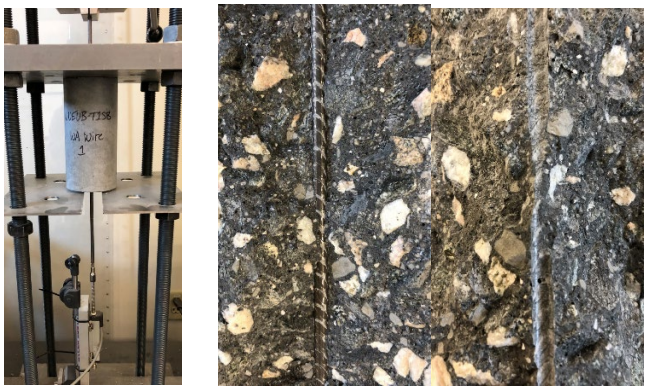
Quarterly Progress Report:
Project Number and Title: 3.5 Prevention of Stress-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure
Research Area: New Systems for Longevity and Constructability
PI: *Moochul Shin and Western New England University*
Co-PI(s): *ChangHoon Lee and Western New England University*
Reporting Period: ***1/1/2020~3/31/2020***
Submission Date: *3/27/2020*

Overview: (Please answer each question individually)

In this period, the WNEU research team has been working on Tasks 1,2 and 4.

- The research team was able to produce high-strength concrete for the railroad concrete crossties. The compressive and splitting tensile strengths are 6100 psi and 425 psi at 14 days, respectively.
- Using the developed concrete, the team was able to successfully conduct pull-out tests with three different prestressing wires: 1) smooth, 2) shallow chevron indentation, and 3) deeper chevron indentation (see Figure 1).
- The deeper indentation pattern required higher pull-out force than the shallow pattern at the same level of displacement due to strong mechanical interlocking; it also shows the lower ductility. (see Figure 2).



(a) (b)

Figure 1. Pullout-test (a) and split section of the specimen after the testing (b).

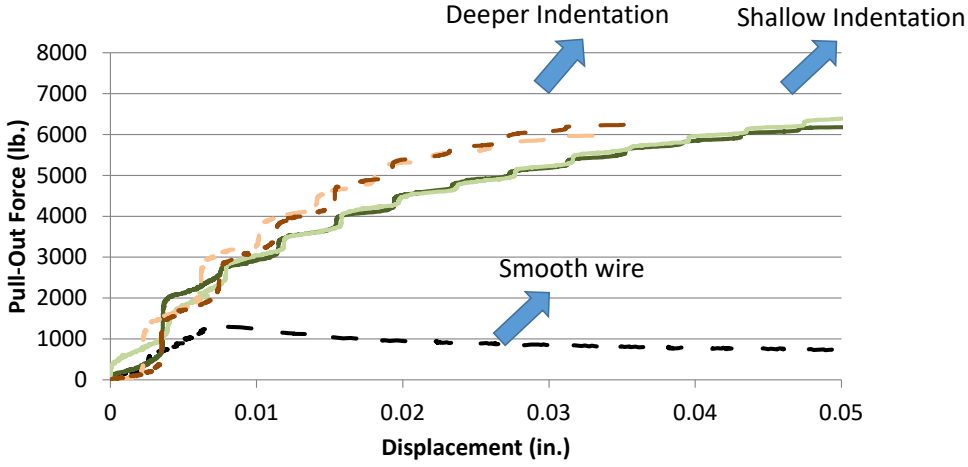


Figure 2. Pull-out test results.

At the same time, the in-house code using the high-performance computing power based on a parallel computing algorithm (Task2) has been updated. A 2 in x 2 in x 34.5 in- presterssed concrete prism with the shallow chevron indentation wire model was built, and the number of degrees of freedom is about 7 million and the number of the tetrahedron element is

about 42.5 million respectively. Up to 1000 cores were used to simulate the model; it took 64 second CPU time with 1000 cores, while 6,270 seconds were taken by using 4 cores.

With this large scale simulation, the research team will be able to model a real size concrete crosstie with the larger size of problems to identify how bond-slip characteristics can affect the performance of railroad crossties.

Table 1: Task Progress

Task Number	Start Date	End Date	% Complete
Task 1: 3D FE Models	09/01/2018	12/30/2019	90 %
Task 2: 3D FE Models on HPC	03/01/2019	09/30/2020	45 %
Task 3: Crosstie Models	06/01/2020	09/30/2021	0 %
Task 4: Introduction of Engineered Cementitious Materials	12/01/2018	09/30/2020	65 %
Overall Project:	09/01/2018	09/30/2020	

Table 2: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date*
$385,000	$138,455 to 2/29/2020	36.0 % to 2/29/2020

Include the date the budget is current to.

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events

Title	Event	Type	Location	Date(s)
Numerical Study of the Effect of Indentation Patterns in Prestressed Concrete Prisms Using High-Performance Computing	The 2020 TRB Annual Meeting	Conference	Washington D.C.	January 12~16, 2020

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Peer-reviewed journal	Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials	C. H. Lee, S. J. Lee, M. Shin, and S. Bhattacharya, "Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials," Construction and Building Materials, 2019	03/24/2020	Under review

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 Task 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
Abdoulaye Diallo		Master	Civil Engineering	Numerical analysis
Caleb Tourtelotte		Senior	Civil Engineering	Specimen manufacture
Matthew Colonna		Senior	Civil Engineering	Fracture Testing preparation
Nicholas Pantorno		Junior	Civil Engineering	Specimen manufacture
Cameron Cox		Junior	Civil Engineering	Specimen manufacture
Andrew Masullo		Junior	Civil Engineering	Specimen manufacture
Alexis Herrera		Senior	High School	Intern

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:

The technical champion, Dr. Yu recently switched her position at STV an engineering consulting company after 20 years of work at the US-Volpe center. However, the research team believes that Dr. Yu's expertise in the railroad track structure is instrumental to the project.

Due to the pandemic coronavirus, all of the students including graduate and undergraduate researchers are not allowed to work on the project. A 3~6 month delay is expected.

Alexis Herrera, a local high school senior (Minnechaug Regional High school), has joined the team as an intern as of 1/28/2020. She has been studying relations between environmental changes and transportation infrastructure with the aim of presenting her findings to local middle and high school students. However, due to the pandemic coronavirus, the intern activities have been interrupted for the rest of the semester.

Planned Activities:

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

2. The research team will continue developing UHPC for the railroad crossties. Instead of recycled aggregates, the team will test granite (quartz-oriented) and basalt aggregates (silica-oriented).

3. We are planning to conduct a series of a pull-out test with the newly developed UHPC.