Florida Department of Transportation Research

Corrosion Propagation of Carbon Steel Rebars in High Performance Concrete

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Current Situation

Some bridges built in Florida using steel-reinforced concrete from the mid 1980s through the early 1990s will soon reach an age at which the chloride concentration at the rebar could initiate corrosion. Some research suggests that steel reinforcement in concrete with higher electrical resistivity has a lower corrosion rate. Concrete's resistivity is influenced by many factors, including moisture content, age, and curing condition. The fact that field-measured and lab-mearsured resistivity can differ significantly further complicates this picture. Therefore, the time between the onset of corrosion and the need for corrective action is not clear.

As corrosion of steel reinforcing bars proceeds, it can cause cracking and loss of concrete.

Research Objectives

Florida Atlantic University researchers examined steel-reinforced concrete samples exposed to a variety of conditions in the field and in the laboratory to develop a better understanding of corrosion propagation in carbon steel rebar embedded in high performance concrete.

Project Activities

The researchers prepared a wide variety of specimens and subjected them to a variety of exposure protocols. The principle characteristics varied among the samples were concrete cover and concrete mix. Concrete cover ranged from 7 mm to 8.9 cm. Concrete mixes were prepared with Portland cement, either alone or including fly ash or fly ash–silica fume. Specimens were made with one, two, four, or five rebars. The researchers also used specimens dating from 10 to 24 years old. Exposure environments included a lab with moderate temperature and humidity, an elevated humidity chamber, or outdoors in marine conditions. Exposure periods ranged from weeks to years. Some exposures included ponding in which the top surface of samples was fitted with an enclosure that was periodically filled with seawater. As an example, in one of the exposure protocols, a four-rebar specimen spent 60 days in a high humidity chamber, followed by 60 days in the lab environment, followed by 3-6 months outdoors with cyclic seawater ponding, followed by 1-3 years in the lab. Several samples from each time-of-exposure group were subjected to electromigration, in which electrodes were used to accelerate chloride transport. This method effectively initiated corrosion allowing propagation to be measured starting at a known date.

Specimens were tested with techniques that included linear polarization resistance, galvanostatic pulse, solution resistance, and rebar potential measurements. Specimens were also visually inspected for cracking or staining. For some samples, the concrete cover was removed, and rebars inspected with optical and scanning electron microscopy. Corrosion rates and mass loss fraction were determined as well as concrete resistivities.

The extensive testing program produced a great deal of specific information related to concrete composition, rebar placement, and the initiation of corrosion. In general, it was found that cracks occurred on some of the specimens cast with high performance concrete and that the duration of the corrosion propagation that caused the cracks was a few years.

Project Benefits

A better understanding of the behavior of steel-reinforced high performance concrete can lead to more durable structures requiring less maintenance and repair.

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