RESEARCH PROJECT CAPSULE [13-4ST]

August 2013

TECHNOLOGY TRANSFER PROGRAM

I-10 Girder Repair Using Post-Tensioned Steel Rods and Carbon Fiber Composite Cables (CFCC)

JUST THE FACTS:

Start Date:
March 18, 2013

Duration:
12 months

End Date:
March 17, 2014

Funding:
State: TT-Reg

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Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used Implementation Potential

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PROBLEM

The I-10 Littlewood Bridge is a two-bound 250-ft. span prestressed concrete girder bridge. Each bound consists of six prestressed cornet girders. Portions of the girders have been submerged in relatively stagnant water since completion of construction. As a result, these girders experienced severe corrosion in the prestress strands and spalling of the concrete in the submerged portion of the girders. Several of the strands were observed to be broken.

The Louisiana Department of Transportation and Development (DOTD) decided to externally reinforce the girders to ensure the safety of the bridge. The external reinforcement consisted of steel reinforcing bars. There was a concern on the use of unprotected steel reinforcing bars that will be exposed to a wet environment most of the time. It was determined that one of the spans (all six girders) would be reinforced with carbon fiber composite cables (CFCC) due to their excellent corrosion resistance property. A 30 kips tension was applied to the CFCC cables. Results from a previously funded study, LTRC 07-3ST, titled "Repairing/Strengthening of Bridges with Post-tensioned FRP Materials and Performance Evaluation," where theoretical work was performed and CFCC was used as a reinforcing system designed to strengthen a load posted bridge, were used on this current project.

Carbon fiber is a high modulus synthetic fiber made from an acrylic containing carbon, hydrogen, and nitrogen atoms that is heated in three successive stages to eliminate all but the carbon atoms. It is naturally black in color and is essentially unaffected by UV exposure. First used successfully in the America's Cup, carbon fiber laminates provide exceptionally low stretch for their weight. Recent manufacturing advances have led to improved fiber flexibility, which translates to a longer sail life in exchange for lower modulus numbers. The balance between low stretch and high flexibility means that carbon fiber can be extremely brittle and damage intolerant.

The CFCC's behavior is highly temperature dependent. While the UV degradation is not a significant factor impacting the properties of the fiber itself, the resin used to bond the carbon fiber can be greatly affected by UV. Similarly, moisture condensation can break up the matrix material that bonds the carbon fiber composite and eventually causes the fiber to loose strength.

OBJECTIVE

The objective of this research is to continuously monitor the stress changes in all external reinforcement to ensure the safety of the bridge structure. This monitoring effort will assist the Department on the future operation of the bridge. In addition, since both the traditional steel reinforcement and CFCC will be used, comparisons of the long-term performance of the two materials will be made.

Due to the corrosive environment of the subject bridge there is a concern of continuing deterioration of the bridge girders and to the installed reinforcing steel bars and CFCCs. Continuous monitoring for the following throughout the life time of this bridge is desirable: sudden change in stresses of the external reinforcing bars; gradual change in stresses of the external reinforcing bars and temperature.

Any sudden increase in stresses of the internal reinforcement would indicate further deterioration of the prestressed girders either from spall of the concrete or prestressed strands breaking. Conversely, any sudden decrease in stresses would indicate failure of the anchorage of the reinforcement rendering the repair ineffective.

Gradual change in stresses is most likely to be related to creep or corrosion of the reinforcement. Monitoring the change can provide insight into the behavior of the reinforcement. In order to better isolate the change of stresses due to structural condition changes from environment, temperature will be recorded along with the stresses.

METHODOLOGY

Work on this project will comprise the following tasks:

1. Develop an instrumentation plan to instrument the strengthening rods.
2. Acquire the CFCCs (carbon fiber composite cables) and check the testing and sampling report results for acceptance.
3. After construction completion, the research team will collect the data and evaluate the data to assess the performance of the reinforcement. Data collected will be evaluated in a weekly to bi-weekly basis to determine the effectiveness of the repair.
4. Long-term data will be used to evaluate the creep behavior of the CFCC and deterioration rate of the steel reinforcement. Comparison between the traditional steel rods and CFCCs will be made to assist the Department in determining the future CFCC implementation potential.
5. Prepare a cost-benefit analysis between the CFCC and the steel rods.

IMPLEMENTATION POTENTIAL

This study will serve as an implementation of the LTRC project 07-3ST mentioned earlier. Successful performance of the CFCC strengthening system will allow the designer to use it elsewhere for bridge repair and potentially to increase capacity of load-posted bridges.

Longitudinal CFCC tendons and installed load cells

[Source: Structural Testing and Health Monitoring For the Bridge Street Bridge Deployment Project (Construction Technology Laboratories, Inc.)]

For more information about LTRC's research program, please visit our Web site at www.ltrc.lsu.edu.