

Identifying Number MPC-340

Project Title:

Long Term Performance of FRP Repair Materials

University:

Colorado State University

Principal Investigator:

Dr. Rebecca Atadero
Department of Civil and Environmental Engineering
Phone: (907) 491-3584

Description of Research Problem:

Fiber reinforced polymer composites (FRPs) are currently being used by state departments of transportation to repair deteriorating concrete structures. FRPs are attractive as a repair option because they can be applied quickly, they can conform to a variety of existing geometries, they are lightweight, and they do not significantly alter the dimensions of a structure. They are also attractive because they do not corrode in the presence of chlorides as steel reinforcement does. However, other environmental exposures such as moisture, UV light and freeze-thaw cycles do have the potential to degrade the material. Although extensive research has demonstrated their effectiveness as a structural material, concerns remain about their long term performance. These concerns are primarily due to the fact that FRP is still a relatively new technology and as such there are few FRP projects with extended time in service. The vast majority of existing durability studies on FRP materials have occurred in laboratory settings using accelerated testing conditions and degradation models to predict FRP performance in the field. What is needed is degradation data on FRP materials that have been in service environments. Furthermore, their relative novelty means that designers may not be familiar with the materials, and design guidance is needed.

Engineers at the Colorado Department of Transportation are interested in the material, but have questions about the long term performance and application techniques for FRP (particularly with respect to environmental conditions in Colorado), which currently prevent its frequent use. In this project we will work with CDOT to begin to address these concerns. The project will assess the condition of a structure that was repaired using FRP in

the summer of 2003. Samples of the FRP material will be collected from the bridge to verify residual mechanical properties of the composite. The project will include a literature review to determine which of CDOT's concerns have been addressed by previous research, and which merit further experimental study. We will also initiate a laboratory testing program to begin to understand the effect of Magnesium Chloride deicing agent on the mechanical properties of the FRP and the bond between FRP and concrete.

Research Objectives:

The objectives of this project are to:

- 1) Characterize the mechanical properties of FRP that has been in service on a bridge for approximately 7 years.
- 2) Assess the condition of the repaired structure, considering corrosion monitors installed at the time of repair if possible.
- 3) Conduct a literature review on topics of concern to CDOT including the effects of fatigue and environmental conditions representative of Colorado on the FRP and FRP/concrete bond.
- 4) Establish a laboratory testing program to study the effect of Magnesium Chloride on the durability of FRP repair materials and their bond to concrete.

Research Approach/Methods:

The objectives of this project will be reached through completion of the following tasks.

Task 1- Collect Information and Develop Testing Plan

In this task information will be collected about the FRP repair that was applied in 2003, the monitoring devices that were installed at that time, and the exposure conditions at the bridge site. We will also verify the mechanical tests that will be viable on FRP samples removed from the bridge and determine the quantity of material that must be collected. Using the information collected we will develop a testing plan.

Task 2 – Conduct Testing on Site and Collect Samples for Laboratory

The second task will be to visit the bridge site. At the site we will collect the FRP samples needed for laboratory testing. We will conduct direct tension bond tests on site to ensure that the FRP-concrete bond is still performing as desired. We will also try to collect data from the corrosion monitors installed at the time of the repair.

Task 3 – Laboratory Testing of FRP Specimens and Analysis of Data

The FRP samples collected from the bridge site will be returned to the lab at CSU for testing. Planned tests include differential scanning calorimetry, thermogravimetric analysis, and tension tests. Test results will be analyzed in comparison to the testing conducted by researchers at CU at the time of repair. If data is available from the corrosion monitors we will analyze this data to better describe the condition of the bridge.

Task 4 – Literature Review for Additional FRP Topics

In this task we will first develop a list of topics relevant to FRP based on previous discussion with CDOT engineers. The list will include fatigue, environmental and chemical exposure, bond behavior, and existing design details/guidance. We will confirm this list with CDOT, and then conduct the review to produce a summary document identifying areas that do not merit further research and areas that do.

Task 5 – Establish Long Term Testing Plan for Magnesium Chloride Exposure

In this task we will collect data on magnesium chloride and develop a durability testing plan that can be easily maintained with no or very limited additional funding. We will manufacture the durability specimens, conduct testing to establish baseline conditions, and initiate the conditioning program.

Task 6 - Develop a Guideline for Design of FRP Strengthening of Bridge Members

In this task we will use the results of the literature review to identify best practices and state-of-the-art for the design of FRP strengthening. We will compile these design procedures into a document with calculation examples for use by CDOT staff.

MPC Critical Issues Addressed by the Research:

1. Infrastructure Longevity

Contributions/Potential Applications of Research:

This research will contribute to the limited amount of information on the durability of FRP composite materials in service environments. It will also use existing literature to answer questions posed by CDOT engineers. Both activities will give the engineers more confidence in the long term performance of FRPs and in their ability to effectively design repair schemes with the material. The project will also begin to assess the durability of FRP when it is exposed to Magnesium Chloride, a de-icing agent used in Colorado.

Potential Technology Transfer Benefits:

This project will be conducted in cooperation with the Colorado Department of Transportation. This working relationship will ensure that the findings of this project are directly relevant to the concerns and questions of CDOT engineers. It will also give researchers at CSU the opportunity to share their findings with CDOT engineers on a continuous basis. The findings of this research will also be shared with a broader audience through publication of journal articles, and presentations at conferences.

Time Duration:

July 1, 2010 – June 30, 2011

Total Project Cost:

\$102,000

MPC Funds Requested:

\$52,000

Source of Matching Funds:

Colorado Department of Transportation: \$50,000

TRB Keywords: Fiber Reinforced Composites, Field Studies, Durability Tests