REQUEST FOR PROPOSALS

Rehabilitation of Deteriorated Timber Piles using Fiber Reinforced Polymer (FRP) Composites
LTRC Project No. 15-3ST, SIO No. DOTLT1000043

PROBLEM STATEMENT

Louisiana has a large inventory of timber bridges in service. The timber piles in these bridges are succumbing to the effects of biological degradation that initiates in the wet-dry zones of piles. Replacing these deteriorated piles is a costly process and in-situ repair of the piles with FRP (fiber reinforced polymers) is an economic alternative. However, currently there are no well-developed design methods for the use of FRP reinforcement to repair deteriorated timber piles that are based on data and observations from a sound experimental program. Also, existing literature does not provide sufficient details about the effectiveness of the materials/mixes used as fillers in dispersing adequately to fill the voids, bonding to the wood and preventing progression of decay. These details are needed for designers to recommend one or more of the fillers in practice. Comparison of the cost of the FRP repair method to that of the commonly used current repair method -- namely, replacement of the decayed section with a stub -- will enable the bridge owner to make an informed decision on the repair method to use. A successful completion of the tasks outlined in the proposed research section below will provide LADOTD the tools needed to implement methods to strengthen deteriorated timber piles with FRP instead of replacing these piles.

OBJECTIVE

The objective of this research project is to develop and verify simplified design methods for rehabilitating deteriorated timber piles using (FRP) composites. The research is anticipated to encompass, at a minimum, the following tasks:

RESEARCH APPROACH:

Louisiana Transportation Research Center (LTRC) is seeking the insight of proposers on how best to achieve the research objectives. Proposers are expected to describe research plans that can be realistically accomplished within the constraints of available funds and contract time as allowed in this RFP. Proposals must present the candidate's current thinking in sufficient detail to demonstrate their understanding of the problem and the soundness of their approach. Task descriptions are intended to provide a framework for conducting the research. The proposal shall address at a minimum, the following tasks:

Task 1 Review literature pertaining to the use for FRP in rehabilitating deteriorated timber piles and develop a detailed work plan for Tasks 2 & 3 for approval by LTRC's Project Review Committee. LTRC has conducted a limited literature search with lists of selected references provided in Appendix "A" for review consideration.

Task 2 Evaluate the axial load capacity of FRP strengthened deteriorated timber piles -- with different lengths of deterioration zone -- and determine the bond strength between the FRP and the exterior surface of timber piles through a well-developed laboratory test program. Rationale for the inclusion/exclusion of one or more types of fiber reinforcement -- glass, Kevlar, carbon, etc. -- in the test program must be presented.

Task 3 Identify, through a laboratory test program, filler materials/mixes suitable for use in deteriorated timber piles and with high level of void penetration, good bonding and decay arresting potential.

Task 4 Develop a simplified design method for the use of FRP reinforcement in repairing deteriorated timber piles and a procedure for estimating costs of the FRP repair and replacement with a stub.

Task 5 Develop a guideline document that includes the following:

Task 5a Specifications for the materials and repair method for FRP strengthening of timber piles.

Task 5b Structural load rating method for FRP repaired piles based on AASHTO Manual for Bridge Evaluation (MBE).

Task 5c Field inspection techniques for evaluation of FRP repaired timber piles.

Task 6 Conduct two workshops -- that includes field demonstration -- to train bridge maintenance personnel in the FRP repair methods and bridge design staff on the design and load rating methods.

DELIVERABLES

The proposal shall include project deliverables for appropriate tasks. Deliverables shall be due as defined in the proposal. The proposal shall include at a minimum the following deliverables:

- Task 1: Work plan for Tasks 2 & 3 for review by PRC.
- Task 2: Interim report summarizing results.
- Task 3: Interim report summarizing results.
- Task 4: Simplified Design method for the use of FRP in repairing timber piles.
- Task 5: Guideline document for: (a) specifications for the materials and repair method; (b) structural load rating method; and (c) field inspection techniques.
- Task 6: Delivery of two workshops that include field demonstrations to train bridge maintenance personnel in the FRP repair methods.
- Task 7: Final Report documenting all work done throughout the study.

