Eltham Bridge – General Information

The movable portion of the Eltham Bridge is a double leaf bascule bridge. Bascule bridges open by rotating a leaf (or leaves) from the normal horizontal position to a point that is typically nearly vertical, providing an open channel of unlimited height for marine traffic. The width of the channel is limited by the length of the leaf. If the channel is narrow, one leaf may be sufficient, in which case the bridge is called a “single-leaf bascule” bridge. For wider channels, two leaves are used, one on each side of the channel, and such bridges are known as “double leaf bascule bridges”. When the leaves are in the lowered position they meet at the center of the channel. Double-leaf bascule bridges employ a locking mechanism that connects the ends of the two leaves when they are in the lowered position. This mechanism keeps the leaves together for vehicular traffic.

There are three basic types of bascule bridges: trunnion, rolling-lift, and heel-trunnion. These types have slight variations in configuration and gear mechanisms. The Eltham Bridge is a double leaf trunnion bascule, which is by far the most common of the three types. The accompanying schematic diagram is included to provide a better understanding of how such structures function.

Schematic Diagram of a Typical Double Leaf Trunnion Bascule Bridge

The spans leading to the bascule portion of the bridge are known as approach spans, and they use a technology known as post-tensioning. The post-tensioned spans are indicated as “PT Segments” in the photo below. The movable (double leaf bascule) portion of the bridge is located between the post-tensioned segments.
The post-tensioning method used on the Eltham Bridge approach spans employs 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. The schematic diagram below shows how these prefabricated segments are pulled together by the strands.

Large Post-Tensioning Forces (T) Applied to the Steel Strands Keep the Segments of a Post-Tensioned Bridge Together. Segments are Pre-Built Separately and Installed in the Field

Schematic Diagram of the Post-tensioned Spans of the Eltham Bridge

The schematic diagram shows the manner in which a post-tensioned structure functions, but it also reveals a problem with the Eltham Bridge that was discovered several years after its construction. Specifically, the grout pumped into the tendons segregated, causing portions of the tendons to have voids or soft grout. The diagram shows the locations where soft grout and voids were found. Soft grout and voids make the strands vulnerable to corrosion, as there is inadequate grout to protect the steel in these locations. Pictures of grouted ducts and post-tensioning tendons are provided below:

Grouted Tendons with Conduit Removed. These examples are from a “mock-up” that was constructed separately from a bridge.
### Movable Bridges - 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>Conduit Rehabilitation</td>
<td>1</td>
<td>$2M</td>
<td>• Conduits house post-tensioning strands that are the primary means for supporting the approach spans</td>
</tr>
<tr>
<td>2</td>
<td>Acoustic Monitoring and Corrosion Protection</td>
<td>3</td>
<td>$15M</td>
<td>• The acoustic monitoring system is required as the best means for determining if strand failure(s) occur</td>
</tr>
<tr>
<td>3</td>
<td>Span Lock Rehabilitation and Motor Replacement</td>
<td>16</td>
<td>$3M</td>
<td>• Vital systems for the functioning of the movable bridge will have reached the end of service life</td>
</tr>
</tbody>
</table>
| 4              | Post-Tensioning Rehabilitation        | 27                         | $15M                | • It is anticipated that a significant number of post-tensioning strands will require repair at this stage.  
  • Post-tensioning tendons serve a crucial function in the load carrying capacity of the bridge.                                          |
|                | **Eltham Bridge 30-Year Plan Total in 2018 Dollars** |                            |                     | **$35M**                                                                                                                                 |

### Project #1 – Conduit Repair - Start Year 1 in 30-Year Plan

The conduits containing the post-tensioning strands need to be sealed as a preventive measure against corrosion. Conduits with water need to be drained and sealed to protect the strands. The existence of soft grout and water in the tendons was discovered when large spalls (flakes of delaminated concrete) began to appear on the sides of certain bridge girders (see photos).

### Project #2 – Acoustic Monitoring and Corrosion Protection - Start Year 3 in 30-Year Plan

Acoustic monitoring systems are the most economical technology for identifying corrosion in tendons. The system identifies the time and locations of any wire breaks on a structure. This close monitoring allows for plans to be made for replacement. The monitoring system uses sensors, placed at strategic locations throughout the bridge. The sensors detect sound signatures of the structure and use triangulation to locate any localized wire failures. A photo of a typical sensor is provided.
Movable Bridges

Eltham Bridge: Route 33 over Pamunkey River (#6)

**Project #3 – Span Lock Rehabilitation and Motor Replacement - Start Year 16 in 30-Year Plan**

Certain elements of movable bridges require periodic rehabilitation and replacement. This applies to the span locks and the motors of the bascule span. These are vital systems for the functioning of the movable bridge, and they will have reached the end of service life by this time.

**Project #4 – Post-Tensioning Repair - Start Year 27 in 30-Year Plan**

As previously addressed, the post-tensioning system on this bridge is vulnerable to corrosion. Accordingly, it is anticipated that there will be significant amount of repair required to address the tendons.