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: 4/1/22 – 6/30/22
Submission Date: June 30, 2022

****IMPORTANT: Please fill out each section fully and reply with N/A for questions/sections with nothing to report. For ease of reporting to the USDOT, please do not remove, or change the order of, any sections/text. You may remove/add each rows in tables as needed. Thank you! ****
The report is due on the last day of the reporting period in .doc format to tidc@maine.edu.

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 along with X-ray and SEM imaging, Figure 1 and Figure 2.
- Participated in technology transfer activities by presentation of results at relevant technical conference and publication in conference proceedings.
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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…

- Collected X-ray 3-d tomographic images and SEM high resolution images of sample under Goal 2.
- Presented results at Engineering Mechanics Institute Conference at Johns Hopkins University in Baltimore

Task, Milestone, and Budget Progress:
Complete the following tables to document the work toward each task and budget (add rows/remove rows as needed, make sure you complete the Overall Project progress row and include all tasks even if they have ended or have not been started)…

Table 1: Task Progress			
Task Number: Title	**Start Date**	**End Date**	**% Complete**
Task 1.1: Shrinking Fiber Development and Manufacture	6/1/19	6/30/22	100%
Task 1.2: Laboratory Performance Testing	6/1/19	6/30/22	95%
Task 1.3: Mechanical Modeling	6/1/19	6/30/22	95%
Phase 1 Overall Project:	6/1/19	6/30/22	95%
Task 2.1 Quantify performance in larger laboratory samples	6/1/2022	1/31/2023	0%
Task 2.2 Examine microstructure	9/1/2022	1/31/2023	0%
Task 2.3 Examine low-cost chitosan	11/1/2022	5/31/2023	0%
Task 2.4 Test prestressing steel fibers	9/1/2022	5/31/2023	0%
Phase 2 Overall	6/1/2022	5/31/2023	0%
Phase 3 Overall	Enter Phase 3 Actual Start Date	Enter Phase 3 Planned/Actual End Date	Enter Phase 3 % Complete

Table 2: Milestone Progress			
Milestone #: Description	**Corresponding Deliverable**	**Start Date**	**End Date**
Milestone 2.1: Quantify performance in larger laboratory samples	Report describing performance in larger laboratory samples	6/1/2022	1/31/2023
Milestone 2.2: Examine microstructure	Report describing microstructure	9/1/2022	1/31/2023
Milestone 2.3: Examine low-cost chitosan	Report describing low-cost chitosan	11/1/2022	5/31/2023
Milestone 2.4: Test prestressing steel fibers	Report describing tests of prestressing steel fibers	9/1/2022	5/31/2023

Table 3: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date (include the date)**
$220,000	$266,249.74	121.02%
$117,888	$0	0%
Enter Phase 3 Full Budget	Enter Phase 3 Full Spend Amount (Federal + Cost Share)	Enter Phase 3 % Spent

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? (i.e. The research team provided an in the field training for the SAR technology for 3 maintenance crew members of the MassDOT on 3/31/2021. The members learned how to use the technology and interrupt the data.) 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? (i.e. The research team held a meeting with MaineDOT to update them on the progress of the research findings and how the findings can be implemented on 3/31/2021. 15 DOT maintenance members were present at the meeting.) 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? (i.e. 25 8th graders and 2 teachers visited the concrete lab and created small concrete trinkets like Legos on 3/31/2021. They learned about the different types of fibers that can be used in the concrete.) NA

Technology Transfer:

Complete all of the tables below and provide additional information where requested. Please provide ALL requested information as this is one of the most important sections for reporting to the USDOT. ***ONLY provide information relevant to this reporting period.***

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 presentation	Shrinking Fibers for Enhanced Durability of Concrete	Huston D, Gregory D, Allen J, Worley II R, Liu Z. (2022) "Shrinking Fibers for Enhanced Durability of Concrete" Engineering Mechanics Institute Conference, Johns Hopkins University, Baltimore, MD	Engineering Mechanics Institute Conference, intended audience is engineering mechanics researchers	Johns Hopkins University, Baltimore, MD	6/2/22

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**
NA				

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 is 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

