Evaluation & Life Extension of Eleven Bridges

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In This Presentation

We will discuss:

- Corrosion Evaluation and Life Extension of:
  - Eleven Bridges along I-95 in Richmond
- Partnering with you to solve problems cost effectively
Eleven Bridges - VDOT

- Constructed in 1950’s (60 years old)
- Heavy traffic corridor
- Full replacement: costly, disruptive
CORROSION COST PROGRESSION

Condition of Structure

Cost of Maintenance

- Internal Damage
- First Visible Damage
- Damage Accelerates
- Critical Point
- Potential Failure

Good: Preserve
Fair: Extend Life
Poor: Replace
Temporary Piers
Corrosion Damage
Corrosion Damage
Evaluation

- How much delam/spall existed at the time?
- Chloride presence at various depths?
- Future penetration & effects of chlorides?
- Active corrosion occurring? How quickly?
- Existing and future damage?
- Presence and progression of ASR?

High risk of prescribing a poor solution without proper diagnosis...
PIER 1 COLUMN 2
EAST/NORTH ELEVATION

LEGEND:
1) RED HATCHED AREA REPRESENTS DELAMINATION
2) RED FILLED AREA REPRESENTS SPALLING

PIER 1 COLUMN 2 EAST FACE
COVER | HALF-CELL
--- | ---
1.20 | 2.10 | 2.30 | -333 | -375 | -260
2.30 | 2.15 | 1.95 | -325 | -357 | -325
1.35 | 1.75 | 1.75 | -291 | -228 | -362
2.00 | 1.65 | 2.00 | -262 | -178 | -263
2.10 | 1.80 | 2.30 | -255 | -226 | -268

PIER 1 COLUMN 2 NORTH FACE
COVER | HALF-CELL
--- | ---
2.10 | 1.50 | 2.20 | -370 | -375 | -347
2.15 | 1.50 | 2.16 | -344 | -258 | -354
2.15 | 1.50 | 1.65 | -326 | -222 | -340
2.15 | 1.50 | 1.50 | -268 | -233 | -288
2.10 | 1.75 | 2.15 | -309 | -301 | -249
Boulevard - Structure Total Corrosion Potential

90% Probability of Active Corrosion
Boulevard - Structure Total
Chloride Concentration Histogram

Chloride Content (% Wt. Concrete)

Frequency (# of Samples)

0.005 0.015 0.025 0.035 0.045 0.055 0.065 0.075 0.085 0.095 0.105 0.115 0.125 More

- Threshold
- Active Corrosion

- Surface Sample
- Rebar Sample
- Behind Rebar Sample
GPR – Good Concrete

Line Scan 28

*Time (ns)*

*Position (ft)*

*Depth (ft, v=0.374 ft/ns)*

[Image of a GPR scan with arrows indicating reflections]
GPR – Delam. Concrete

Line Scan 29

Time (ns)

Position (ft)

