I/UCRC Executive Summary - Project Synopsis	**Date**: May 26, 2021

Title: Timber pile rehab with FRP composite wraps

Tracking No.: **WVU-5**	**Phone :** (304) 293-9986	**E-mail :** Hota.Gangarao@mail.wvu.edu
Center/Site Director: WVU-CFC/Hota GangaRao		**Type:** Continuing
Project Leader: Hota GangaRao		**Proposed Budget**: $233,069

Project Description: Timber bridge piles are highly susceptible to decay in the vicinity of the waterline, and the use of Fiber Reinforced Polymer (FRP) wraps to restore the lose strength with filler materials to arrest future decay can be a cost effective and long-lasting method for repair of timber piles. However, the installation methods and design guidelines for piles to be brought back to carry original design loads through FRP repair of piles are severely lacking. The first phase of this project evaluated the strength of piles that were wrapped with FRP to bridge the deteriorated timber. Although the FRP had sufficient axial strength, the bond failed due to the lack of strength between the growth rings in the timber at insufficient strength to carry the required loads. A supplement was submitted and approved to assess the strength of piles repaired via the cut and splice method wherein the decayed section is cut off and a new section of pile is installed in its place. The strength of three legacy designs connecting the piles with steel and timber will be compared to a new design with FRP wraps.

Experimental plan: New pile sections will be cut apart and then joined back together. Samples will be made to evaluate the axial, bending and shear capacities of the spliced piles following ASTM D198. Piles will be repaired via the 3 typical LaDOTD methods (steel channels, steel grader blades, and 4”x6” timber sections), and with Fiber Reinforced Polymer (FRP) wraps. The use of FRP wraps will encapsulate and seal the timber piles, which will inhibit further deterioration and will provide equal strength in all directions without the need to drill boltholes. The strength of the legacy systems will be determined first and the FRP system designed to meet or exceed the legacy systems. The pile-cap joint will not be evaluated.

Related work elsewhere: WVU-CFC has worked with FRP wrapped timber members extensively over the last 22 years including beams, stringers, pile caps, and piles on railroad bridges. Other research centers have also evaluated FRP wraps on timber pile sections and conducted in field repairs.

How this project is different: LaDOTD has no data on the axial, bending or shear strength of their legacy pile splices. The use of FRP for the splice has been done in the field, but no lab testing is known.

Milestones for the current proposed year: All testing should be complete this year.

Deliverables for the current proposed year: The final report will be updated to include the capacity of the splices under axial, bending, and shear loads.

How the project may be transformative and/or benefit society: The actual strength of the legacy splices will be determined. In addition, the FRP wrap will provide strength in all directions and prevent moisture ingress and further deterioration.

Research areas of expertise needed for project success: Advanced understanding of FRP composite wraps and systems behaviors and mechanics. Field experience with FRP composite manufacturing and testing. Previous experience with developing engineering guidelines and specifications.

Potential Member Company Benefits: Upon completion of the project, CICI members will have access to a list of validated commercially available FRP composite repair systems. Furthermore, a set of engineering guideline facilitating a level of comfort of future timber repair with FRP will be available.

Progress to Date: All work for the first phase has been completed and submitted as a final report. Testing of the legacy splices is complete and testing of the FRP splices in well underway. A draft final report will be submitted this month.

Estimated Start Date: 11/1/2015	**Estimated Knowledge Transfer Date**: 6/30/21

The Executive Summary is used by corporate stakeholders in evaluating the value of their leveraged investment in the center and its projects. It also enables stakeholders to discuss and decide on the projects that provide value to their respective organizations. **Ideally, the tool is completed and shared in advance of IAB meetings to help enable rational decision making.**

I/UCRC Executive Summary - Project Synopsis	**Date**: May 26, 2021

Title: Development of sheet pile wall test procedure

Tracking No.: **WVU-6**	**Phone :** (304) 293-9986	**E-mail :** Hota.Gangarao@mail.wvu.edu
Center/Site Director: WVU-CFC/Hota GangaRao		**Type:** Ongoing
Project Leader: Hota GangaRao		**Proposed Budget**: $120,000

Project Description: For certain applications, Fiber Reinforced Polymer (FRP) sheet piles have distinct advantages over steel sheet piles including lighter weight, ease of cutting, and inability to corrode. Steel sheet piles have been extensively used over time and thus their design and performance is well-understood and documented in design guides, including by the USACE. Though there have been numerous successful installations, FRP sheet piling is relatively new and there are no formalized design or testing requirements. FRP manufacturers have filled this void on their own, but significant differences exist between manufacturers. The West Virginia University Constructed Facilities Center (WVU-CFC) is working with a manufacturer to develop a standardized testing procedure for FRP sheet piles, and aims to further this work via the inclusion of FRP specific requirements into the USACE Engineer Manual on the Design of Sheet Pile Walls.

Experimental plan: The current test involves installing sections of sheet pile wall into a box filled with sand. This will create a consistent testing base, conform to any FRP shape, and deform under horizontal loading to replicate field conditions and prevent stress concentrations in the FRP-soil interface. The pile will be pulled horizontal to failure and the moment capacity calculated. The exact testing procedure will be refined to ensure it is repeatable and accurately replicates field conditions for a cantilever pile.

Related work elsewhere: WVU-CFC has previously tested sheet pile for Creative Pultrusions. Some testing using internal water pressure was completed on steel sheet piles.

How this project is different: A standardized test method for determining the moment capacity of FRP sheet pile does not exist. Unlike steel, the non-homogenous nature of FRP can lead to unexpected failures do to small scale (coupon) testing not scaling up to full size members.

