

Request for Research Funding for FY 2023-2024

Project Number (Research Center Use Only): SMO-24-05

Requesting Office	CO Structures Design	Priority	5 of 5
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Proposed Title Detailing of Externally Bonded FRP for Shear Strengthening, Phase 2

Justification

Carbon fiber reinforced polymer (CFRP) strengthening has been used throughout the state for bridges that have been damaged by over-height vehicles, corrosion damage, and for load strengthening. Increased use for shear strengthening has occurred over the past several years. Currently, Volume 4 of the FDOT Structures Design Manual (SDM) allows for complete wrapping or 3-sided wrapping only. The 3-sided method requires anchorage details to prevent debonding. Complete wrapping is typically impractical, therefore making the 3-sided with anchorage the most utilized method. The current issue is the methodology of properly anchoring the CFRP wrap. The primary method that has been utilized to anchor the CFRP wrap has been evaluated with past research work at TxDOT. This research evaluated the use of spike anchors. The spike anchors are invasive to the concrete section as it requires drilling holes, however it has shown to be effective. Due to the invasive nature, however, it extends the working time and could possibly create further issues if an excessive number of holes is required. Other anchorage methods have been proposed but they have not been properly evaluated to allow their use.

Research was recently completed which consisted of a synthesis of existing research on the topic, along with some basic analytical effort (project BEA90). The previous project identified three potential design alternatives for CFRP anchorages. These anchorage details need to be further evaluated experimentally to validate their shear resistance capabilities.

The primary objective of this proposed research is to evaluate the performance of the proposed details and to compare their performance to existing FDOT details that do not utilize bi-directional layout. A total of nine AASHTO Type IV girders are proposed in the experimental program. To this end there will be two control beams, one is a beam with no CFRP and the second is a beam with CFRP but without anchorage. All beams will utilize 2 layers of 12 in. CFRP vertical strip spaced at 24 in. on-center. Variables will include uni- and bi-directional CFRP and three different types of anchors (mechanical, spike and CFRP strip).

Impact

The results of this research will investigate improving the process and efficiency of repairing bridge girders which have insufficient shear capacity with FRPs. This could result in fewer bridges needing replacement due to insufficient capacity and allowing a more optimized design and reduce the construction time of the repair.

Affected Offices CO Structures Design Office, Structures Maintenance Offices

Existing Work

Use of CFRP with Anchors for Shear-Strengthening and Design Recommendations/Quality Control Procedures (TxDOT 0-9783-1)

Shear Strengthening of Reinforced and Prestressed Concrete Beams Using CFRP Sheets and Anchors (TxDOT 0-6306 and 5-6306)

Anchorage Devices Used to Improve the Performance of RC Beams Retrofitted with FRP Composites: State-of-the-Art Review, R. Kalfat, R. Al-Mahaidi, and S. Smith, Journal of Composites for Construction, ASCE January/February 2013.

Use of Anchors in Shear Strengthening of RC T-beams with FRP, L. Koutas and T. Triantafillou, Journal of Composites for Construction, ASCE January/February 2013.

Development of Anchorage System for FRP Strengthening Applications Using Integrated FRP Composite Anchors, G. McGuirk and S. Brena, CRC ACI Foundation, October 2012.

Effect of FRP Anchors on the FRP Rehabilitation of Shear Critical RC Beams and Flexure Critical RC Slabs, D. Baggio, Thesis for University of Waterloo, 2013

Design and Detailing of Anchorages for Externally Bonded CFRP, N. Suksawang, P. Ryan, D. Su, Final Report for FDOT Project BEA90

PROJECT: Design of Anchors for Rapid and Durable Strengthening of Bridges with Externally Bonded Carbon Fiber Reinforced Polymer Composites—Phase 2

	Center for Integrated Asset Management for Multimodal Transportation Infrastructure Systems (CIAMTIS), \$149418, 2022, Active 2022-01-04		
Keywords Used In Existing Work Search (Cannot leave blank)	FRP shear strengthening		
Related Contracts (Give contract numbers)	BDV31 977-01, BDK82 977-03, BC354-55, BC190, BEA90		
Funding Request	\$360k	Anticipated Duration	3 years
Project Manager	Christina Freeman	Contracting Method	RFP to all registered vendors
Equipment	None		
Urgency	5	This project scored fifth in a rating of 25 research ideas by FDOT's Central and District Structures Design Offices.	
Implementability	1	FRP repairs have already been extensively researched and can currently be used on bridges in service. FRP is commonly used to strengthen for moment due to insufficient capacity or an over-height hit. FRP shear strengthening can be done but is currently invasive. This project will evaluate and determine less invasive anchoring methods for shear strengthening so that the technology can be expanded for shear strengthening bridge girders in service.	
Project Benefits			
This research will make it more feasible to repair in-service bridge girders which have insufficient shear capacity. By expanding the number of bridges which can be repaired, fewer bridges will need to be replaced due to insufficient shear capacity. Non-invasive methods will allow for repair with less traffic closure. In addition, current anchoring methods will not work for Florida-I Beams, so research is needed to determine how those new beams should be repaired.			
Project Benefits (Select all that apply and explain)	Quantifiable Benefits (units, dollars, etc...if applicable)	Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits	
<input type="checkbox"/> Materials Enhancement		This research could enhance the current methods and materials by proposing new anchorage methods.	
<input type="checkbox"/> Materials Savings		Fewer bridge replacements means less material used.	
<input type="checkbox"/> Time Savings		Less invasive methods would complement the current advantages of using CFRP which minimizes repair time and has minimal impact to traffic.	
<input type="checkbox"/> Lives Saved/Injuries Prevented		Less invasive methods may require less MOT, which will increase driver safety.	
<input type="checkbox"/> Other (Explain)			

*Comments should explain and support urgency, financial benefit, and implementability scores