

**Quarterly Progress Report:**

**Project Number and Title:** 2.13: Performance Structural Concrete Optimized for Cost, Durability and Manufacturability

**Research Area:** Thrust 2 – New Materials for Longevity and Constructability

**PI:** Dryver Huston, University of Vermont

**Co-PI(s):**

**Reporting Period:** 10/1/21 – 12/31/21

**Submission Date:** December 31, 2021

**Overview:**

This was the third quarter of the project. The activities included:

- Set up and used concrete shrinkage ring testers to establish test procedures and operating characteristics, Figure 1 to Figure 4.
- Met with VTrans test and research personnel to discuss project planning, and future test efforts and staffing on December 6, 2021.

**Meeting the Overarching Goals of the Project:**

The overarching goal(s) of the project are: 1. Develop cost optimized mixes in the laboratory using New England sourced materials. Machine learning methods will be applied to accelerate the identification of the most promising mixes; 2. Interact with concrete suppliers; 3. Participate in pilot tests at concrete supplier; 4. Evaluate performance on large scaled structural elements; 5. Reporting and technology transfer.

- Set up and used concrete shrinkage ring testers – This activity aligns with Goal 1. Develop cost optimized mixes in the laboratory using New England sourced materials.
- Met with VTrans test and research personnel to discuss project planning – This activity aligns with Goal 1. Develop cost optimized mixes in the laboratory using New England sourced materials and Goal 5. Reporting and technology transfer.

**Accomplishments:**

- Set up and used concrete shrinkage ring testers

**Task, Milestone, and Budget Progress:**

<b>Table 1: Task Progress</b>			
<b>Task Number: Title</b>	<b>Start Date</b>	<b>End Date</b>	<b>% Complete</b>
Task 1: Develop and verify laboratory testing procedures	1/1/21	9/1/21	50%
Task 2: Identify and test prototype HPC mix	1/1/21	11/30/21	25%
Task 3: Meet with concrete suppliers	1/1/21	11/30/21	15%
Task 4 Develop plan for pilot test, including partner participation.	2/1/21	11/30/21	
Task 5 Conduct pilot test batch run of HPC at industrial partner's facility	1/1/22	4/30/22	
Task 6 Evaluate performance of HPC prepared at industrial partner's facility	5/1/22	11/30/22	
Task 7 Test large planar structural elements	5/1/22	11/30/22	
Task 8 Reporting	1/1/23	8/31/23	
Overall Project:	1/1/21	8/31/23	15%

<b>Table 2: Milestone Progress</b>			
<b>Milestone #: Description</b>	<b>Corresponding Deliverable</b>	<b>Start Date</b>	<b>End Date</b>
Milestone 1: Develop and verify laboratory testing procedures	Report describing concrete laboratory testing procedures and experiments that verify testing performance	9/1/20	pending
Milestone 2: Identify and test prototype HPC mix	Prototype HPC mix designs	9/1/20	pending
Milestone 3: Meet with concrete suppliers	Report describing input and results from meeting with concrete suppliers	9/1/20	pending
Milestone 4: Develop plan for pilot test, including partner participation	Report describing plan for pilot test at concrete supplier	9/1/21	1/31/22

Milestone 5: Conduct pilot test batch run of HPC at industrial partner's facility	Report describing results of pilot test batch run of HPC at concrete supplier	2/1/22	8/31/22
Milestone 6: Evaluate performance of HPC prepared at industrial partner's facility	Report describing results of tests performed on specimens created at concrete supplier in pilot test run	2/1/22	8/31/22
Milestone 7: Test large planar structural elements	Report describing durability and strength tests at UVM on large planar structural elements cast at concrete supplier in pilot test run	9/1/22	8/31/23
Milestone 8: Reporting	Quarterly, final and other required project reports	9/1/21	8/31/23

**Table 3: Budget Progress**

<b>Project Budget</b>	<b>Spend – Project to Date</b>	<b>% Project to Date (12/31/2021)</b>
\$503,744	\$ 58,675.90	11.65%

**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? Met with VTrans test and research personnel to discuss project planning, and future test efforts and staffing on December 6, 2021. Five people attended (four from VTrans, and one from UVM)
  
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. 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:*

<b>Table 4: Presentations at Conferences, Workshops, Seminars, and Other Events</b>					
<b>Type</b>	<b>Title</b>	<b>Citation</b>	<b>Event &amp; Intended Audience</b>	<b>Location</b>	<b>Date(s)</b>
NA					

*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.*

<b>Table 5: Submitted/Accepted Publications, Technical Reports, Theses, Dissertations, Papers, and Reports</b>				
<b>Type</b>	<b>Title</b>	<b>Citation</b>	<b>Date</b>	<b>Status</b>
NA	NA	NA	NA	NA

