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NON-DESTRUCTIVE AND DESTRUCTIVE INVESTIGATION OF AGED-IN-THE FIELD CARBON FRP-WRAPPED COLUMNS

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UDOT RESEARCH & DEVELOPMENT REPORT ABSTRACT

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16. Abstract

The common practice of applying deicing salts on highway bridges increases the potential of reinforcing steel in these structures to experience extensive corrosion in the decks as well as the substructure. A new rehabilitation method which is believed to arrest the corrosion, restore structural integrity, extend the life, and provide interim safety until replacement at a later time is FRP jacketing. In line with this concept, all the columns of the Highland Drive Bridge at I-80 in Salt Lake City were rehabilitated with carbon FRP composites in June 2000. The present project will evaluate the performance of the carbon FRP composite for two of these columns and its ability to maintain a good bond to the concrete, thus restoring and maintaining the column's capacity after exposure to field conditions for 8 years. In addition, the use of a GFRP spiral as a non-corroding column tie will be examined.

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EXECUTIVE SUMMARY 1

EXECUTIVE SUMMARY

Many bridges in the Unites States are aging such that they are in need of repair or strengthening. Due to its high strength to weight ratio, corrosion resistance, and increasingly competitive cost, one popular material that is used for bridge repair is fiber reinforced polymer (FRP) composite. The purpose of this research is to evaluate the effectiveness of externally wrapped carbon FRP composite jackets to arrest the corrosion of the column steel reinforcement, and the soundness of the bond of the carbon FRP composite to the columns after exposure to field conditions for 8 years. In addition, the use of internal FRP reinforcement in the form of a GFRP spiral as a non-corroding column tie will be examined.

This quarterly report presents the milestones that have been achieved. According to the schedule, the following tasks are to be performed for completion of this project:

Task 1. Review existing experimental results and analytical models for corrosion arrest of steel reinforcement using external CFRP jackets.

Task 2. Evaluate corrosion progression, concrete quality and chloride penetration from field samples.

Task 3. Perform concentric axial and eccentric axial load tests of two full-scale columns aged in the field with external CFRP composite jackets.

Task 4. Perform axial load tests of small-scale columns with and without external CFRP jackets.

Task 5. Perform concentric axial load tests of small-scale columns with GFRP spirals as internal column ties.

In this first quarter, we have completed to a large part Task 1, and have focused most of our effort on Tasks 3, 4 and 5.

According to the proposal, the following activities should have taken place in the first quarter:

1. Construction of Small Scale Specimens
2. Material Properties of Two Columns from Pier #3 WB
3. Corrosion Mapping of Two Columns from Pier #3 WB

In the first quarter, the following activities were completed:

1. Construction of Small Scale Specimens

All the small scale specimens are currently being fabricated, as shown in Figures 1-6. A total of 14 specimens will be cast. The specimens are the same as in the proposal with the addition of two specimens where both the internal vertical bars and internal hoops are made with GFRP composites. This was done to compare the three types of internal reinforcement as follows: (a) steel vertical bars with steel hoops, (b) steel vertical bars with internal GFRP hoops, (c) internal GFRP vertical bars with internal GFRP hoops, as shown in Figure 2. For the (a) category with steel vertical bars and steel hoops, two specimens will be wrapped with carbon fiber jackets as described in the proposal.

Figure 1. Forms for 14 specimens.

(a) (b) (c)

Figure 2. Various configurations of specimens: (a) steel vertical bars with steel hoops, (b) steel vertical bars with internal GFRP hoops, (c) GFRP vertical bars with internal GFRP hoops.

To carry out the corrosion investigation, a tank with a water-salt solution of 5% salt by weight will be used, similar to the one shown in Figure 3 to apply the current through the four vertical bars in the steel reinforcement at the top (shown in Figure 4) and with a steel rod in the water as shown in Figure 5. The corrosion process will be monitored using ASTM Standard C 876 “Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete”.

All specimens that are being corroded will have strain gauges on the exterior of the specimen as well as Linear Variable Displacement Transformers to measure hoop and axial strains. The specimens that are not being corroded (control specimens) will have nine strain gauges each (four on the longitudinal bars and five on the internal hoop steel or internal hoop GFRP) as shown in Figure 6.