Depth (ft, v=0.374 ft/ns)
<table>
<thead>
<tr>
<th>No.</th>
<th>Bridge Member</th>
<th>Past Concrete Damage (sq.ft.)</th>
<th>2009 Concrete Damage (sq.ft.)</th>
<th>Damage Increase percentage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lombardy - Pier 2 - Southbound Cap</td>
<td>61</td>
<td>110</td>
<td>80%</td>
<td>2000 data</td>
</tr>
<tr>
<td>2</td>
<td>Lombardy - Pier 2 - Column 1</td>
<td>13</td>
<td>33</td>
<td>154%</td>
<td>2000 data</td>
</tr>
<tr>
<td>3</td>
<td>Lombardy - Pier 2 - Column 3</td>
<td>25</td>
<td>47</td>
<td>88%</td>
<td>2000 data</td>
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<tr>
<td>4</td>
<td>Lombardy - Pier 2 - Northbound Cap</td>
<td>152</td>
<td>248</td>
<td>63%</td>
<td>2000 data</td>
</tr>
<tr>
<td>5</td>
<td>Overbrook - Abutment B - Northbound</td>
<td>10</td>
<td>22</td>
<td>120%</td>
<td>2000 data</td>
</tr>
<tr>
<td>6</td>
<td>Overbrook - Pier 1 - Northbound Cap</td>
<td>69</td>
<td>150</td>
<td>117%</td>
<td>2000 data</td>
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<tr>
<td>7</td>
<td>Overbrook - Pier 2 - Southbound Cap</td>
<td>114</td>
<td>127</td>
<td>11%</td>
<td>2000 data</td>
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<tr>
<td>8</td>
<td>Overbrook - Pier 2 - Column 1</td>
<td>3</td>
<td>13</td>
<td>333%</td>
<td>2000 data</td>
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<tr>
<td>9</td>
<td>Overbrook - Pier 2 - Column 8</td>
<td>16</td>
<td>49</td>
<td>206%</td>
<td>2000 data</td>
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<tr>
<td>10</td>
<td>Robinhood - Pier 1 - Southbound Cap</td>
<td>127</td>
<td>223</td>
<td>76%</td>
<td>2000 data</td>
</tr>
<tr>
<td>11</td>
<td>Robinhood - Pier 1 - Column 1</td>
<td>15</td>
<td>45</td>
<td>200%</td>
<td>2000 data</td>
</tr>
<tr>
<td>12</td>
<td>Robinhood - Pier 1 - Column 2</td>
<td>3</td>
<td>39</td>
<td>1200%</td>
<td>2000 data</td>
</tr>
<tr>
<td>13</td>
<td>Robinhood - Pier 1 - Northbound Cap</td>
<td>19</td>
<td>36</td>
<td>89%</td>
<td>2000 data</td>
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<tr>
<td>14</td>
<td>Sherwood - Pier 1 - Southbound Cap</td>
<td>83</td>
<td>171</td>
<td>106%</td>
<td>2000 data</td>
</tr>
<tr>
<td>15</td>
<td>Sherwood - Pier 2 - Column 5</td>
<td>10</td>
<td>22</td>
<td>120%</td>
<td>2000 data</td>
</tr>
<tr>
<td>16</td>
<td>Boulevard - Abutment B - Northbound</td>
<td>9</td>
<td>34</td>
<td>278%</td>
<td>1997 data</td>
</tr>
<tr>
<td>17</td>
<td>Boulevard - Pier 1 - Southbound Cap</td>
<td>230</td>
<td>379</td>
<td>65%</td>
<td>1997 data</td>
</tr>
<tr>
<td>18</td>
<td>Boulevard - Pier 1 - Column 2</td>
<td>50</td>
<td>79</td>
<td>58%</td>
<td>1997 data</td>
</tr>
<tr>
<td>19</td>
<td>Hermitage - Abutment B - Southbound</td>
<td>15</td>
<td>37</td>
<td>147%</td>
<td>1997 data</td>
</tr>
<tr>
<td>20</td>
<td>Hermitage - Pier 1 - Column 1</td>
<td>2</td>
<td>37</td>
<td>1750%</td>
<td>1997 data</td>
</tr>
<tr>
<td>21</td>
<td>Hermitage - Pier 1 - Column 2</td>
<td>1</td>
<td>22</td>
<td>2100%</td>
<td>1997 data</td>
</tr>
<tr>
<td>22</td>
<td>Hermitage - Pier 1 - Column 3</td>
<td>3</td>
<td>21</td>
<td>600%</td>
<td>1997 data</td>
</tr>
<tr>
<td>23</td>
<td>Hermitage - Pier 2 - Northbound Cap Outside</td>
<td>1</td>
<td>29</td>
<td>2800%</td>
<td>1997 data</td>
</tr>
<tr>
<td>24</td>
<td>Hermitage - Pier 2 - Column 10</td>
<td>1</td>
<td>12</td>
<td>1100%</td>
<td>1997 data</td>
</tr>
<tr>
<td>25</td>
<td>Hermitage - Pier 3 - Northbound Cap Inside</td>
<td>1</td>
<td>51</td>
<td>5000%</td>
<td>1997 data</td>
</tr>
<tr>
<td>26</td>
<td>Laburnum - Abutment B - Southbound</td>
<td>76</td>
<td>119</td>
<td>57%</td>
<td>1997 data</td>
</tr>
</tbody>
</table>
Spall and Delamination Comparison over Boulevard
2009 Siva Corrosion Services and 1997 Alpha Corporation