SPECIAL NOTES

A. LTRC research projects will be conducted in accordance with the LTRC Manual of Research Procedures, 2003 edition. (http://www.ltrc.lsu.edu/pdf/research_man03.pdf)
B. Any work that is anticipated to be required from LTRC or DOTD forces shall be specifically detailed in the proposal.
C. LTRC projects are intended to produce results that will be applied in practice. It is expected that the implementation of the results of this research into practice will evolve as a concerted effort during this project. The final report must contain an implementation plan to include, as a minimum, the following:
    a. The "product" expected from the research;
    b. A realistic assessment of impediments to successful implementation;
    c. The activities necessary for successful implementation; and
    d. The criteria for judging the progress and consequences of implementation.
D. To assist in the implementation process, the investigators of this research shall present the final results to LA DOTD officials in an oral presentation to be held in Baton Rouge, Louisiana at LA DOTD Headquarters after acceptance of the final report.
E. The proposal should include travel to meet with the Project Review Committee for a presentation of the interim reports, and presentation of the final report at a minimum. Funds budgeted for travel shall be limited to what is necessary for the conduct of the research. Funds shall not be budgeted for conference travel. Funding for technology transfer of research results is available upon request subject to LTRC approval and available funds.
F. LTRC's mission includes the support of higher education in Louisiana. Consultant and out-of-state institutions submitting proposals are encouraged to cooperate and collaborate with Louisiana universities for the purpose of sharing of knowledge and increasing transportation expertise in the academic community.
G. Graduate assistance stipends are allowed. Tuition reimbursement or tuition remission rates applied to stipends are not allowed.
H. To equitably answer any questions regarding this Request for Proposals, the Louisiana Department of Transportation and Development (LA DOTD) website will be updated with questions and answers and related documents regarding the project. http://webmail.dotd.louisiana.gov/agrestat.nsf/WebAdvertisements?OpenPage
LA DOTD makes these documents available for informational purposes only to aid in the efficient dissemination of information to interested parties. LA DOTD does not warrant the documents against deficiencies of any kind. The data contained within this web site will be periodically updated. Interested parties are responsible to be aware of any updates. Questions regarding this RFP should be submitted in writing to the LTRC contact person. Questions must be received by close of business seven calendar days prior to deadline date.
I. Consultants and business entities shall be registered with the Secretary of State in order to be able to work in Louisiana prior to award of contract. http://www.sos.la.gov/tabid/1011/Default.aspx
J. If Sub-Consultants/Entities are used, the Prime Consultant/Entity must perform a minimum of 51% of the work for the overall project.

K. LTRC reserves the right to withhold invoice payments for delinquent deliverables as defined in the proposal.

ESTIMATED COST OF RESEARCH
$150,000

ESTIMATED COMPLETION TIME
24 Months *(includes 3 months for review and approval of final report - i.e. final report due 21months)*

LTRC PRIMARY CONTACT
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AUTHORIZATION TO BEGIN WORK:
March 2015 (estimated)

PROPOSAL FORMAT
All proposals are required to be formatted according to LTRC Manual of Research Procedures. Chapter 2 provides guidance on proposal development. A copy of the Manual may be downloaded from our website (http://www.ltrc.lsu.edu/publications.html).

PROPOSAL SELECTION
The Project Review Committee selected for this project will review, evaluate and rank all proposals received using the criteria established on the attached proposal review form.

DEADLINE FOR RECEIPT OF PROPOSALS
Ten copies of the proposal must be received by LTRC by the close of business day of **January 30, 2015**.

Proposals should be submitted to:
Mr. Harold Paul, P.E.
Director
Louisiana Transportation Research Center
4101 Gourrier Ave.
Baton Rouge, LA 70808

APPENDIX "A"

SELECTED REFERENCES FOR "REPAIR/REHABILITATION OF TIMBER PILES WITH FRP COMPOSITES"

1. "Assessment and Evaluation of Timber Piles Used in Nebraska for Retrofit and Rating" Alireza Mohammadi, Jawad H. Gull, Ramin Taghinezhad and Atorod Azizinamini, Florida International University, Final Report to Nebraska Department of Roads, April 2014.

