Quarterly Progress Report

TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

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: 01/01/2020~03/31/2020
Date: 03/31/2020

Overview:

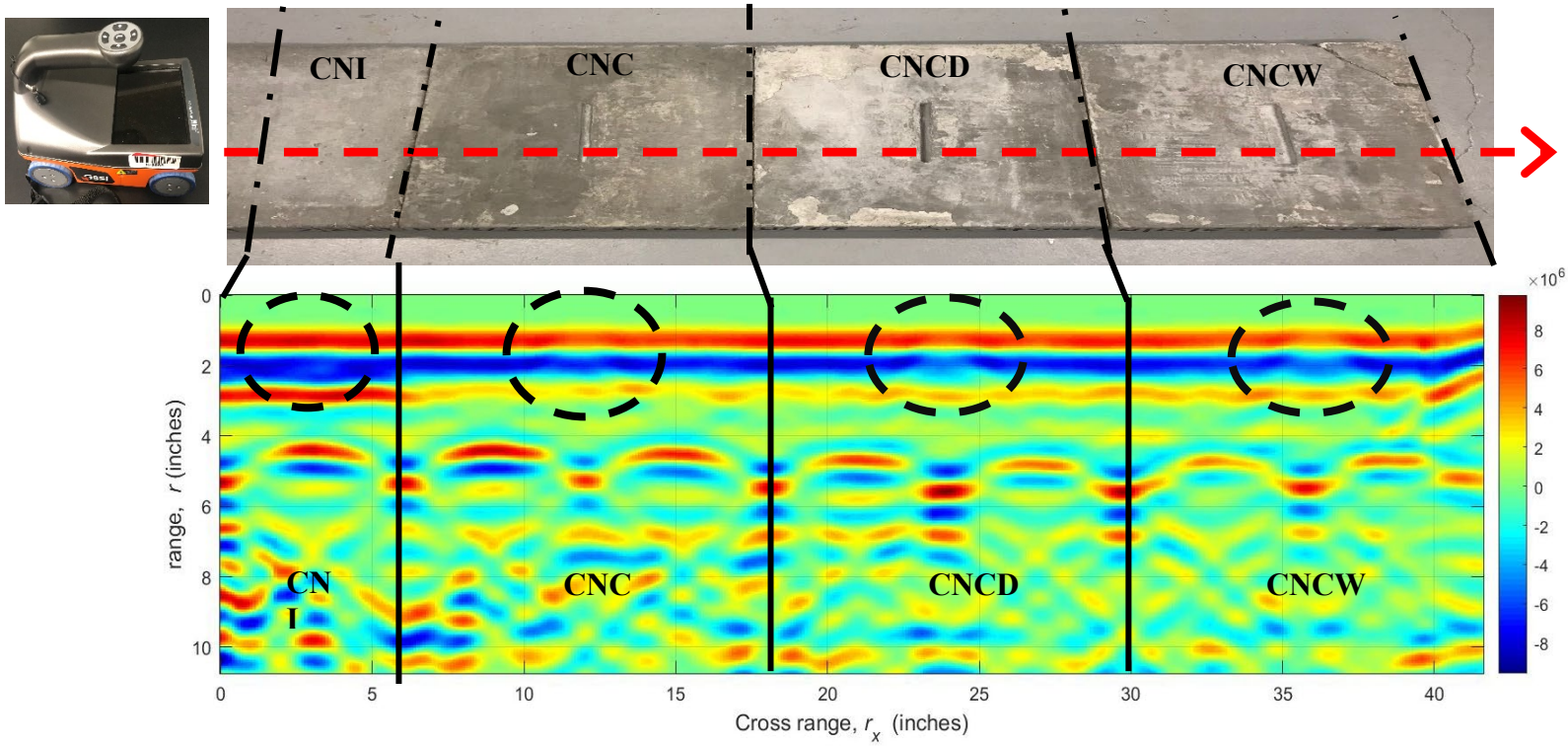
The research problem we are trying to solve is the structural assessment of aging concrete bridges (reinforced and prestressed) in New England, targeting at concrete cracking and degradation. Table 1provides our progress on individual tasks. Table 2 reports our budget progress.

