FHWA

Designing Post-Tensioned Bridges to Accommodate Nondestructive Evaluation

by Reggie Holt, Federal Highway Administration

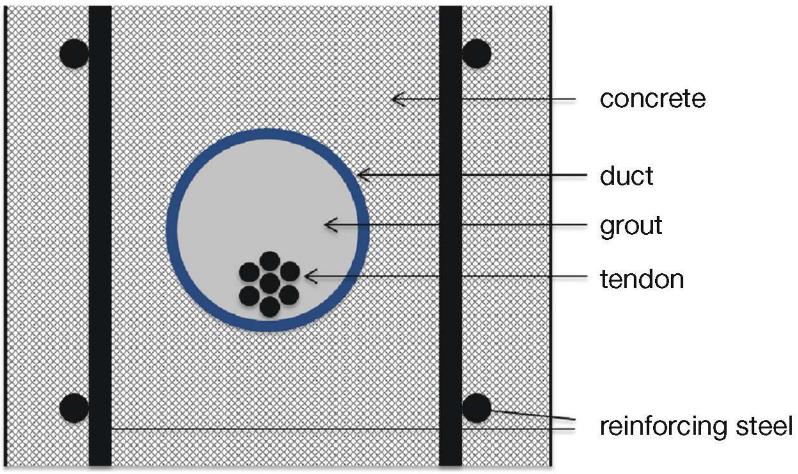

Figure 1. Typical post-tensioning strand encasement. All Figures and Photos: WSP/Parsons Brinckerhoff.

Post-tensioning (PT) has increased the strength and serviceability for many of our nation's bridges and will continue to play an important role in the design of future bridges. In-service post-tensioned bridges have proven to be very durable, however given the significant contribution that PT tendons provide to the bridge's load-carry capacity, there is great interest in assessing their in-service condition. Inspection of PT strands can be difficult due to their multiple layers of encasement, which typically include grout, ducts, reinforcing steel, and structural concrete (Fig. 1).

Nondestructive evaluation (NDE) technologies provide the best tools and techniques to assess the condition of PT tendons. NDE technologies are advancing rapidly and are offering increased assessment capability and portability. Past PT NDE research has focused primarily on choosing the appropriate NDE technology for the application, which many times has reduced the effectiveness of the NDE technology. The Federal Highway Administration (FHWA) has initiated research tasked to do the reverse, which is to design and detail the bridge to accommodate the NDE technology in order to maximize the effectiveness of the most promising tools.

Research Goals

The primary goal of this research is to reduce the likelihood of premature deterioration of post-tensioned bridge components and systems by identifying issues early through the use of NDE and provide better information about load-carrying capacity. This research will develop guidance for the design and detailing of post-tensioned bridges and tendon components to facilitate application of promising NDE methods. The effort is focused on evaluation of grouted internal and external PT systems. The ultimate goal is to find combinations of NDE, PT system details, and bridge superstructure details, that can be implemented into future structures to increase the reliability and ease of inspection for post-tensioned systems.

Research Approach

The first task for this research was to identify promising and readily available NDE technologies with the ability to detect strand corrosion, grout voids/condition, and remaining prestress. No one NDE technology can detect all the possible issues, however many can accurately detect one or more. Each of these NDE technologies was assessed on its ability to be applied to a PT bridge structure and provide accurate assessment data. Both strengths and limitations for each NDE technology were documented along with any current use in assessing and inspecting PT bridges.The numerous promising NDE technologies investigated are listed below.

- Acoustic emission
- Electrically isolated tendons
- Ground-penetrating radar
- Half-cell potential
- Impact echo
- Infrared thermography
- Radiography
- Time domain reflectometry
- Ultrasonic testing
- Visual inspection

In addition, this research identified PT system components and bridge superstructure details that hinder the NDE method's ability to effectively evaluate the PT tendon. Using this information, practical details for new design and recommendations on how to alter PT system components and bridge superstructure elements will be developed. As one might expect, the applicability and accuracy of many NDE technologies are affected by the type of

Figure 2. Monitoring at post-tensioning anchorage.

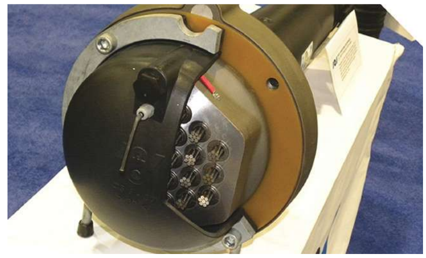

Figure 3. Electrically isolated tendon anchorage.

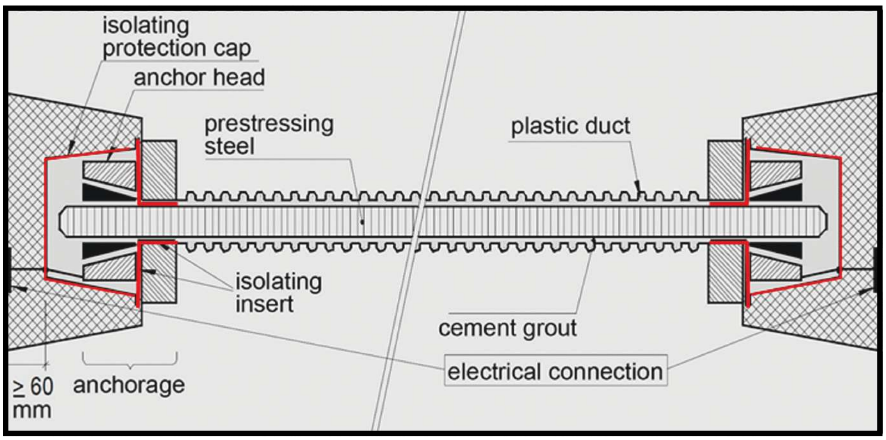

Figure 4. Electrically isolated tendon schematic.

encasement around the PT strand with the typical encasement variables being metal versus plastic PT duct, internal versus external PT tendon, and amount of reinforcing steel.

Research Findings

The research identified four promising NDE technologies that could be integrated into new construction and be used for routine inspection of the PT tendon throughout the lifespan of the structure. These promising technologies included electrically isolated tendons (EIT), time domain reflectometry, half-cell potential, and ultrasonic testing methods. The literature review and findings from this research are available electronically at www.atlss.lehigh.edu/documents/Reports/ATLSS_Report_14_01.pdf.

Three of the four identified promising NDE technologies will require additional research in order to thoroughly demonstrate their applicability and effectiveness in PT bridges. However, the EIT technology is very mature and routinely used in Europe and could easily be deployed in the United States. In fact, EIT is already recognized in the PTI/ASBI *Guide Specification for Grouted Post-Tensioning* as a viable PT system. The specification identifies an EIT post-tensioning system as protection level three (PL-3), which represents the highest level of PT tendon protection possible. Another major benefit identified in the research is EIT's ability to provide a very rigorous QC check during construction. EIT readings during construction can accurately detect breaches in the PT tendons protection system.

Future Opportunities

FHWA has started additional research to advance the electrically isolated tendon (EIT) technology (Fig. 2-4). The greatest needs to make this technology fully implementable are system qualification specifications and testing along with system detailing guidance. The recently started FHWA research will address these needs by developing system specifications and qualification testing along with guidance on EIT system detailing, installation, and monitoring. The research team will deliver the draft specification to the PTI/ASBI M50 Committee in the spring of 2016 and we look forward to implementing this promising technology in our nation's bridges in the near future.