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): Ting Tan, University of Vermont
Reporting Period: 4/1/21 – 6/30/21
Submission Date: June 30, 2021

Overview:

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

- Began to develop a machine learning algorithm to analyze concrete mix designs. The potential machine learning algorithms include Lasso, Ridge, Bayesian Ridge, K neighbors, Support vector machine, Gaussian Process, Decision tree, etc. Figure 1 shows a performance score comparison between multiple machine learning regression algorithms, the calculated scores include R squared score, explained variance score and cross validation score for acoustic emission testing. This shows the results of using machine learning to predict the concrete acoustic emission source locations, the algorithms could be further utilized in the mix design of concrete.
- Undertook a series of tests to develop methods of assessing the performance of concrete mixes. Figure 2 and Figure 3 shows concrete samples following fracture testing. Figure 4 shows an environmental chamber that is being used for freeze-thaw testing of concrete.

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.

The progress in this quarter primarily focused on Goal 1 with the development of machine learning methods for mix design and testing methods for concrete samples.

Accomplishments:

The only accomplishments are the initiation of research into machine learning methods for mix design and laboratory performance test methods.

Task Progress and Budget:

Table 1: Task Progress

Task Number	Start Date	End Date	% Complete
Task 1: Develop and verify laboratory testing procedures	1/1/21	9/1/21	20%
Task 2: Identify and test prototype HPC mix	1/1/21	11/30/21	15%
Task 3: Meet with concrete suppliers	1/1/21	11/30/21	10%
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	1/1/22	4/30/22	

industrial partner's facility			
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	10%

Table 2: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date*
$503,744	$49,646.22 3 – 06/30/21	9.86%

Professional Development/Training Opportunities:
NA

Technology Transfer:
NA

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
NA				

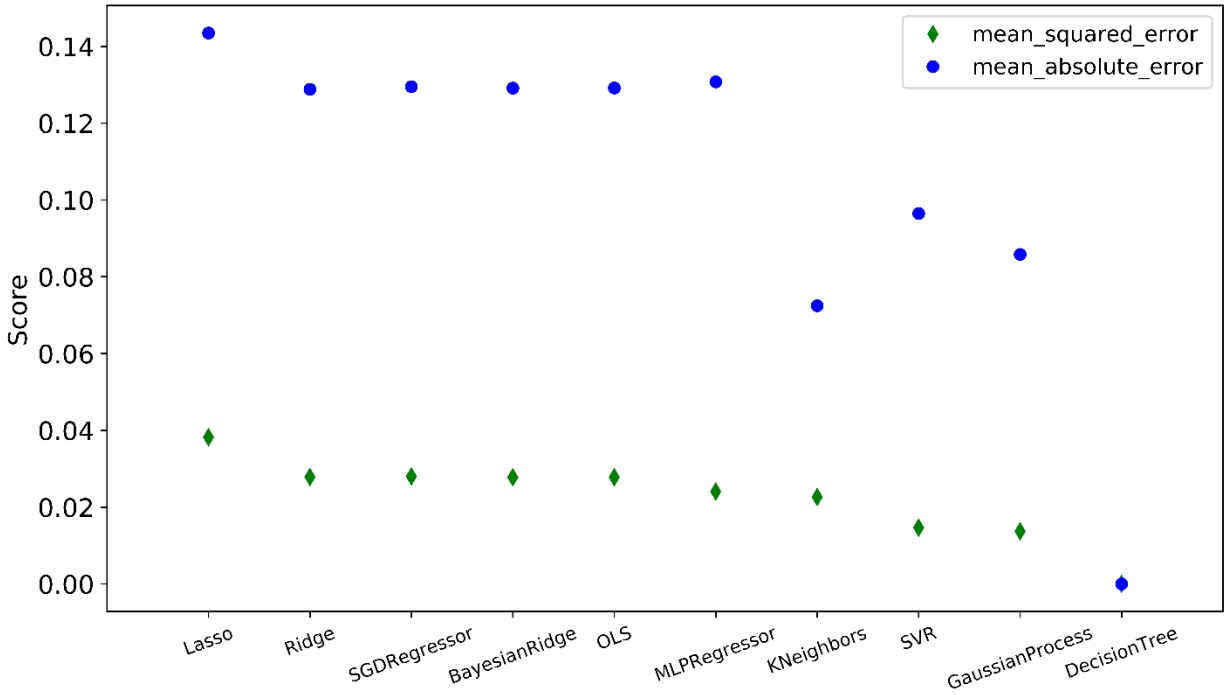

Figure 1 Comparison of different machine learning techniques in acoustic emission location performance in concrete

Figure 2 Concrete block sample following fracture testing

Figure 3 Concrete cylinder with fiber reinforcement following fracture testing

Figure 4 Environmental test chamber for freeze thaw testing of concrete samples

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**
Matt Kaplita		Junior	Civil Eng	Laboratory testing

Table 7: Students who Graduated During the Reporting Period			
Student Name	**Degree**	**Graduation Date**	**Employment or continued degree**
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**
VTrans	Montpelier, VT		Ring shrinkage test equipment			

Table 9: Other Collaborators			
Collaborator Name and Title	**Contact Information**	**Organization and Department**	**Contribution to Research**
James Wild	Vermont Agency of Transportation	Materials	Technical Champion
Nick van den Berg	Vermont Agency of Transportation	Materials	Advised planning

Who is the Technical Champion for this project?
Name: James Wild
Title: Concrete Materials Manager

Organization: Vermont Agency of Transportation
Location (City & State): Montpelier, VT
Email Address: Jim.Wild@vermont.gov

Changes:

The project did not start until January 1, 2021, instead of the proposed September 1, 2020. The task schedule in Table 1 has been adjusted accordingly.

A graduate student has not yet been hired on the project. During the summer of 2021, an undergraduate Civil Engineering graduate student has been hired to conduct laboratory experiments.

The availability of concrete shrinkage ring tests is pending due to the need for completing an equipment loan agreement between VTrans and University of Vermont.

Planned Activities:

1. Continue to develop formulations for mix designs
2. Continue to develop laboratory test procedures
3. Use laboratory tests on preliminary mixes
4. Acquire aggregate samples from Vermont and Northern New England based suppliers