

# REPAIR OF CORROSION-DAMAGED CONCRETE USING FRP COMPOSITE WRAPS

H. Karpate, H.G. Wheat\*, J. O. Jirsa, D. W. Fowler, and D.P. Whitney

Civil Engineering Department, \*Mechanical Engineering Department, University of Texas at Austin, Austin, TX 78712

## Introduction

Steel-reinforced concrete bridge decks in marine environments and cold climates can experience premature corrosion damage due to the ingress of chlorides from salt-laden air or deicing salts. Concrete spalling and a loss in overall structural integrity can accompany the corrosion damage. Fiber reinforced polymer (FRP) composite materials that are light weight and have a high strength to weight ratio can be used to wrap portions of these corrosion-damaged concrete structures and thereby restrict oxygen as well as additional chlorides and other aggressive species. When used in combination with other repair techniques, composite wrapping could offer years of additional service life for these structures. There is some concern, however, that wrapping the structures might actually make the problem worse by trapping chlorides and other aggressive species that are already present.

## Experimental

To determine the effectiveness of wrapping chloride-contaminated structural concrete with FRP wraps, a long-term investigation was initiated several years ago (1-2). The investigation consisted of a laboratory program and a field program and the major goal was to evaluate the long-term effectiveness for improving the performance of reinforced columns and pier caps in a corrosive environment. Some of the "worst case" field conditions were incorporated into the laboratory investigation. In all, more than 60 cylindrical or rectangular specimens were designed to simulate

bridge columns and beams. Some of the specimens were damaged, repaired and wrapped with composite materials, and then exposed to salt-containing environments. The composite systems that were investigated included two epoxy systems (one commercially available and one generic system) as well as a generic vinyl ester system. These systems were used in combination with selected fabrics containing glass fibers. Variables included type of repair material, type of composite wrapping system, length of wrap, presence or absence of cracks, and presence or absence of pre-existing chlorides. Two years into the investigation, another set of cylindrical specimens was cast and added to the investigation to examine the effect of spray-on corrosion inhibitors (3).

The field investigation included 12 corrosion-damaged bridges in the northern part of Texas (1-3). A commercially available wrapping system was used on these bridges.

The laboratory specimens were exposed to intermittent saltwater conditions for approximately seven years. The bridges were exposed to severe environmental conditions in northern Texas during that same period. The laboratory specimens and the bridges have been monitored using half-cell potential, corrosion rate, and chloride measurements. Selected laboratory specimens were removed from testing over the seven-year period and they were subjected to forensic analysis (3-5). The bridges were examined over the same period of time. This paper is a summary of some of the major conclusions from this investigation. There is

particular focus on the laboratory specimens that were wrapped with the commercially available epoxy-glass wrap system.

## Results and Discussion

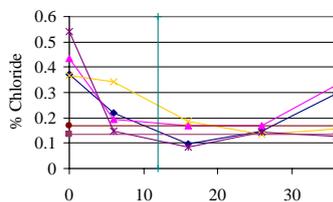
Forensic analysis showed that in general, chloride contents were lower for the wrapped specimens. Wraps provided a barrier to the ingress of chlorides and air. This was true in the absence or presence of cracks. In addition, FRP wraps reduced corrosion activity in the wrapped region. In fact, corrosion rates for one set of specimens removed after two years of exposure were approximately 0.4 mpy for the wrapped specimens and approximately 2.0 mpy for the unwrapped specimens (3). A few of the fully wrapped specimens did show moisture underneath the wrap. Also, wraps may not completely stop corrosion underway before wrapping. Selected cylindrical specimens are shown in Fig. 1a-c. Chloride contents vs distance from the bottom for selected partially wrapped specimens are shown in Fig. 2.



**Figure 1a. Unwrapped Specimen**

**Figure 1b. Completely wrapped specimen**

**Figure 1c. Partially wrapped specimen**



**Figure 2. Chloride content vs distance**

## Conclusions

Chloride contents after exposure to saltwater conditions were lower for wrapped reinforced concrete specimens. The wraps helped to minimize corrosion activity in the wrapped portion of the specimens even if cracks and chlorides were initially present.

## References

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