Assessment of Weathering Steel Bridge Performance in Iowa and Development of Inspection and Maintenance Techniques

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History of Weathering Steel Bridges in Iowa

- 1930’s: Weathering steel first evolved
- 1964: First used for a bridge application
- 1980: Michigan moratorium, Iowa followed
- Research studies
- Mid-1990’s: Weathering steel bridges reintroduced in Iowa
- Recent years: Certain Iowa bridges are not performing properly

- Currently Iowa has approximately 139 weathering steel bridges
- 93% were constructed after 1994
Questions for study

- A few of bridges with flaking patina, heavy chloride contamination
- What is a good patina?
- Objective evaluation method?
- Inspection procedures?
- Effectiveness of washing?
- Washing methods?
Typical Patina Behavior

Excessive chlorides, poor exposure, increased time of wetness

Protective Rust

Corrosion Loss vs. Exposure Time

- Typical unpainted carbon steel without copper
- Weathering steel (urban)
- Weathering steel (rural)
Project Objectives

- Identify problematic bridges
- Identify problematic locations or details
- Evaluate inspection techniques
- Prioritize bridges:
  - Condition
  - Location
  - Exposure
- Recommend maintenance program
Field Investigation
Inspection and Testing Methods

- Visual Inspection
- Chloride Testing
- Tape Adhesion
- Color Testing
- Core Samples
- SEM/FTIR/XRD
Inspection and Testing Methods

- Goals of Inspection Method:
  - Consistent
  - Reliable
  - Repeatable
  - Objective Results

- Visual Inspection: easy and practical, but not always objective
- Tape Adhesion Tests: simple, practical, and objective
- Color Testing: not always consistent
- Chloride Testing: not always reliable
- Core Samples, SEM, XRD: not practical or cost effective
Inspection and Testing Methods

- Non-Protective
- Increasing Flake Size
- Thick Rust
- Protective Coat

Corrosion Loss vs. Exposure Time

- Typical weathered carbon steel with copper
- Weathering steel (urban)
- Weathering steel (rural)
# Proposed Rating Scale (NBIS Format)

<table>
<thead>
<tr>
<th>Patina Rating</th>
<th>Condition Description</th>
<th>Example Condition in Field</th>
<th>Example Tape Test Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Patina</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Uniform color pattern, generally dark brown with some lighter reddish-brown, metallic, and purple-brown spots. May be difficult to see small rust products. Texture may be dimplled or rough but uniform in pattern. Patina layer is thin but dense and very adherent, indicative of very good protective properties. Superior adherence; tape test specimen with very small flake (&lt; 1 mm).</td>
<td><img src="image1" alt="Example Condition in Field" /></td>
<td><img src="image2" alt="Example Tape Test Specimen" /></td>
</tr>
<tr>
<td>2 Good</td>
<td>Uniform color pattern, generally dark brown with some lighter reddish-brown, metallic, and purple-brown spots. Individual rust products clusters visible. Texture is dimplled through burnishing in pattern. Patina layer is thick and dense and adherent, indicative of good protective properties. Tape test easily removes very small (&lt; 1 mm) flakes.</td>
<td><img src="image3" alt="Example Condition in Field" /></td>
<td><img src="image4" alt="Example Tape Test Specimen" /></td>
</tr>
<tr>
<td>3 Satisfactory</td>
<td>Dark brown, relatively pure color, no flakes visible. 1-2 mm flakes loose on surface, easily removed with tape test. Underlying layer adherent, mild relative density, thin and protective. Texture more granular and loose flakes may be less protective, holding water and salts. Chalky patina layer may be present, but not significantly affecting performance (e.g., flake size).</td>
<td><img src="image5" alt="Example Condition in Field" /></td>
<td><img src="image6" alt="Example Tape Test Specimen" /></td>
</tr>
</tbody>
</table>

- **Overall Appearance**
- ** Flake Size and Density**
- ** Color and Consistency**
Example 1: No Chloride Exposure
Example 1: No Chloride Exposure
Example 1: No Chloride Exposure
Example 2: Chloride Exposure
Example 2: Chloride Exposure
Example 2: Chloride Exposure
Example 2b: Chloride Exposure
Example 2b: Chloride Exposure
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Iowa Weathering Steel Bridges
Conditions Affecting Patina Performance

- **Chloride Use:**
  - Salted from above
  - Salt spray from below
  - Both
  - Time of wetness

- **Location:**
  - Urban
  - Suburban
  - Rural

- **Exposure:**
  - Bold
  - Sheltered
  - Tunnel Effect

- **Service Below:**
  - Interstate or waterway
  - Low clearance?
  - High % trucks?

- **Detailing**
Iowa Weathering Steel Bridges
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Prioritization and Maintenance
Washing methods

- Existing washing specifications (flushing):
  - Designed to not damage paint
  - Minimum 5 gallons/minute
  - Maximum 1000 psi

- Proposed specifications (power wash):
  - Remove contaminations from surface
  - 3.5 gallons/minute
  - 3500-5000 psi, 15deg nozzle
  - Tip 12” from surface, 3-6 square feet/gallon
Prioritization and Maintenance

Environment

Bridge Prioritization and Washing Interval

Structure Type and Exposure

Patina Condition Rating
## Prioritization and Maintenance

### Proposed Washing Intervals

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Environment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Suburban</td>
<td>Rural</td>
</tr>
<tr>
<td>Grade separation, Interstate below</td>
<td>Priority 1</td>
<td>Priority 2</td>
<td>Priority 3</td>
</tr>
<tr>
<td></td>
<td>1 to 2 years</td>
<td>3 to 4 years</td>
<td>5 to 7 years</td>
</tr>
<tr>
<td>Grade separation, arterial or local road below</td>
<td>Priority 2</td>
<td>Priority 3</td>
<td>Priority 4</td>
</tr>
<tr>
<td></td>
<td>3 to 4 years</td>
<td>5 to 7 years</td>
<td>7 to 10 years</td>
</tr>
<tr>
<td>Stream crossing, rail crossing, or limited access road below</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Priority 3</td>
<td>Priority 4</td>
<td>Priority 4</td>
</tr>
<tr>
<td></td>
<td>5 to 7 years</td>
<td>7 to 10 years</td>
<td>7 to 10 years</td>
</tr>
</tbody>
</table>
### Proposed Patina Maintenance

<table>
<thead>
<tr>
<th>Patina Rating</th>
<th>Proposed Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;7 Good or Very Good</td>
<td>Continue periodic NBIS inspections to ensure patina is performing as intended</td>
</tr>
<tr>
<td>6 Satisfactory</td>
<td>Continue periodic NBIS inspections to ensure patina is performing as intended, consider provisional care such as periodic washing at baseline intervals</td>
</tr>
<tr>
<td>5 Fair</td>
<td>Determine cause of detrimental corrosion in areas of poor performance, routine washing at baseline intervals or more frequently</td>
</tr>
<tr>
<td>4 Poor</td>
<td>Determine cause of detrimental corrosion, routine washing more frequently than baseline intervals, monitoring, and consider painting if washing does not improve performance</td>
</tr>
<tr>
<td>3 Serious</td>
<td>Washing will likely not improve patina performance, painting should be scheduled</td>
</tr>
</tbody>
</table>
Questions?

http://www.iowadot.gov/research/bridges_structures.html

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