Project Summary

Texas Department of Transportation

0-4588: Effects of Voids in Grouted, Post-Tensioned Concrete Bridge Construction

Background

Post-tensioned (PT) bridges have several advantages over other bridge types: they can span longer distances, can be constructed relatively fast, and are economical. The tendons of PT bridges are critical components, essentially the backbone of the PT bridge system. Tendons consist of strands, ducts, and grout that fill the interstitial space between the strands and ducts. Grout is intended to protect the strands from corrosion, especially when the duct is damaged or water or other deleterious substances infiltrate the tendon. However, past construction practices and materials have resulted in voids in tendons. Corrosion of the strands in these tendons has resulted in bridge failures in Europe. More recently, voids have been detected in PT bridges in the United States with some of the strands in these voids exhibiting corrosion. In fact, tendon failures have been reported on PT bridges, especially in Florida, that are exposed to aggressive environments. This history has raised concerns about conditions in PT bridges in Texas.

A recent inspection of tendons in PT bridges in Texas identified voids. However, all environments in Texas may not be classified as aggressive. Research was needed to assess how the environmental and other conditions, especially the conditions inside the voids in tendons, affect the corrosion of strands and how this corrosion influences the structural reliability of PT bridges. In addition, economical and high-performance grout materials and efficient inspection and repair methods needed to be defined.

What the Researchers Did

TTI researchers evaluated the corrosion performance of PT strands under various environmental and void conditions. Using these data the researchers developed probabilistic models for the tension capacity of PT strands. These models were then used to evaluate the time-variant structural reliability based on flexural and service stress limit states.

In addition to the electrochemical testing and structural reliability models, the researchers found that current methods for inspections and repairs were not well defined or efficient. Although repairing or filling the voids with grout has been temporarily suspended, researchers developed more efficient methodologies to fill the voids with grout. Also, an inspection method was developed and a corresponding repair manual was written.

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What They Found

Researchers found that the types of voids and resulting grout-void interfaces that are not parallel (or near parallel) to the strands result in localized corrosion at the interface and higher losses in strand capacity. However, environmental conditions lacking water and/or aggressive elements result in limited corrosion. If high humidity conditions are present and condensation occurs on the strands, corrosion activity can be high. Both uncontaminated and chloride-contaminated water can result in significant localized corrosion, reduced strand capacities, and early-age failures of the tendons. Thus, an inspection method has been proposed that can identify voids not parallel to the strands. This inspection method identifies and assesses potential void and water conditions inside tendons.

Before the moratorium on repair grouting (filling the voids with grout) was put into effect, a vacuum-grouting method was recommended to inject grout into the voids in tendons. However, this vacuum-grouting method was time-consuming and expensive. Researchers developed an alternative grouting method using both vacuum and pressure. This alternative method (known as a pressure-vacuum-grouting method) fills the voids with a similar efficiency to that of the vacuum-grouting method and requires much less preparation time.

The researchers evaluated various repair grouts. Findings led to the conclusion that limits should be placed on the maximum size of aggregates in grout and that grout be required to pass a mud balance test. Researchers developed a fillability test and recommend that grout meet the requirements of this test when used in PT structures.

What This Means

In cases where water or aggressive conditions are present in the tendon, significant corrosion activity can occur and the flexural capacity and serviceability of PT bridges can be adversely affected at relatively young ages. Efforts should be placed on identifying voids in tendons that contain or have contained moisture or aggressive elements. Moisture should be removed from these tendons and the point or points of infiltration should be repaired or sealed to prevent further infiltration.

If galvanic coupling is found not to occur at the interface between the existing grout and the repair grout, the pressure-vacuum-grouting method should be used to repair the voids in PT systems. If galvanic coupling is found to occur at these interfaces, it is recommended that regular inspections be performed, aggressive conditions be identified, and these aggressive conditions be eliminated. It is also recommended that further research be performed to develop an effective repair methodology and materials. Also it is recommended that the proposed modifications to the repair grout specifications be implemented.

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