Varina-Enon Bridge: I-295 over James River (#14)

**Richmond District**
- Age: 28 Years
- Condition: Fair
- ADT = 36,000
- Detour: 25 miles
- Cable-Stayed Bridge

**Varina-Enon Bridge – General Information**

The Varina-Enon Bridge is a post-tensioned and a cable-stayed bridge. The cable stays are the large, visible cables that spread diagonally from the main towers to the bridge superstructure. The cable stays serve to support the loads of the superstructure, but they are assisted in this function by post-tensioning tendons that are inside of the bridge’s superstructure, running parallel with the roadway. The main span, which crosses the James River, uses cable stays and post-tensioning. The approach spans, which lead up to the main span, use only post-tensioning.

Post-tensioned bridges employ high-strength steel strands, similar to wire ropes, to hold prefabricated segments of the bridge together. Multiple steel strands are placed inside a hollow duct, and together a duct and the strands inside are collectively referred to as a tendon. The strands are pulled with extremely large forces after being placed in ducts. Those large forces are referred to as “post-tensioning” forces, and they serve to connect separate segments and serve a crucial function in the load-carrying capacity of the bridge. After post-tensioning forces are applied, grout is pumped into the ducts in order to protect the tendons from corrosion.

All portions of the bridge used a technique called “segmental construction”, which involves precasting large segments of the bridge superstructure and erecting those segments into place. The photograph below shows a typical post-tensioned, segmental box structure section being erected. This section will be connected to adjacent sections by internal post-tensioning strands.

The Varina-Enon Bridge uses external post-tensioning, meaning that the strands and tendons are located inside the openings within the box sections rather than within the concrete. See photo below.
Large Complex Structures

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The Varina-Enon Bridge also uses “transverse post-tensioning” to connect portions of the deck. The sectional view below shows how the northbound and southbound box segments, which were fabricated as discrete and separate elements, are connected in the field with transverse (perpendicular to traffic) tendons.

### Large Complex Structures - Major Projects in 30-Year Plan

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Project Description</th>
<th>Start Year in 30-Year Plan</th>
<th>Cost (2018 Dollars)</th>
<th>Reason for Importance/Potential Consequences of Inaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deck Rehabilitation</td>
<td>1</td>
<td>$12M</td>
<td>• Severe corrosion was discovered in the post-tensioning strands that provide a significant portion of the bridge deck’s strength</td>
</tr>
<tr>
<td>2</td>
<td>Pylon Rehabilitation</td>
<td>3</td>
<td>$55M</td>
<td>• The pylons are the bridge’s primary support towers</td>
</tr>
<tr>
<td>3</td>
<td>Tendon Regrouting and Replacement</td>
<td>6</td>
<td>$44M</td>
<td>• The post-tensioning tendons connect primary superstructure segments</td>
</tr>
<tr>
<td>4</td>
<td>Tendon Regrouting and Replacement</td>
<td>12</td>
<td>$25M</td>
<td>• A second phase of this work is anticipated as the structure ages</td>
</tr>
<tr>
<td>5</td>
<td>Deck Rehabilitation</td>
<td>22</td>
<td>$14M</td>
<td>• The deck is integral with the superstructure, so deck deterioration could affect both deck &amp; superstructure</td>
</tr>
<tr>
<td></td>
<td><strong>Varina-Enon Bridge 30-Year Plan Total in 2018 Dollars</strong></td>
<td></td>
<td><strong>$150M</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Project #1 – Deck Rehabilitation - Start Year 1 in 30-Year Plan**

A transverse post-tensioning strand located in the deck broke in May, 2017, leading to an investigation of the integrity of these strands, which are located at regular intervals along the bridge deck. See picture titled “Inside the Varina-Enon Segmental Box”, showing the broken strand. The post-tensioning system and deck will require additional repair and preservation work as part of this initial project.

Photo of the broken strand inside the box segment and at its anchorage are provided.
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**Project #2 – Pylon Repair - Start Year 3 in 30-Year Plan**

The pylons of the Varina-Enon Bridge are the primary supports for the main span. They are currently experiencing cracking at the base due to a phenomenon known as alkali-silica reaction (ASR), wherein the concrete essentially attacks itself by expanding. This is caused by reactive aggregates that are intrinsically part of the concrete. See photos.

The pylon columns are constructed over vertically post-tensioned hollow box sections. There are significant repair needs in these sections, as they currently are exhibiting endemic vertical cracking.

**Projects #3 and Project #4 - Tendon Regrouting and Replacement – Start Year 6 and Year 12 in 30-Year Plan**

The longitudinal post-tensioning tendons in the Varina-Enon Bridge have been a continual source of maintenance need since a tendon failed due to corrosion in 2007, seventeen years after the bridge was built. A picture of the broken tendon is shown below. This tendon was replaced as part of a tendon repair project that was performed in the aftermath of the tendon failure.

A thorough examination of the primary post-tensioning system was conducted after the tendon failure, and it was found that the grouting procedure had been inadequate. The majority of tendons had incomplete grout and low quality grout, creating highly corrosive environments within the tendons. Additional tendons were also found to have been compromised due to corrosion.

Given the condition of the existing tendons on the bridge, VDOT is embarking on a program of tendon repair, replacement and preservation. This will be conducted on a regular basis, with the first two projects beginning in years 6 and 12 of the program.

**Project #5 - Deck Rehabilitation - Start Year 22 in 30-Year Plan**

The bridge deck will require a second and more significant rehabilitation in Year 22. This will be both restorative and preventive in nature.