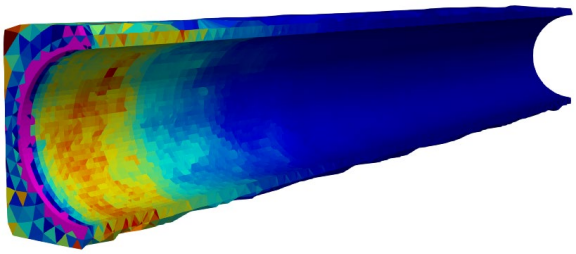
Quarterly Progress Report:
Project Number and Title: 3.5 Prevention of Stress-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure
Research Area: New Systems for Longevity and Constructability
PI: *Moochul Shin and Western New England University*
Co-PI(s): *ChangHoon Lee and Western New England University*
Reporting Period: ***7/1/2020~9/30/2020***
Submission Date: *9/30/2020*

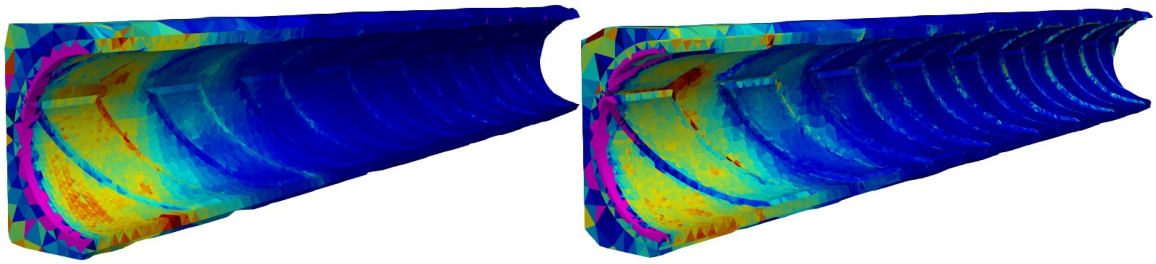
Overview: (Please answer each question individually)

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.

- 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 (see Fig.1). The research team was able to simulate the numerical model with up to 46.7 million of the degrees of freedom by using 1000 cores. Fig. 1 shows the maximum principal stress contour on the concrete surrounding a wire after de-tensioning the prestressing wires.
- The simulation results indicated that the maximum principal stress of the deeper-indented chevron pattern wires is 42.9 % than the shallow-indented chevron pattern wire. The depth of the indentation of the deeper indentation is approximately twice as deep as that of the shallow indentation. In addition, the sidewall angle of the deeper indentation is approximately twice as steep as that of the shallow indentation. Higher stress concentration was found at the first indentation where the indentation ends.
- By investigating the change of the stress along the longitudinal line of the wire, the location of the indentation can be identified (see Fig.2).



(a) Smooth wire



(b) Shallow indentation *(c) Deeper indentation*

Figure 1. Maximum principal stress contour on the concrete surrounding (a) smooth wire, (b) shallow indentation wire, and (c) deeper indentation wire.

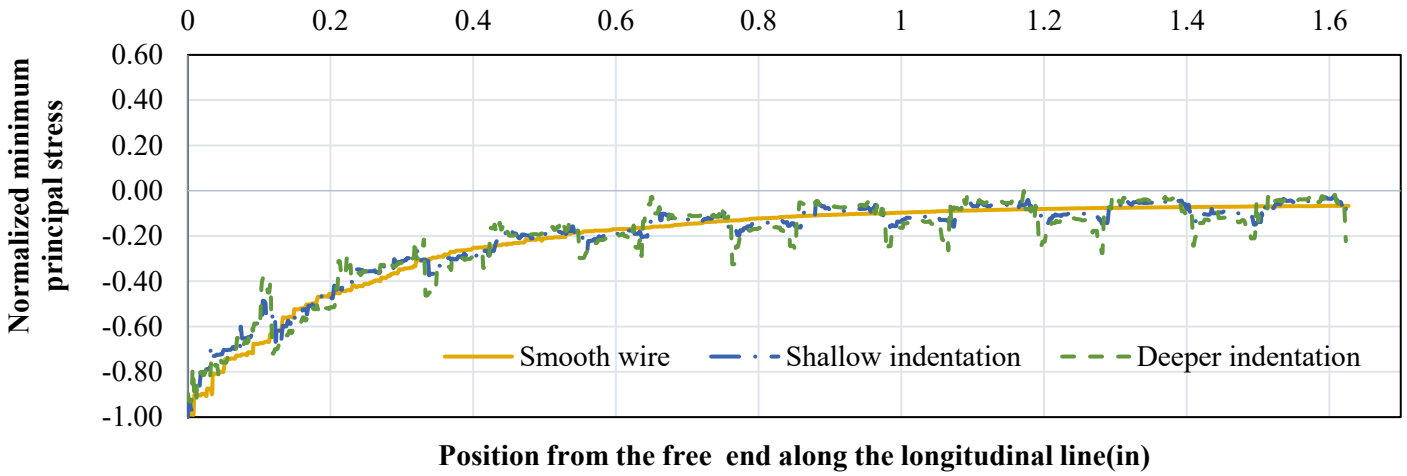


Fig.2 The minimum principal stress distribution along the longitudinal line of a wire

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	12/30/2020	80 %
Task 3: Crosstie Models	06/01/2020	09/30/2021	20 %
Task 4: Introduction of Engineered Cementitious Materials	12/01/2018	05/30/2021	65 %
Overall Project:	09/01/2018	09/30/2021	60%

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date***
$385,000	$203,645.97 to 8/31/2020	53.0 % to 8/31/2020

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," *Construction and Building Materials*, 251, 118984	8/10/2020	Published

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

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.

WNEU is holding most of the classes on-ground (face-to face) for 2020 fall. In order for the campus to remain open, everyone has to follow the COVID safety and health guidelines such as face covering, social distancing, etc. The research team has opened the Concrete lab for the research activities. However, there are many challenges while following safety and health guidelines. A 3~6 month delay is expected.

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

Georgii Tifaniuk, a junior undergraduate student in Civil Engineering has just joined the research team.

The project for utilizing high-performance computing (HPC) resource through Stampede2-TACC (#MSS180002) has been extended to 3/31/2021.

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 keeps monitoring the safety of the lab environments.

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).