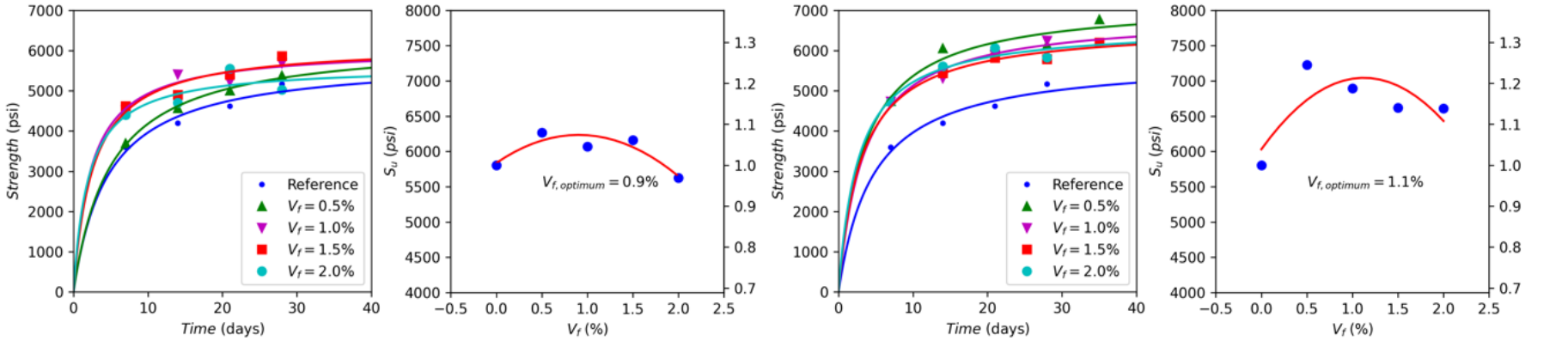
Quarterly Progress and Performance Indicators Report:
Project Number and Title: 3.5 Prevention of Stress-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure
Research Area: New Systems for Longevity and Constructability
PI: *Moochul Shin and Western New England University*
Co-PI(s): *ChangHoon Lee and Western New England University*
Reporting Period: *1/1/2022~3/31/2022 Period start and end dates (i.e. 7/1/2021-9/30/2021)*
Submission Date: *3/29/2021*

Overview:

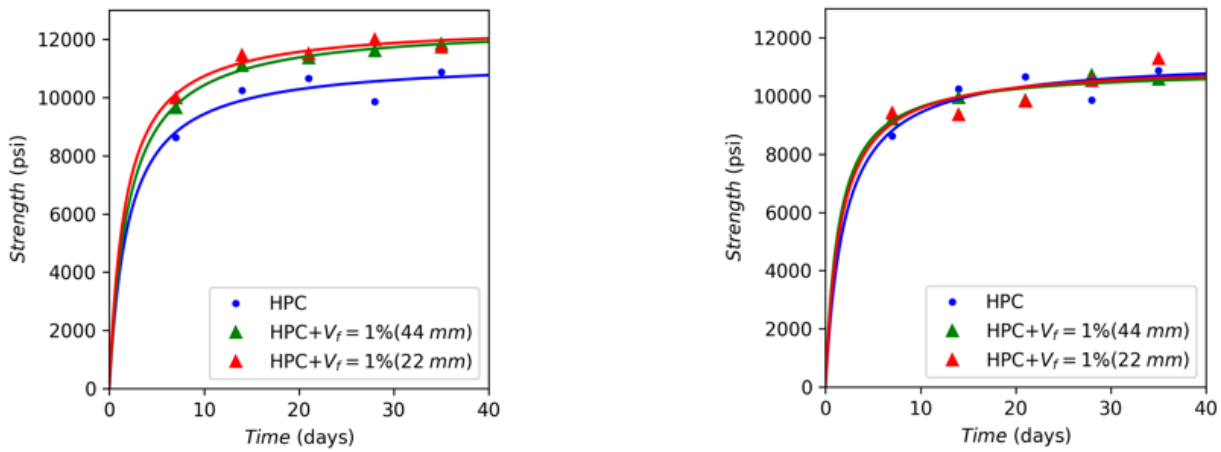
During the reporting period, the WNEU research team has been focusing on Phase 2 of the project (i.e. Task 2.1), while continually working on Phase 1 (i.e. Tasks 1.3 and 1.4). The research team was able to successfully develop fiber-reinforced concrete mixtures and explore the optimum doses of fibers to produce higher compressive strengths. Basalt fiber was selected to enhance the impact resistance, crack propagation resistance, and corrosion resistance of concrete mixtures.