Table 1: Task Progress

Task Number	Start Date	End Date	Percent Complete
Task 1	1/1/19	6/31/19	100%
Task 2	9/1/19	3/31/20	90%
Task 3	9/1/19	6/31/20	50%
Task 4	9/1/19	12/31/20	50%
Task 5	1/1/20	12/31/20	50%

Table 2: Budget Progress

Entire Project Budget	Spend Amount	Spend Percentage to Date
$269,791.11	$173,364.22	65%



In the last report, we provided the information on series of image processing techniques to detect the crack in artificially cracked specimens CNI, CNC, CNCD and CNCW using the 1.6 GHz portable ground penetrating radar (GPR). In this report, we formulate the mathematical model to calculate the depth of an artificial crack on concrete panels. Fig. 1 shows the 1.6 GHz GPR and the B-scan GPR images of intact and artificially-cracked

concrete panels. In Fig. 1, it is clear that the presence of an artificial crack on the surface of concrete panels can be detected by the presence of reduced GPR amplitude at the crack location. It is also observed that the change of crack geometry has led to different scattering patterns of hyperbola in the GPR B-scan images, suggesting the promising use of GPR for quantifying crack geometry.

Fig. 2 shows a series of processed GPR B-scan images for background subtraction, consisting of the following two steps: i) development of a representative background signature from the intact specimen CNI, and ii) removal of background signature in the GPR images of specimens CNC, CNCD, and CNCW to reveal the hyperbolic pattern of a crack. Fig. 3 shows the hyperbolic patterns of surface cracks with different geometries. Fig. 4 shows our pattern extraction for the hyperbolas representing different cracks in concrete.

