

**Quarterly Progress Report:**

**Project Number and Title:** C3.2018: Condition Assessment of Corroded Prestressed Concrete Bridge Girders

**Research Area:** Thrust 1: Transportation infrastructure monitoring and assessment for enhanced life

**PI:** Tzuyang Yu (UMass Lowell)

**Co-PI(s):** Susan Faraji (UMass Lowell), ChangHoon Lee (WNEU), Moochul Shin (WNEU)

**Reporting Period:** 10/01/2019 ~ 12/31/2019

**Submission Date:** 12/31/2019

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

The objective of this project is to assess the condition of corroded prestressed concrete (PC) bridge girders in New England by performing multiphysical field inspection and developing an integrated assessment framework. In the reporting period, the UML-WNEU team has been working on Task 1: (Component- and System-Level) Field Inspection/Measurements of proposed research and Task 2: (Meso-to-Macro Level) Development of Macro-Scale Mechanical Damage Model due to corrosion. The UML team has conducted lab measurements of reinforced concrete (RC) beams (6" by 6" by 39") and RC cylinders (a No.3 steel rebar embedded in a 3" by 6" concrete cylinder) using synthetic aperture radar (SAR) imaging in order to develop criteria for the field measurements and a better understanding of the results of concrete bridge girder inspections.

**Table 1: Task Progress**

Task Number	Start Date	End Date	Percent Complete
Task 1:	3/1/19	9/31/19	100%
Task 2:	9/1/19	2/28/20	80%
Task 3:	10/1/19	3/31/20	50%

**Table 2: Budget Progress**

Entire Project Budget	Spend Amount	Spend Percentage to Date
\$89,403 (UML)	\$62,638.15 (UML)	70.1%
\$85,000 (WNEU)	\$55,878.84 (WNEU)	65.7%

*Describe any opportunities for training/professional development that have been provided...*

*Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period. Please use the tables below for any Publications and Presentations in addition to the description of any other technology transfer efforts that took place during the reporting period. )... Use the tables below to complete information about conferences, workshops, publications, etc. **List all other outputs, outcomes, and impacts after the tables** (i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings).*

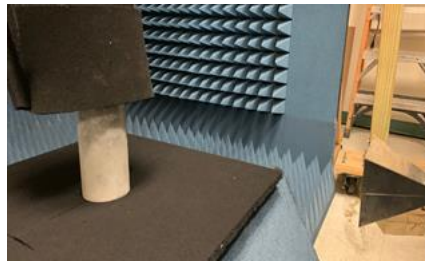
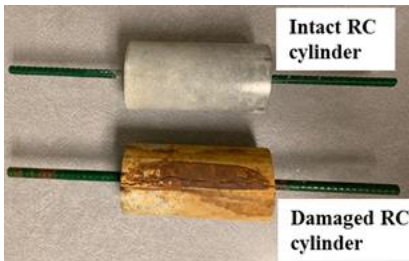
**Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events**

Title	Event	Type	Location	Date(s)
Condition Assessment of Concrete Structures using Radar Imaging	School of Engineering Seminar	Invited seminar talk	Department of Civil Engineering, Chung Yuang University, Chungli, Taiwan	12/20/19

