Montana Department of Transportation

Stage 2 - Research Topic Statement

2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001
www.mdt.mt.gov

Print Form

RESEARCH PROGRAMS USE ONLY	
RESEARCH IDEA NO:	23-006
DATE OF RECEIPT:	May 6, 2022
TOTAL MDT COST W/ICAP:	

RESEARCH PROGRAMS

Please submit completed forms via e-mail to MDTResearch@mt.gov. All fields are required, except the last field: XVIII, Sponsor(s). Incomplete forms will not be accepted.

TITLE (required): Use of Fiber-Reinforced Polymer Composites for Bridge Repairs in Montana

TOPIC STATEMENT:

New methodologies are needed for repairing and strengthening the aging and failing transportation infrastructure. The use of fiber-reinforced polymer (FRP) composites for repair has gained popularity over the last decade as these methods have been shown to be affordable, effective, and easy to implement. FRPs in general offer several key advantages over conventional building materials. Specifically, they have high strength to weight ratios, have increased durability and corrosion resistance, and are generally “greener” than conventional materials in terms of embodied energy. FRPs are composed of either thermoset or thermoplastic resins reinforced with (usually) glass or carbon fibers, GFRP and CFRP, respectively. FRPs can be used for strengthening in several forms, such as near-surface mounted (NSM) bars and externally applied wrapping. The use of FRPs as a repair method for bridges has been investigated by several state departments of transportation in recent years. For example, FRPs have been used to restore the original flexural strength of damaged reinforced concrete bridge girders, strengthen simple-span reinforced concrete slab bridges, and seismically retrofit bridge columns. It should also be noted that MDT has used externally bonded FRPs with mixed results. For example, MDT successfully used externally bonded FRPs to strengthen existing timber piles but had limited success using them to strengthen concrete columns due to bonding issues.
The focus of the proposed project is on investigating the various FRP repair/strengthening techniques, determining the methods most suitable for use on Montana bridges, filling any research gaps that may impede their use in Montana’s unique climate, and helping implement this methodology in a bridge project in the state. This project is a necessary step to fully understand and capitalize on the benefits of using FRP for repairing/strengthening, and to subsequently increase the performance, and durability of Montana bridges.

RELATED RESEARCH SUMMARY FROM STAGE 1:

A literature review on the use of FRP in bridge repairs was conducted by the MDT librarian as a result of the Stage 1 submission. Key findings from this review include: 1) FRP materials have been successfully implemented in repair/ strengthening applications by several state DOTs, 2) the long-term performance of FRP wrapping is somewhat limited and has been (and continues to be) evaluated by several state DOTs, and 3) research is lacking concerning the material’s short- and long-term performance in cold environments. The lack of information on the long-term performance/durability of these methods is particularly concerning for Montana bridges due to their exposure to extreme temperature ranges and cycles.
Additionally, to supplement the research proposed herein, MSU conducted preliminary research on the use of externally bonded FRP to strengthen reinforced concrete beams and evaluate their performance at cold temperatures. The research included testing a total of 6 beams, which included 3 beam designs at two temperatures (20ºC and -31.5ºC). The 3 beam designs consisted of three different FRP reinforcement schemes: a control beam with no FRP reinforcing, a longitudinal-

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strengthened beam with CFRP wrap secured on the bottom of the beam, and a longitudinal and transverse strengthened beam with CFRP secured longitudinally along the bottom with transverse GFRP wrapping. This study found that the cold temperatures resulted in higher ultimate load carrying capacities and delayed FRP delamination. Overall, the results from this work were promising, indicating that externally bonded FRPs are suitable for repairs in cold environments, although the long-term performance was not evaluated.

RESEARCH PROPOSED:

The primary objective of the proposed research is to investigate and help implement the use of FRPs to enhance the performance of Montana bridges. Specifically, the proposed research will (1) conduct an updated and thorough literature review to investigate the feasibility of using FRPs in various bridge applications in Montana, (2) identify the most promising applications of this technology for use in the state, (3) fill any minor research gaps with laboratory testing that may affect/limit the successful application in Montana's unique climate, (4) assist in implementing the application(s) of this material in a bridge demonstration project in the state, and (5) monitor the performance of this bridge after the demonstration project. FRP composites could provide a viable solution to the repair/strengthening needs of Montana's aging infrastructure. This research will provide the necessary step to capitalizing on the inherent benefits of these composites.

RESEARCH PERIOD (Time to complete research project.):

3 Years

IT COMPONENT: Identify if the project includes an IT component (purchasing of IT hardware, development of databases, acquisition of existing applications, etc.). If so, describe IT component in as much detail as possible.

