Advanced Composite Materials in New England's Transportation Infrastructure - Technology Transfer Phase 1: Selection of Prototype

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Colin Franco, Rhode Island Department of Transportation, Chairman
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16. Abstract

A wealth of research on the use of advanced composite materials (ACMs) for civil engineering applications has been conducted and published during the last two decades. The use of ACMs in the transportation infrastructure has also been demonstrated through a limited number of trial projects throughout the United States. The use of these materials in civil engineering was originally promoted to solve the problem of an aging and deteriorating transportation infrastructure. To this date, however, the full potential of ACMs has not been realized due to obstacles encountered during the design/construction process of these demonstration projects. In order to further advance the application of ACMs in transportation infrastructure projects this project will identify a component commonly used in the transportation infrastructure in New England and propose its fabrication using advanced composite materials (ACMs). Development of a research problem statement for phase II of the project will allow solicitation of proposals to fabricate and implement the selected component in future transportation projects in New England.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	mililitres	mL
gal	gallons	3.785	Litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celcius temperature	°C

* SI is the symbol for the International System of Measurement

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C+32	Fahrenheit temperature	°F

°F 32 98.6 212
-40 0 40 80 120 180 200 °F
-40 -20 0 20 40 60 80 100
°C 37 °C

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Project: NETC 01-1 (T2-Phase I)
Advanced Composite Materials in New England's Transportation Infrastructure – Technology Transfer Phase I: Selection of Prototype

T2 - Phase I Report

Submitted by
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This interim report provides a summary of activities conducted as part of the project NETC 01-1 (T2-Phase I). The activities listed below constitute the main tasks of this phase of the project. A brief description of the activities that were carried out within each of the tasks is provided, followed by a more detailed description of the major activities in separate sections.

1. *Task 1 – Meetings at New England transportation agencies*: a literature review was conducted to update availability of documents related to design using advanced composite materials in the transportation infrastructure. Meetings were scheduled an held at different transportation agencies within New England over the course of approximately 8 months.
2. *Task 2 – Definition of performance requirements of ACM prototype*: the prototype selected was a standard drain system to be used throughout New England. Current details were collected from various states to define the prototype requirements for preliminary costing.
3. *Task 3 – Approximate cost and fabrication time of ACM prototype*: an ACM manufacturer was contacted to provide information related to fabrication of the drain system. The manufacturer provided data that was used in elaboration of the scope of work for Phase II of this project.
4. *Task 4 – Develop research problem statement and scope for Phase II*: this task was completed following NETC standard format for these documents. Input was received from members of the technical committee and incorporated into the document.
5. *Task 5 – Interim report*: this document.

Task 1 - Summary of Meetings at New England Transportation Agencies

These notes are intended to provide the main outcomes of meetings held at transportation agencies in New England to identify possible applications of advanced composite materials in the transportation infrastructure. Participants in each meeting were mostly transportation agency personnel. The meetings in ME-DOT and MassHighway also included representatives from the composites industry. Although other possible applications were discussed during these meetings, the selected list of applications in each of the locations was developed at the end of each meeting. Each list reflects the views of the participants in each state as the most promising applications that were discussed during the meeting.

Location: New Hampshire DOT, Concord, NH
Date: July 7, 2008
No. of Attendees: 8
Selected list of possible applications using advanced composite materials:

- Bridge drainage/scupper system
- Sign posts or road delineating posts
- Reinforcement in safety barriers

Location: Maine DOT, Augusta, ME
Date: July 8, 2008
No. of Attendees: 10
Selected list of possible applications using advanced composite materials:

- Stay in place forms
- Reinforcing bars
- Drains
- Culvert linings (bottom part of culvert) – FRP channel in invert region of culvert attached to existing metal culvert

Location: Connecticut DOT, Newington, CT
Date: August 28, 2008
No. of Attendees: 9
Selected list of possible applications using advanced composite materials:

- Trough under bridge joints/combined steel-FRP bridge joint system
- Bridge drainage
- Electric boxes
- Topping over platforms at train stations
- Culvert retrofit system for undamaged (lining) and damaged (invert region) cases

Location: Vermont Agency of Transportation, Montpelier, VT
Date: November 12, 2008
No. of Attendees: 7
Selected list of possible applications using advanced composite materials:

