Quarterly Progress 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): Ting Tan, University of Vermont
Reporting Period: 4/1/20 – 6/30/20
Submission Date: June 30, 2020

Overview: (Please answer each question individually)

The activities in this quarter largely centered on developing numerical models of shrinking fibers in concrete. Laboratory activity was suspended due to a shutdown of the experimental facilities. The numerical studies consisted of finite element stress analysis with the models formulated as simple cases that will provide confirmation of mechanical fidelity as a prelude to more complicated models. Figure 1 shows the stress in a concrete block subjected to the shrinking of a single fiber that is bound to the matrix at the ends and unbound in center. Figure 2 shows the stress of a concrete block in a similar configuration subjected to differential thermal expansions.

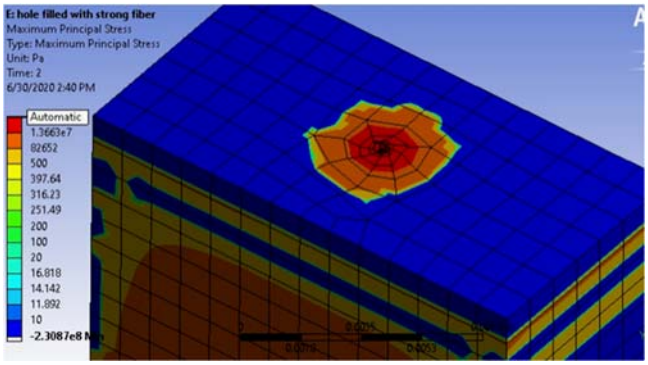

Figure 1 Stress in concrete block with internal fiber applying prestress

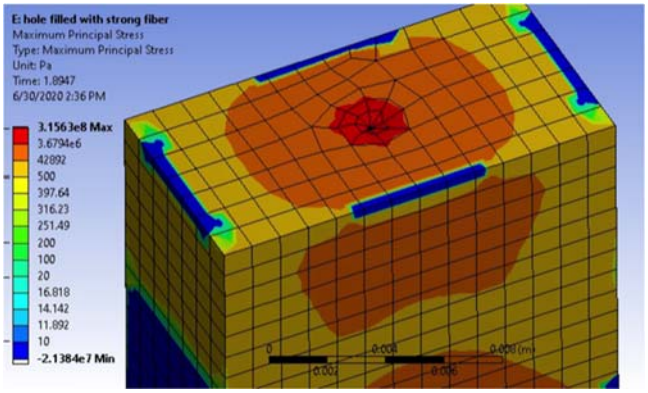

Figure 2 Stress in concrete block with differential thermal expansion applying stress through internal fiber

This numerical analysis was part of Task 3 Mechanical Modeling.

Following a lull in staffing a new graduate student (Diarmuid Gregory) has started working the project. This graduate student will work part time on the project in the summer months of 2020 and start full time in September with the start of the Fall 2020 academic semester.

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**Percent Complete**
Task 1: Shrinking Fiber Development and Manufacture	6/1/19	5/30/21	35%
Task 2: Laboratory Performance Testing	6/1/19	5/30/21	30%
Task 3: Mechanical Modeling	6/1/19	5/30/21	35%

Table 2: Budget Progress		
Entire Project Budget	**Spend Amount**	**Spend Percentage to Date**
$220,000	$88,458	40.20%

Activities involving the dissemination of research results primarily involved working on getting some of the related research on the fracture avalanched behavior of fiber-reinforced concrete published in peer reviewed journals.

The opportunities for training/professional development during this quarter were minimal.

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**
NA				

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
Peer-reviewed journal	Avalanches During Flexure of Early-Age Steel-Fiber Reinforced Concrete Beams	Materials and Structures	6/20/20	Accepted for publication

The underlying patent application for this research (submitted prior to the start of this project under 02962-135USU1 Self-Stressing Engineered Composite Materials) required an extensive response to the patent examiner.

Participants and Collaborators:

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
Dryver Huston	dryver.huston@uvm.edu	Mechanical Engineering	PI
Ting Tan	Ting.Tan@uvm.edu	Civil and Environmental Engineering	Co-PI

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Diarmuid Gregory		M.S./Senior	Mechanical Engineering	Just began this quarter

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**
NA			

Table 8: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
NA						

List all other outputs, outcomes, and impacts here (i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings). Please be sure to provide detailed information about each item as with the tables above. NA

Have other collaborators or contacts been involved? NA

Changes:

Due to the pandemic-related shutdown of experimental facilities at the UVM campus, the research pivoted to numerical modeling of concrete with embedded shrinking fiber elements. The development of the numerical models proceeded on the Ansys finite element platform. A key feature is to model the amount of bonding between the fiber and cement matrix. Fibers produce stress when the ends bind to the matrix, the center portion moves freely and fiber shrinks. The addition of a graduate student (Diarmuid Gregory) working part time on the project produced the results in Figure 1 and Figure 2.

Planned Activities:

The planned activities during the coming months depend on the availability of laboratory testing facilities. The laboratories have just opened with new restrictions on activities to prevent possible coronavirus spread. These restrictions will likely slow the pace of activity, but not severely. The goal during the upcoming quarter will be to restart the concrete tests and continue with the numerical modeling of shrinking mechanics.