Post-Tensioning Assessment and Rehabilitation of the I-526 Wando River Bridge

Opened in 1991, the James B. Edwards Bridge carries the I-526 Mark Clark Expressway over the Wando River in Charleston, South Carolina. The twin 7,900' long structures, which are a critical link for regional and national freight operations, are comprised of precast segmental concrete superstructures supported by precast segmental piers on prestressed pile foundations. The 400' main spans were erected using the balanced cantilever method while the 150' approach spans were erected using span-by-span. Since 2016, HDR has supported the South Carolina Department of Transportation (SCDOT) with a variety of engineering services, including post-tensioning evaluation, rehabilitation and strengthening design, load rating, and design support services during construction.

Initial Repairs

In late Fall 2016, SCDOT commissioned HDR to perform a structural analysis and design repairs for a ruptured post-tensioning tendon that was found in the main span unit of the westbound bridge. The 1,010' tendon, which runs continuously through five spans, failed due to corrosion of the strands resulting from a combination of grout voids and water infiltration. HDR developed a 3D, time-dependent, staged construction model, evaluated the bridge's condition with the failed tendon, and designed the tendon replacement, which was completed in February 2017.

Phase I – Condition Assessment and Emergency Tendon Replacement

Following the initial tendon replacement, HDR coordinated a team of subcontractors to conduct a limited inspection, testing, and analysis program to identify the source and extent of corrosion in the external longitudinal tendons throughout both structures and develop recommendations for remedial action. Testing and inspection activities included:

- Borescope inspections of post-tensioning anchors to identify grout voids and corrosion in tendon anchorages and high points
- Visual tendon inspections and testing to identify active strand corrosion or deficiencies in grout quality
- Magnetic flux testing to identify section loss in the free tendon length
- Capacitive probe inspection to identify grout voids tendon ducts.
- Initial load ratings of the main span units

During the condition assessment, a second main span tendon failed in the westbound structure, triggering a temporary closure in May 2018. HDR conducted emergency analysis and design for the installation of two supplemental tendons and provided field inspection and support during installation to quickly reopen the structure three weeks later. Following this, HDR developed plans and specifications for the removal and replacement of the failed tendon.

Phase II – Design and Implementation of Initial Repairs

HDR developed plans and specifications to address a number of deficiencies identified in the condition assessment. These included the repair of grout voids, replacement of tendon anchor protection measures, deck surface and pourback repairs, deck sealing, design of two steel frames and overhead precast drop slabs to repair two damaged segment joints, installation of two 1,010' supplemental tendons in the eastbound structure, replacement of two existing 1,010' tendons in the westbound structure, and the installation of a polyester polymer concrete (PPC) overlay. As part of the tendon replacement activities, HDR supported the contractor in the development of an innovative system of

remote-controlled power saws to detension the tendons in a controlled manner that maximized worker safety.

Additionally, HDR designed a supplemental tendon system to strengthen an approach span unit containing a 153’ detensioned tendon. The original tendon had splices that were embedded in the pier segment closure pours and a path that included an internal length in the bottom slab, preventing its removal and replacement. Further, the original bridge design did not include accommodation for future post-tensioning in the approach spans. To replace the effect of this failed tendon, HDR developed a supplemental tendon system that used anchor/deviator blocks locked to the structure with PT bars and deviator buildouts in the pier segments. The system was designed to accommodate additional tendon replacements in the future, up to a complete replacement of all tendons in the span. Comprehensive 3D finite element solids models of the anchor/deviators and local segments were developed to evaluate local effects.