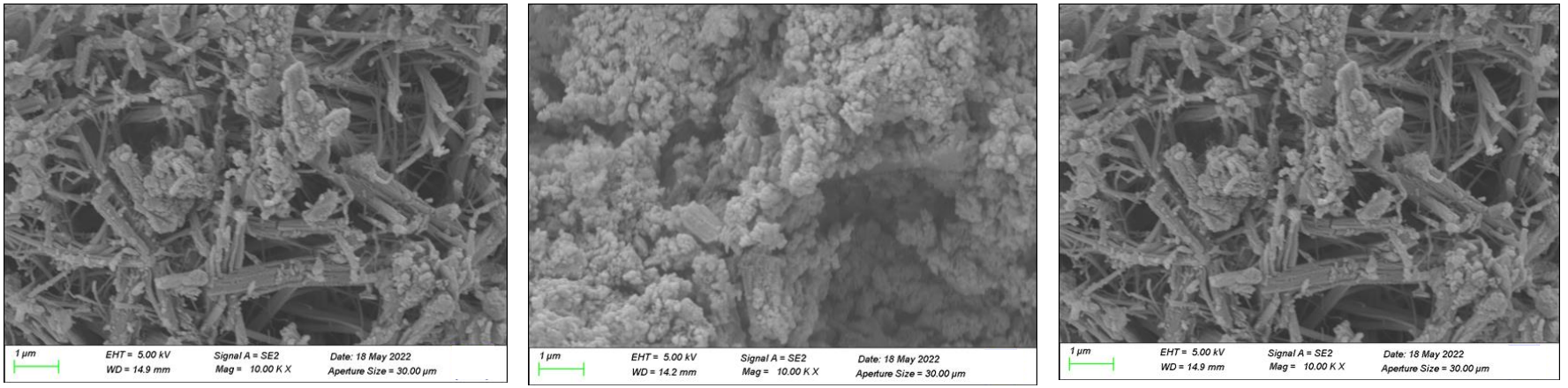
4. Were any licenses granted to industry as a result of findings from this work? If so, when? To whom was the license granted? NA

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

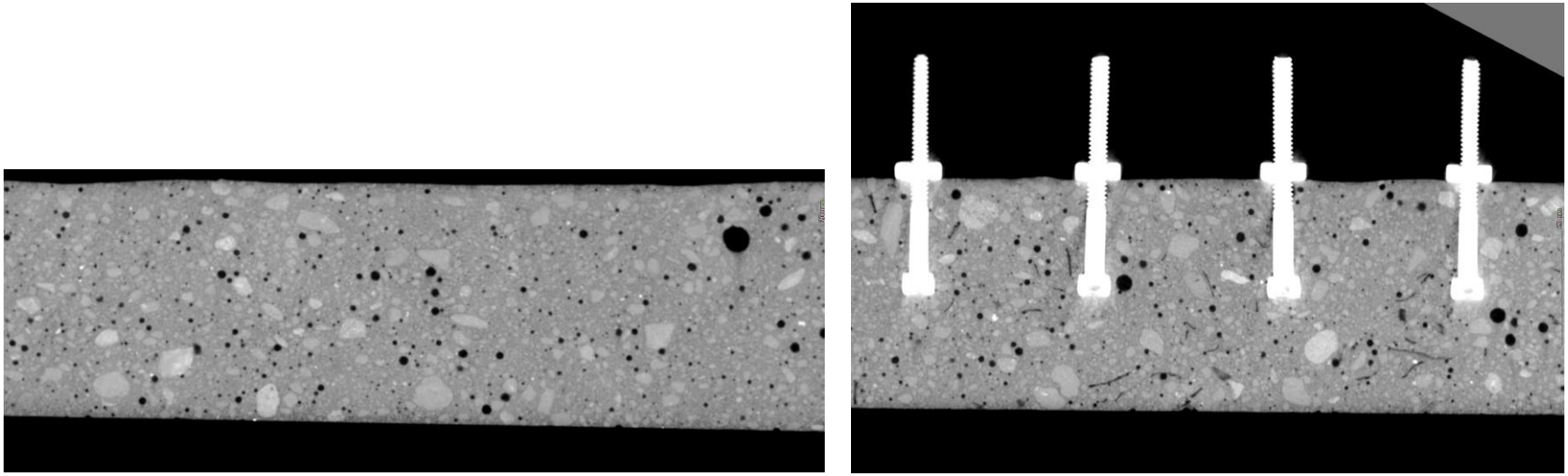
Please add figures/images that can be included on the website and/or in marketing/social media materials to further clarify your research to the general public. This is very important to our Technology Transfer initiatives.