- The optimum fiber dosage is investigated for 4,500 psi. of the design compressive strength (i.e., the highest design strength regarding the worst durability condition per ACI 318) (Please see Figure 1)
- Based on the optimum dosage of the fibers, two different types of fiber-reinforced cements (i.e., Type I/II and Type III) are tested as changing the aggregate types available near western Massachusetts.
- From the investigation, it is observed that there is no influence of fiber length when using the identical dosage is used. (Please see Figure 2.)
- The use of Type I/II cement and granite aggregates produce a higher compressive strength (approximately 11%) as compared to that of the cylinders with Type III and basalt aggregates.



(a) Strength Development (Long) (b) Limiting Strength with Fiber Content (Long) (c) Strength Development (Short) (d) Limiting Strength with Fiber Content (Short)

Figure 1: Experimental results to search for the optimum fiber contents



(a) Strength Development for ECM (Type I/II + Granite agg.) (b) Strength Development for ECM (Type III+ Basalt agg.)

Figure 2: Strength development for fiber-reinforced ECM according to different cement and aggregate types

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.

- From the previous outcomes, the research team was able to investigate a set of mixtures that meet a performance indicator (i.e., compressive strength) of the developing fiber-reinforced ECM.
- The average value of different optimum values of the fiber content (from the previous outcome) was tested, and no significant difference is observed in the resulting compressive strength.

Accomplishments:

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

- The use of granite aggregates produces about 11% higher compressive strength. (Note that both basalt and granite aggregates are popular in New England area.)
- Without steam curing, the developing ECM achieved about 10,000 psi at 7 days. This infers that the regular practice of stream curing in the industry will accelerate the early strength gaining.

Task, Milestone, and Budget Progress:

Table 1: Task Progress			
Task Number: Title	**Start Date**	**End Date**	**% Complete**
Task 1.1: 3D FE Prism Models	09/01/2018	9/30/2022	99 %
Task 1.2: Development of a Detailed Bond-Slip Model based on Large-scale Computations	03/01/2019	9/30/2022	99 %
Task 1.3: Crosstie Analysis	06/01/2020	9/30/2022	95 %
Task 1.4: Introduction of Engineered Cementitious Materials	12/01/2018	5/31/2022	95 %
Task 2.1 Development of fiber-reinforced ECM	10/01/2021	9/30/2022	40 %
Task 2.2 Investigation of the optimal steam-curing temperature profile	10/01/2021	9/30/2022	5 %
Task 2.3 Surface condition evaluation	2/01/2022	9/30/2022	0 %
Task 2.4 Accelerated corrosion test	2/01/2022	9/30/2023	0 %
Task 2.5 Pull-out test	10/01/2022	9/30/2023	0 %
Phase 1 Overall	09/01/2018	09/30/2022	93 %
Phase 2 Overall	10/01/2021	9/30/2023	10 %

Table 2: Milestone Progress			
Milestone #: Description	**Corresponding Deliverable**	**Start Date**	**End Date**
Milestone 1: Development of Engineered Cementitious Materials (ECM)	Concrete cylinders; Report	12/01/2018	09/30/2022
Milestone 2: Numerical Concrete models	Report	09/01/2018	09/30/2022
Milestone 3: Development of fiber-reinforced ECM	Cylinders; Report	10/01/2021	09/30/2022
Milestone 4: Investigation of the optimal steam-curing temperature profile	Report	1/01/2022	12/31/2022
Milestone 5: Surface condition evaluations	Report	10/01/2022	09/30/2023
Milestone 6: Accelerated corrosion test	Report	10/01/2022	09/30/2023
Milestone 7: Pull-out test with various indented wires	Report	10/01/2021	09/30/2023

Table 3: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date (include the date)**
$385,000	$ 360,318 to 2/28/2022	93.6 %
$260,000	$ 93,177 to 2/28/2022	35.8 %

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?

