

Semi-Annual Progress Report

Project Number and Title: 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: 01/01/2019~03/31/2019

Date: 03/29/2019

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. During the reporting period, we have been working on Task 1 and Task 2 of the proposed research; **Task 1:** Preparation of laboratory concrete specimens with single and multiple cracking mechanisms (6 months), and **Task 2:** Laboratory radar imaging of concrete specimens (6 months). These two tasks will provide us the data (radar images) to understand how single crack on concrete specimens can be characterized and quantified by radar images, such that ultimately, we can use field-collected radar images to quantify cracks on real concrete bridges and to achieve the following **project goals**.

- a. Develop a data driven field inspection procedure for concrete cracking on concrete bridges
- b. Develop a radar signature database of concrete cracking at various levels such that bridge engineers can use it for efficient assessment of concrete cracking in the field.

In the past two months, we have accomplished 35% of Task 1 and 30% of Task 2 by manufacturing laboratory concrete specimens with different sizes of single crack. In **Task 1**, we have designed and manufactured four concrete panel specimens (0.3m-by-0.3m-by-0.04m) with various types of single crack including Type 1 (0.1m-by-0.005m-by-0.005m), Type 2 (0.1m-by-0.005m-by-0.02m), Type 3 (0.1m-by-0.015m-by-0.005m), and Type 4 (0.3m-by-0.001m-by-0.04m). Figure 1 shows five concrete panel specimens with different sizes of single crack (and one without). The intact concrete panel will be used for generating the background radar image for subtraction. Cracked concrete panel Type 1 is a standard crack, while Type 2 and Type 3 are its derivatives.

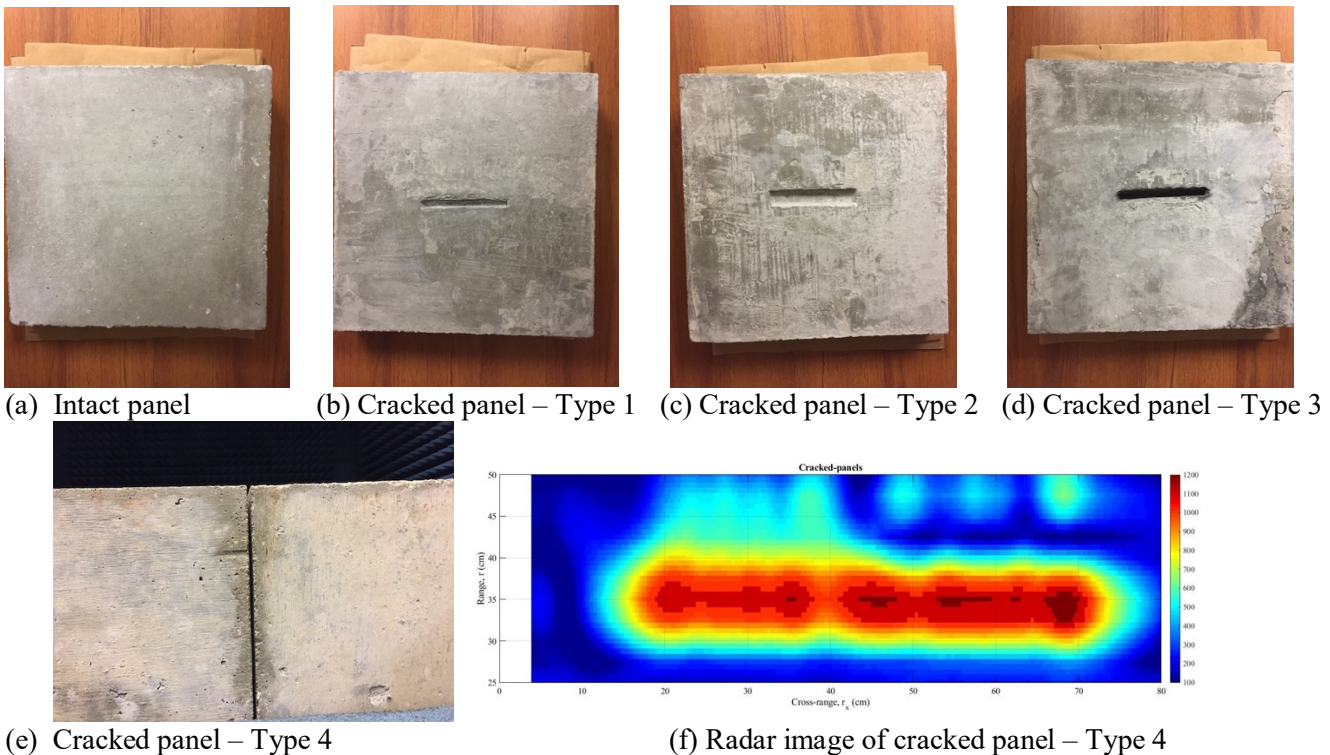


Figure 1. Intact and artificially cracked concrete panels

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In **Task 2**, we have collected preliminary radar images using a SAR (synthetic aperture radar) sensor in our radar lab and a GPR (ground penetrating radar) in the field (Lincoln St. Bridge, Lowell, MA), as shown in Figure 2. We will continue collecting radar images in the lab and in the field.



