Florida Department of Transportation Research

Corrosion Characteristics of Unprotected Post-Tensioning Strands under Stress
BDK84-977-22

Post tensioned concrete is used in many Florida transportation structures, many of which are exposed to fresh or salt water. The steel strands that supply the tension are encased in a plastic duct which is later filled with grout, so the strands are generally well protected from the elements. However, during construction, strands may reside in the pipe for a while before tensioning or grouting. During this time, the strands are vulnerable to corrosion. Florida Department of Transportation (FDOT) guidelines specify sealing the duct to exclude moisture or other harmful agents from reaching the steel strand. However, if moisture is sealed in the duct or the duct is inadequately sealed, corrosion can result. Ideally, ducts are grouted within hours of stressing, but there are circumstances that can delay grouting for days or, rarely, weeks. If damaged, strand failure can be immediate, or it can mature over time to produce delayed failure.

Previously, University of South Florida researchers examined the impact of corrosion on unstressed steel strands (FDOT project BDK84-977-04). In that work, they found resistance to moderate amounts of corrosion. In this project, the same researchers applied their methods to stressed steel, which might be more susceptible.

Of special interest were the possibilities of stress-corrosion cracking (SCC) and hydrogen embrittlement (HE). SCC occurs when a susceptible material is stressed in corrosive environments. Networks of thin cracks can develop and weaken the steel or cause failure. HE occurs because elemental hydrogen can be a byproduct of corrosion. Hydrogen atoms are small even for an atom, allowing them to migrate through the steel, drawn to areas of high stress where they promote brittle fracture.

Field testing was conducted in duplicate with near-full-scale ducts at various levels of moisture exposure, salt exposure, and with and without desiccant. Ducts containing either stressed or unstressed strands were tested and were located at both inland and seaside facilities. Each duct contained two seven-wire strands. Exposure periods were 1, 2, and 4 weeks. After exposure, tendons were de-tensioned and extracted for testing. Strands were examined for surface rusting and hydrogen pickup and evaluated mechanically with standardized tensile tests and limited reverse bending tests.

A worker puts the finishing touches on a test pile. The ducts containing the steel strand are visible here by the white caps that seal them.

Stressed strands performed similarly to unstressed strands. However, trapped water aggressively promoted corrosion, so excluding water and moisture exposure is important. But with proper protection, strands were secure within the two-week period allowed between placement of strands and grouting. Salt deposited on the strand accelerated corrosion significantly, especially when moisture was present in the duct. Desiccant arrested surface rust development and might be useful as a means of controlling corrosion.

Project findings supported current FDOT guidelines on post tensioning and highlighted areas critical to successful use of post tensioning strand. More precise practice can lead to lower maintenance costs and longer service lives for structures employing the studied technique.

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