   N/A

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?

   - The research team had a meeting with Kiewit Corporation to consult a practical applicability of the project on the job site (02/24/2022). The team presented an overview of the project and got their feedback on some potential issues when transferring the technology into the practice.

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?

   N/A

Technology Transfer:

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)**
N/A	N/A	N/A	N/A	N/A	N/A

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**
N/A	N/A	N/A	N/A	N/A

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?

   N/A

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?

   N/A

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?

   N/A

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

   N/A

   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.

   N/A

5. 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).

   N/A

(a) *(b)*

Four-point bending test on a fiber reinforced ECM beam (a) and a broken beam after test (b)

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:

- N/A

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:

- N/A

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:

- N/A

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**
Moochul Shin, Associate Professor	1/01/2022~3/31/2022	moochul.shin@wne.edu	Civil Engineering	PI
ChangHoon Lee, Assistant Professor	1/01/2022~3/31/2022	Changhoon.lee@wne.edu	Civil Engineering	co-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**
Christopher Spinazola	2/15/2022	3/31/2022	Moochul Shin		UG	Civil Engineering	TIDC	Conducting fracture testing and analyzing test data
Evan Blake	1/31/2022	3/31/2022	ChangHoon Lee, Moochul Shin		UG	Civil Engineering	TIDC	Preparing testing samples
Christa-Elizabeth Cicerone	1/31/2022	3/31/2022	ChangHoon Lee		UG	Civil Engineering	Course credits	Conducting compressive strength test
Brian Leclair	1/31/2022	3/31/2022	ChangHoon Lee		UG	Civil Engineering	Course credits	Analyzing test data
Daniel Doyle	1/31/2022	3/31/2022	ChangHoon Lee		UG	Civil Engineering	Course credits	Preparing concrete mix
Archer Parker	1/31/2022	3/31/2022	ChangHoon Lee		UG	Civil Engineering	TIDC, Course credits	Preparing concrete mix

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**
Texas Advanced Computing Center	Austin, TX			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
Rusty Croley, Senior Vice President of Operations and Engineering		Vossloh Tie Technologies, Rocla Concrete Tie Inc.	3/28/2022	Technical champion
Logan Lemmertz, Project Engineer		Vossloh Tie Technologies, Rocla Concrete Tie Inc.	3/29/2022	Industry partner
Hailing Yu		Volpe Center (currently at STV)	3/28/2022	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
CEE 451	Construction Materials	Undergraduate/Grad	WNE	Moochul Shin	Spring 2022	23
CEE310	Civil Engineering Research	Undergraduate	WNE	Chang Hoon Lee	Fall 2021	5
CEE410	Civil Engineering Research	Undergraduate	WNE	Chang Hoon Lee	Fall 2021	5

Changes:

- The vendor of the reflectometer, LabSphere, notified that the delivery of the equipment is significantly delayed due to world-wide supply chain disruption. (Expected delivery date: Mid April) Accordingly, the starting date of Phase 2.3 must be postponed.
- Robert Halversen left the research team and Christopher Spinazola joined the team in the beginning of 2022 spring semester.

Planned Activities:

- The research team will be finalizing the modeling works proposed in Phase I.

- The research team will develop fiber-reinforced high performance concrete and investigate their properties.
- The research team will be evaluating surface conditions of the fiber-reinforced concrete mixtures using a reflectometer (LiDAR sensor)