- Use of open grid FRP in for pedestrian use in historic trusses (minimal weight addition; no need to plow)
- Signs panels to meet new retro-reflectivity requirements (solution in place by 2012)
- In-place retrofit of existing sign and traffic control structures (wind deficient); arresting tensile crack failures observed in these structures

Location: Massachusetts Highway Department, Boston, MA
Date: November 14, 2008
No. of Attendees: 9
Selected list of possible applications using advanced composite materials:

- Crash resilient sign posts (recover their undeformed configuration after an accident); no need for expensive replacement after accidents
- Lightweight sign panel systems; possible use in variable message signs
- Barrier system/guardrails

After all the meetings at the New England transportation agencies took place, a telephone conference was held with members of the technical committee to select the application to be fabricated using ACMs. The application that was picked by consensus during this conference call was to fabricate a standard ACM drain system that could be used throughout New England.

Task 2 – Definition of performance requirements of ACM prototype

This task was completed by collecting standard drain details from several New England states. Details from Connecticut, New Hampshire, and Maine were obtained and used to determine the approximate cost to fabricate drains from an ACM manufacturer.

Task *3 – Approximate cost and fabrication time of ACM prototype*

Kazak Composites (MA) was contacted to provide an approximate cost for the drain details collected in Task 2. This manufacturer has experience with pultrusion and other composite manufacturing methods. At this stage, only an approximate cost was obtained to determine the approximate required funds for the second phase of the project. The actual details of drains are dependent on the bridge(s) selected for implementation. These details would be part of the second phase of this project, and at this point the PI for the second phase could determine actual cost of the pieces and specific delivery time.

Task 4 – Develop research problem statement and scope for Phase II

The research problem statement developed for Phase II is attached to this interim report as Appendix A. This document was distributed to members of the technical committee of NETC 01-1 T2: Phase I for review and comment. Comments received were incorporated into the final version presented here.

Appendix A
Research Problem Statement – NETC 01-1 T2: Phase II

NEW ENGLAND TRANSPORTATION CONSORTIUM
SCOPE OF WORK

PROJECT NUMBER: NETC 01-1-T2: Phase II

PROJECT TITLE: NETC 01-1 (T2 Phase II) - Advanced Composite Materials in New England's Transportation Infrastructure: Technology Transfer Phase II: Design, Fabrication and Installation of ACM Bridge Drain System.

RESEARCH PROBLEM STATEMENT: Advanced composite materials (ACM), also known as fiber-reinforced composite materials, have increasingly been used in civil engineering applications. Their primary use in civil engineering applications to date has concentrated on rehabilitation of existing structures or in applications prone to corrosion damage. ACMs have properties that make them attractive for use in a variety of other applications that have not been fully exploited to date.

For this reason, the New England Transportation Consortium has conducted two research projects to date to identify those applications within the transportation infrastructure in New England where ACMs could replace traditional materials used in civil engineering. The primary objective of NETC 01-1 was to identify obstacles for the widespread use of ACMs in New England's transportation infrastructure as a first step to promote their broader use. The research project report for NETC 01-1 can be found at www.netc.umassd.edu/01_1_finalreport1.pdf. NETC 01-1-T2: Phase I was subsequently conducted to identify and select an application for which ACMs offered a rational alternative to traditionally used materials with the goal of eliminating observed problems caused by the use of traditional materials. The objective was to select a prototype application that could be competitively fabricated and installed in the transportation infrastructure throughout New England. The prototype that was selected as an outcome of NETC 01-1-T2: Phase I was to develop a standard drain system that could be used throughout bridges in New England to eliminate the problems with corrosion and leakage that occurs when using traditional materials, and to extend the service life of bridge drains. Selection of this prototype was achieved through a series of meetings held at transportation agencies throughout New England and consensus among members of the technical committee for the project.

The objective of the current research project is to fabricate and install (implement) the prototype selected in Phase I described above in representative field applications within New England. Detailed objectives and the main tasks of this project are described in the paragraphs that follow.

OBJECTIVES:
The main objectives of this project are to:

1. Design and fabricate a standard drain that can be produced economically for use throughout New England bridges.
2. Install the fabricated drain system in 2 to 3 representative bridge applications in New England to provide information on its performance, ease of construction, and cost.

These objectives will be accomplished by at least conducting the following principal tasks.