**Table 4: Publications and Submitted Papers and Reports**

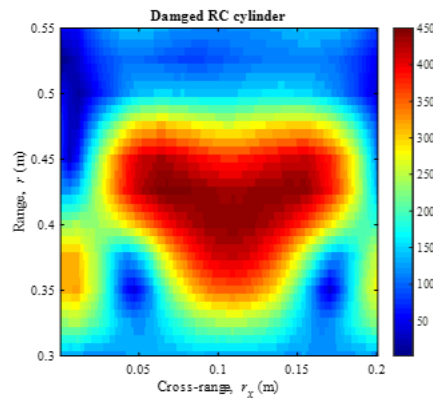
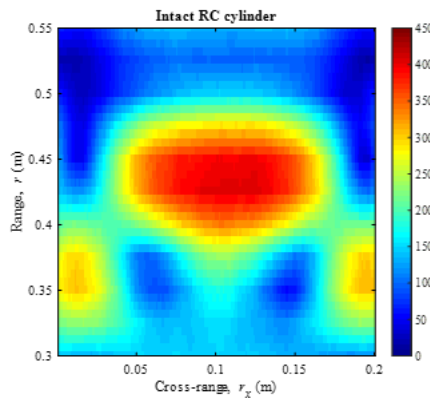
Type	Title	Citation	Date	Status
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Peer-reviewed journal	Subsurface characterization of moisture content and the water-to-cement ratio of concrete specimens using synthetic aperture radar imaging	Journal of Applied Remote Sensing	12/11/19	Under review
Peer-reviewed journal	Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials	<u>C. H. Lee</u> , S. J. Lee, <u>M. Shin</u> , and S. Bhattacharya, "Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials," Construction and Building Materials, 2019	12/31/2019	2nd Review