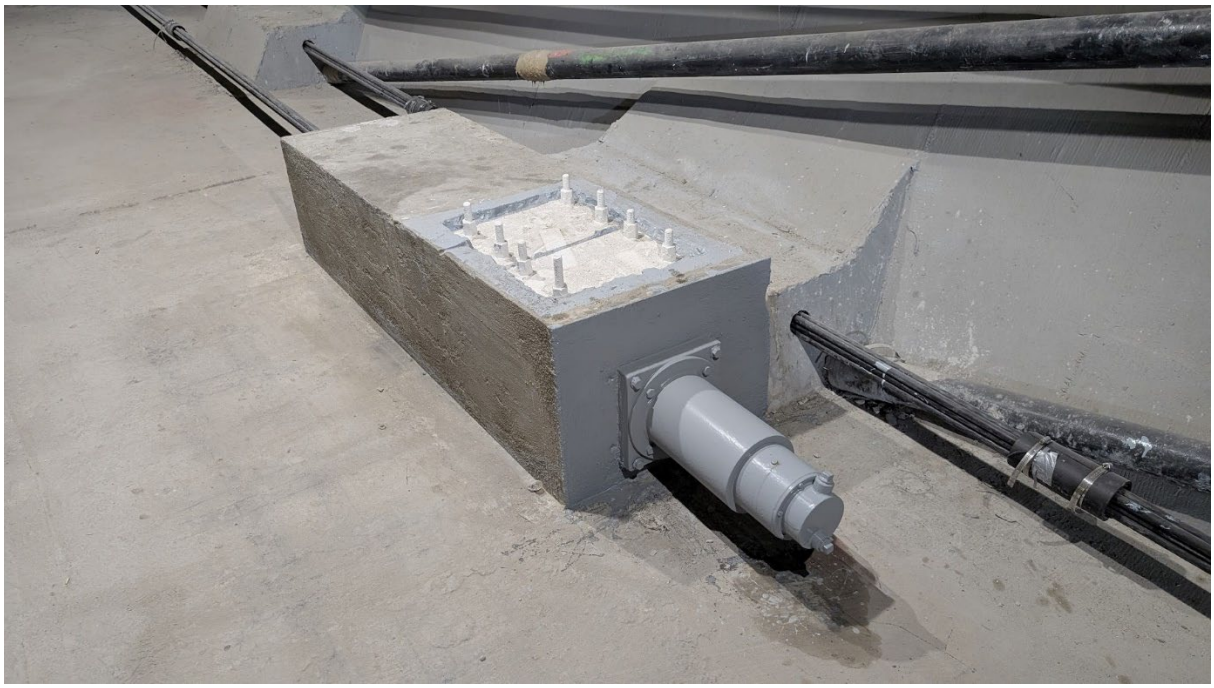
Phase III – Durability Improvements and Additional Strengthening

Based on the findings from the post-tensioning condition assessment, HDR identified external tendons and tendon segments in both bridges for impregnation with a corrosion inhibiting material. The very low viscosity hydrocarbon silicon polymer resin fills the interstitial space between the wires and impregnates the surrounding grout to provide a barrier to oxygen and moisture. HDR worked with the supplier to validate procedures for impregnating a variety of conditions including tendon couplers, tendon high points, and buried anchors, and then produced plans and specifications for the project.

In this phase HDR also designed a strengthening plan to replace the effect of a partially detensioned draped tendon. The design included carbon fiber reinforced polymer (CFRP) sheets on the webs of the affected span to add shear capacity. Additionally, the design utilized an asymmetric configuration of five new straight tendons. As the first unducted post-tensioning system in a bridge superstructure in the United States, this innovative solution used individually greased-and-sheathed strands and custom anchor assemblies to simplify installation and avoid the need for grouting ducts while still providing a comprehensive tendon protection system.

HDR is currently assisting SCDOT with the evaluation options for a structural health monitoring system and remains a responsive partner in maintaining this critical piece of infrastructure for the state of South Carolina.

Installation of CFRP on exterior face of webs from snooper (photos from Structural Technologies)



New anchor block with custom anchor designed for tendons comprised of individually greased and sheathed strands.

Anti-Vibration Posts for new 12-strand tendons. The upper connection of the post is designed to move in order to avoid transferring traffic load.

