

**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: 4/1/2021~6/30/2021**

**Submission Date: 6/30/2021**

**Overview: (Please answer each question individually)**

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 ) were able to capture crack patterns of the prestressed crossties after releasing the prestressing tendons (See Figure 1).
- The deeper indentation tendon and the shallow indentation tendon models tend to have 50~60% and 20~30% higher damage volume than that of the smoother tendon model after the release.

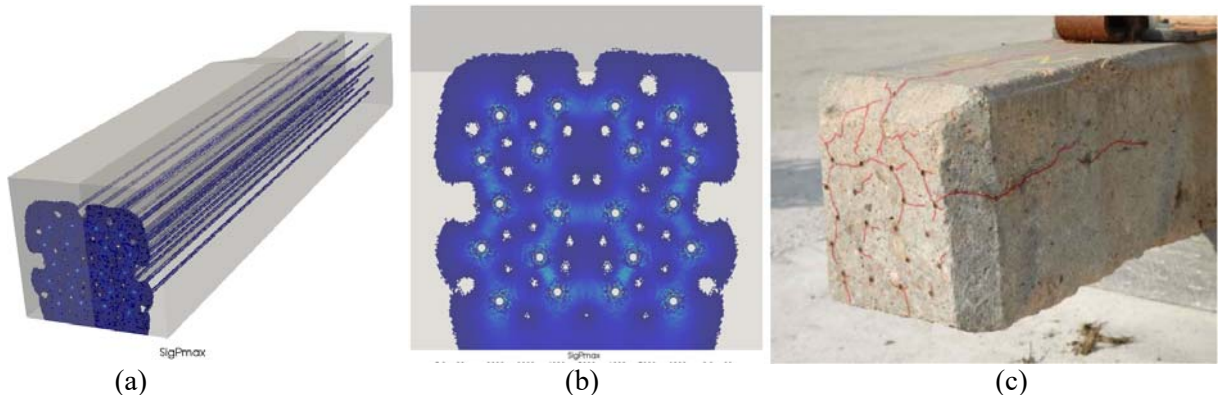


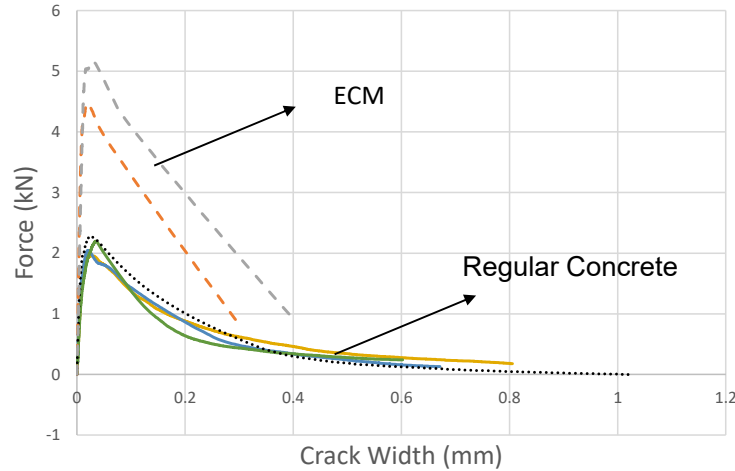
Figure.1 Quarter symmetric prestressed concrete crosstie models crack damage: (a) 3D view (b) cross-sectional view, and (c) crack example (Yu, 2017)\*

\*Original picture was submitted by NDT Corporation as a part of progress report to Federal Railroad Administration (2014).

- A four point bending test were conducted to measure the modulus of rupture ( $f_t$ ) and the fracture energy ( $G_f$ ) of the developed engineered cementitious material (ECM) (see Figure 2.a)
- $f_t$  and  $G_f$  of the developed ECM were 140% and 120% higher than those of the regular concrete (see Figure 2.b).



(a)



(b)

Figure 2. (a) Four point bending test with a crack-opening device and (b) crack-width and force graphs.

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	99 %
Task 3: Crosstie Models	06/01/2020	09/30/2021	70 %
Task 4: Introduction of Engineered Cementitious Materials	12/01/2018	05/31/2021	80 %
Overall Project:	09/01/2018	09/30/2021	80%

Table 2: Budget Progress		
Project Budget	Spend – Project to Date	% Project to Date*
\$385,000	\$303,327.73 to 5/31/2021	78.8 % to 5/31/2021

\*Include the date the budget is current to.

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	Event	Type	Location	Date(s)
Study of Prestressed Concrete Prisms Using a Parallel Computing Algorithm	ASME 2021 Joint Rail Conference	Oral Presentation (virtual)	Virtual	April 20 <sup>th</sup> , 2021

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

**Participants and Collaborators:**

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

<b>Table 6: Student Participants during the reporting period</b>				
<b>Student Name</b>	<b>Email Address</b>	<b>Class</b>	<b>Major</b>	<b>Role in research</b>
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

<b>Table 7: Student Graduates</b>			
<b>Student Name</b>	<b>Role in Research</b>	<b>Degree</b>	<b>Graduation Date</b>
Cameron Cox	Development of ECM	B.S. in Civil Engineering	May 15, 2021
Andrew Masullo	Development of ECM	B.S. in Civil Engineering	May 15, 2021
Jacob Eberli	Development of ECM	B.S. in Civil Engineering	May 15, 2021

<b>Table 8: Research Project Collaborators during the reporting period</b>						
<b>Organization</b>	<b>Location</b>	<b>Contribution to the Project</b>				
		<b>Financial Support</b>	<b>In-Kind Support</b>	<b>Facilities</b>	<b>Collaborative Research</b>	<b>Personnel Exchanges</b>
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)

**Reference:**

*Yu, Hailing (2017) "Causes and Prevention of Splitting/Bursting Failure of Concrete Crossties: A Computational Study" Proceedings of the American Railway Engineering and Maintenance-of-Way Association (AREMA) Annual Conference, Indianapolis, IN*

**Changes:**

*WNEU held 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 graduated in May 2021. The research team is currently recruiting undergraduate research assistant students. Daniel Doyle and Archer Parker joined the research team in the late 2021 spring semester.*

*As a post-graduate MS researcher, Mr. Abdoulaye Diallo worked on the project until the middle of June since he has started his new career at the MassDOT.*

*The research team needs to train new research assistant students.*

**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.*