Repair and Maintenance of Post-Tensioned Bridges: An NCHRP Synthesis Report

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Post-tensioned (PT) bridge construction provides a durable, economical means of spanning long distances. Coordinated efforts by the industry and stakeholders have greatly improved the durability of these structures since the technology's introduction in the United States. While most states have PT bridge structures, the way these bridges are designed, repaired, inspected, and maintained remains nonuniform. National Cooperative Highway Research Program (NCHRP) Synthesis 562[1] assembles valuable information about the repair and maintenance of PT concrete bridges, making it available to the entire highway community. This effort collates the most recent PT bridge repair and maintenance experiences and includes a literature review, a survey of state departments of transportation (DOTs), and five case studies from around the country.

State of Post-Tensioning Practices

Post-tensioning made its way to the United States in the early 1950s with the Walnut Lane Bridge in Philadelphia, Pa. Soon after that, the first PT bridge in Florida—the Sunshine Skyway Bridge in Tampa—was constructed in 1954. Although PT concrete is a durable construction method, some aspects present inherently difficult repair and maintenance situations. Most notably, the grout used to encapsulate a post-tensioning tendon's prestressing strands creates a difficult-to-inspect scenario. The geometry and heavy reinforcement in anchorage regions and deviation blocks also make it difficult to inspect tendons in these areas.

Several incidents in the early 2000s instigated improvements in the industry, ranging from the publication of guidance documents to the development of certification programs for post-tensioning personnel (for details, see articles in the Winter 2017 and Summer 2019 issues of *ASPIRE*®). Because

In 2010 an inspector noted light penetrating the interior box of the Plymouth Avenue Bridge in Minneapolis, Minn. The inspection findings prompted further investigation and rehabilitation plans. All Photos: Corven Engineering, a Hardesty and Hanover company.

construction practices and the quality of cementitious grout commonly used in bridge tendons have been identified as significant contributors to tendon damage, significant efforts have been made to improve them. Many efforts were undertaken to address grout issues of that era, including concerns about poor grout quality, incomplete filling of tendons, grout contamination, and underweight bags. Additional improvement to corrosion-protection systems for PT structures came with the switch from metal to plastic ducts, and the introduction of superior duct-splicing details.

The industry continues to evolve in response to stakeholders' concerns. The introduction of prebagged thixotropic grouts was one innovation aimed at improving the durability of PT structures; however, grout deficiencies have not been completely resolved. Newer grouts have also demonstrated the potential for grout segregation, soft grout, excessive bleed water, and high chloride and sulfate contents when the latest specifications and procedures are not followed.[2] Additional approaches have been undertaken to improve the overall serviceability and durability of PT bridges, including the use of redundant tendons, flexible filler materials for new tendons, proprietary impregnation materials for grouted tendon repair, and surface seal coatings of the main concrete section.[3]

Improvements to PT structure durability are due in part to the post-tensioning community's development of consensus documents, certification programs, and research efforts. Taken as a whole, these investments in both standardizing and advancing the technology have gone a long way in improving the state of the practice. However, implementation by state DOTs remains fragmented and inconsistent.

Survey

As part of the NCHRP synthesis, state DOTs were surveyed about their experiences with PT bridge structures, including detailed aspects related to design, construction, maintenance, and repair. (Survey responses can be downloaded from http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_562Answers.pdf.) There are thousands of PT structures in state bridge inventories; nearly every state DOT (44, to be exact) reported having PT structures, with a wide variety of structure types represented. States without PT structures cited lack of familiarity, concerns regarding durability and quality, lack of need, and lack of local industry presence as reasons they do not have such structures.

The Plymouth Avenue Bridge in Minneapolis, Minn., is coated with surface seal for enhanced protection after repairs.

Most state DOTs have updated their post-tensioning specifications within the past seven years, and many refer to two consensus documents from the Post-Tensioning Institute (PTI) and the American Segmental Bridge Institute (ASBI) for best practices: PTI/ASBI M50.3, *Specification for Multistrand and Grouted Post-Tensioning*[4] and PTI M55.1, *Specification for Grouting of Post-Tensioned Structures*.[5] Lessons learned since the grout problems uncovered in the early 2000s are generally, but not universally, reflected in DOTs' guidance for PT bridge construction. A notable number of state DOTs model their post-tensioning installation practices on the PTI documents or other states' specifications, but inconsistency still remains among many states. Additional efforts to ensure nationwide awareness of improved practices for PT construction may be warranted.

According to the survey, 23 state DOTs have experience with repair to their PT structures. DOTs reported that many of their repair actions occur during construction and are performed on problematic construction details such as duct splices, anchorage pour backs, confinement reinforcement, and other geometry conflicts. DOTs also reported that they still have issues with the injection process, including grouting, air pressure tests, and vacuum procedures, and they emphasized the importance of personnel training and experience. Repairs are still periodically performed to address grout deficiencies associated with the pre-2000 materials and procedures. Other causes of damage leading to repair are not specific to PT structures, such as vehicle impact, poorly designed drainage systems, poor concrete quality, and defective waterproofing membranes.

State DOT interest in innovative approaches to repairing and maintaining PT structures is high. Many agencies have used fiber-reinforced polymers and proprietary corrosion inhibitors in their repairs, and interest in these materials is increasing. Innovative approaches for internal tendon remediation, including the use of drying techniques and impregnation products, are under investigation.[6] Though most states rely on visual inspection for their PT structures, many states have investigated the use of nondestructive technologies to enhance the ability to assess the condition of grouted tendons.

Case Studies

NCHRP Synthesis 562 presents five case studies of PT bridges and their repair and maintenance actions. The cases were chosen to represent different geographic areas: Florida, South Carolina, Ohio, Virginia, and Minnesota. One thing some of the case studies have in common is a lack of post-tensioning-specific knowledge held by persons

performing the routine inspections of these structures. In some instances, evidence of damage to the PT system was not identified until the damage became critical. Just as the implementation of certification programs has gone a long way toward improving the construction of PT structures, the education of inspectors and other personnel engaged in the repair and maintenance of PT structures is imperative for improving in-service performance.

References

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The Plymouth Avenue Bridge's failed drainage system allowed water from the deck passing through pipes in the post-tensioned box girder to be a source of moisture intrusion for many years. Remediation included tendon replacement, re-entombment of exposed tendons, repair of pour backs, crack injection, and removal of the original drainage system.

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