Semi-Annual Progress Report

Project Number and Title: C3.2018: Condition Assessment of Corroded Prestressed Concrete Bridge Girders
Research Area: Thrust 1: Transportation infrastructure monitoring and assessment for enhanced life
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Co-PI(s): Susan Faraji (UMass Lowell), ChangHoon Lee (WNEU), Moochul Shin (WNEU)
Reporting Period: 01/01/2019 ~ 03/31/2019
Date: 03/31/2019

Overview:

In the reporting period, the UML-WNEU team has been working on **Task 1: (Component- and System-Level) Field Inspection/Measurements of proposed research**. The UML team has conducted field measurements of a local prestressed concrete (PC) bridge (Plain St. Bridge, Lowell, MA) using 3D photogrammetry. One bridge cap with four piers was selected for this preliminary study. Two 3D point cloud models of the bridge cap are shown in Figure 1, using eighty-four photographs extracted from a video captured by a commercial drone (DJI Phantom Pro III). To examine the resolution of 3D photogrammetry, we also applied 3D photogrammetry on a #3 steel rebar in the lab. Figure 2 illustrates the geometric details of a #3 steel rebar. It was found that 3D photogrammetry is capable of capturing the geometric features of a target specimen/structure with sufficient accuracy.

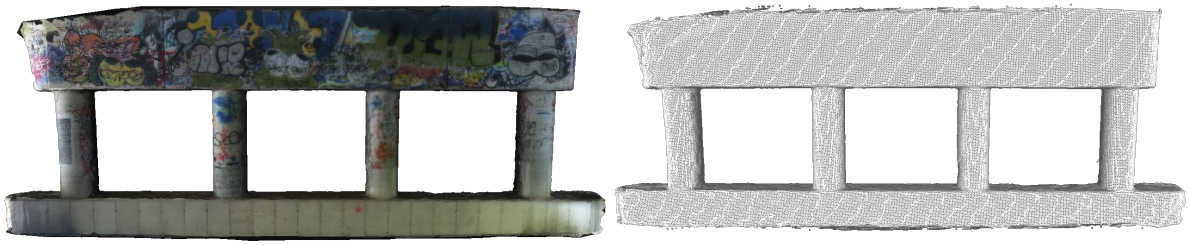


Figure 1: 3D point cloud models of Plain St. Bridge, Lowell, MA

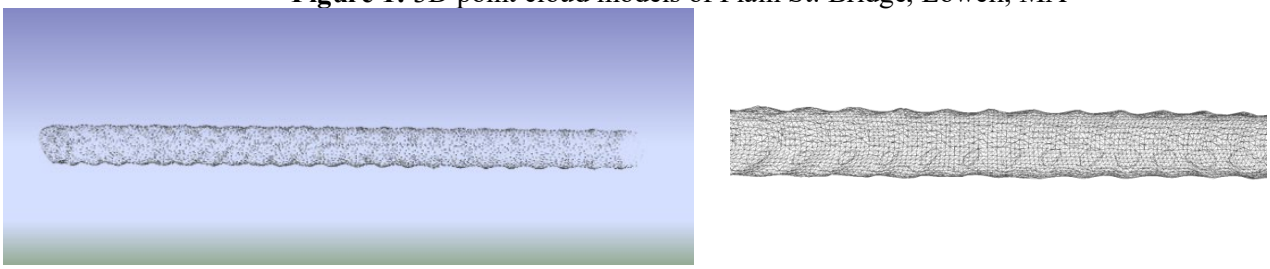
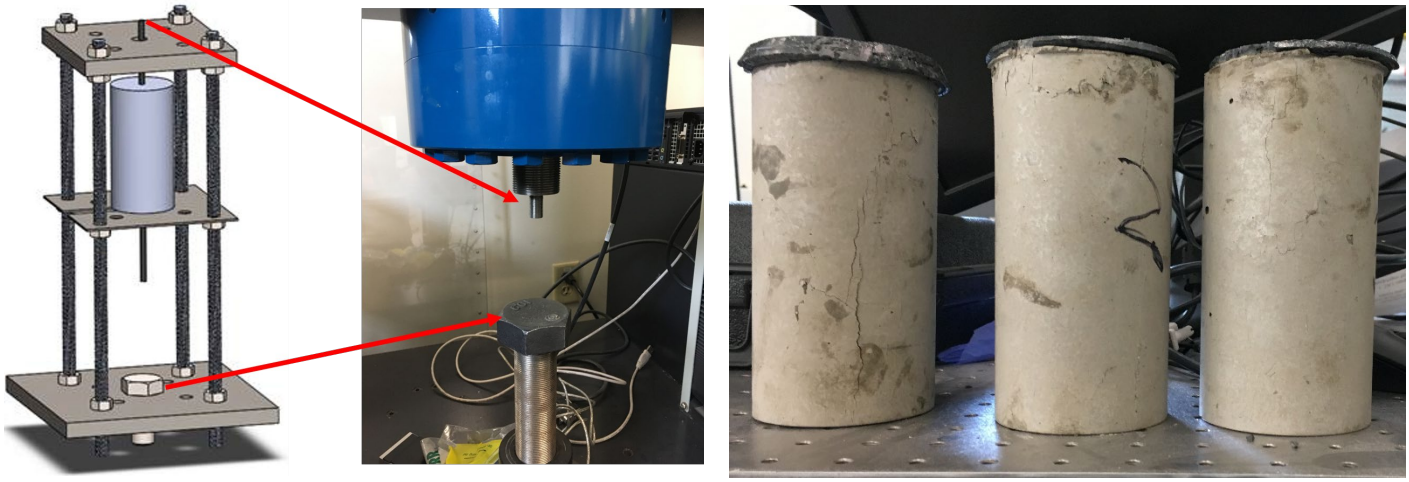