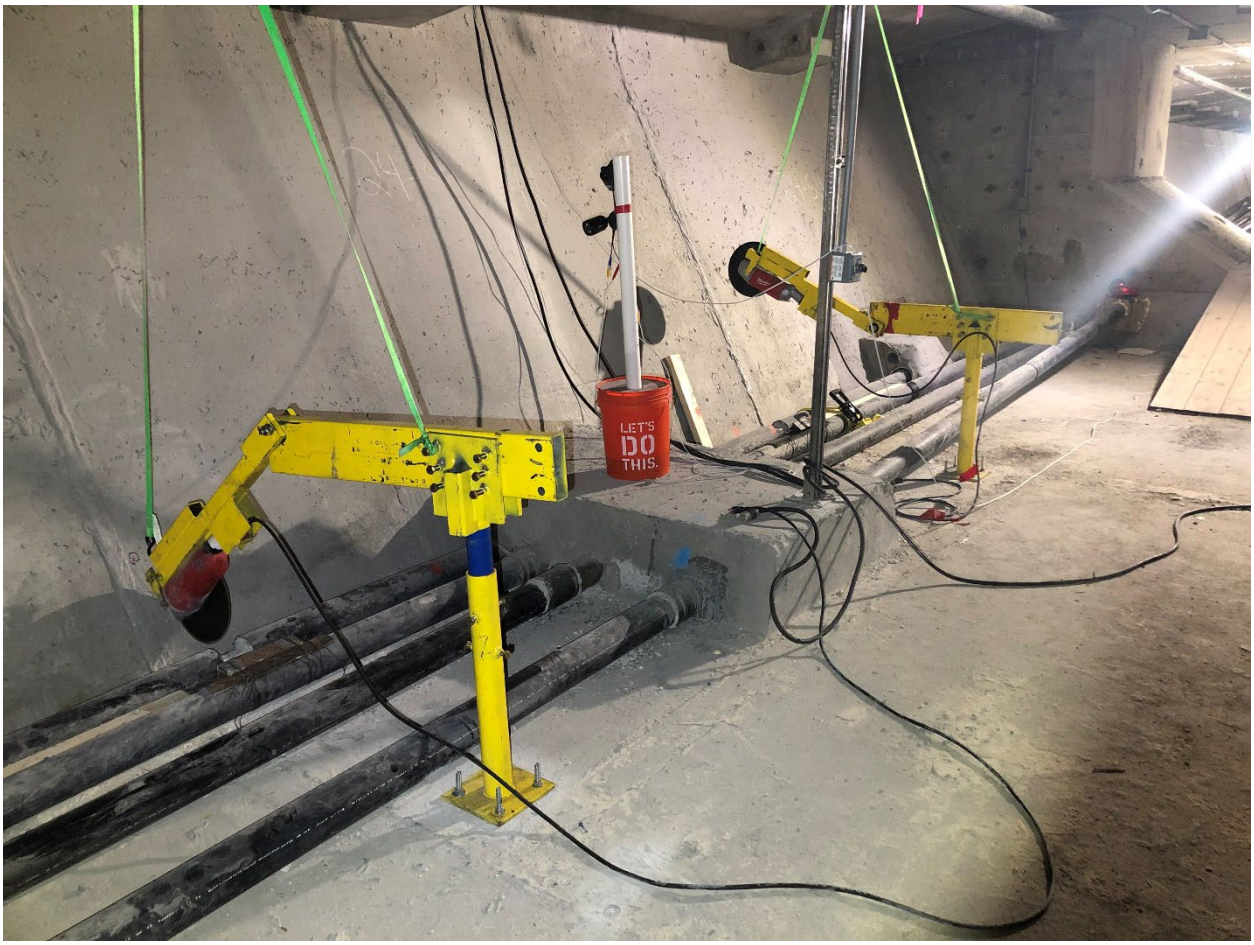
Frame and precast drop slab used to stabilize a damaged segment joint

Diaphragm coring for new tendons. Note CFRP sheet used on the right face of the diaphragm to resist anchorage general zone bursting forces. (Photo from Structural Technologies)

New anchor/deviator designed to anchor and deviate new draped tendons

New pier segment deviator designed to deviate up to six future tendons

I-526 Wando River Bridge



Remote-controlled power saws used for detensioning a long, multi-span tendons

I-526 Wando River Bridge (Looking East from Daniel Island)