

Quarterly Progress Report:

Project Number and Title: 1.4 Electromagnetic Detection and Identification of Concrete Cracking in Highway Bridges

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

PI: Tzuyang Yu (UMass Lowell)

Co-PI(s): *Co-PIs and home institution(s)*

Reporting Period: 10/1/19~12/31/19

Submission Date: 12/31/19

Overview: (Please answer each question individually)

The research problem we are trying to solve is the structural assessment of aging concrete bridges (reinforced and prestressed) in New England, targeting at concrete cracking and degradation. During the reporting period, we have been working on Tasks 1, 2, 3, 4, and 5 of the proposed research; **Task 1:** Preparation of laboratory concrete specimens with single and multiple cracking mechanisms. **Task 2:** Laboratory radar imaging of concrete specimens, **Task 3:** Preliminary field radar imaging of concrete bridges, **Task 4:** Development of an EM (electromagnetic) database, and **Task 5:** Data analysis and image interpretation. We have completed Tasks 1 and 2 and found that various parameters extracted from synthetic aperture radar (SAR) images can be used to estimate the width, length, and depth of concrete cracks of a regular geometry. The findings developed from Tasks 1 and 2 will help us to complete the development of an EM database and to better characterize actual concrete cracks in the field.

Table 1: Task Progress

Task Number	Start Date	End Date	Percent Complete
Task 1:	1/1/19	6/30/19	100%
Task 2:	6/30/19	12/31/19	100%
Task 3:	6/30/19	6/30/20	70%
Task 4:	1/1/20	12/31/20	10%
Task 5:	1/1/20	12/31/20	10%

Table 2: Budget Progress

Entire Project Budget	Spend Amount	Spend Percentage to Date
\$127,641.11	\$75,584.67	60%

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

Title	Event	Type	Location	Date(s)
Imaging of Concrete Materials and Structures using Synthetic Aperture Radar	International Seminar in Civil Engineering	Invited seminar talk	Department of Civil Engineering, National Cheng-Kung University, Tainan, Taiwan	12/19/19
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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Conference paper	Synthetic aperture radar imaging of concrete cracking	SPIE Smart Structures/NDE Conference	10/17/19	Submitted and accepted
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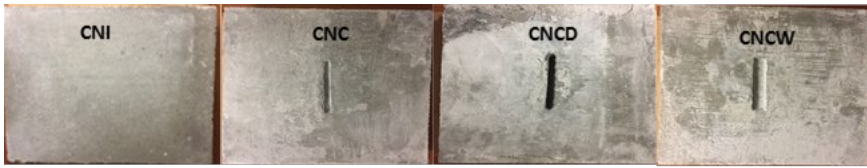


