Experimental Study of Accelerated Corrosion of Steel Reinforcement in Concrete near Patch Repairs

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Macrocells that produce anodes in the vicinity of repairs are set up when chloride contaminated concrete is repaired with chloride-free mortar. The repair region provides a cathode which drives corrosion in the unrepaired area containing residual chloride. With a nearby cathode, situated on the same bar as the corroding metal, the rate of the process is limited by transport of oxygen to cathodic sites. The corrosion rate may also controlled by ohmic resistance to the passage of current through the concrete if the current density is large or if the cathode and anode are more than a few centimeters apart.

This experimental study addressed electrochemical aspects of the corrosion of reinforcement adjacent to repairs. One objective of the experiments was to characterize the corrosion macrocells driven by differences in the electrochemical environment in contaminated concrete and repair mortar. Additional influences such as galvanic contact between the test reinforcement bar and remote cathode bars were also considered. The tests were based on ASTM standard G109, with modifications to incorporate simulated repairs. In addition to the standard test prisms, modified prisms were constructed to simulate a repair. In the simulated-repair prisms, a portion of the upper half, where the test bar was located, was left void of concrete by insertion of a Styrofoam block before the pouring. After the concrete had cured for 24 hours, the block was removed, and the void was filled with repair mortar or concrete. Simulated repairs of two sizes, covering either one half or one quarter of the test bar, were prepared. Electrochemical measurements were also performed in simulated pore solutions.

A complete macrocell is formed by the test bar alone, and corrosion occurs with or without cathode bars. However, the active attack forces the potential of the test bar to a negative value, and current does flow from the cathodes to the actively corroding test bars. While this current is not a measure of the total corrosion rate, it is an indicator of active corrosion on the test bar. The actual corrosion rate on the active zone is much larger for two reasons. First, the majority of the corrosion is sustained by a cathodic current in the repair area. Second, the corrosion is localized near the repair area and not spread uniformly over the bar.

Corrosion of reinforcement near repairs is driven by an active/passive macrocell. The anode is actively corroding rebar in chloride-contaminated concrete. The passive region is contained within the repair mortar and may extend one or two centimeters into the concrete. If the macrocell current distribution were controlled entirely by ohmic resistance in the concrete and repair mortar, the corrosion current would be at a maximum adjacent to the repair. However, the current bypasses a portion of the bar outside the repair. Whatever mechanism initiates this protection, it may be sustained by migration of chloride out of the concrete next to the repair, driven by the corrosion current that passes toward the ring anode. The more distant counter electrodes used in ASTM 109 account for a small portion of the corrosion current near the repair.

Acknowledgement

This work was supported by a grant from the New Hampshire Industrial Research Commission and Conproco Coatings, Dover NH.

References

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