

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: 4/1/2020~6/30/2020

Submission Date: 6/30/2020

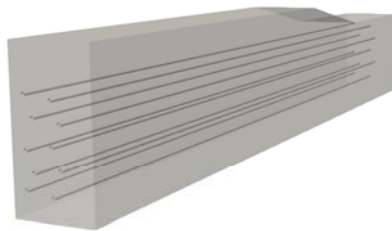
Overview: (Please answer each question individually)

Due to the COVID-19 pandemic, the research activities have been significantly disrupted. Limited numerical analyses were performed. In this period, the WNEU research team has been working on Tasks 2 and 3.

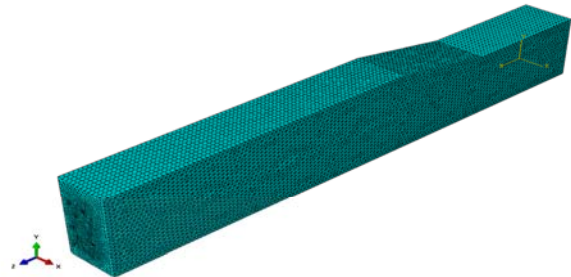
- *Speedup test was performed on a 2 in x 2 in x 34.5 in- prestressed concrete prism with the shallow chevron indentation wire model; the number of degrees of freedom is about 21 million and the number of the tetrahedron element is about 42.5 million respectively. It indicated that the conversion and the partitioning time changed minimally with respect to the number of cores. With 1000 cores after 1000 partitions on the model, the analysis time was 64 seconds. With 128 cores, the analysis time was 353 seconds.*
- *A real-size 3D prestressed concrete crosstie (PSCCT) model has been built with three different wires: 1) smooth wires, 2) shallow-indented chevron pattern wires, and 3) deeper-indented chevron pattern wires. Only a quarter of a PSCCT was modeled due to the symmetric conditions.*
- *The simulation results indicated that the greatest displacement was observed with the smooth wires upon de-tensioning, the greatest compressive stress at the interface between concrete and the prestressing wires was observed with the deeper-indented chevron pattern wires (see Fig.2).*
- *Upon de-tensioning the prestressing wires tend to go back to the original position along the longitudinal direction, and the deformed shape of the wires shows that the wires not only displaced along the longitudinal axis, but also it displaces on the plane, which might create secondary bending on the ties (see Fig.2).*



(a) Prestressed concrete crosstie

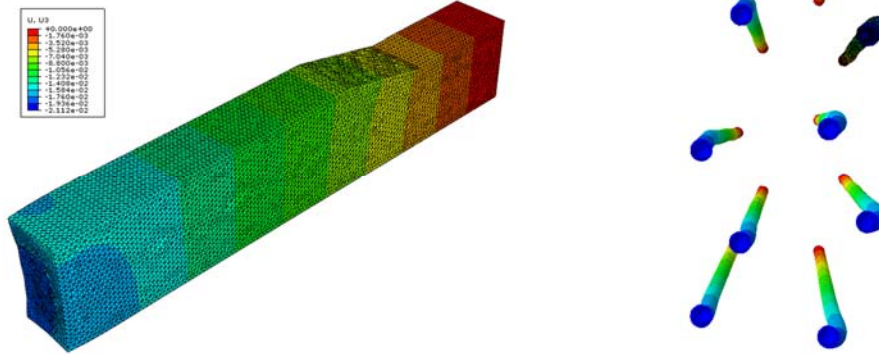


(b) 3D Prestressed concrete crosstie model with 10 prestressing wires



(c) 3D mesh model

Figure 1. Prestressed concrete crosstie (a), 3D numerical model (b), and 3D mesh model (c).



(a) Deformed shape of the PSCCT model (b) Deformed prestressing wires

Figure 2. Deformed shape of the PSCCT model (a) and prestressing wires (b).

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	70 %
Task 3: Crosstie Models	06/01/2020	09/30/2021	10 %
Task 4: Introduction of Engineered Cementitious Materials	12/01/2018	05/30/2021	65 %
Overall Project:	09/01/2018	09/30/2021	50%

Table 2: Budget Progress		
Project Budget	Spend – Project to Date	% Project to Date*
\$385,000	\$171,038.19 to 5/31/2020	44.4 % to 5/31/2020

*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
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, (2020) “Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials,”	Available online 04/10/2020	Published

		<i>Construction and Building Materials, 251, 118984</i>		
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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

Table 7: Student Graduates

Student Name	Role in Research	Degree	Graduation Date
Abdoulaye Diallo	Numerical analysis	Master in Civil Engineering	5.17.2020
Caleb Tourtelotte	Specimen manufacture	Bachelor of Science in Civil Engineering	5.16.2020
Matthew Colonna	Fracture Testing preparation	Bachelor of Science in Civil Engineering	5.16.2020

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:

Due to the COVID-19 pandemic, the research lab has been completely closed. Limited numerical analyses have been performed remotely. A 3~6 month delay is expected.

Two senior students and one graduate student graduated.

Abdoulaye Diallo, who just graduated with the master's degree in Civil Engineering, will be hired as a temporary post-graduate researcher.

Planned Activities:

1. *The research lab will be prepared to reopen.*
2. *Two or three new undergraduate/graduate researchers will be hired.*
2. *Large-scale prestressed concrete crosstie models will be further developed with multiple wires in order to investigate the overall responses using the HPC.*
3. *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).*