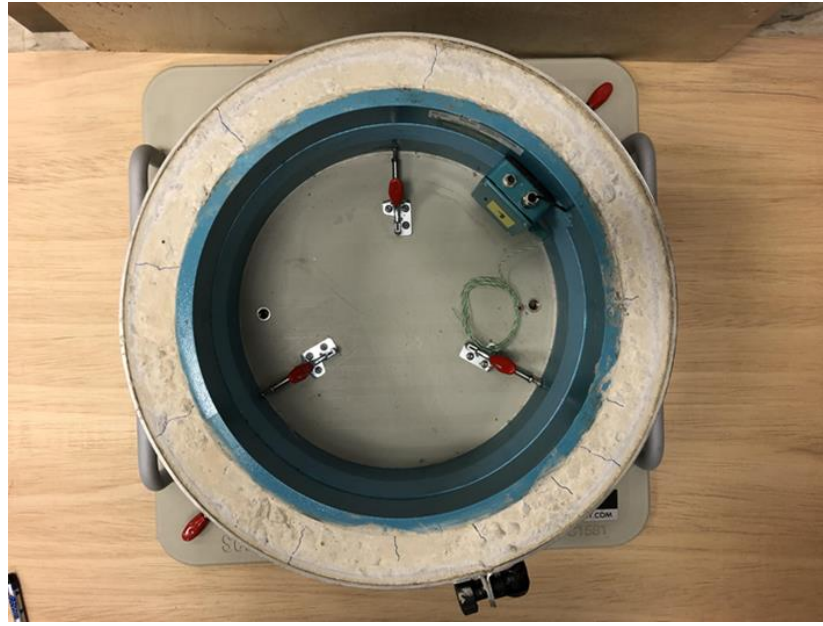
*Answer the following questions (N/A if there is nothing to report):*

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

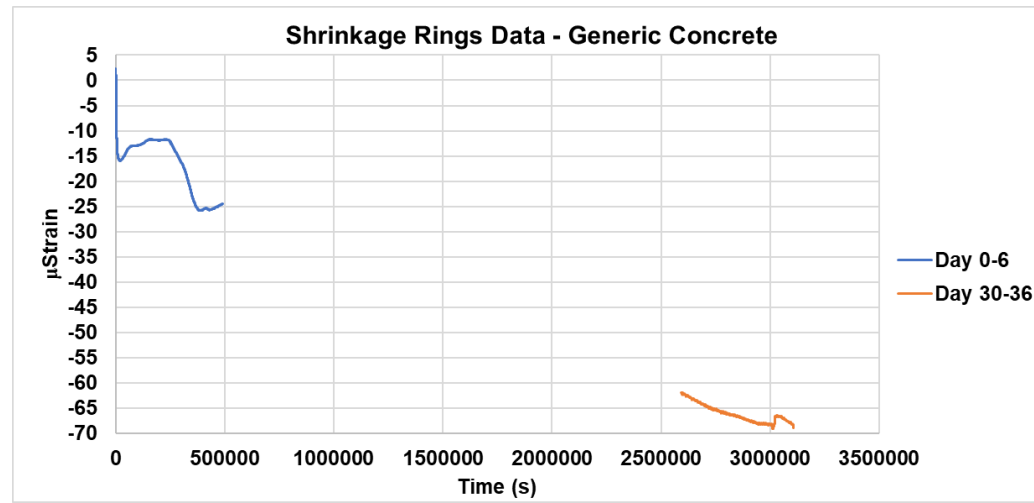
3. Did findings from this research project result in changing industry or transportation agency practices, decision making, or policies? If so, what was the change? When was the change implemented? Who adopted the change? NA
4. Were any licenses granted to industry as a result of findings from this work? 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



**Figure 1** Shrinkage test ring with freshly cast concrete



**Figure 2** Cured concrete in shrinkage ring with shrinkage cracks



**Figure 3** Strain data from shrinkage ring, note that data from Day 7 to 29 were lost due to an overwriting error.



**Figure 4.** Concrete ring following removal from shrinkage test ring

*Describe any additional activities involving the dissemination of research results not listed above under the following headings:* Undergraduate students Matt Kaplita and Josh Allen were recognized for their contributions to the project as part of TIDC Student Recognition Night 2021.

**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:*

- NA

**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.*

<b>Table 6: Active Principal Investigators, faculty, administrators, and Management Team Members</b>				
<b>Individual Name &amp; Title</b>	<b>Dates involved</b>	<b>Email Address</b>	<b>Department</b>	<b>Role in Research</b>
Dryver Huston, Professor	10/1/2021	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.***

<b>Table 7: Student Participants during the reporting period</b>								
<b>Student Name</b>	<b>Start Date</b>	<b>End Date</b>	<b>Advisor</b>	<b>Email Address</b>	<b>Level</b>	<b>Major</b>	<b>Funding Source</b>	<b>Role in research</b>
Matt Kaplita	10/1/2021	12/31/2021	D. Huston		Junior	Civil Eng	TIDC	Laboratory testing
Josh Allen	10/1/2021	12/31/2021	D. Huston		Senior	Mech Eng	TIDC	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?
NA			

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?
NA			

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 Agency of Transportation	Barre, VT	\$0	Long term loan of shrinkage test rings	X	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**

<b>Collaborator Name and Title</b>	<b>Contact Information</b>	<b>Organization and Department</b>	<b>Date(s) Involved</b>	<b>Contribution to Research</b>
James Wild, Concrete Materials Manager	Jim.Wild@vermont.gov	Vermont Agency of Transportation, Materials	10/1/2021-12/31/2021	Technical Champion
Nick van den Berg	nick.vandenberg@vermont.gov	Vermont Agency of Transportation, Materials	10/1/2021-12/31/2021	Advised planning

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**

<b>Course Code</b>	<b>Course Title</b>	<b>Level</b>	<b>University</b>	<b>Professor</b>	<b>Semester</b>	<b># of Students</b>
NA						

**Changes:**

Co-PI Prof. Ting Tan unexpectedly left the project due to a change in his employment status.

Progress on this project has been delayed due to the lack of graduate student participation. It is anticipated that one or possibly two graduate students will be active in research on this project starting in January 2022.

**Planned Activities:**

- Continue with Tasks 1 – 4 as listed in Table 1.
- Send students to ACI concrete test procedure training with VTrans support in January 2022.
- Replace Co-PI Prof. Ting Tan.
- Add graduate student to project team.