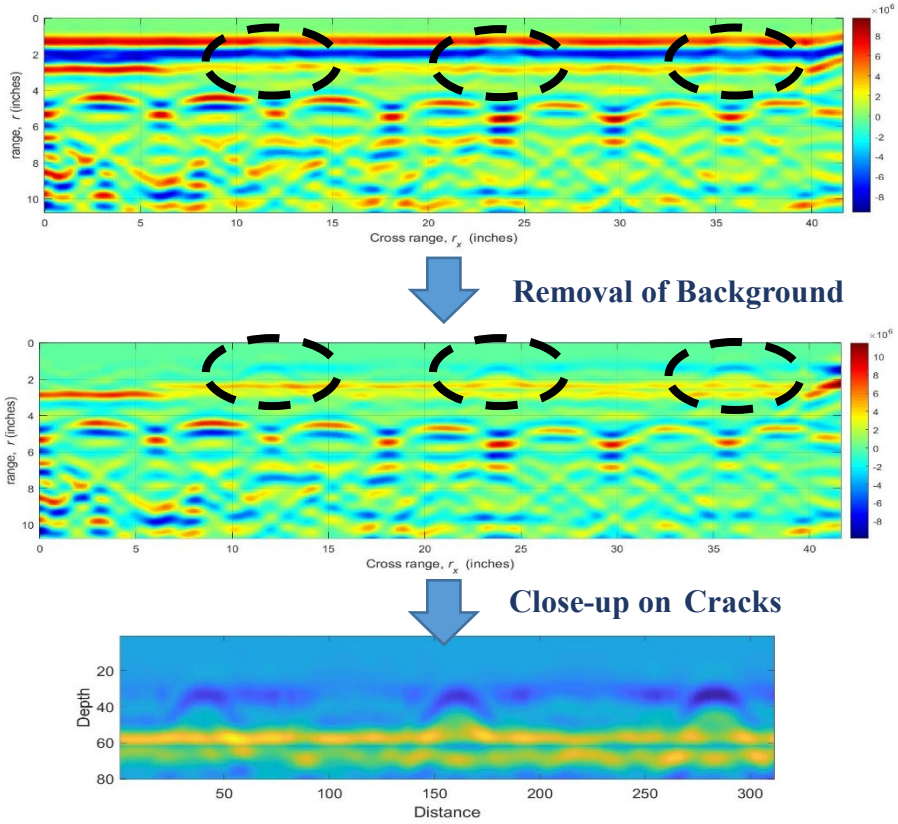


Fig 2: Processed GPR B-scan images

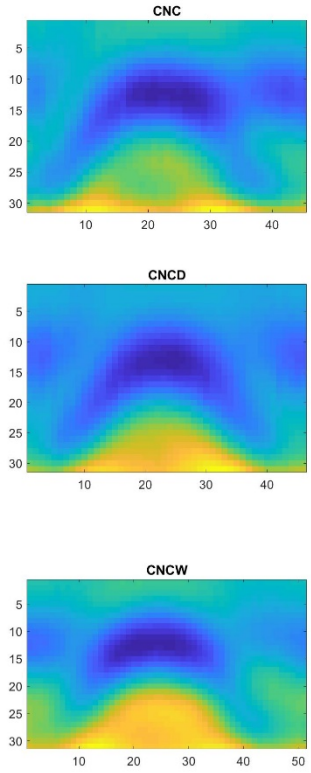
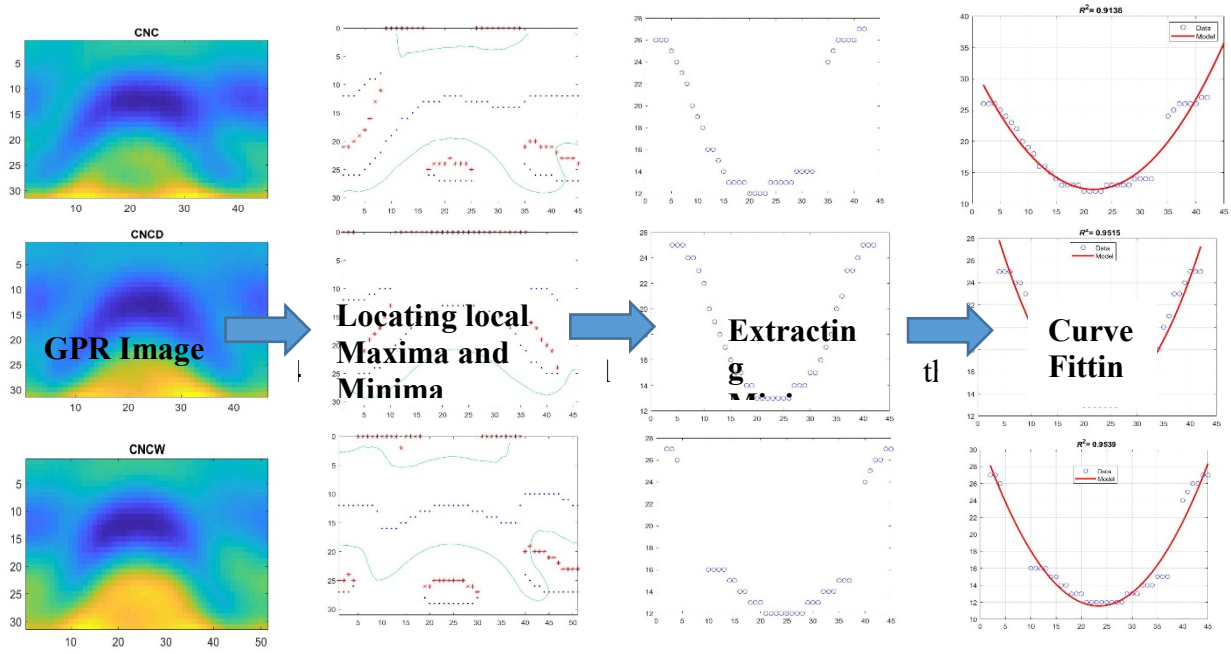


