Florida Department of Transportation Research

Corrosion of Post-Tensioned Tendons with Deficient Grout

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Current Situation

Stressed steel cables greatly increase the strength and capability of concrete structural components, providing tensile strength that concrete alone does not possess. The cables – called tendons – run through sealed tubes in the concrete which are filled with grout. In Florida's coastal environments, salt sometimes finds a way into the grout and attacks the steel. If the steel is weakened, it can lose its tension, and the concrete structural member can fail. But grout by itself has been shown to contribute to tendon failures. Grout from failed tendons revealed severe corrosion associated with grout that had several deficiencies, such as high moisture, high free sulfate levels, and high pore water pH.

Research Objectives

Florida International University researchers examined the contribution of grout to corrosion of post-tensioned steel in concrete construction.

The Seabreeze Bridge in Daytona Beach, Florida, is one of many that use post-tensioned concrete components.

Project Activities

Two grout products were studied for effects of excessive moisture, chloride, and sulfate on their corrosion potential. To test moisture effects, grout materials were exposed to high humidity for up to 28 days then mixed with water – sometimes in excess of recommended amounts. Once hardened, the samples were exposed to high humidity for weeks, after which high sulfate levels were found in water that leached out of the grout. The researchers also found that the high humidity exposure and excess mix water contributed to grout deficiencies.

To clarify how and at what levels sulfate affected corrosion, the electrochemical potential of steel cable sections was monitored during immersion in highly alkaline solutions containing a range of sulfate levels. In general, sulfates alone showed no tendency to initiate or enhance corrosion.

To observe corrosion of steel encased in deficient grout, chloride and/or sulfate were added to grout exposed to high humidity for a month. The electrical potential of carbon steel wire encased in this grout was monitored for up to 300 days. Chloride initiated corrosion when present at medium and high levels while sulfate initiated corrosion only at high levels. However, low chloride levels in combination with even modest sulfate levels initiated corrosion if the sulfates were present earlier in the system.

Tests were also performed at a scale closer to the actual cable-grout environment: 15-foot lengths of steel cable were encased in grout cast in clear PVC tubes inclined at 15 degrees to provide a gradient of conditions. The grout was made with either tap water (control), two levels of chloride, or three levels of sulfate. Again, chloride was a much stronger initiator of corrosion than sulfate. Corrosion appeared to be enhanced in the upper part of the tubes as the electrochemical potential was continuously changing along the length of the inclined tubes. The difference in potential between the top and bottom may be enough to set up a battery effect that can enhance corrosion.

Project Benefits

A better understanding of the effects of grout composition and behavior on steel post-tensioning tendons can lead to better product specifications and installation procedures, reducing corrosion, maintenance, and replacement costs for structures that use this technology.

For more information, please see dot.state.fl.us/research-center