Insert figures here

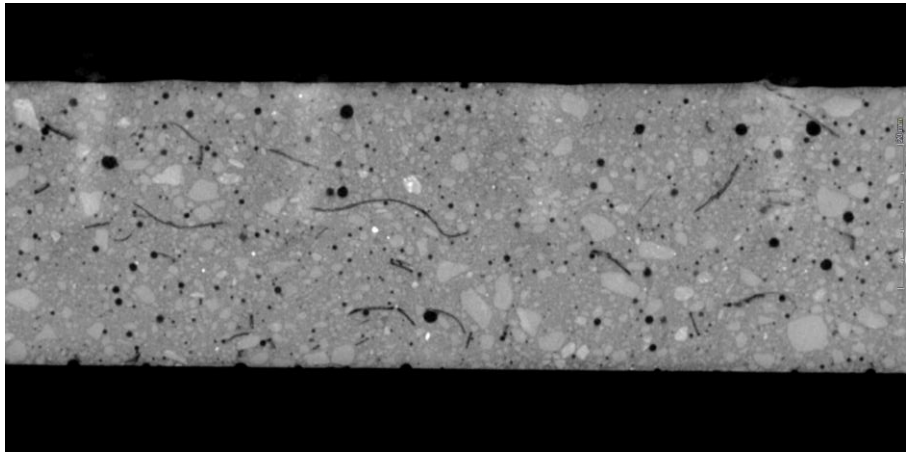


a. 0.25 % Chitosan b. 1.0 % Chitosan c. 2.0 % Chitosan

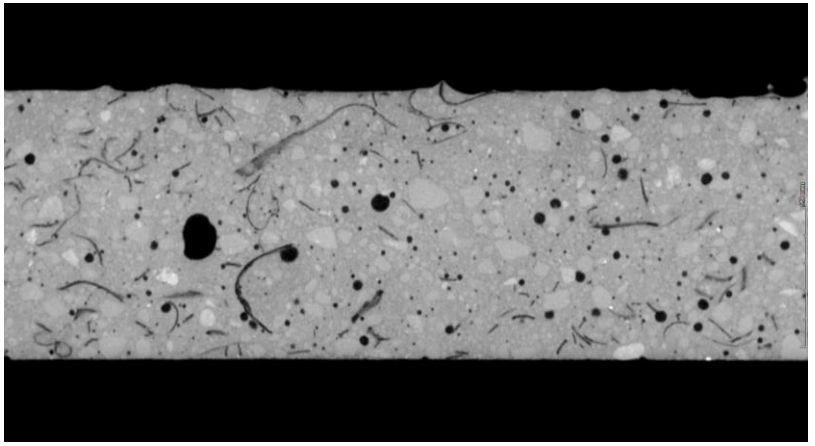
Figure 1. SEM images of concrete specimens with a. 0.25% chitosan, b. 1.0% chitosan, and c. 2.0% chitosan



a. 0.0 % Chitosan b. 4 Electrodes for Wenner test



c. 0.25 % Chitosan



d. 1.0 % Chitosan

Figure 2. X-ray computed tomography images of concrete samples with chitosan a. 0.0% chitosan, b. 4 electrodes for Wenner resistivity test, b. 0.25% chitosan, and d. 1.0% chitosan

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:

- 3-D tomographic and SEM imaging tests provide information regarding the internal and microstructure of the shrinking fiber concrete. This information may prove to be valuable in future research and development efforts.

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**
Matt Kaplita	10/1/2021	6/30/2022	D. Huston		Junior	Civil Eng	TIDC/UVM	Laboratory testing
Josh Allen	10/1/2021	6/30/2022	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?**
			Please list the organization or degree
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?**
			Please list the organization or degree
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**
Vermont Technical College	Randolph, VT	0	0	x	x	

*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						

Changes:

Submittal proposal for Year 2 project and funding, denoted as Project 2.7.2. The Year 2 Tasks and Milestones in Table 1 and Table 2 reflect the addition of Project 2.7.2.

Graduate student graduated. A new graduate student with concrete mixing experience is anticipated to join the project in September 2022, pending visa approval.

Planned Activities:

- Continue to develop methods of mass producing chitosan fibers
- Analyze microscopic and tomographic images of internal structure, with the goal being to verify hypothesis that shrinking fibers alter microstructure
- Continue to develop mechanical models on the action of the shrinking chitosan fibers.