

Quarterly Progress and Performance Indicators Report:

Project Number and Title: 2.7 High Performance Concrete with Post-Tensioning Shrinking Fibers

Research Area: Thrust 3 Use new materials and systems to build longer-lasting bridges and accelerate construction

PI: Dryver Huston, University of Vermont

Co-PI(s):

Reporting Period: 1/1/22 – 3/31/22

Submission Date: March 31, 2022

Overview:

- Continued with durability testing of laboratory specimens with various levels of shrinking chitosan fiber loading. The focus is on correlating chloride penetration versus amount of shrinking fiber in the concrete, Figure 1.
- Participated in technology transfer activities by presentation of results at relevant technical conference and publication in conference proceedings.

Meeting the Overarching Goals of the Project:

How did the previous items help you achieve the project goals and objects? Please give one bullet point for each bullet point listed above.

The overarching goal(s) of the project are:

1. Expand the range of tested shrinking fibers beyond the present chitosan and shape memory polymers to include preloaded steel, shape memory alloy (nitinol) and possibly other polymers
2. Test performance in larger laboratory specimens
3. Develop mechanical models to describe and predict enhanced performance due to post-tensioning shrinking fibers
 - The rapid chloride testing addressed Goal 2 by testing larger laboratory specimens
 - The technology transfer activities addressed the overall information dissemination requirements of the project.

Accomplishments:

List any accomplishments achieved under the project goals in bullet point form...

- Completed sampling for rapid chloride tests under Goal 2.
- Fabricated batch of shrinking fibers for more tests to confirm previous tests from Goal 2.
- Presented paper at SPIE Smart Structures Conference on results from this research.

Task, Milestone, and Budget Progress:

Complete the following tables to document the work toward each task and budget

Table 1: Task Progress			
Task Number: Title	Start Date	End Date	% Complete
Task 1: Shrinking Fiber Development and Manufacture	6/1/19	6/30/22	95%
Task 2: Laboratory Performance Testing	6/1/19	6/30/22	90%
Task 3: Mechanical Modeling	6/1/19	6/30/22	85%
Overall Project:	6/1/19	6/30/22	90%
Task 1: Shrinking Fiber Development and Manufacture	6/1/19	6/30/22	95%
Task 2: Laboratory Performance Testing	6/1/19	6/30/22	90%
Task 3: Mechanical Modeling	6/1/19	6/30/22	85%
Overall Project:	6/1/19	6/30/22	90%

Table 2: Milestone Progress			
Milestone #: Description	Corresponding Deliverable	Start Date	End Date
Milestone 1: NA			
Milestone 2: NA			
Milestone 3: NA			
Milestone 4: NA			
Milestone 5: NA			
Milestone 6: NA			
Milestone 7: NA			
Milestone 8: NA			
etc.			

Table 3: Budget Progress		
Project Budget	Spend – Project to Date	% Project to Date (include the date)
\$220,000	\$254,330.23	115.60%

Is your Research Project Applied or Advanced?

- Applied** *(The systematic study to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.)*
- Advanced** *(An intermediate research effort between basic research and applied research. This study bridges basic (study to understand fundamental aspects of phenomena without specific applications in mind) and applied research and includes transformative change rather than incremental advances. The investigation into the use of basic research results to an area of application without a specific problem to resolve.)*

Education and Workforce Development:

Answer the following questions (N/A if there is nothing to report):

1. Did you provide any workforce development or training opportunities to transportation professionals (already in the field)? If so, what was the training? When was it offered? How many people attended?

NA

2. Did you hold meetings with any transportation industry organizations or DOTs? If so, what was the meeting's purpose? When was it offered? How many people attended?

NA

3. Did you host/participant in any K-12 education outreach activities? If so, what was the activity? What was the target age/grade level of the participants? How many students/teachers attended? When was the activity held?

NA

Technology Transfer:

Complete all of the tables below and provide additional information where requested.

Use the table below to complete information about conference sessions, workshops, webinars, seminars, or other events you led/attended where you shared findings as a result of the work you conducted on this project:

Table 4: Presentations at Conferences, Workshops, Seminars, and Other Events					
Type	Title	Citation	Event & Intended Audience	Location	Date(s)
Conference paper and presentation	Chitosan-Based Shrinking Fibers for Post-Cure Stressing to Increase Durability of Concrete	Gregory D, Worley II R, Allen J, Kaplita M, Huston D. (2022) "Chitosan-Based Shrinking Fibers for Post- Cure Stressing to Increase Durability of Concrete" SPIE Smart Structures NDE 2022 Behavior and Mechanics of Multifunctional Materials XVI	SPIE Smart Structures NDE Conference	Long Beach, CA	

Use the table below to report any publications, technical reports, peer-reviewed articles, newspaper articles referencing your work, graduate papers, dissertations, etc. written as a result of the work you conducted on this project. Please list only completed items and exclude work in progress.

Table 5: Submitted/Accepted Publications, Technical Reports, Theses, Dissertations, Papers, and Reports				
Type	Title	Citation	Date	Status
Conference paper	Chitosan-Based Shrinking Fibers for Post-Cure Stressing to Increase Durability of Concrete	Gregory D, Worley II R, Allen J, Kaplita M, Huston D. (2022) "Chitosan-Based Shrinking Fibers for Post-Cure Stressing to Increase Durability of Concrete" SPIE Smart Structures NDE 2022 Behavior and Mechanics of Multifunctional Materials XVI	3/7/2022	Presented and in press

Answer the following questions (N/A if there is nothing to report):

1. Did you deploy any technology during the reporting period through pilot or demonstration studies as a result of this work? If so, what was the technology? When was it deployed?

