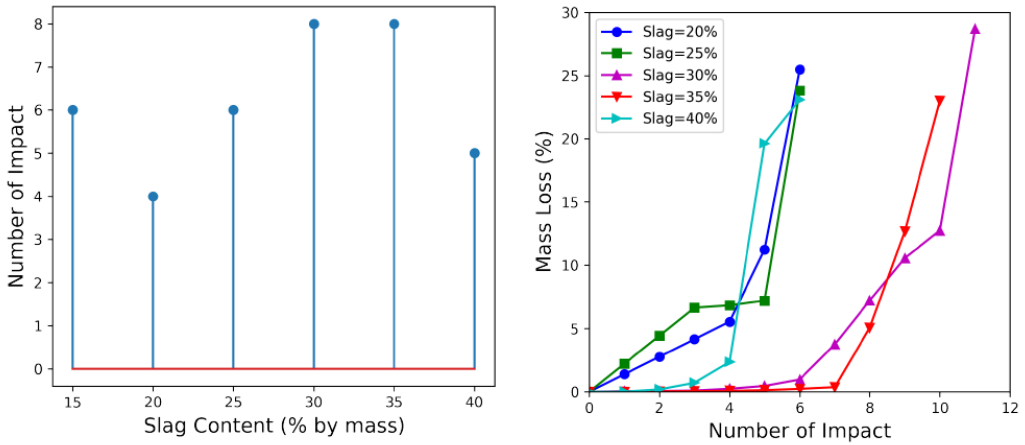
Quarterly Progress and Performance Indicators Report:
Project Number and Title: 3.5 Prevention of Stress-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure
Research Area: New Systems for Longevity and Constructability
PI: *Moochul Shin and Western New England University*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

****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:

During the reporting period, the WNEU research team has been focusing on Phase 2 of the project (i.e. Task 2.1), while finalizing Phase 1 (i.e. Tasks 1.3 and 1.4). The research team continues examining the effect of Granulated Ground Blast Furnace Slag (GGBFS) on the fiber-reinforced ECM, and the impact loading resistance. In addition, the team started working on investigating the effects of Fly Ash on the fiber-reinforced ECM. (The corresponding results will be reported in the next reporting period.)



(a) Comparison of Strength at Each Test Age (b) Mass Loss per repeated impact loadings

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

- A qualitative failure criteria of the impact load resistance is defined by the number of drops when an 18 lb hammer doesn't rebound to the surface of the specimen. Figure 1(a) shows that 30% and 35% of GGBFS contents showed the best impact resistance performance.

- Figure 1(b) illustrates that 30% of GGBFS content showed the minimum mass loss (damage) under the repeated impact loadings up to seven times drops. However, 40% of GGBFS content showed no improvement in the impact resistance as compared to the speicmens with 20~25% of GGBFS contents.

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 reporting period, the WNE team found that 30~35% of GGBFS contents showed the highest compressive strength. In exploring the optimum content of GGBFS with 1% of basalt fiber, the impact load resistance is another criterion for designing the optimum content of GGBFS. During this reporting period, the team identified 30% showed the best impact loading resistance.

Accomplishments:

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

- The research team implemented a quantitative testing criterion to measure the performance of the impact loading resistance. The criterion needs further revision as considering the kinetic energy driven by the impact loading. (i.e., x% per y kJ of kinetic energy)

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: 3D FE Prism Models	09/01/2018	9/30/2022	100 %
Task 1.2: Development of a Detailed Bond-Slip Model based on Large-scale Computations	03/01/2019	9/30/2022	100 %
Task 1.3: Crosstie Analysis	06/01/2020	9/30/2022	99 %
Task 1.4: Introduction of Engineered Cementitious Materials	12/01/2018	9/30/2022	95 %
Task 2.1 Development of fiber-reinforced ECM	10/01/2021	9/30/2023	50 %
Task 2.2 Investigation of the optimal steam-curing temperature profile	10/01/2021	12/31/2022	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	5 %
Task 2.5 Pull-out test	10/01/2022	9/30/2023	0 %
Phase 1 Overall	09/01/2018	09/30/2022	98 %
Phase 2 Overall	10/01/2021	9/30/2023	27 %

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
Milestone 8:			
etc.			