Milestones for the current proposed year: The first phase of work is the development and evaluation of the test method, which will be completed in the next year.

Deliverables for the current proposed year: The test method will be developed and the moment capacities of several different sheet piles will be established.

How the project may be transformative and/or benefit society: Currently, manufacturers have published moment capacities that differ greatly for the same shape. Traditional mechanics based methods may not be applicable to the complex behavior of sheet piles, including pile-soil interaction (particularly in reference to stress concentrations), joint behavior, out of plane strength, etc. The testing method and data derived can also be incorporated into sheet pile design guides.

Research areas of expertise needed for project success: Advanced understanding of FRP composite wraps and systems behaviors and mechanics. Field experience with FRP composite manufacturing and testing. Previous experience with developing engineering guidelines and specifications.

Potential Member Company Benefits: Upon completion of the project, CICI members will have access to a standardized test method to uniformly evaluate sheet piles. This benefits manufacturers by referencing an independent test method and end users by enabling performance based specifications.

Progress to Date: The pile was tested using sand in the test bin, which was found to not provide enough resistance to lateral movement to cause the pile to fail before the actuator stroke was exceeded. Testing was completed using concrete to anchor the pile which was successful in anchoring the pile. Additional testing will be completed to refine and simplify the concrete anchor to reduce costs and promote re-usability.

Estimated Start Date: 8/1/19	**Estimated Knowledge Transfer Date**: 12/31/21

I/UCRC Executive Summary - Project Synopsis	**Date**: May 26, 2021

Title: Rheology of Polymer Melts with and without Chopped Carbon Fiber

Tracking No.: **WVU-7**	**Phone :** (304) 293-9986	**E-mail :** Hota.Gangarao@mail.wvu.edu
Center/Site Director: WVU-CFC/Hota GangaRao		**Type:** Ongoing
Project Leader: Rakesh Gupta		**Budget**: $20,000

Project Description:

Contents for these boxes below are under Industry Member's review

Experimental plan:

Related work elsewhere:

How this project is different:

Milestones for the current proposed year:

Deliverables for the current proposed year:

How the project may be transformative and/or benefit society:

Research areas of expertise needed for project success:

Potential Member Company Benefits:

Estimated Start Date: 1/1/21	**Estimated Knowledge Transfer Date**: 6/30/21

I/UCRC Executive Summary - Project Synopsis	**Date**: May 26, 2021

Title: Thermomechanical Response of FRP Composite Jacketing for Tank Cars under Impact and Fire

Tracking No.: **WVU-8**	**Phone :** (304) 293-9986	**E-mail :** Hota.Gangarao@mail.wvu.edu
Center/Site Director: WVU-CFC/Hota GangaRao		**Type: New**
Project Leader: Hota GangaRao		**Proposed Budget**: $1,915,377

Project Description: Tens of thousands of rail tank cars haul highly flammable hazardous materials (HM) such as crude oil, petroleum products, ethanol, and others. These tank cars sometimes have tank failures during derailments, leading to environmental hazards. New US DOT rules require enhanced performance from rail cars necessitating retrofitting of old tank cars to bring them up to new specifications. This project proposes to develop multifunctional multilayer FRP jackets to retrofit the in-service tank cars. These innovative jackets will consist of glass-polymer composites, polyurethane foams with glass beads and intumescent sheathing on outer composite surfaces. The proposed jacket will demonstrate exceptional fire resistance and thermal properties to protect flammable materials within tank cars and provide excellent puncture resistance to prevent breaching of HM while limiting self-weight increase, and maintaining cost-effectiveness, which will be analyzed by comparing costs from the proposed approach with others.

Experimental plan: Experimental plan involves resin infusion based manufacturing of coupon size specimen and testing for their mechanical (impact & puncture), thermal and fire resistance properties. Later larger curved samples will be manufactured and tested in collaboration with our partners. This work will also be supported by performing finite element analysis.

Related work elsewhere: WVU-CFC has previously manufactured and tested multifunctional multilayer FRP structures with enhanced thermomechanical properties including fire resistance.

How this project is different: Such multifunctional FRP jackets for retrofitting do not exist. Economically viable retrofit development will be essential to minimize derailment associated damages.

Milestones for the current proposed year: The first year work involves development of coupon size samples and their evaluation.

Deliverables for the current proposed year: The results from testing of about 276 such samples will be provided along with the ones from both the finite element and cost analyses.

How the project may be transformative and/or benefit society: The proposed multifunctional jacket would possess superior performance over conventional materials, with high strength and stiffness, better puncture resistance, and excellent energy absorption under the impact, in addition to providing longer survival time under fire, which will potentially result in significant reduction in damages and loss of life and property. The proposed effort would have the capability to reduce both the cost and time burdens of retrofitting to meet current standards. The multifunctional jacket can be mass-processed in minimum time (2 vs. 150 days for conventional retrofit), which can speed-up the overall retrofitting capacity.

Research areas of expertise needed for project success: Advanced understanding of FRP composite responses to impact, fire, puncture and other environmental loads. Field experience with FRP composite manufacturing and testing. Previous experience with developing engineering guidelines and specifications.

Potential Member Company Benefits: Upon completion of the project, CICI members will have access to FRP jacketing systems for safer HM transportation. This benefits rail service and the society with less accidents and disasters, eliminating or reducing amount of property damages and even loss of lives.

Progress to Date: Project has just started on 09/30/2020. We have had introductory meeting with PHMSA. Infusion process is established to produce multifunctional sheets.

Estimated Start Date: 09/30/20	**Estimated Knowledge Transfer Date**: 9/29/23