NA

2. Was any technology adopted by industry or transportation agencies as a result of this work? If so, what was the technology? When was it adopted? Who adopted the technology?

NA

3. Did findings from this research project result in changing industry or transportation agency practices, decision making, or policies? If so, what was the change? When was the change implemented? Who adopted the change?

NA

4. Were any licenses granted to industry as a result of findings from this work? If so, when? To whom was the license granted?

NA

5. Were any patent applications submitted as a result of findings from this research? If so, please provide a copy of the patent application with your report.

NA

6. Did industry organizations or DOTs provide cost-share (cash or in-kind) to your research during the reporting period? Who was the organization? Please provide an in-kind support invoice from the organization with your report (this is kept confidential and used for record keeping purposes only).

NA

Please add figures/images that can be included on the website and/or in marketing/social media materials to further clarify your research to the general public. This is very important to our Technology Transfer initiatives.



Figure 1. Rapid chloride testing of concrete beams with various levels of shrinking fiber content following long term salt water soaking

Describe any additional activities involving the dissemination of research results not listed above under the following headings:

Outputs:

Definition: Any new or improved process, practice, technology, software, training aid, or other tangible product resulting from research and development activities. They are used to improve the efficiency, effectiveness, and safety of transportation systems. List any outputs accomplished during this reporting period:

- Experiments with rapid chloride testing are to confirm that chitosan shrinking fibers can increase the durability of concrete. It is hypothesized that this effect is due to an alteration of the microstructure during curing.

Outcomes:

Definition: The application of outputs; any changes made to the transportation system, or its regulatory, legislative, or policy framework resulting from research and development activities. List any outcomes accomplished during this reporting period:

- NA

Impacts:

Definition: The effects of the outcomes on the transportation system such as reduced fatalities, decreased capital or operating costs, community impacts, or environmental benefits. The reported impacts from UTCs are used for the assessment of each UTC and to make a case for Federal funding of research and education by demonstrating the impacts that UTC funding has had on technology and education. NOTE: The U.S. DOT uses this information to assess how the research and education programs (a) improve the operation and safety of the transportation system; (b) increase the body of knowledge and technologies; (c) enlarge the pool of people trained to develop knowledge and utilize technologies; and (d) improves the physical, institutional, and information resources that enable people to have access to training and new technologies. List any outcomes accomplished during this reporting period:

- NA

Participants and Collaborators:

Use the table below to list individuals (compensated or not) who have worked on the project other than students.

Table 6: Active Principal Investigators, faculty, administrators, and Management Team Members				
Individual Name & Title	Dates involved	Email Address	Department	Role in Research
Dryver Huston	10/1/2021-3/31/2022	dryver.huston@uvm.edu	Mechanical Engineering	PI

Use the table below to list **all** students who have participated in the project during the reporting period. (This includes all paid, unpaid, intern, independent study, or any other student that participated in this project.) **ALL FIELDS ARE REQUIRED.**

Table 7: Student Participants during the reporting period								
Student Name	Start Date	End Date	Advisor	Email Address	Level	Major	Funding Source	Role in research
Diarmuid Gregory	10/1/2021	3/7/2022	D. Huston		M.S	Mechanical Engineering	TIDC	Graduate research assistant
Matt Kaplita	10/1/2021	3/31/2022	D. Huston		Junior	Civil Eng	TIDC/UVM	Laboratory testing
Josh Allen	10/1/2021	3/31/2022	D. Huston		Senior	Mech Eng	TIDC/UVM	Laboratory testing

Use the table below to list any students who worked on this project and graduated or received a certificate during this reporting period. Include information about the student's accepted employment during the reporting period (i.e. the student is now working at MaineDOT) or if they are continuing their students through an advanced degree (list the degree and where they are attending).

Table 8: Students who Graduated During the Reporting Period			
Student Name	Degree/Certificate Earned	Graduation/Certification Date	Did the student enter the transportation field or continue another degree at your university?
N/A	N/A	N/A	N/A

Use the table below to list any students that participated in Industrial Internships during the reporting period:

Table 9: Industrial Internships			
Student Name	Degree/Certificate Earned	Graduation/Certification Date	Did the student enter the transportation field or continue another degree at your university?
N/A	N/A	N/A	N/A

Use the table below to list **organizations** that have been involved as partners on this project and their contribution to the project during the reporting period.

Table 10: Research Project Collaborators during the reporting period						
Organization	Location	Contribution to the Project				
		Financial Support	In-Kind Support	Facilities	Collaborative Research	Personnel Exchanges
		List the amount	List the amount	Mark with an "x" where appropriate		
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Use the table below to list **individuals** that have been involved as partners on this project and their contribution to the project during the reporting period. (**List your technical champion(s) in this table.** This also includes collaborations within the lead or partner universities who are not already listed as PIs; especially interdepartmental or interdisciplinary collaborations.)

Table 11: Other Collaborators				
Collaborator Name and Title	Contact Information	Organization and Department	Date(s) Involved	Contribution to Research
James Wild, Concrete Materials Manager		Vermont Agency of Transportation	10/1/2021-12/31/2021	Technical Champion

Use the following table to list any transportation related course that were taught or led by researchers associated with this research project during the reporting period:

Table 12: Course List						
Course Code	Course Title	Level	University	Professor	Semester	# of Students
		Grad or undergrad?	Where was the course taught?	Who taught the course?	Enter Spring, Fall, Summer, Winter and the year	How many students were enrolled in the class?
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Changes:

Applied for and received a no-cost extension with new end date of 6/30/22

Planned Activities:

- Continue with additional durability tests
- Attempt microscopic imaging to assess the hypothesis that the positive effect of the chitosan fibers is to alter the microstructure of the concrete.
- Continue to develop mechanical models on the action of the shrinking chitosan fibers.