Implementation of an Electrically Isolated Tendon Post-Tensioning System in the United States

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Post-tensioned concrete bridges represent an important component of the current U.S. bridge inventory. These systems, whether cast-in-place or precast concrete construction, can be used to create long-span continuous bridge superstructures with long service lives. However, ensuring the quality of the post-tensioning duct system and grout material used to encapsulate the strands has been a concern. The post-tensioning ducts are conventionally located within the web of the concrete girders, and critical sections—such as splices and anchorages—are heavily reinforced to provide adequate transfer of forces into the members. These practical requirements of post-tensioning (PT) make visual and nondestructive inspection techniques difficult to implement during construction and throughout the life of the bridge. Quality control methods are well established for PT installation and grouting, but traditional inspection methods are not easy to implement during regular service-life inspections of internal tendons.

To address this issue, electrically isolated tendon (EIT) systems have been developed. These systems, which can be easily integrated into new construction, provide full electrical isolation of the steel PT tendons from the surrounding concrete of the bridge structure. With isolation, the PT steel cannot form a corrosion cell with the exterior reinforcement, and corrosion of the tendon is nearly eliminated because the amount of oxygen within the duct is low.

System Components

The EIT system is composed of an enhanced tendon and anchorage system. The anchorage includes an isolation plate, a plastic trumpet, and proper encapsulation of the anchorage head. The tendon system uses a plastic duct, with plastic duct couplers and plastic half shells to protect the integrity of the corrosion protection system along the length of the tendon. The plastic half shells are used between the plastic duct and the transverse reinforcement to provide additional protection to the duct during member fabrication and tensioning.

Several companies commercially produce the required components of the EIT system for the European market, making this an off-the-shelf technology. For the past 20 years, EIT systems have been used in various post-tensioned concrete bridges in Europe, including the Piacenza Viaduct and Marchiazza Viaduct in Italy and the P.S. du Milieu and the Wiesebrücke Basel in Switzerland.

With the EIT system, the encapsulation system is assessed from time of construction through the service life of the bridge by using commercially available inductance/capacitance/resistance (LCR) meters to measure the AC resistance, capacitance, and loss factor between the isolated PT strands and the reinforcing steel located in the surrounding bridge structure. These readings can be compared to limiting acceptance criteria values[1] to provide owners with an assessment of the quality of the encapsulation and any unexpected corrosion initiation. These measurements are often taken at key stages of construction, such as during tensioning or tendon installation, before and after grout installation, during deck placement, and during service. The EIT system has the potential to provide long-term condition assessment of the tendon system over the life of the bridge.

First U.S. Demonstration Project

The many benefits of the EIT system and its successful use in Europe have prompted research and development efforts geared toward implementation in the United States, including a series of

The main unit of the Coplay-Northampton Bridge consists of a 540-ft-long, three-span section over the Lehigh River. The superstructure consists of five prestressed concrete PA bulb tees, which were spliced and post-tensioned. All Photos: Dr. Clay Naito.

Post-tensioning anchorages in precast concrete beams during spiral reinforcement installation, with an electrically isolated tendon trumpet (top) and a traditional trumpet (bottom).

Post-tensioning splice prior to placement of the closure joint. No difference can be seen between the electrically isolated tendon at the top and the three conventional tendons below.

demonstration bridge projects sponsored by the Federal Highway Administration (FHWA). The first demonstration project integrates the EIT system into the Lehigh County–owned Coplay-Northampton Bridge between Coplay and Northampton boroughs in Pennsylvania. This construction project is currently underway. Deck placement is expected in spring 2019, and the bridge is scheduled to open in fall 2019.

The primary portion of the Coplay-Northampton Bridge consists of a three-span, 540-ft-long unit over the Lehigh River. The superstructure consists of prestressed concrete PA bulb tees, which were spliced and post-tensioned in the field. The beams were precast at Northeast Prestressed Products in Cressona, Pa. The bridge was designed by AECOM and constructed by Trumbull Corporation, with project management provided by Pennoni. Each beam has four PT ducts. As a demonstration, only the top PT duct in each beam line has the EIT system, which was provided by DYWIDAG-Systems International (see the Focus article in this issue of *ASPIRE*® on page 6).

As mentioned previously, the EIT system requires the use of a plastic duct with plastic duct couplers and plastic half shells. In the demonstration project, the addition of the required isolation plate and plastic trumpet in the EIT anchorage was not a significant change to a traditional PT system. All the PT ducts, including the single EIT duct, were spliced in the field using plastic couplers combined with heat-shrink tubing. To ensure electrical continuity of the beam reinforcement located outside of the PT ducts, two uncoated pretensioning strands were left protruding from each end of each beam. Electrical continuity along the entire span is important because the measurements are taken at one end of the bridge. Failure to maintain electrical continuity of some spans would limit the effectiveness of the EIT system. The continuity strands were tied to the uncoated steel shear reinforcement within each beam during precasting and were tied together at each splice after erection. The two electrical continuity strands were located at the bottom of the beams.

The EIT system was monitored during selected stages of the construction project (following tensioning of the tendons, prior to and following grouting, and 28 days after grouting), and monitoring will continue to evaluate the long-term performance of the PT system. Measurements are taken by connecting the LCR meter to one of the exposed continuity strands located at the bottom of the flange and to the PT strands of the EIT system, using an exposed wire connection. These measurements are compared to the threshold performance limits and indicate the level of electrical isolation of the tendons.

Initial measurements indicate that the EIT system meets the current isolation requirements needed to achieve the highest level of corrosion protection, PL3, as defined in *PTI/ASBI M50.3-12: Guide Specification for Grouted Post-Tensioning*[2] and additional recommendations developed by Angst and Büchler for FHWA.[1]

According to discussions with the precast concrete producer, project manager, contractor, and Pennsylvania Department of Transportation, the use of the EIT system required minimal added construction effort, has had nominal impact on project costs, and appears to be a viable approach for providing additional quality assurance of the PT system.

References

1. Angst, U., and M. Büchler. 2015. *Monitorable Post-Tensioning Systems Sub Task 2: State of the Art Report*. Zurich, Switzerland: Swiss Society for Corrosion Protection.
2. Post-Tensioning Institute (PTI) and American Segmental Bridge Institute (ASBI). 2012. *PTI/ASBI M50.3-12: Guide Specification for Grouted Post-Tensioning*. Farmington Hills, MI: PTI.

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Measurement of the electrically isolated tendon (EIT) system after grouting. The inductance/capacitance/resistance meter is connected to the exposed steel located at the bottom flange and to the post-tensioning strands using the wire connection to the top EIT anchorage.