(a) Laboratory radar imaging



(b) Field radar imaging at Lincoln St. Bridge (Lowell, MA)
(Left: Grad. RA: A. Alzeyadi / Right: Grad. RA: H. Gandhi)

Figure 2. Laboratory and field radar imaging

Regarding **training/professional development**, we have recruited three graduate and two undergraduate research assistants to work on this research (one graduate RA is fully committed, others are participating and assisting). Figure 2 (b) shows the training of radar imaging with two graduate research assistants using a GPR sensor.

Regarding the dissemination of research results during the reporting period,

- 1) **Launching of TIDC project website at UML** – We have successfully launched our project website at UML: <https://stage.uml.edu/Research/tidc/>. A screenshot is provided in Figure 3.

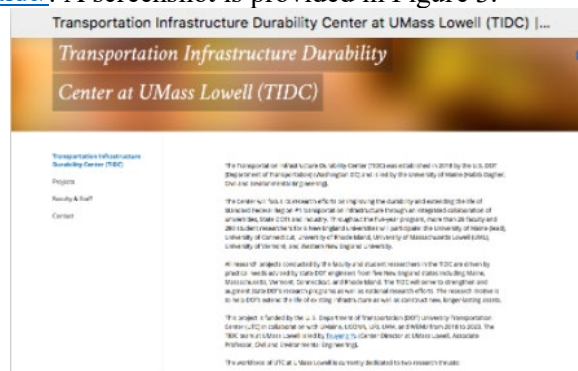


Figure 3. TIDC project website at UML – Screenshot of the frontpage

- 2) Attending the 2019 SPIE Smart Structures (SS)/NDE Symposium (Denver, CO) – Graduate RA A. Alzeyadi attended the 2019 SPIE SS/NDE Symposium and presented three papers on the use of radar for subsurface sensing.

Participants and Collaborators:

During the reporting period, the following students have worked on the project.

- Dr. Tzuyang Yu, Associate Professor, Civil and Environmental Engineering – Project principle investigator and Institutional Lead at UML; overseeing all projects and working on radar imaging and interpretation with other graduate RAs
- Mr. Ahmed Alzeyadi, full-time graduate RA, doctoral candidate, Civil and Environmental Engineering – Design and manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing
- Mr. Harsh Gandhi, part-time graduate RA, Master's student, Civil and Environmental Engineering – Manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing

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- Ms. Sanjana Vinayaka, part-time graduate RA, doctoral student, Civil and Environmental Engineering – Manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing
- Mr. Ruben Diaz, Jr., part-time undergraduate RA, Bachelor’s student, Civil and Environmental Engineering – Manufacturing of laboratory specimens
- Mr. Jade Man, part-time undergraduate RA, Bachelor’s student, Civil and Environmental Engineering – Manufacturing of laboratory specimens

Collaboration with MassDOT and the City of Lowell – We have been working with MassDOT and the City of Lowell on this project. These activities are reported in the following.

- On December 19, 2018, Mr. Ed Newton (Bridge Engineer, MassDOT) and the team held a teleconference meeting to identify the target structures (reinforced concrete and prestressed concrete bridges) for field inspection.
- On March 14, 2019, the team visited the City of Lowell with Ms. Christine Clancy (City Engineer) and Mr. Joesph Assenza (Bridge Engineer) to identify potential candidate bridges for field inspection.
- On March 21, 2019, Ms. Clancy and Mr. Assenza visited our labs at UML to learn more about our radar imaging technique and discuss its potential applications for the City of Lowell. They are interested in using imaging radar for other transportation infrastructure systems such as parking garages, pavements, and walkways.
- On March 29, 2019, Mr. Alex Bardow (Director of Bridges and Structures) and the team held another teleconference to identify two local concrete bridges (one in Essex and the other in Andover) for field inspection.

Changes:

At this stage of the project, we do not anticipate any problems or delays in our project. We also do not plan any changes to be made to our original research plan.

Planned Activities:

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

Task 1: Preparation of laboratory concrete specimens with single and multiple cracking mechanisms – To be completed in the next four months.

Task 2: Laboratory radar imaging of concrete specimens – To be completed in the next four months.

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.

We also plan to attend the 2019 QNDE (Quantitative Non-Destructive Evaluation) Symposium in Portland, OR during July 14~18, 2019 to disseminate our research findings.