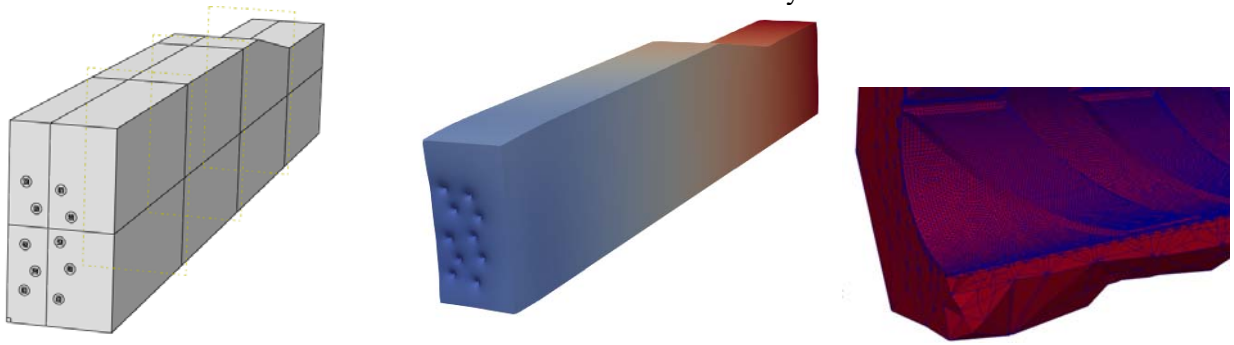
Quarterly Progress Report:
Project Number and Title: 3.5 Prevention of Stress-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure
Research Area: New Systems for Longevity and Constructability
PI: *Moochul Shin and Western New England University*
Co-PI(s): *ChangHoon Lee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

Overview: (Please answer each question individually)

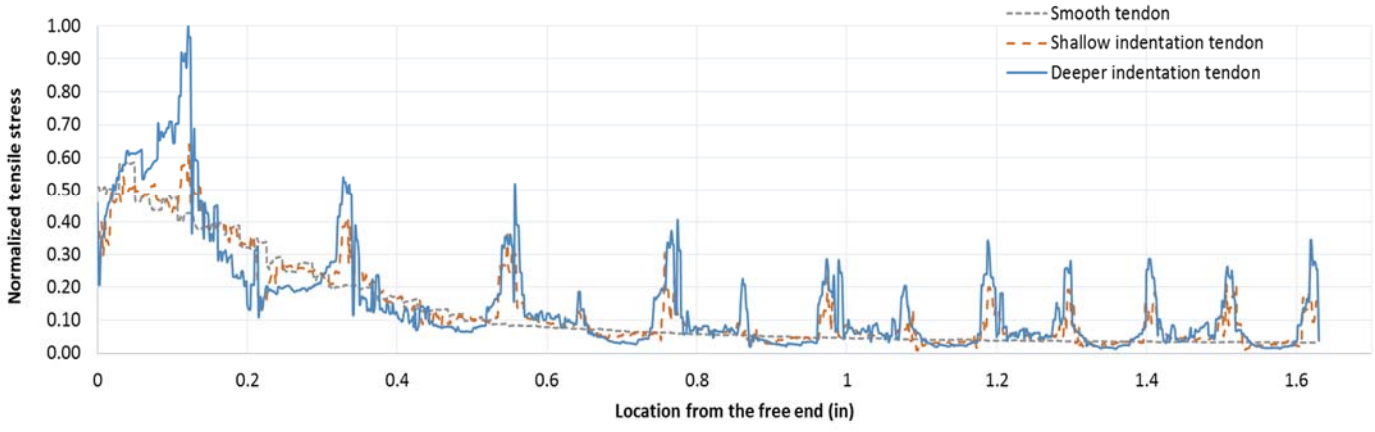
Due to the COVID-19 pandemic, limited numerical analyses and lab experiments have been conducted. During the reporting period, the WNEU research team has been working mostly on Tasks 2, 3, and 4.

- Quarter symmetric prestressed concrete crossties models (DoFs of 100 ~ 145 million) with three different prestressing tendons were constructed and simulated.
- The deeper the depth of the indentation was, the higher the tensile stress was observed. The maximum tensile stress from the deeper indentation tendon model was 56 % higher than that of the shallow indentation tendon model.
- The smoother tendon model showed a gradual decrease of the tensile stress from the free end upon de-tensioning while the models with the indented tendons showed sudden stress increases at every indentation.



(a) before (b) after (c)

Figure.1 Quarter symmetric prestressed concrete crosstie models: (a) before and (b) after detentioning wires, and (c) the mesh of the deeper indentation tendon model at the interface (concrete side).

