Coatings & Linings

Coating Performance in Duluth Superior Harbor—Part 2

RICHARD I. RAY AND BRENDA J. LITTLE, FNACE, Naval Research Laboratory, Stennis Space Center, Mississippi

Sixteen miles (26 km) of carbon steel (CS) sheet piling (12-mm thick ASTM A328 cold rolled) used for docks, bridges, and bulkheads in the Duluth Superior Harbor (DSH) in Minnesota and Wisconsin are corroding at an accelerated rate of 3 mm/y or higher. The corroded pilings have an orange rusty appearance characterized by tubercles (i.e., corrosion products and deposits covering areas of localized corrosion). Barrier coatings provide one option for protection of extensive structures in fresh water, and nine coatings were evaluated for corrosion protection of CS coupons and I-beams around DSH after 46 and 35 months, respectively. Part 1 (September 2012 MP) described the coatings used and the locations of coupons and I-beams. Part 2 discusses the results of the evaluation.

Products

The following coatings were selected for this evaluation:

1. Aquapure HR
2. Chevron Phillips TZ9043
3. Standard epoxy
4. Humidur ML
5. Wasser MC-zinc/MC-tar
6. Sherwin-Williams Fast clad ER
7. Poly-Spec LPE 5100
8. Coal tar epoxy
9. Zinc-rich primer VZ108/V766

These products are identified throughout the article by number.

Coupons

There were no corrosion products or tubercles on any of the painted coupon surfaces like those that covered areas of localized corrosion on unprotected piling surfaces. The outward-facing coated surfaces were colonized with zebra mussels and a freshwater sponge. Zebra muss-

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Coating 1 coupons.

Observations:
- Few byssal threads still attached
- Algae growing on one side of coupon
- Top layer of coating peeling from scribe
- Corrosion evident in scribe area
- Muddy coating on surface

Coating 4 coupons.

Observations:
- Few byssal threads still attached
- Coating appears intact even in scribe areas
- Corrosion evident in scribe areas
- Muddy coating on surface except where silicone caulk used to attach Teflon holder

I-Beams

Table 1 summarizes I-beam coating performance after exposure.

The topcoat of Coating 1 delaminated and peeled from the surface of the I-beam (Figure 5).
**FIGURE 3**

<table>
<thead>
<tr>
<th>Coating 5</th>
<th>Coating 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Side A)</td>
<td>(Side A)</td>
</tr>
</tbody>
</table>
| U.S. Coast Guard Cell C  
Red urethane micaceous iron oxides  
and refined coal tar  
Total exposure time 46 months |
| (Side B)  | (Side B)  |
| Observations  
Few byssal threads still attached  
Some algae on coating surface  
Coating appears intact even in scribe area  
Corrosion evident in scribe  
Muddy coating on surface |
| U.S. Coast Guard Cell C  
Blue/grey zinc primer/vinyl copolymers  
Total exposure time 46 months |
| Observations  
Few byssal threads still attached  
Some algae on coating surface  
Coating appears intact even in scribe area  
Corrosion evident in scribe  
Muddy coating on surface |

Coatings 5 and 9 coupons.

**FIGURE 4**

<table>
<thead>
<tr>
<th>Coating 6</th>
<th>Coating 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Side A)</td>
<td>(Side A)</td>
</tr>
</tbody>
</table>
| U.S. Coast Guard Cell B  
White amine epoxy (one coat)  
Total exposure time 46 months |
| (Side B)  | (Side B)  |
| Observations  
Few byssal threads still attached  
Coating appears intact even in scribe area  
Coating lumpy and thick  
Corrosion evident in scribe  
Muddy coating on surface |
| U.S. Coast Guard Cell C  
Black polysulfide modified epoxy novolac  
Total exposure time 46 months |
| Observations  
Few byssal threads still attached  
Some algae on coating surface  
Coating appears intact even in scribe area  
Corrosion evident in scribe  
Muddy coating on surface |

Coatings 6 and 7 coupons.
The I-beams were not scribed so the intentional defect was not necessary to initiate the delamination. The base coat remained intact and no localized corrosion was obvious. Coating 7 peeled from the surface in large sections, exposing uncoated steel with corrosion and tubercles (Figure 6).

All other coatings performed adequately. Chips along the edges of the I-beams may have occurred during transport.

**Conclusions**

Over a three- to four-year period, coatings prevented the formation of tubercles and localized corrosion on CS surfaces. Coating performance varied among the products and two products (Coatings 1 and 7) failed due to peeling. None of the coatings protected the sub-stratum at an intentional defect.

Details showing all coating results are available from the authors.

**Reference**


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**BRENDA J. LITTLE**, FNACE, is a senior scientist at the Naval Research Laboratory. She uses surface analytical chemistry, electron microscopy, and electrochemical techniques to investigate adsorption, biofouling, biodegradation, bioremediation, and corrosion in marine environments. She is a NACE International Fellow and has been a NACE member since 1984.

**TABLE 1**

<table>
<thead>
<tr>
<th>Product/Chemistry</th>
<th>Pass/Fail</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1—white two-part solvent-free polyamine epoxy</td>
<td>Fail</td>
<td>Delamination, blistering, peeling</td>
</tr>
<tr>
<td>2—light green/white two-part epoxy</td>
<td>Pass</td>
<td>Thick, uneven, intact, chips</td>
</tr>
<tr>
<td>3—grey two-part polyamide epoxy/zinc primer</td>
<td>Pass</td>
<td>Thick, smooth, intact, chips</td>
</tr>
<tr>
<td>4—dark green two-part polyamine epoxy</td>
<td>Pass</td>
<td>Thick, lumpy, intact, chips</td>
</tr>
<tr>
<td>5—red urethane micaceous iron oxides/refined coal tar</td>
<td>Pass</td>
<td>Thin, intact, fingerprints, chips</td>
</tr>
<tr>
<td>6—white amine epoxy (one coat)</td>
<td>Pass</td>
<td>Thick, lumpy, intact, chips</td>
</tr>
<tr>
<td>7—black polysulfide modified epoxy/novolac</td>
<td>Fail</td>
<td>Broken, peeling, corrosion</td>
</tr>
<tr>
<td>8—black two-part coal tar polyamide epoxy</td>
<td>Pass</td>
<td>Thin, smooth, intact, few chips</td>
</tr>
<tr>
<td>9—blue/grey zinc primer/vinyl copolymers</td>
<td>Pass</td>
<td>Thin, rough, intact, chips</td>
</tr>
</tbody>
</table>

**FIGURE 5**

Coating 1 shown on the I-beams.

**FIGURE 6**

Coating 7 shown on the I-beams.
Sixteen miles (26 km) of carbon steel (CS) sheet piling (12-mm thick ASTM A3281 cold rolled) used for docks, bridges, and bulkheads in the Duluth Superior Harbor (DSH) in Minnesota and Wisconsin are corroding at an accelerated rate of 3 mm/y or higher. The corroded pilings have an orange rusty appearance characterized by tubercles (i.e., corrosion products and deposits covering areas of localized corrosion). Barrier coatings provide one option for protection of extensive structures in fresh water, and nine coatings were evaluated for corrosion protection of CS coupons and I-beams around DSH after 46 and 35 months, respectively. Part 1 (September 2012 MP) described the coatings used and the locations of coupons and I-beams. Part 2 discusses the results of the evaluation.