(a) A picture of RC cylinders

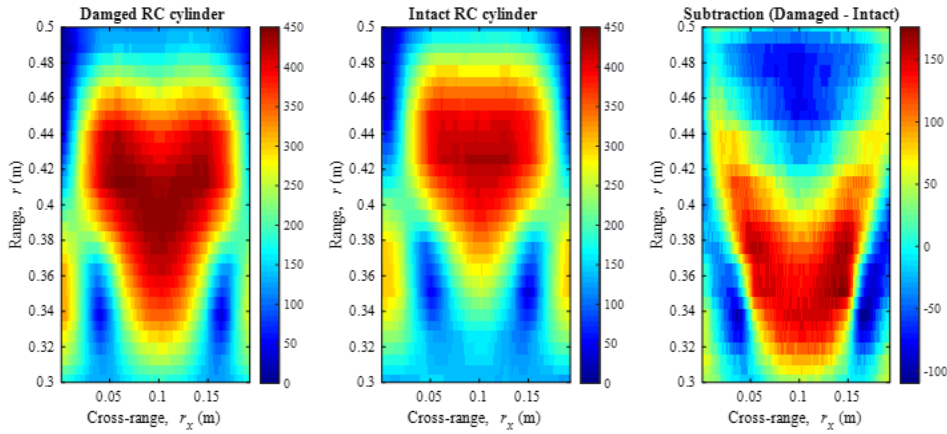
(b) Experimental set up of SAR imaging



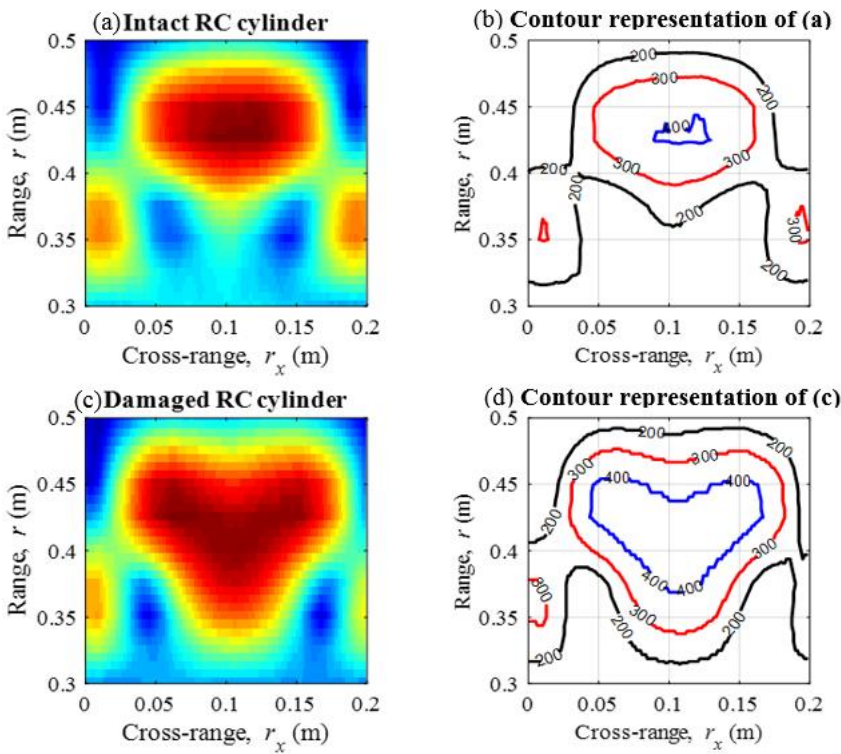
(c) SAR image of intact RC cylinder

(d) SAR image of damaged RC cylinder

**Figure 1.** SAR images of RC cylinders (intact and damaged) at range,  $r = 40$  cm



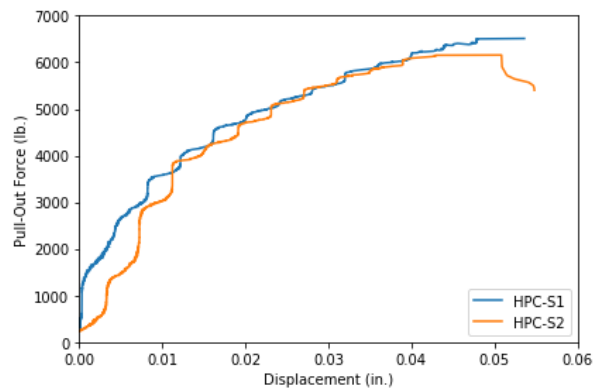
**Figure 2.** Difference of SAR images between damaged and intact cylinders



**Figure 3.** SAR images of RC cylinders with their contour representation



(a) Pull-Out UHPC specimens with un-corroded bar  
**Figure 4.** Pull-Out Test Results for Un-corroded bar



(b) Pull-out force and displacement response

**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>
Tzuyang Yu	Tzuyang_Yu@UML.EDU	Civil and Environmental Engineering	Project principle investigator and Institutional Lead at UML; overseeing all projects and working on radar imaging and interpretation
Susan Faraji	Susan_Faraji@UML.EDU	Civil and Environmental Engineering	Structural analysis and design of bridge girders
Chang Hoon Lee	Changhoon.Lee@WNE.EDU	Civil and Environmental Engineering	Development of degradation model and design concrete for pull out test specimen (Task 2)
Moochul Shin	Moochul.Shin@WNE.EDU	Civil and Environmental Engineering	Data analysis of the pull-out test results (Task 2)

<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>
Ahmed Alzeyadi		Ph.D.	Civil and Environmental Engineering	Design and manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing
Sanjana Vinayaka		Ph.D.	Civil and Environmental Engineering	Manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing
Jade Man		Sophomore	Civil and Environmental Engineering	Manufacturing of laboratory specimens
Caleb Tourtelotte		Senior	Civil Engineering	Specimen manufacturing
Nicholas Pantorno		Junior	Civil Engineering	Specimen manufacturing
Cameron Cox		Junior	Civil Engineering	Specimen manufacturing
Andrew Masullo		Junior	Civil Engineering	Specimen manufacturing

**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
Massachusetts Department of Transportation (MassDOT)	Boston, Massachusetts				X	X
City of Lowell	Lowell, Massachusetts			X	X	X

**Changes:**

- Task 2 has been delayed due to administration setup and manufacturing time of the pull-out test apparatus. Also, it has been challenging to obtain multiple degrees of corrosion during the accelerated corrosion test. Therefore, this task requires to extend 6 months.

**Planned Activities:**

In the next reporting period, we plan to continue working on following tasks.

Task 1: (Component- and System-Level) Field Inspection/Measurements (UML: T. Yu and S. Faraji)

Task 2: (Meso-to-Macro Level) Development of Macro-Scale Mechanical Damage Model due to corrosion (WNEU: C.Lee and M. Shin)

Task 3: (System Level) Development of capacity reduction model for PC bridges due to corrosion (all members)

The WNEU team will continue conducting the pull-out test by collaboration with the UML team. The obtained data will be used for calibrating the degradation model.