



Florida Department of Transportation Research

Analysis and Estimation of Service Life of Corrosion Prevention Materials Using Diffusion, Resistivity, and Accelerated Curing for New Bridge Structures — BDK79-977-02

Much infrastructure on Florida's coasts relies on steel-reinforced concrete that is exposed to seawater. Corrosion of steel reinforcing bars (rebar) in concrete exposed to seawater has been documented as a major cause of bridge deterioration. Therefore, the Florida Department of Transportation (FDOT) continuously investigates the performance of concrete and steel in search of materials and methods that will extend service life and reduce maintenance costs.

In a series of tasks, Florida Atlantic University researchers studied the performance of materials that may prevent corrosion of steel-reinforced concrete. The project was distinguished by the range of materials and methods used on new samples and on samples conditioned for years.

Researchers first focused on diffusivity, which is how quickly chloride in seawater migrates, or diffuses, through concrete to attack rebar; it is valuable in estimating reinforced concrete's service life. Researchers measured diffusivity in tests simulating natural chloride exposure and compared results with high-performance concrete samples exposed to seawater in weekly wet/dry cycles for 18 years and cores from the five-year-old Key Royale Bridge.

Next, long-term behavior of corrosion-resistant alloys was examined in simulated deck concrete slabs exposed to wet/dry cycles for six to ten years. Steels tested included 316.16, 316.18, 304, 2205, 2304, 2101, A1035, 3Cr12, and A615. The researchers also studied a short-term method in which chloride transport was accelerated to study corrosion initiation and propagation of duplex stainless steel embedded in concrete. Rebar was made of either UNS32304SS or UNS32101SS.

Effects of initial surface condition on corrosion initiation were studied by direct exposure of steel bars to concrete pore solutions with various additives. Three steels — 304, 2101, and 2304 — were tested with three surface conditions — as



Many Florida bridges, from the Key Royale Bridge, shown here, to the Sunshine Skyway are set in seawater and subject to the effects of salt exposure.

received, with mill scale, and with mill scale then sandblasted.

In further tests of reinforced concrete bars, bars were set in simulated marine environments to simulate electrical potentials in bridge piers. When piers are exposed to salt water, a potential gradient is created from the wet zone to the dry one, which can promote corrosion. Potential across samples was measured at various elevations and over time and compared with field results.

Another material that can delay corrosion onset up to ten-fold is high alkalinity cement; however, silica in aggregate may react with highly alkaline concrete over time, causing expansion and loss of strength, up to failure. Concrete with various levels of sodium hydroxide and lithium nitrate was tested with a number of aggregates, including silica, granite, and limestone.

Many samples used in this study remain in conditioning environments for long-term evaluation. Concrete and steel are very basic materials, yet they are remarkably subtle, and projects like this one are needed to advance our knowledge of the nature, behavior, and interaction of these materials. Considering the value of Florida's infrastructure, this research is a small down-payment on significant savings.