Quarterly Progress Report:
Project Number and Title: C3. 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), Chang Hoon Lee and Moochul Shin (Western New England University or WNEU)
Reporting Period: 10/01/2020 to 12/31/2020
Submission Date: 12/29/2020

Overview:
The objective of this project is to assess the condition of corroded prestressed concrete (PC) bridge girders in New England by performing multiplysical field inspection and developing an integrated assessment framework. During the reporting period, our project activities were disrupted by increasing tightened rules and restrictions due to covid-19 at both UML and WNEU. Under existing covid-19 rules and restrictions in Massachusetts, the WNEU team has been building a corrosion chamber to perform the accelerated corrosion experiment for Task 2. In the past quarters, we designed and manufactured five reinforced concrete (RC) cylinders corroded to different corrosion levels from conducting accelerated corrosion test at UML. With the corrosion developed by the UML team, the WNEU team is developing a corrosion model to calibrate the temperature effect. The model behind the calibration is based on the physical chemistry, and the postulated activation energy used for the analysis is 60 kJ/mol. Currently, the WNEU team is building another corrosion chamber in order to make progress under enhanced covid-19 restrictions. Figure 1 shows the corrosion chamber under construction at WNEU. Meanwhile, the UML team is working on improving the shielding in our SAR imaging experiment with a new type of electromagnetic absorbers. Figure 2 shows the setup of our new shielding scheme.

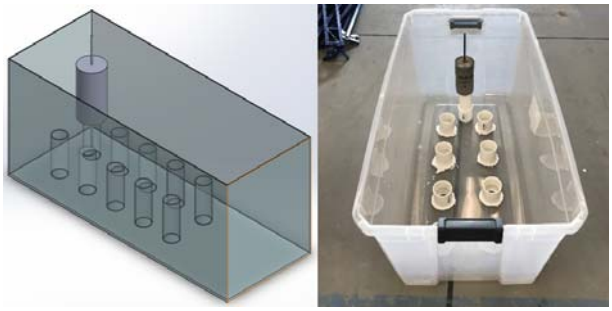


Fig. 1. WNEU's corrosion chamber).

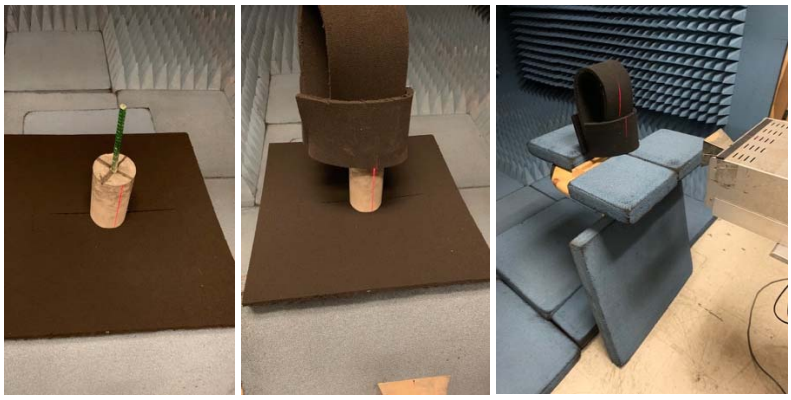
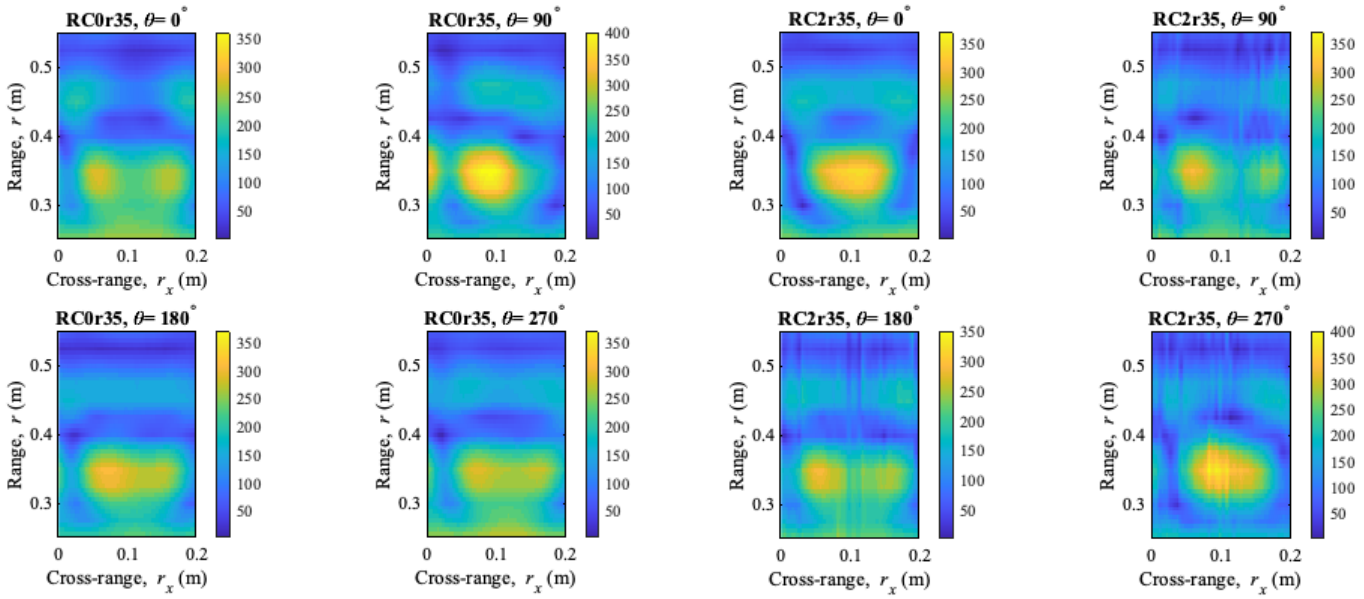


