

## Strengthening of Bridge Beams Using Fiber Reinforced Polymers (FRP)

*Start Date:* 7/1/2003  
*Duration:* 24 months  
*Completion:* 6/30/2005  
*Funding:* State

*Principal Investigator:*  
Paul H. Ziehl, Ph.D., P.E.  
*Assistant Professor*  
Tulane University

*Co-Principal Investigator:*  
Anthony J. Lamanna, Ph.D., P.E.  
*Assistant Professor*  
Tulane University

### LTRC Contacts

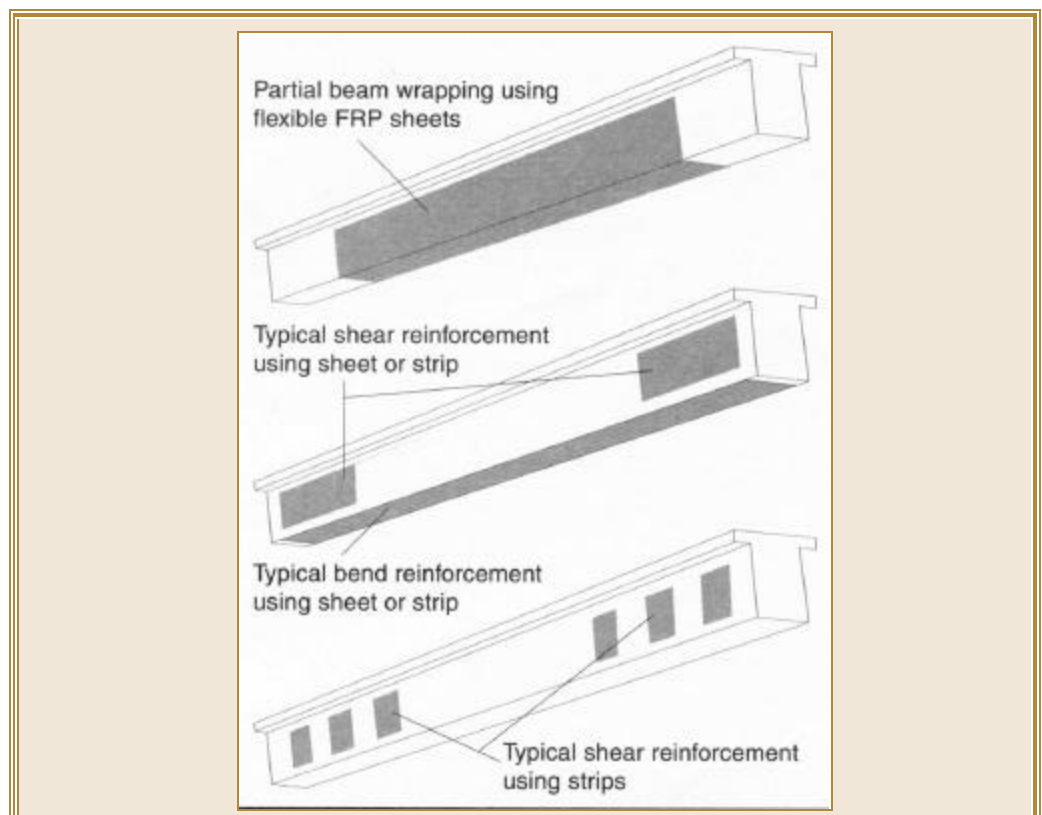
*Administrative:*  
Harold "Skip" Paul, P.E.  
*Assoc. Director, Research*  
(225) 767-9102

*Technical:*  
Walid Alaywan, P.E.  
*Structures Research Engineer*  
(225) 767-9106

### Problem

Bridge structures are generally rated in accordance with the "weakest link" principle. If any of its structural components are unable to safely carry a specified load, a bridge must be closed, or permitted to carry only reduced loads. A large number of bridges in Louisiana have been posted with weight restrictions. Often, these restrictions have resulted in the loss of state commerce and an inconvenience to the public.

In the case of reinforced concrete bridges, the weakest link is frequently the flexural or shear capacity of the bridge beams. Carbon fiber reinforcement appears to be one method of increasing the flexural and shear capacity of existing reinforced concrete bridge beams. Strengthening with fiber reinforced polymers (FRPs) has advantages in terms of light weight, ease of attachment, and a non-corrosive nature.



Typical FRP beam reinforcement



LTRC



Louisiana Transportation  
Research Center

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

4101 Gourrier Avenue  
Baton Rouge, LA 70808-4443

Although prestressed concrete, post-tensioned concrete, steel and timber beams can also be effectively strengthened with FRPs, this project will only address the strengthening of reinforced concrete bridge beams.

## Objective

The objective of this study is to prove the viability of the FRP strengthening approach as a means to strengthen existing weight-restricted bridges in Louisiana.

## Description

Two FRP strengthening systems will be identified for use on bridges selected by the Louisiana Department of Transportation and Development (LADOTD). Hand calculations of candidate weight-restricted bridges will be performed to determine the amount and location of FRP strengthening necessary to remove the weight restrictions. Selection of the different strengthening systems will depend on cost and probability of successful implementation. Data supplied by the manufacturers regarding material properties and behaviors will be verified beforehand.

In addition to alleviating weight restrictions for strengthened bridges, the FRP approach is also expected to reduce the range of stresses developed in a bridge's reinforcing steel, thereby increasing the useful service life for the bridge.



*Above left: Shear strengthening  
Above right: Flexural strengthening*

Bridge behavior will be monitored prior to strengthening, immediately after strengthening, and periodically after strengthening. Strain, displacement, and acoustic emission will be monitored in the short-term to determine dynamic impact factors. A long-term monitoring system, capable of remotely transmitting strain and temperature data for at least ten years, will be installed and activated.

## Implementation Potential

The long-term safety of weight-restricted bridges may be substantially increased by implementation of FRP strengthening. The useful life of strengthened bridges will be significantly extended, with cost savings to be realized over time.

A cost-benefit analysis of the FRP strengthening approach will be conducted. Recommendations will be given in regard to the feasibility of future FRP strengthening projects. Conclusions regarding the relative performance of different strengthening systems will be given.