2. "Behavior of split timber stringers reinforced with external GFRP sheets", Sara Gómez and Dagmar Svecova. Journal of Composites for Construction (ISSN: 10900268). v 12, n 2, p 202-211, 2008

3. "The behaviour of damaged timber beams repaired with glass fibre-reinforced polymer laminates", Leon D.Wegner, and Wade Gasmo. Proceedings of the Canadian Society for Civil Engineering, 3ed; pp493-499, 2000.

4. "A Case Study on the Use of Advanced Fiber Wrap Composites for Timber Pile Repair and Protection of a Pier Structure", T. Jiménez; D. Kost; and J. Percival, Coastal Engineering Practice, pp. 10-14. 2011.

5. "Compression Tests of Circular Timber Column Confined with Carbon Fibers Using Inorganic Matrix", Husam Najm, Jerame Secaras, and Perumalsamy Balaguru, Journal of Materials in Civil Engineering. 19(2), 198–204, 2007.

6. "Compressive Behavior of Longitudinally Cracked Timber Columns Retrofitted Using FRP Sheets", Weiping Zhang, Xiaobin Song, Xianglin Gu, and Hongyong Tang, Journal of Structural Engineering. v 138, n 1, pp 90-98, Jan 2012.

7. "Experimental characterization of FRP composite-wood pile structural response by bending tests", Roberto Lopez-Anido, Antonis P.Michael, and Thomas C.Sandford, Marine Structures (ISSN: 09518339), v 16, n 4, p 257-274, June 2003.

8. "Extending the Service Life of Electric Distribution and Transmission Wooden Poles Using a Wet Layup FRP Composite Strengthening System", Mohamed Saafi and Eric Asa. Journal of Performance of Constructed Facilities. 24(4), 409–416, 2010

9. "Feasibility Investigation into Strengthening of Timber Bridge Stringers", By Anthony J. Lamanna, Arda Akbiyik, James C. Ray, and Gerardo I.Velazquez. US

Army Corps of Engineers, Engineer Research and Development Center, Vicksburg MA Geotechnical and Structures Lab. May 2007.

10. "Feasibility of Rehabilitating Timber Bridges Using Mechanically Fastened FRP Strips", Alyssa E Schorer, Lawrence C Bank, Michael G Oliva, James P Wacker, and Douglas R Rammer, Midwest Regional University Transportation Center and Wisconsin Department of Transportation, June 2008

11. "Fiber reinforced polymer composite-wood pile interface characterization by push-out tests", Roberto Lopez-Anido, Antonis P.Michael, and Thomas C.Sandford. Journal of Composites for Construction (ISSN: 10900268). v 8, n 4, p 360-368, July/August 2004.

12. "Fiber-Reinforced Polymer-Confined Circular Concrete Columns: Investigation of Size and Slenderness Effects." Michèle Thériault, Kenneth W. Neale, and Simon Claude, Journal of Composites for Construction, v8 n4. p. 360-368, 2004.

13. "Flexural Stiffness and Strength of GFRP-Reinforced Timber Beams." By By Hanan Al-Hayek, and Dagmar Svecova, Journal of Composites for Construction (ISSN: 1090-0268), Vol. 16, No. 3, pp 245-252, June 2012.

14. "Flexural Strength of Posttensioned Timber Beams." By Hanan Al-Hayek, and Dagmar Svecova, Journal of Composites for Construction (ISSN: 1090-0268), Vol. 18, No. 2, Apr 2014.

15. "Flexural Strengthening of Timber Bridge Beams using FRP", Christopher J. Gentile. Thesis Submitted to the Department of Civil and Geological Engineering; University of Manitoba; Winnipeg, Manitoba, Canada. Jan 2000.

