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VDOT EXPERIENCE WITH GROUTED TENDONS IN VARINA-ENON PRECAST SEGMENTAL POST-TENSIONED BRIDGE

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Bridge Construction and Typical Segment

Dedication Ceremony
July 18, 1990

I-295 Varina-Enon Bridge
28 spans

2001 Varina-Enon Inspection:
hole in duct; rust on strand & void in duct; rust was confined to vicinity of hole
Why did tendon fail in 17 years?

- Original grout (water, cement, admixture)
- Vacuum grout (high performance)
- Original grout and vacuum grout
- Chloride ions (none found)
- Carbonation of grout (original grout at failure)
- Moisture (grout has high moisture content)
- Oxygen (voids in tendons, unsealed vent tubes and inspection holes)
- Combination of factors

Concerns About Grouts in Tendons

- Voids due to bleeding and segregation
  (Bleeding in grouts used prior to 2000 was approximately 4 percent. In a 150 ft long tendon, 4 percent bleeding can cause 6 ft of void at the high points in the tendon)
- Voids due to incomplete grouting and leaks

Concerns?

- Long Term Performance of Structure
- Preventive Maintenance Requirements to Extend Service Life
- Future Rehabilitation Costs
- In-Depth Inspection Requirements
  - What Techniques?
  - How Frequently?
- Health Monitoring Requirements
  - Short Term Monitoring
  - Long Term Monitoring
Tendon Inspection and Repair

- Inspected tendons for voids in grout, flaws in ducts, and corrosion of strands and anchors (visual, wire probes, sounding, and bore scope) (2001 and 2002)
- Vacuum grouted some voids (2003 and 2004)
- Sealed some tendons (2003 and 2004)
- Replaced 2 tendons (1 failed, 1 with 3 broken wires) (2007)
- Evaluated condition of tendons using Magnetic Flux (approximately 90% of each duct) (2007)
- Twenty tendons selected for detailed evaluation by removal of a 2-ft section of duct (18 because of corrosion in bore scope pictures, 1 because of Magnetic Flux measurements by Dr. Al Ghorbanpoor and 1 because of his visual inspections) (2007)
- Plan to monitor tendons representing 6 conditions (2008)
### Magnetic Flux Testing

- **Failed Section**: Section loss identified by magnetic flux testing.
- **8 Ft Downstream of Failed Section**: Images showing the condition downstream of the failed section.

### Grouted Section

- Images showing the grouted section.

### Section Loss Identified by MF

- Images showing the section loss identified by MF.

### Grout Moisture Content

<table>
<thead>
<tr>
<th>Tendon</th>
<th>Broken wires</th>
<th>Section loss</th>
<th>color</th>
<th>Moisture content, %</th>
<th>Absorption, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP13T10</td>
<td>2</td>
<td>7 wires</td>
<td>5.3 %</td>
<td>Gray</td>
<td>32.8</td>
</tr>
<tr>
<td>SP12T9</td>
<td>1</td>
<td>4.8 wires</td>
<td>3.6 %</td>
<td>Gray (top)</td>
<td>36.6</td>
</tr>
<tr>
<td>SP12T9</td>
<td>1</td>
<td>4.8 wires</td>
<td>3.6 %</td>
<td>White (top)</td>
<td>21.6</td>
</tr>
</tbody>
</table>
Monitoring 6 Tendon Conditions

1. Voids, no vacuum grout (45 per cent of tendons)
2. Voids, incomplete vacuum grout
3. Drying shrinkage cracks in grout
4. Small section with minor pitting corrosion
5. Pitting corrosion and several broken wires
6. Vacuum grouted tendon with broken wires
Tentative Conclusions

- Tendons have voids
- Approximately 55% of tendons were vacuum grouted
- Grout typically has high pH and high moisture content
- Corrosion typically associated with access to oxygen and absence of grout

Recommendations

- Vacuum grout tendons with accessible voids
- Repair ducts and vacuum grout tendons subjected to detailed inspections
- Monitor tendons representing 6 tendon conditions using visual inspections through transparent duct repairs, half cell and rate of corrosion measurements and acoustic emission sensors.

Recommendations

- Consider Other Health Monitoring Technologies Based on Failure Analysis
- Determine Future In-Depth Inspection Requirements
- Perform Additional Repairs As Recommended from On-going Evaluation of Bridge

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