Fig 3: Hyperbolic pattern of crack

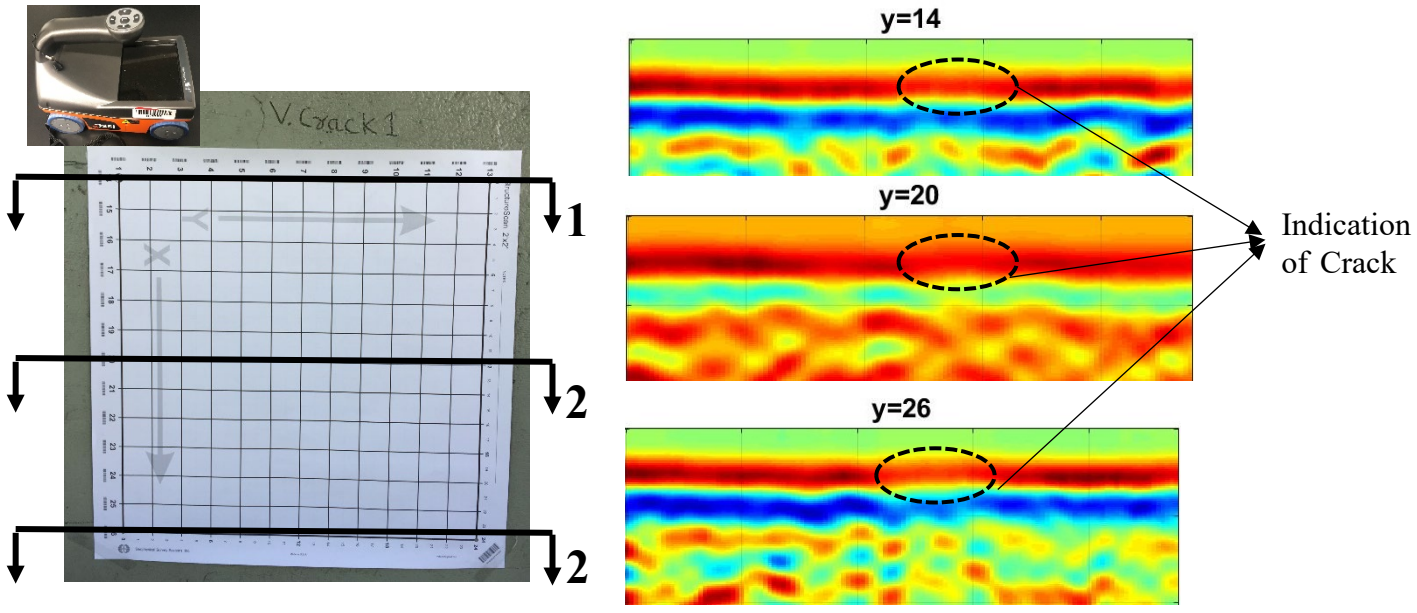
Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**
N/A				

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
Peer-reviewed journal	Subsurface characterization of moisture content and the water-to-cement ratio of concrete specimens using synthetic aperture radar imaging	A.Alzeyadi, T. Yu, *Journal of Applied Remote Sensing*	03/27/20	Accepted / Under revision

Peer-reviewed journal	Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials	C. H. Lee, S. J. Lee, M. Shin, 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



We also conducted field GPR tests on a concrete bridge with the result shown in Fig. 5. In Fig. 5, our conclusions on the reduced GPR amplitude and an induced hyperbolic pattern representing the presence of a crack are confirmed.



B-Scans at grid line y=14,20,26

Fig. 5: GPR C-scan of crack obtained from the vertical crack on bridge

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		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

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	X
City of Lowell	Lowell, Massachusetts			X	X	X
Geophysical Survey Systems, Inc. (GSSI)_	Lowell, Massachusetts				X	X

Changes:

The recent rapid development of coronavirus and consequent restrictions from the Massachusetts State government and the University regarding group meetings and laboratory access on campus, we have to develop various approaches to continue conducting research with restricted access to our research facilities. We have identified two approaches in the following:

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1) Hold daily research meetings via teleconference calls – We have been holding research meetings on Zoom since March 16, 2020 and been making progress via teleconferencing.
2) Transition to numerical simulation – We are also in the process of setting up a server on campus to allow research assistants to remotely conduct simulation-related and data processing research tasks on the project.

We will also monitor this rapidly developing situation on coronavirus in Massachusetts and accommodate restrictions and regulations while continuing our research work on the project.

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.