PRINCIPAL TASKS:

Task 1: Conduct review of typical bridge drain details that are representative in New England bridges. Conduct a review of ACM drain applications in other parts of the country that can be used as basis to develop standard details for New England applications. Review and summarize existing federal drain performance standards and those used currently in New England transportation agencies.

Task 2: Develop standard drain requirements for new or rehabilitation projects in consultation with members of the technical committee assigned to the project. Establish performance requirements of the drain system using information collected in Task 1 and specific requirements for projects within the New England region.

Task 3: Identify and contact ACM manufacturers in New England that are qualified to fabricate the standard drains identified in Task 2. Work with manufacturers to develop specific details of drain system for new or rehabilitation projects. As guidance, a list of ACM manufacturers located throughout New England is included in the NETC 01-1 research report. The detailed designs must be developed collaboratively among the researcher, manufacturers, and engineers at state transportation agencies to ensure acceptability. The researcher must ensure that the drain design (fiber type, fiber orientation, and resin type), the fabrication method, connection details, and other necessary parameters are defined to facilitate installation in the field without sacrificing adequate performance of drain system or other bridge components.

Task 4: Identify 2 or 3 bridges being constructed within New England where the ACM standard drains can be used. Using the list of qualified ACM manufacturers from Task 3, develop a budget and delivery schedule of drain systems for the bridges identified in this task.

Task 5: Coordinating with field personnel in each of the bridge sites selected in Task 4, document relevant aspects of installation of ACM drains during construction. These should include at least photographic records, time/labor employed to install drains, needed field modifications, integration with other elements of the bridge structure. Make comparisons with installation of drains made from other construction materials whenever possible.

Task 6: Document the drain initial condition after installation during construction. Prepare a condition assessment checklist that can be used for future assessment of the drain system in future inspections of the bridges.

Task 7: Prepare a research report highlighting the outcomes of the research. The report must include all relevant technical aspects developed, including detailed design drawings of the drain system, cost, time of fabrication, special handling requirements, and documentation of the drain system installation performance. Anecdotal statements from field personnel comparing installation of ACM drains and standard construction material drains should also be included.

MEETING WITH PROJECT TECHNICAL COMMITTEE: The proposal should provide for a minimum of **three (3) meetings per year** with the Technical Committee that has been established to monitor the progress of the project.

REPORTS: The Principal Investigator will be required to prepare and distribute the following reports:

Quarterly Progress Reports: One (1) copy prepared and submitted via email, on a calendar quarter basis, to the NETC Coordinator. The Coordinator will forward copies to the Project Technical Committee.

Draft Final Report: Seven (7) copies of the Draft Final Report will be prepared and distributed to the members of the Project Technical Committee for review prior to printing of the Final Report.

Principal Investigators should allow ninety (90) days, in the Project Schedule, for completion of the review of the Draft Final Report including resolution of the Project Technical Committee's comments and receipt of approval from the Project Technical Committee Chairperson to submit the Final Report to the NETC Coordinator.

Final Report: Upon receipt of approval from the Chairperson of the Project Technical Committee to submit the Final Report to the NETC Coordinator, the PI will submit the following: a paper copy and a copy in ADOBE TM PDF on disk. Upon submittal of the Final Report to the NETC Coordinator, Principal Investigators should allow thirty days in the project schedule for completion of the Coordinator's review.

TECHNOLOGY TRANSFER STRATEGY: NETC recognizes that research results are not automatically put into practice upon completion of the research and publication of the final report. Effective implementation is more likely when researchers and user agencies collaborate to plan for implementation. Therefore, NETC requires that all research proposals, for NETC funded research, include a technology transfer and implementation plan for incorporating the research results/products into practice.

FUNDS AVAILABLE: $165,000

TIME TO COMPLETE: 2 years

PROJECT SCHEDULE: Proposals must include a schedule showing the start and end of each Principal Task including preparation and review of Draft Report and preparation of Final report. The dates shown in the schedule should be generic, i.e., "Month #1, Month #2, etc."

DEVIATION FROM THE SCOPE OF WORK: In the event that the proposer deems it necessary to deviate from the Scope of Work (Cost, Principal Tasks, Time to Complete, etc.) in order to accomplish the objectives of the research project, such deviation should be noted and the reasons clearly stated in the proposal.