The work proposed herein does not require IT hardware, software or support.

FEASIBILITY, PROBABILITY OF SUCCESS, AND RISK:

Previous research has clearly established the benefits and effectiveness of using FRP for bridge repair/strengthening, and several states have demonstrated their applications in actual bridge projects, some of which have resulted in specifications/guidelines. While these applications have been successful, research is still needed to identify the most appropriate methods for use in Montana and its unique infrastructure and demanding climate. The research team is well suited to complete the proposed research, as it has the necessary expertise, equipment, instrumentation, laboratory space (including cold labs), and experience with implementation projects. The proposed research has a high likelihood for success and is low risk.

URGENCY, IMPORTANCE, AND EXPECTED BENEFITS/PAY-OFF: Address urgency, timeliness, and importance of the research. Identify if the research is required for any federal or state initiative or compliance. This section must include a description of how this research will help to meet MDT's mission (i.e., serve the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality and/or sensitivity to the environment).

The aging and deteriorating transportation infrastructure requires proven, cost-effective, and efficient repair/strengthening methods, especially when replacement is not feasible due to economic and technical constraints. FRP repair methods are well suited to address this need. These methods have been successfully used by various DOTs across the country; however, research is needed to determine the most appropriate methods for Montana, and to ensure the successful implementation of these methods including the development of appropriate specifications for their use. This research will lead to more confidence in using FRP in bridge repairs in the state, and will allow the state to capitalize on the inherent benefits of this material and related repair methods.

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IMPLEMENTABILITY, IMPLEMENTATION PLAN, AND RESPONSIBILITY: Address the implementability of the expected results from the proposed project. Identify products that will enhance implementation. Identify any known implementation barriers and how these barriers might be eliminated or reduced. Identify MDT office or entity outside of MDT responsible for implementation. Describe initial implementation plan, include timeframe for implementation.

This project will culminate in an implementation project in which the chosen FRP repair/strengthening technique will be used on an actual bridge project in Montana. The research team will assist in developing the specifications for the chosen FRP method, which will include appropriate material properties, surface preparation requirements, and application/curing processes. This project will demonstrate the benefits of using FRP in the chosen application, and MDT will have a refined and proven technique for repairing/strengthening existing bridges.

MDT PRIORITY FOCUS AREAS: MDT may, as often as annually, identify priority research focus areas. These focus areas will be listed on http://www.mdt.mt.gov/research/unique/solicit.shtml.

None

TOTAL COST ESTIMATE (If the project proposal comes in at a higher cost, it may require further approval and may be delayed.):

The preliminary cost estimate is $250,000.

MDT FUNDING SOURCE (If MDT Research, enter SPR): SPR

FUNDING MATCH SOURCE AND AMOUNT: None

FUNDING PARTNER(S): None

POTENTIAL TECHNICAL PANEL MEMBERS (At this time, individuals do not necessarily need to be identified; rather, MDT offices and outside entities can be named. However, if known, individuals may be named):

Stephanie Brandenburger, Nathan Haddick, Lenci Kappes, David Crumley

SUBMITTED BY: (required)	
NAME:	Kirsten Matteson; Michael Berry
TITLE:	Assistant Professor; Associate Professor
AFFILIATION:	Montana State University
ADDRESS:	205 Cobleigh Hall, Bozeman, MT 59717
PHONE NO.:	(406) 994-6125; (406) 994-1566
E-MAIL:	kirsten.matteson@montana.edu; berry@montana.edu

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CHAMPION: Must be internal to MDT, feel strongly that the research will benefit the Department, and is willing to chair the technical panel. Note: If a champion is not identified by you or Research staff, this topic statement will not move forward.

NAME:	Stephanie Brandenberger
TITLE:	Bridge Bureau Engineer
AFFILIATION:	MDT
ADDRESS:	2701 Prospect Ave, Helena, MT 59620
PHONE NO.:	(406) 444-6260
E-MAIL:	stbrandenberger@mt.gov

SPONSOR(S) (optional): Must be internal to MDT (Division Administrator or higher) and willing to ensure implementation occurs, as appropriate. If a sponsor is not identified by you or Research staff, this topic statement will not move forward.

NAME:	Dustin Rouse
TITLE:	Highways & Engineering Division Administrator
AFFILIATION:	MDT
ADDRESS:	2701 Prospect Ave, Helena, MT 59620
PHONE NO.:	406-444-6005
E-MAIL:	drouse@mt.gov

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