USE OF FRP FOR CORROSION MITIGATION APPLICATIONS IN A MARINE ENVIRONMENT

PROBLEM STATEMENT

Fiber-reinforced polymers are increasingly being used for the repair and rehabilitation of structures. More recently, their application has extended to repairing corrosion damage. However, little information exists on its effectiveness particularly when used for repairing corrosion-damaged piles in sub-tropical coastal regions.

OBJECTIVES

The principal objective of the study was to conduct laboratory and field research to evaluate the effectiveness of alternate FRP systems in reducing the post-repair corrosion rate in prestressed piles. The laboratory studies were intended to quantify the effectiveness of the FRP through strength and gravimetric testing. The field studies were demonstration projects that evaluated this new repair system through appropriate instrumentation and monitoring.

The primary focus of the laboratory studies was to determine (1) the effect of the fiber type and number of FRP layers on the corrosion rate, (2) the effect of exposure on the FRP-concrete bond, (3) the role of surface preparation on FRP performance, and (4) strengthening effectiveness of underwater wrap using a newly developed water-activated resin. The demonstration studies evaluated two disparate FRP systems – two wet wrap and a dry wrap system using coffer dam construction. Piles were instrumented to allow measurement of the corrosion rate and on-site pullout tests were conducted to evaluate the FRP-concrete bond following exposure.

FINDINGS AND CONCLUSIONS

The focal point of the laboratory study was to determine whether a FRP wrap reduced corrosion in chloride contaminated prestressed specimens. Results from exposure tests under both ambient and accelerated conditions convincingly demonstrated that the FRP wrap was effective in slowing down the corrosion rate. In both exposures, identical wrapped and unwrapped specimens were exposed to simulated tidal cycles under outdoor ambient conditions or at a nominal 140F temperature. Under ambient exposure, the reduction in strand weight loss in newly fabricated CFRP and GFRP wrapped specimens was only 50% that in unwrapped controls. In the 140F exposure the *increase* in strand metal loss in unwrapped specimens initially pre-corroded to a target 25% loss and then exposed for nearly 2 years was 64.1% compared to only 12.1% in the *worst* performing FRP wrapped specimen.

Gravimetric and ultimate strength tests from this study also showed that the effect of the type of repair prior to wrapping was relatively unimportant. Results for full repair in which chloride contaminated concrete was removed, the surfaces sand blasted and corrosion inhibitors applied before re-forming the cross-section were comparable to repairs in which only surface cracks were sealed using epoxy.

Pull out tests were carried out to evaluate the FRP-concrete bond for selected specimens from the ambient exposure study. These specimens had all been wrapped under dry conditions. Bond was evaluated at three different locations – constantly dry, constantly submerged and the region in the middle that was subjected to drying and wetting. The results of the tests showed that the average bond stress was similar for all three regions for both the carbon and glass systems.

Two field demonstration projects were conducted using both dry (coffer dam) and wet wrap systems. In both studies, a significant number of piles were instrumented to allow corrosion assessment. Measurements over 2½ years showed that the corrosion rate in the wrapped piles was lower compared to unwrapped controls. On-site bond tests carried out showed that residual bond values were lower than that obtained from laboratory testing. However, bond values from one of the two wet wrap systems evaluated was comparable to that from the dry system using cofferdam construction.

BENEFITS

The results of the study indicate that fiber reinforced polymers not only offer a simple method of strengthening structures but can also slow down the rate of corrosion rate. The field demonstration projects showed that underwater pile repair was feasible. Overall these findings provide the department with an alternative cost-effective method for repairing corrosion-damaged piles in a marine environment.

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