CFRP WRAP FOR REPAIRING CORROSION DAMAGE

(Supplemental Study)

PROBLEM STATEMENT

Corrosion of steel in prestressed piles driven in a marine environment is a continuing problem. Current methods of repair cannot adequately address the causes of corrosion damage. Indeed, it is not uncommon to find examples of second, third, fourth, and fifth generation repairs carried out on the same member.

Recently, fiber reinforced polymer (FRP) materials have been used to wrap columns in seismic regions to improve their ductility. The same mechanism responsible for increasing ductility may also assist in providing a longer lasting and more economical repair of corrosion damage. In this case, it has been suggested that the epoxy resin used to bond the composite material to the concrete forms an impervious barrier to the diffusion of oxygen and moisture, which are essential for corrosion to take place. Moreover, expansion caused by the products of corrosion initiates tensile stresses in the composite material that confine the concrete and change its electro-chemistry.

The effectiveness of the accelerated corrosion procedure described in final report for ***Contract BC-353-2*** (Part I) led the Florida Department of Transportation (FDOT) to fund a supplemental study to examine the feasibility of using FRP wrap for repairing corrosion-damaged piles. Apart from using prism specimens and the accelerated corrosion method, this supplemental study is unrelated to the pile bent study (***BC-353-2, Part I)***.

OBJECTIVES

The goal of this study was to assess the feasibility of using carbon fiber reinforced polymer (CFRP) wrap for mitigating corrosion in prestressed piles. Consequently, researchers needed to accurately quantify the transverse strains that develop in corroding specimens, so that the confinement needed to withstand the expansive forces may be designed in the future.

The principal objectives may be summarized as follows:

(1) To experimentally measure transverse strains in corroding square prestressed elements for targeted levels of metal loss.

(2) To measure the post-repair corrosion rate in square prestressed elements for targeted levels of metal loss.

(3) To determine the effectiveness of the CFRP wrap as a method of repairing corroded piles.

FINDINGS AND CONCLUSIONS

Researchers conducted a 16 month experimental study to evaluate the effect of carbon fiber reinforced polymer (CFRP) wrapping in limiting corrosion in square, prestressed chloride contaminated specimens.

A total of ten specimens were utilized in the study. Three of these were destructive controls used to provide an accurate measure of the actual metal loss prior to wrapping. Researchers utilized a constant current acceleration scheme (described in Part I, Chapter 6) to corrode the specimens. Four specimens were wrapped after attaining targeted metal loss levels of 10% and 20%. Researchers conducted detailed surveys to assess the state of the specimen. This process included gravimetric tests that were performed on the destructive controls, crack surveys, and electro-chemical measurements. At the conclusion of these surveys, the specimens were wrapped and subjected to accelerated corrosion with metal loss targeted for 35% (10% initial) and 40% (20% initial). Two wrapping schemes were used—one layer and two layer. The CFRP material evaluated had been previously used in FDOT projects. All specimens in the 35% series used external counter electrodes, while those in the 40% series used internal counter electrodes. The relative performance was compared against three unwrapped controls.

Six specimens were heavily instrumented—four throughout and two after wrapping—to obtain information on the transverse strains that develop. Stainless steel crack gages were positioned, on each face, along the line of strands at three levels—at the middle and 10 inches from the ends. Crack gage measurements were monitored throughout the study. At the end of the exposure period, researchers conducted detailed surveys, as before, and gravimetric tests to evaluate the actual metal loss.

The results indicated that CFRP was effective in limiting corrosion. Compared to unwrapped controls, reductions in the overall metal loss ranged from 9.41% (single layer) to 13.83% (two layer). The performance of the internal and external counter electrodes was found to be comparable. Transverse strain values from crack gages were on the high side, since they included the effect of the crack opening. Strains calculated from the crack width measurements gave values of 1970 με and 3182 με for 10% and 20% metal loss. These results may be used in design.

Overall, the results were poorer than that reported for circular sections because (1) confinement was poorer and (2) the wrapping was applied onto over half of the corroded region. Researchers believe that the performance of the wrap will be better if it is extended over the entire corroded region. Furthermore, at least two layers should be used, and the wrap should be extended beyond the corroded part, since increased cracking was observed in the unwrapped part of wrapped specimens.

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