FDOT

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Identification of the Mechanisms that Produce Hydrogen Embrittlement on Post-Tensioning Members and the Effects of Galvanic Coupling on Bridge Tendons

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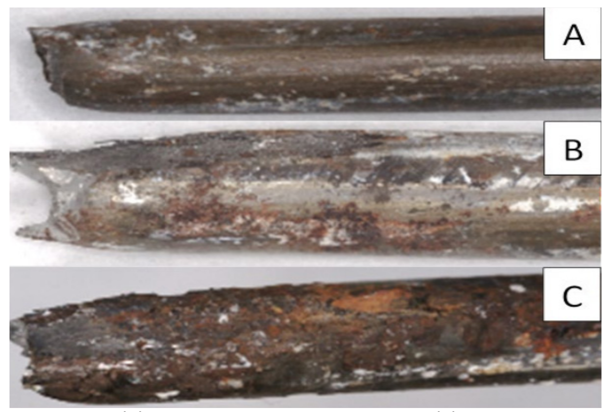
Current Situation

Can the quality and placement of cementitious grout within a galvanized steel diaphragm duct allow for the conditions for localized corrosion to be present?

The South Carolina Department of Transportation (SCDOT) suspected hydrogen contributed to the fracturing of steel cables on the Wando River Bridge. It was unknown if galvanic coupling , an electrochemical process that causes corrosion between dissimilar metals in the presence of hydrogen in the air, played a contributing role.

With more than 15 cases of similar corrosion on bridges of its own, the Florida Department of Transportation (FDOT) used the Wando River Bridge as a case study to further investigate the impacts of galvanic coupling on post-tensioned steel strands.



Example of (A) strands that have no corrosion; (B) mild corrosion; and (C) moderate corrosion.

One example is the Mid-Bay Bridge in Northwest Florida. It is 3.6 miles long and made of 141 spans connecting Destin and Niceville. Corrosion of the steel strands was observed in areas where grout voids and bleed water were present, which resulted in the replacement of several tendons.

If FDOT could find sources of galvanic coupling early, it could potentially save repair costs and extend the life of bridges.

Research Objectives

University of South Florida and FDOT researchers hypothesized that galvanic coupling between the galvanized steel duct and the steel strands of bridge members could be one of the mechanisms behind hydrogen production – which accelerates the embrittlement of steel. The objective of this project was to identify the conditions that promote hydrogen production that lead to galvanic coupling and identify the consequences of galvanic coupling between post-tensioned steel and galvanized ducts.

Project Activities

After a literature review, the research team autopsied failed tendon components from SCDOT and FDOT bridges. Through experiments and simulations, the team then established the likelihood of embrittlement of the steel strands under various grouting conditions. Then, mechanical testing and theoretical estimates were used to describe how galvanic coupling weakens steel strands and galvanized steel ducts.

Project Conclusions and Benefits

The research team found the most likely cause of failure for these types of strands were the result of pH assisted corrosion and hydrogen assisted cracking along the surface of the wire strand. The reaction could be attributed to the presence of a void within the duct, bleed water, segregation, and chlorides within the cementitious grout. A repeating series of events led to the removal of the passivation of the outer wire, creating a corrosive environment within the duct, making the wire more and more brittle until failure.

Ultimately, when built correctly, cementitious grouted tendons can perform as intended and achieve the anticipated service life. This research highlighted concerns that should assist or benefit other State DOTs in the design, construction, and repair of grouted tendons in their custody.

For more information, please see fdot.gov/research.