16. "Freeze-thaw resistance of fiber-reinforced polymer composites adhesive bonds with underwater curing epoxy", Roberto Lopez-Anido, Antonis P Michael, and Thomas C Sandford. Journal of Materials in Civil Engineering (ISSN: 08991561), v 16, n 3, p 283-286, May/June 2004.

17. "Functionally Graded Adhesive Patch Repairs of Wood Beams in Civil Applications", R J C Carbas, G M S O Viana, L F M da Silva, and G W Critchlow, Journal of Composites for Construction (ISSN: 1090-0268), Online Publication Date: 2 Jul 2014.

18. "Glass fiber reinforced polymer strengthening and evaluation of railroad bridge members", GangaRao Hota, P.V. Vijay, and Reza S. Abhari. Structural Engineering International: Journal of the International Association for Bridge and Structural Engineering (IABSE) (ISSN: 10168664), v 20, n 4, p 423-426, November 2010.

19. "Interface shear tests on FRP composite piles", Miguel A Pando, George M Filz, Joseph E. Dove, and Edward J.Hoppe, Geotechnical Special Publication (ISSN: 08950563), n 116 II, p 1486-1500, 2002 ;

20. "Inuvik Timber Piles Field Assessment", A. Mufti, ISIS Canada at University of Manitoba, RiP Project 9640.

21. "Load Rating and Retrofit Testing of Bridge Timber Piles Subjected to Eccentric Loading", Pablo Caiza, Moochul Shin, and Bassem Andrawes, Civil Engineering Studies, Illinois Center for Transportation Series, November 2012

22. "Nonlaminated FRP Strap Elements for Reinforced Concrete, Timber, and Masonry Applications", J M Lees and A U Winistorfer, Journal of Composites for Construction, v 15, n 2, pp 146-155, Apr 2011.

23. "Performance characterization of wood-FRP bonded interfaces", Junhui Jia, Julio F. Davalos, Pizhong Qiao, and Gary Panariello, Structural Engineering Research Frontiers, pp. 1-15. May 2007.

24. "Rehabilitation of Railroad Bridges using GFRP composites", GangaRao V.S.Hota, P.V.Vijay, and Reza S.Abhari. Proceedings of the ASME Joint Rail Conference 2010 (ISBN-13: 9780791849064), v 1, p 57-64, 2010.

25. "Rehabilitation of Timber Railroad Bridges with FRP Composites", By GangaRao V.S. Hota, P V Vijay, Reza S Abhari. Transportation Research Board 88th Annual Meeting, 2009.

26. "Repair of heavily decayed timber piles using Glass Fiber Reinforced Polymers, GFRP, and Cementitious grout", Michael W.Hagos, Thesis Submitted to the Department of Civil and Geological Engineering; University of Manitoba; Winnipeg, Manitoba, Canada, July 2001.

27. "Repair of Wood Piles Using Prefabricated Fiber-Reinforced Polymer Composite Shells", Roberto Lopez-Anido, Antonis P. Michael, Thomas C. Sandford, Barry and Goodell, Journal of Performance of Constructed Facilities, 19(1), 78–87. 2005.

28. “Retrofitting pre-cracked RC beams using CFRP and epoxy injections”, R. Hawileh, A. Tamimi, J.A. Abdalla, and M.H. Wehbi, Key Engineering Materials (ISSN: 10139826), v 471-472, p 692-696, March 2011.

29. “Strengthening of Bridge Wood Pilings Retrofits for Moment Resistance - Phase II”, Bassem Andrawes, Report to Illinois Department of Transportation, RiP Project 34094.

30. “Strengthening of the Timber Members Using Fibre Reinforced Polymer Composites”, Gabriel Oprisan, N. Taranu, and Ioana-Sorina Entuc. Gheorghe Asachi, Technical University of Jassy. 2004.

31. “Timber Beams Strengthened by Carbon–Fiber Reinforced Lamellas”, P Neubauerová, Procedia Engineering (ISSN: 1877-7058), V 40, pp 292-297, 2012.