Fig. 2. Improvised SAR imaging shielding at UML

After improvising our shielding design, we repeated our SAR imaging experiment on two RC cylinders (RC0 = 0% corrosion level, RC2 = 100% corrosion level). In addition to modification of shielding, we also investigated the effect of inspection angle. This is due to the fact that concrete cracking due to steel rebar corrosion is no uniformly distributed in space inside RC structures, as we also experimentally observed on our RC cylinder specimens. Figure 3 shows the SAR images of cylinders RC0 and RC2. We further compared the range SAR curves of cylinders RC0 (blue solid curves) and RC2 (red dashed curves), as shown in Figure 4. We found that the presence of steel rebar corrosion generally reduces the electromagnetic scattering response of RC cylinders. After taking the average SAR curves on the range and cross-range axes, we also confirmed this finding. Figure 5 shows the averaged range SAR curves of cylinder RC0 and RC2, while Figure 6 shows the averaged cross-range SAR curves of cylinders RC0 and RC2.

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	2/28/21	82% (stalled)
Task 3	10/1/19	9/31/21	55% (stalled)



(a) Cylinder RC0 (0%) (b) Cylinder RC2 (100%)

Fig. 3. SAR images of cylinders RC0 and RC2

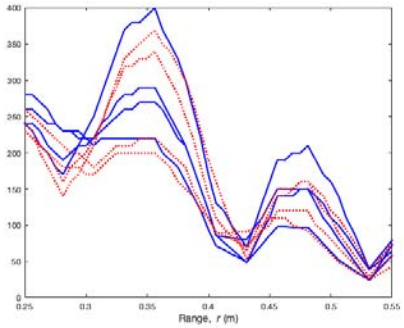


Fig. 4. Range SAR curves

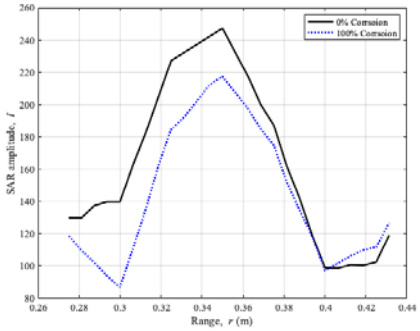


Fig. 5. Averaged range SAR curves

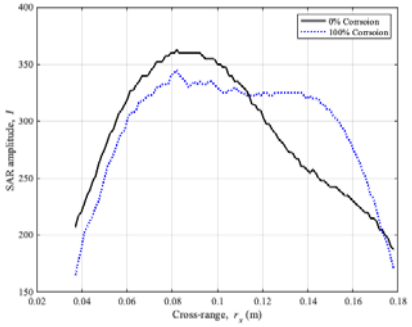


Fig. 6. Averaged cross-range SAR curves

Table 2: Budget Progress		
Entire Project Budget	**Spend Amount**	**Spend Percentage to Date**
$89,403 (UML)	$84,932 (UML)	95% (8/30/2020)
$85,000 (WNEU)	$63,052.86(WNEU)	74.2% (8/30/2020)

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**

Participants and Collaborators:

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**

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 & Environmental Engineering	Task 2: Development of degradation model and design concrete for pull out test specimen.
Moochul Shin	moochul.shin@wne.edu	Civil and Environmental Engineering	Task 2: Data analysis of the pull-out test results.

Table 6: Student Participants during the reporting period

Student Name	Email Address	Class	Major	Role in research
Harsh Gandhi		Doctoral	Civil and Environmental Engineering	Manufacturing of laboratory specimens, laboratory radar imaging
Ronan Bates		Senior	Civil and Environmental Engineering	Manufacturing of laboratory specimens, laboratory radar imaging
Andrew Masullo		Senior	Civil and Environmental Engineering	Construction of Corrosion Chamber.
Nicholas Pantorno		Senior	Civil and Environmental Engineering	Construction of Corrosion Chamber.
Cameron Cox		Senior	Civil and Environmental Engineering	Construction of Corrosion Chamber.
Andrew Masullo		Senior	Civil and Environmental Engineering	Construction of Corrosion Chamber.

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:

1. At UML, our Phase 3 plan has been carried out with extra caution. Few of our students were unexpected advised to self quarantine for 14 days, due to close proximity with their infected friends or roommates.
2. At WNEU, while the university re-opened as resuming face-to-face classes on August 31, 2020, our lab activities with students is still significantly limited by following the social distancing rule. Meanwhile, due to the covid-19, the university's administrative procedures (e.g., procurement, hiring students) has become slow.

Planned Activities:

- The UML team will perform field inspection of corroded concrete structures on selected bridges in Massachusetts in the next reporting period.
- The WNEU team will continue conducting the pull-out test of the corroded tendons by collaboration with the UMass-Lowell team if the laboratory of both institutions will be re-opened.

Task 2: (Meso-to-Macro Level) Development of Macro-Scale Mechanical Damage Model due to corrosion
Task 3. (System Level) Development of capacity reduction model for PC bridges due to corrosion