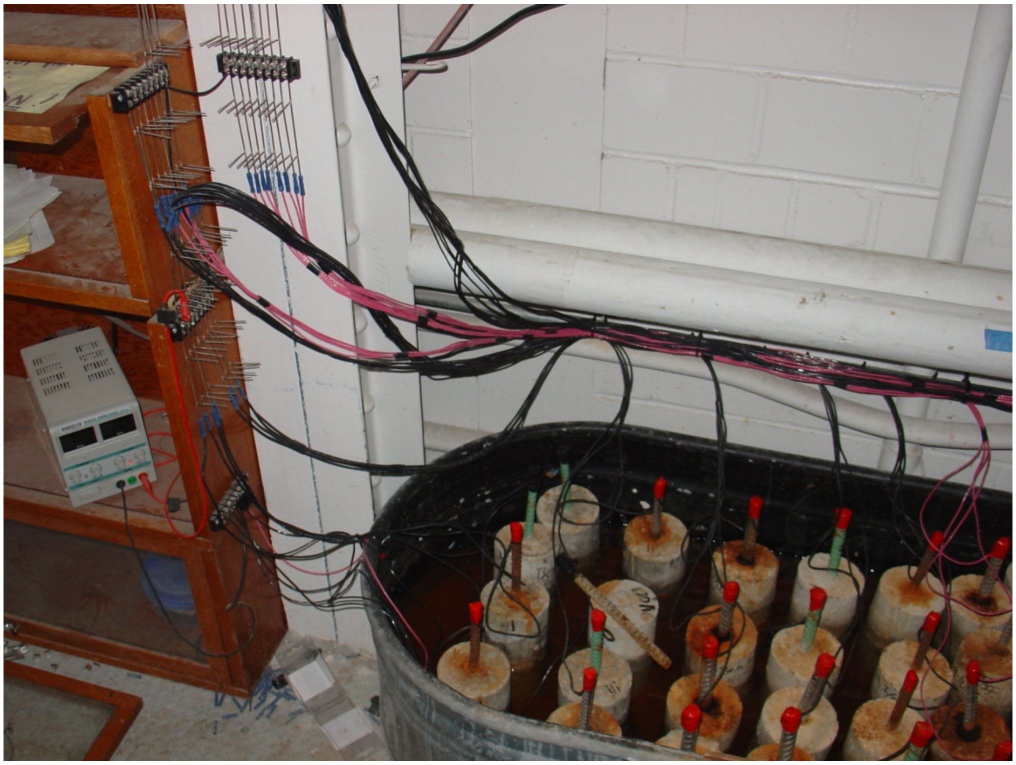

Figure 3. DC-voltage through bars in concrete and salt-water solution tank.

Figure 4. Wires attached to four vertical bars in the steel reinforcement at the top.

Figure 5. DC voltage through steel rod in the salt-water solution tank.

Figure 6. Nine strain gauges each (four on the longitudinal steel or GFRP bars and five on the internal steel or internal GFRP spirals) for control specimens.

2. Material Properties of Two Columns from Pier #3 WB

The material properties of the two columns will be determined as follows: (a) the columns will be saw-cut next week at the two ends to result in two 3ft diameter and 12 ft long columns as described in the proposal (b) cores will be taken from the cut-off column sections to determine the compressive strength of the concrete, (c) carbonation of concrete will be determined using phenolphthalein. This activity will be completed in the next week. In addition, any visible loss of steel area due to corrosion in the #9 vertical steel bars and #4 steel hoops will be recorded both before and after load testing of the two columns. In addition, the bars from the cut-off portions will be exposed to obtain additional data regarding section loss due to corrosion.

3. Corrosion Mapping of Two Columns from Pier #3 WB

Once the two columns are saw-cut next week, we will begin mapping the voids between the carbon FRP jacket and the concrete with an old-fashion method of tapping the surface with a quarter. This is an acoustic method that we have found to be very effective through the years. A three-dimensional graph will be drawn on a computer plot to show the location of the voids. After testing we will at least inspect the column to see if the voids match the tapping method.

In addition to the above activities, the steel column required to apply the 2,000,000 lbs force has been manufactured as shown in Figure 7.

Figure 7. Steel column required to apply 2,000,00 lbs compression load on two RC columns.