Figure 1: Images of specimen CNI, CNC, CNCD and CNCW

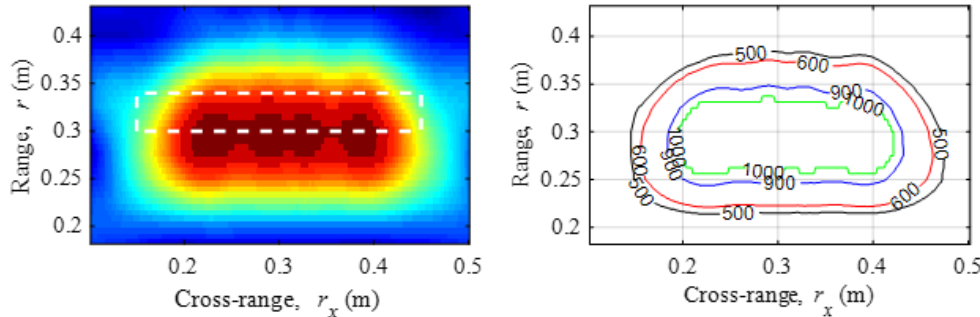


Figure 2a. SAR image of specimen CNI, $\Psi_L = 1.2\%$

Figure 2b. Contour representation CNI, $\Psi_L = 1.2\%$

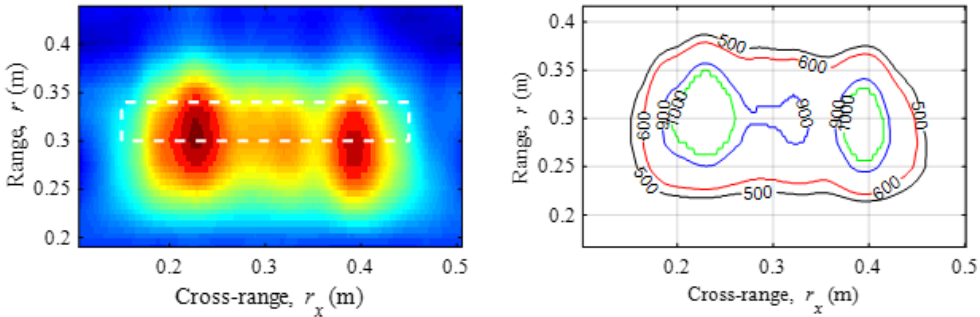


Figure 3a. SAR image of specimen CNCW, $\Psi_L = 1.2\%$

Figure 3b. Contour representation CNCW, $\Psi_L = 1.2\%$

From Figures 2 and 3, we have found that the introduction of crack in concrete specimens splits the contour in SAR images of concrete specimens. The green contour representing the contour level of amplitude 1,000 and blue contour representing the contour level of amplitude 900 is continuous in the intact specimen, whereas in the cracked specimen it splits into two. We study the area(A), perimeter(P) and the average curvature (K_{avg}) to derive an empirical equation for finding crack width. A plot of K_{avg} and $A/P \cdot K$ at different contour levels is shown in Figure 3. Centre of each curve is calculated and plotted against crack width (W).

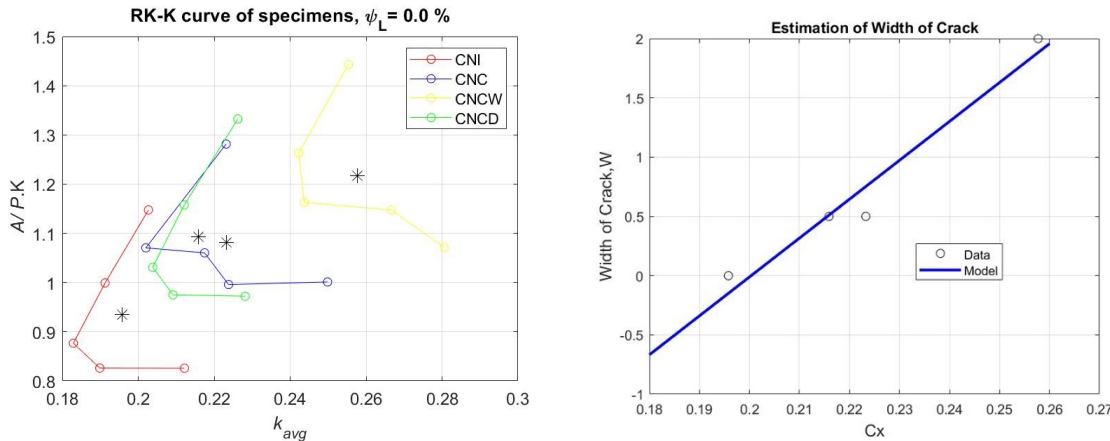


Figure 4a. Plot of k_{avg} vs A/P.K

Figure 4b. Plot of C_x vs Width of Crack

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

Table 6: Student Participants during the reporting period

Student Name	Email Address	Class	Major	Role in research
Ahmed Alzeyadi	Ahmed_Alzeyadi@student.uml.edu	Ph.D.	Civil and Environmental Engineering	Design and manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing
Sanjana Vinayaka	Sanjana_Vinayaka@student.uml.edu	Ph.D.	Civil and Environmental Engineering	Manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing
Jade Man	KarHei_Man@student.uml.edu	Undergrad	Civil and Environmental Engineering	Manufacturing of laboratory specimens

Table 7: Student Graduates

Student Name	Role in Research	Degree	Graduation Date

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	Boston, Massachusetts				X	X

Transportation (MassDOT)						
City of Lowell	Lowell, Massachusetts			X	X	X

Changes:

None.

Planned Activities:

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

Task 3: Preliminary field radar imaging of concrete bridges – Have started our first preliminary field inspection. Will continue working on this task.

Task 4: Development of EM database – Have started developing this EM (electromagnetic) database and will continue working on this task.

Task 5: Data analysis and image interpretation – Have started developing algorithms for analyzing and interpreting radar images for condition assessment. Will continue developing more algorithms.