

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): N/A

Reporting Period: 01/01/2021~03/31/2021

Date: 03/23/2021

Overview:

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. Table 1 provides our progress on individual tasks. Table 2 reports our budget progress.

Table 1: Task Progress			
Task Number	Start Date	End Date	Percent Complete
Task 3	9/1/19	8/31/21	60% (stalled)
Task 4	9/1/19	9/30/21	87%
Task 5	1/1/20	9/30/21	87%

Table 2: Budget Progress		
Entire Project Budget	Spend Amount	Spend Percentage to Date
\$269,791.11	\$242,812 (estimated)	90% (estimated)

In our last quarterly report, we performed a quantitative analysis on detecting and quantifying flexural cracks in a reinforced concrete (RC) beam specimen (Fig. 1 in 12/31/20 report) using GPR and SAR images. Fig. 1 shows the cracked RC beam specimen and our GPR inspection scheme.



Fig. 1 a) Cracked RC beam specimen

b) GPR inspection of RC beam

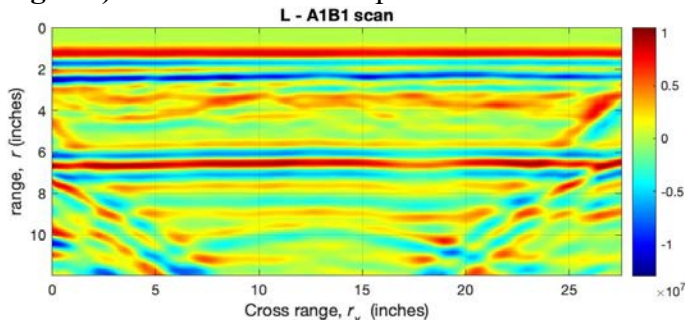
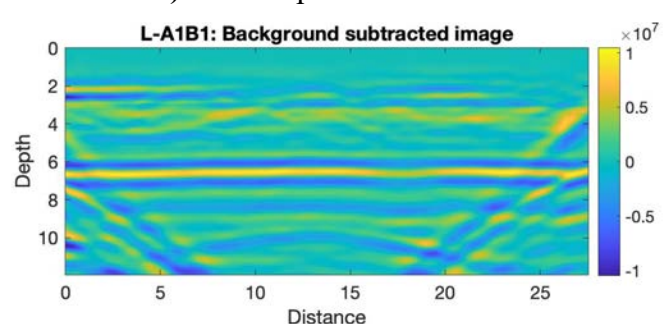


Fig. 2 a) GPR B-scan image of RC beam specimen



b) Background removed GPR B-scan image

After scanning the RC beam along its longitudinal axis, the GPR B-scan image in Fig. 2 was obtained. In Fig. 2, surface reflection (horizontal red strip in Fig. 2a)) of the RC beam is too strong to prevent the presence of a

Quarterly Progress Report

visiable crack from being detectable. To mitigate this effect, we had to remove the background surface reflection in order to reveal the scattering signal representing the presence of a crack at midspan. After the background removal processing, the GPR B-scan image in Fig. 2b) was obtained. This background removal processing was achieved by using an clean background signal shown in Fig. 3a). The scatteirng signal representing the presence of a crack at the midspan is shown in Fig. 3b).

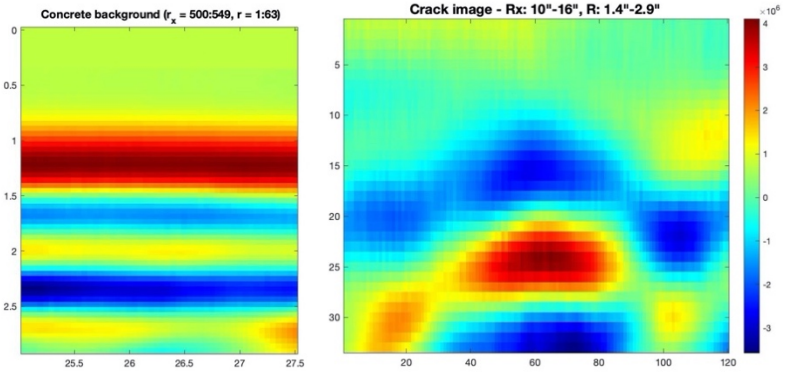


Fig. 3 a) Background reflection signal (left) **b)** Scattering signal representing a crack (right)

It is northworthy to point out that, after the background removal processing, we also found two other cracks in the GPR B-scan image of the RC beam. Currently, we are further investigating the background signal and modeling the scattering signal representing the midspan crack.

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

Title	Event	Type	Location	Date(s)
FDTD Simulation of Near-Field Scattering Pattern of a Surface Crack in Plate-like Structures for Optimal Inspection Angle Determination	2021 SPIE SS/NDE Conference Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XV	Conference presentation	Virtual meeting	March 22, 2021

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Conference paper	FDTD Simulation of Near-Field Scattering Pattern of a Surface Crack in Plate-like Structures for Optimal Inspection Angle Determination	https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11592/115920V/FDTD-simulation-of-near-field-scattering-pattern-of-a-surface/10.1117/12.2593528.short?webSyncID=a5731747-75c7-52b6-5d04-2291e38a26c9&sessionGUID=844dc623-8995-e1d5-289182b0b52619b1&spMailingID=6700208&spUserID=NTE0Mjk3MTA3MDYS1&spJobID=1220588403&spReportId=MTIyMDU4ODQwMgS2&_ga=2.197168167.924825082.1616347826-480614764.1616347826&SSO=1	March 22, 2021	Accepted
Journal paper	Electromagnetic detection of concrete cracking by using synthetic aperture radar and ground penetrating radar	NDT&E International		To be submitted in April 2021

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
Tek Dhant		M.S.	Civil and Environmental Engineering	Laboratory radar imaging and data processing
Ronan Bates		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests

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 Transportation (MassDOT)	Boston, Massachusetts					X
City of Lowell	Lowell, Massachusetts				X	X
Maine DOT	Hampden, Maine			X	X	X
AECOM	Germantown, Maryland					X

Changes:

- 1) Since February 2021, Massachusetts has started the vaccination against the covid-19 virus. Until March 22, more than one million residents have been vaccinated. The Massachusetts state government has been gradually releasing restrictions on public gathering and interstate travels. As of March 22, travelers a) returning to Massachusetts for being out of state and b) entering Massachusetts for fewer than 24 hours are exempt from 10-day quarantine. We envision that more covid-19 restrictions will be released in the near future.
- 2) Since Feb. 1, the University has increased our on-campus population while expanding weekly surveillance testing program. Most classes are conducted in a virtual environment. But the plan to resume face-to-face classes has been initially set to be Fall 2021.
- 3) Doctoral student Abdulla Aljeboure is on a medical leave this semester. He plans to return in summer 2021 or fall 2021 to work on the project.

Planned Activities:

- In the next reporting period, we plan to continue following research tasks with limited access to our laboratories.
- Task 3: Preliminary field radar imaging of concrete bridges
 - Task 4: Development of EM database
 - Task 5: Data analysis and image interpretation