<table>
<thead>
<tr>
<th>Bridge Member</th>
<th>1997 Structure Damage (ft²)</th>
<th>2009 Structure Damage (ft²)</th>
<th>Damage Increase Percentage (1997-2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pier 1 - Southbound Cap - North Face</td>
<td>52</td>
<td>120</td>
<td>131%</td>
</tr>
<tr>
<td>Pier 1 - Southbound Cap - South Face</td>
<td>42</td>
<td>122</td>
<td>190%</td>
</tr>
<tr>
<td>Pier 1 - Southbound Cap - West Face</td>
<td>2</td>
<td>11</td>
<td>450%</td>
</tr>
<tr>
<td>Pier 1 - Southbound Cap - East Face</td>
<td>5</td>
<td>9</td>
<td>80%</td>
</tr>
<tr>
<td>Pier 1 - Southbound Cap - Top Face</td>
<td>3</td>
<td>18</td>
<td>500%</td>
</tr>
<tr>
<td>Total: Pier 1 - Southbound Cap</td>
<td>231</td>
<td>379</td>
<td>64%</td>
</tr>
</tbody>
</table>

* Patch work for steel columns has caused a decrease in damaged concrete. Patches constitute 25% of bottom surface area. Patches are included in total surface area.

Total: Pier 1 - Column 1-4 | 168  | 302  | 80% |
Total: Pier 1 - SB Cap & Column 1-4 | 399  | 681  | 71% |

Notes: • 1997 structure damage supplied by Alpha Corporation.
• 2009 structures damage supplied by Siva Corrosion Services.
• All calculations & pictorial representations of concrete damage are an estimation of actual concrete damage, based on dimensions & locations taken onsite.
• Siva Corrosion Services conducted spall and delamination survey for approximately 50% of the total structure.
Visible concrete damage – significant increase

- Developed a concrete damage % for each element

Average recorded cover – low

Majority of potential readings – active corrosion

High chloride readings behind rebars

Near future concrete damage will result

Significant weakening of the structure within five years
Based on a unique methodology, we developed recommendations for repair / replace / life extension

Concrete repair on all bridges
ECE to lower the chloride concentration
Sacrificial CP to arrest corrosion
25-year additional life for structures
Sprayed Zinc – widely used, easy to apply, approx. $15/ square ft.
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Structure</th>
<th>Replacement cost</th>
<th>Repair cost</th>
<th>Cost Savings</th>
<th>Repair cost/Replacement cost, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boulevard</td>
<td>$1,931,202</td>
<td>$402,300</td>
<td>$1,528,902</td>
<td>21%</td>
</tr>
<tr>
<td>2</td>
<td>Hermitage Road</td>
<td>$3,240,312</td>
<td>$619,720</td>
<td>$2,620,592</td>
<td>19%</td>
</tr>
<tr>
<td>3</td>
<td>Laburnum Avenue</td>
<td>$1,730,258</td>
<td>$380,480</td>
<td>$1,349,778</td>
<td>22%</td>
</tr>
<tr>
<td>4</td>
<td>Lombardy/CSX</td>
<td>$5,821,420</td>
<td>$2,019,420</td>
<td>$3,802,000</td>
<td>35%</td>
</tr>
<tr>
<td>5</td>
<td>Overbrook Road</td>
<td>$1,147,005</td>
<td>$312,240</td>
<td>$834,765</td>
<td>27%</td>
</tr>
<tr>
<td>6</td>
<td>Ramp-A</td>
<td>$926,000</td>
<td>$146,440</td>
<td>$779,560</td>
<td>16%</td>
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<tr>
<td>7</td>
<td>Robin Hood Road</td>
<td>$1,877,817</td>
<td>$568,560</td>
<td>$1,309,257</td>
<td>30%</td>
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<tr>
<td>8</td>
<td>Sherwood Avenue</td>
<td>$1,595,045</td>
<td>$397,700</td>
<td>$1,197,345</td>
<td>25%</td>
</tr>
<tr>
<td>9</td>
<td>Upham Brook Run</td>
<td>$2,287,719</td>
<td>$429,620</td>
<td>$1,858,099</td>
<td>19%</td>
</tr>
<tr>
<td>10</td>
<td>Westwood Avenue</td>
<td>$3,592,000</td>
<td>$402,440</td>
<td>$3,189,560</td>
<td>11%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$24,148,778</td>
<td>$5,678,920</td>
<td>$18,469,858</td>
<td>24%</td>
</tr>
</tbody>
</table>
Benefits

- Why testing? To properly design the solution...
- Department will save $18,400,000
- 25-years additional life
- Peace of mind
Beam End

Life Extension: $2 million vs. $10 million replacement cost
Deck Surveys
About SCS

Three-Part Service:
1. In-Depth Evaluation
2. Design of Life Extension Systems
3. Installation Inspection
Questions?

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