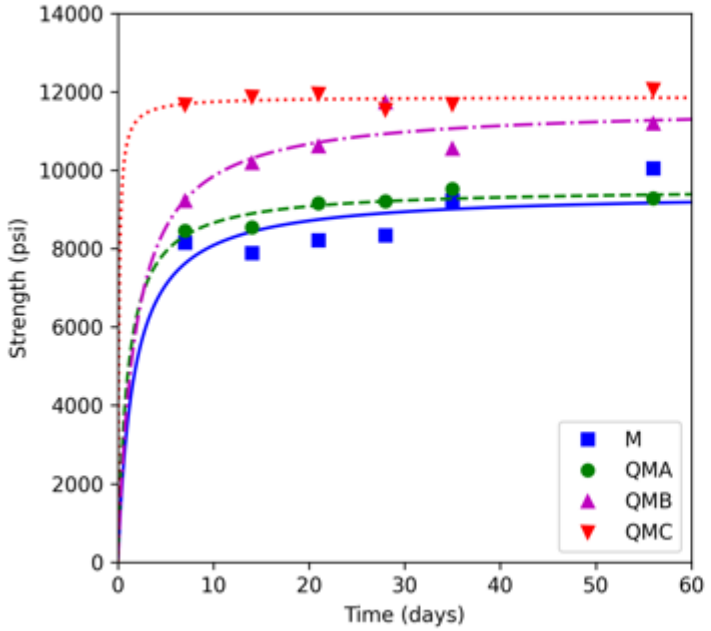


(a) (b)

Figure 2. Normalized tensile stress by the maximum principal stress from the deeper indentation tendon model.

- Among the tested engineered cementitious material (ECM) mix designs, the compressive strength of the ECM design using Type I/II cement without any fibers reached 12,000 psi at 7 days.

- All the ECM mixture designs tested during the period used a large volume of locally available coarse aggregates, expecting that the developed ECM would be competitive in terms of its cost, and the fine aggregate (sand) to coarse aggregate ratios are between 55 % and 60 %.
- In addition, Granulated Ground Blast Furnace Slag was used instead of Fly ash, and it makes the developed ECM more “Green” and cost-effective.



Name	Cement Type	W/B	Paste Vol.	Sand-to-Agg. Vol. Ratio
M	III	0.28	40%	55%
QMA	III	0.28	45%	55%
QMB	III	0.28	40%	60%
QMC	I/II	0.22	40%	60%

(a)

(b)

Figure 2. (a) Strength Development with Time for Various Tested Mixture Design and (b) Common failure modes of QMC specimens (i.e., Splitting failure of Coarse aggregates)

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**% Complete**
Task 1: 3D FE Models	09/01/2018	12/30/2020	99 %
Task 2: 3D FE Models on HPC	03/01/2019	5/31/2021	95 %
Task 3: Crosstie Models	06/01/2020	09/30/2021	50 %
Task 4: Introduction of Engineered Cementitious Materials	12/01/2018	05/31/2021	75 %
Overall Project:	09/01/2018	09/30/2021	70%

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date***
$385,000	$274808.87 to 3/18/2021	71.4 % to 11/30/2020

Include the date the budget is current to.

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

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
n/a				

Participants and Collaborators:

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
Moochul Shin	moochul.shin@wne.edu	Civil and Environmental Engineering	Leading Tasks 1, 2, and 3
Chang Hoon Lee	changhoon.lee@wne.edu	Civil & Environmental Engineering	Leading Task 4.

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Georgii Tifaniuk		Junior	Civil Engineering	Experimental Testing
Cameron Cox		Senior	Civil Engineering	Experimental Testing
Andrew Masullo		Senior	Civil Engineering	Experimental Testing
Jacob Eberli		Senior	Civil Engineering	Experimental Testing
Daniel Doyle		Junior	Civil Engineering	Experimental Testing
Archer Parker		Sophomore	Civil Engineering	Experimental Testing

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**
N/A			

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**
National Center for Supercomputing Applications	Urbana, IL		x			
Texas Advanced Computing Center	Austin, TX			x		

The in-house parallel algorithm code was mainly developed by Dr. Kwack (currently at Argonne National Laboratory) when he was a staff member of the Blue Waters sustained-petascale computing project, which is supported by the National Science Foundation (awards OCI-0725070 and ACI-1238993) and the State of Illinois. In addition, this work partially used the XSEDE resource – Stampede2-TACC through allocation #MSS180002.

Table 9: Other Collaborators			
Collaborator Name and Title	**Contact Information**	**Organization and Department**	**Contribution to Research**
JaeHyuk Kwack		National Center for Supercomputing Applications (currently at Argonne National Laboratory)	Technical support and advice for high performance computing
Hailing Yu		Volpe Center (currently at STV)	Technical champion

Who is the Technical Champion for this project?
Name: Hailing Yu
Title: Mechanical Engineer (Engineering Specialist)
Organization: Volpe center (currently at STV)
Location (City & State): Cambridge, MA (Boston, MA)
Email Address: hailing.yu@dot.gov (hailing_yu@yahoo.com)

Changes:

WNEU has been holding most of the classes on-ground (face-to- face) for the 2021 Spring semester, although there was a 100% online week due to the increased covid-positive cases on campus. The research activities were interrupted periodically throughout the semester. A 6~12 month delay is expected.

Three senior students are expected to graduate at the end of the semester. The research team is currently recruiting undergraduate research assistant students. Daniel Doyle and Archer Parker have newly joined the research team this semester.

The project #MSS180002 for the use of the XSEDE resource (HPC) has been extended to 9/30/2021.

Planned Activities:

1. Large-scale prestressed concrete crosstie models will be further developed with multiple wires in order to investigate the overall responses using the HPC.

2. The research team will be monitoring the safety guidelines of the lab environments.

3. The research team will finalize the development of ECM for the railroad crossties. The use of high volume paste can be a potential risk for shrinkage crack despite denser microstructure. The research team investigates the performance of concrete with respect to combinations of the paste volume and the size distribution of aggregates.