTC-16-08/SPR14-484-1F
  Chloride Contamination Remediation On Steel Bridges
Action levels for chloride levels of concrete that result in steel corrosion

- 0.03 percent chloride to weight of concrete = initiation of corrosion
- 0.08 percent chloride to weight of concrete = accelerated corrosion
- 0.18 percent chloride to weight of concrete = major section loss of steel
Changes in Chloride Content in KYTC Bridge Components

- 2002 - bridge decks at the upper mat level were less than 0.01%
- 2011 - bridge decks at the upper mat level were often 0.20% - 0.30%
- 2011 - pier caps and abutment seats were often 0.30% to 0.40% range
Result of Increased Chloride Contamination
Result of Increased Chloride Contamination
Result of Increased Chloride Contamination
Research Approach

- Identify potential thin film coatings
- Minimal system application time requirements
- User friendly
- Evaluate in laboratory (ASTM D4587) and field
Performance Criteria Evaluated

- Adhesion
- Resistance to chloride transmission
- Color stability
- Gloss retention
<table>
<thead>
<tr>
<th>System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Two component, high-solids, high build, polyamide epoxy, applied in one coat. Two component, polyester modified, aliphatic, acrylic polyurethane, applied in one coat.</td>
</tr>
<tr>
<td>2</td>
<td>Two component, high solids epoxy, applied in one coat. Single component, water-born acrylic, applied in one coat.</td>
</tr>
<tr>
<td>3</td>
<td>Single component, water-born acrylic sealer, applied in one coat. Single component, elastomeric high build acrylic, applied in one coat.</td>
</tr>
<tr>
<td>4</td>
<td>Single component, waterborne blend of silanes, siloxanes and acrylics, applied in one coat. Single component, waterborne, silicon resin coating, applied in two coats.</td>
</tr>
<tr>
<td>5</td>
<td>Methyl methacrylate-ethyl acrylate copolymer sealer, applied in two coats.</td>
</tr>
<tr>
<td>6</td>
<td>Two component, cycloaliphatic amine epoxy mastic, applied in one coat. Two component, Aliphatic Acrylic-Polyester Polyurethane, applied in one coat.</td>
</tr>
<tr>
<td>7</td>
<td>Single component, Waterborne Acrylic, applied in one coat. Single component, Modified acrylic terpolymer, applied in one coat.</td>
</tr>
<tr>
<td>8</td>
<td>Two component castor oil/gypsum coating, applied in one coat.</td>
</tr>
</tbody>
</table>
Coating Application
Coating Application
Coating Application
## Coating Adhesion - Laboratory

<table>
<thead>
<tr>
<th>System</th>
<th>Pre-exposure</th>
<th>1,000 hr exposure</th>
<th>2,000 hr exposure</th>
<th>3,000 hr exposure</th>
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<tbody>
<tr>
<td>1</td>
<td>Psi</td>
<td>738</td>
<td>798</td>
<td>811</td>
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<tr>
<td>2</td>
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### Coating Adhesion - Field

<table>
<thead>
<tr>
<th>System</th>
<th>6 Month</th>
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<td></td>
<td>Psi</td>
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<tr>
<td>6</td>
<td>1635</td>
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<tr>
<td>7</td>
<td>551</td>
</tr>
<tr>
<td>8</td>
<td>519</td>
</tr>
</tbody>
</table>
Conclusions From Thin Film Concrete Coating

- Adhesion of coatings and the ability to resist chloride penetration are two characteristics very important for concrete coating performance.
- Systems 1, 2 and 6 perform better in these characteristics than other systems tested.
- Each of these are two-coat systems with epoxy primers. Two systems have urethane top coats and the third has an acrylic top coat.
Research Approach

- Precondition steel panels by cyclic salt fog exposure (ASTM B117)
- Clean the corroded steel panels with candidate surface preparation methods
- Assess the retained chlorides
- Recommend surface preparation methods for KYTC maintenance painting.
Test Panel Preconditioning
Test Panel Preconditioning
Surface roughness of the preconditioned panels was approximately 20 mils and chloride contamination averaged 500 µg/cm².
Test Panel Apportionment

Chloride Content After Surface Preparation

Chloride Deposition by SEM

Chloride Content Prior to Surface Preparation
Pre-surface Preparation Boiling Extraction
Thirty-two surface preparation methods. Eight dry methods, with combinations of abrasive material (steel grit, mineral slag, glass, and aluminum oxide), abrasive size, and re-blasting (after flash rusting).

Twenty-four wet methods, with combinations of water pressure, water abrasive mixes, water temperature, and chemical additives.
Surface Cleanliness

SSPC SP 10
SSPC VIS4
WJ-1
Surface Cleanliness

SSPC SP 10
SSPC VIS4
WJ-1
Post-surface Preparation
SEM Assessment
Post-surface Preparation SEM Assessment
Post Cleaning % Cl⁻

% Cl⁻

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

Wet Method

Dry Method
Post Cleaning Cl⁻ Surface Concentration

- **Wet Method**
- **Dry Method**

μg/cm²
Chemical Water/Abrasive

1. Map is 73 mils x 59 mils.
2. Spot is 4.7 mils across the horizontal axis.
3. Chloride removed – 99.1%
4. Chloride – 6.4 μg/cm²
Chemical Water Jetting

1. Map is 50 mils x 37.5 mils.
2. Spot is 2.25 mils across the horizontal axis.
3. Chloride removed – 98.5%
4. Chloride – 10.3 μg/cm²
1. Map is 49 mils x 37 mils.
2. Spot is 3.6 mils across the horizontal axis.
3. Chloride removed – 98.1%
4. Chloride – 7.9 μg/cm²
Chemical  Mineral Slag

1. Map is 117 mils x 88 mils.
2. Spot is 30.0 mils across the horizontal axis.
3. Chloride removed – 98.0%
4. Chloride – 10.3 μg/cm²
4.8K psi wash, Steel Grit 40/50

1. Map is 86 mils x 60 mils.
2. Spot is 18.1 mils across the horizontal axis.
3. Chloride removed – 95.9%
4. Chloride – 17.1 µg/cm²
Conclusions

- Wet surface preparation methods are most effective in remediating chlorides.
- Repeated dry abrasive blast cleaning is nearly as effective.
- No method tested cleaned to less than 5 μg/cm² chloride.
- Remaining chlorides are deposited in “hot spots”.
Thank You

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