Table 3: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date (include the date)**
$385,000	$ 375,000 to 7/31/2022	97.4 %
$260,000	$ 70,664.69 to 7/31/2022	27.2 %

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.) *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? *A research update meeting with Reinforce Tech and Alvin Ericson on July 26, 2022. 5 people attended the online zoom meeting.*

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? (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.) *28 10~11th graders visited the Transportation lab on September 24, 2022. Dr. ChangHoon Lee presented the research findings and overviews of the TIDC research activities regarding the ECM with basalt fibers. They learned about the effect of fibers in concrete in terms of the impact resistance.*

Fig.2 Outreach Presentation

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)**
i.e. Conference, Symposium, DOT/AOT presentation, Seminar, etc.	Presentation Title	Full Citation	Name of event (i.e. TIDC 1st Annual Conference) or who was the presentation given to?		
Symposium	Development of High Performance Concrete Using Non-steel Fiber for Prestressed Concrete Crossties	Lee, C., Shin, M., and Parker, A.J. (2022) "Development of High Performance Concrete Using Non-steel Fiber for Prestressed Concrete Crossties", 16th International Symposium on Functionally Graded Materials, Hartford, Connecticut, USA August 7-10, 2022	16th International Symposium on Functionally Graded Materials	Hartford, CT	August 7-10, 2022

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**
i.e. Peer-reviewed journal, conference paper, book, policy paper, magazine/newspaper article	Publication title	Full citation		i.e. Submitted, accepted, under review (by org. submitted to)
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*

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. *N/A*

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). *N/A*

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.

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

- Examples: New sensing technology was developed. This technology will… A UAV was created to hold new monitoring technology. This will allow maintenance crews to… A new college course was created based on the research findings. This will train future transportation professionals to…

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

- Example: The developed sensing technology was installed in Bridge A in town, state on 1/1/2021. This installation will… The UAV was successfully used by ___ Organization to inspect ___ Bridge in in town, state on 1/1/2021… The newly created college course was taken/completed by __ students in the 2021 fall semester.

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

- Example: The developed sensing technology's successful deployment resulted in the adoption of the technology by the StateDOT. The technology will be installed in all new bridge installments of this type. This adoption will… The new UAV monitoring technology was adopted by __ organization to be used for __ bridges inspections. This will allow inspectors to… The college course has been adopted by another member university…

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	7/01/2022~9/30/2022	moochul.shin@wne.edu	Civil Engineering	PI
ChangHoon Lee, Assistant Professor	7/01/2022~9/30/2022	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**
Evan Blake	8/29/2022	9/30/2022	Moochul Shin		UG	Civil Engineering	TIDC	Preparing testing samples
Christopher Spinazola	8/29/2022	9/30/2022	Moochul Shin		UG	Civil Engineering	TIDC	Testing beams and data analysis
Christa-Elizabeth Cicerone	8/29/2022	9/30/2022	ChangHoon Lee		UG	Civil Engineering	Course credits	Conducting compressive strength test
Brian Leclair	8/29/2022	9/30/2022	ChangHoon Lee		UG	Civil Engineering	Course credits	Analyzing test data
Archer Parker	8/29/2022	9/30/2022	ChangHoon Lee		UG	Civil Engineering	TIDC; Course credits	Preparing concrete mix
Adam Gartska	8/29/2022	9/30/2022	ChangHoon Lee		UG	Civil Engineering	Course credits	Preparing concrete mix
Charles Maloy	8/29/2022	9/30/2022	ChangHoon Lee		UG	Civil Engineering	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			Please list the organization or degree

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			Please list the organization or degree

*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**
N/A						

*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.	5/25/2022	Technical champion
Logan Lemmertz, Project Engineer		Vossloh Tie Technologies, Rocla Concrete Tie Inc.	5/25/2022	Industry partner
Hailing Yu		Volpe Center (currently at STV)	3/28/2022	Technical champion
Len Miller		Reinforce Tech	8/08/2022	Industry partner

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
i.e. CE 123		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?
CEE 310	Civil Engineering Research (independent study)	Undergraduate	WNE	Chang Hoon Lee	Fall 2022	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: end of 2022) Accordingly, the starting date of Phase 2.3 must be postponed.
The XSEDE allocations on STAMPEDE 2-Project MSS180002 was expired on July 1st, 2022.

Planned Activities:

- The research team will be finalizing the modeling works in Phase I.
- The research team will develop fiber-reinforced concrete and investigate their impact resistance.
- The research team will be evaluating surface conditions of the fiber-reinforced concrete mixtures using a reflectometer (LiDAR sensor)