Figure 2: 3D point cloud models of a #3 steel rebar

In the meantime, the WNEU team has been working on setting-up a pull-out test by designing a pull-out test apparatus in order to characterize the bond strength of corroded reinforcements and concrete. In addition, the team performed the compressive strength test of the concrete with the aim of developing a concrete with 4,000 psi compressive strength at 28 days, typically used for highway bridge pre-stressed girders. Figure 3(a) shows the designed apparatus that will be coupled with a Universal Testing Machine. The apparatus is currently in the manufacturing process. The WNEU team also developed the mixture design for the concrete used for a series of the pull-out test. The measured average compressive strength of the concrete cylinders, shown in Figure 3(b), at 28 days was 4,000 psi, while its limiting strength (at about 1-year strength) is expected to be approximately 4,300 psi. A series of a pull-out test will be performed to explore the bond-slip response of concrete cylinders with a reinforcement per ASTM 1096 (2015) with respect to a degree of corrosion, and damage of concrete.

These activities undertaken by the UML-WNEU team in Task 1 provide the basis for **Task 2: (Meso-to-Macro Level) Development of Macro-Scale Mechanical Damage Model due to corrosion** and **Task 3: (System Level) Development of capacity reduction model for PC bridges due to corrosion**. These tasks are essential to our project goals (Development of a damage pattern database by conducting multiphysical nondestructive testing/evaluation on field PC bridge girders; Development of structural degradation models/algorithms based on geometric change and material property change; and Development of an integrated assessment framework for predicting capacity reduction).



(a) (b)

Figure 3: (a) Apparatus of pull-out test and (b) the specimens for compressive strength test.

Regarding **training/professional development**, we have recruited one full-time graduate RA, one-part-time graduate RA, and two part-time undergraduate RAs to work on the project at UML. At WNEU, we have recruited two part-time undergraduate RAs to work on the project.

Regarding the dissemination of research results during the reporting period,

1) Launching of **a project website at UML** – We have successfully launched our project website at UML: https://stage.uml.edu/Research/tidc/projects/assessment-corroded-prestressed-bridge-girders.aspx as shown in Figure 3.

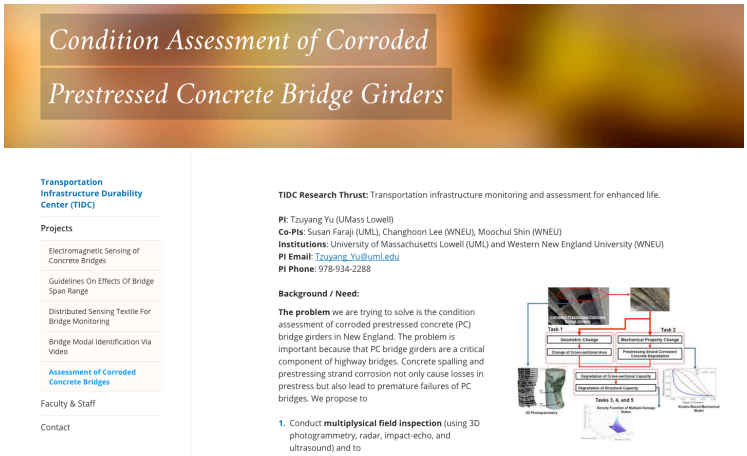


Figure 3. Project C3's website at UML (screenshot)

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 NDT for subsurface sensing.

Participants and Collaborators:

During the reporting period, the following participants have worked on the project at **UML**.

- Dr. Tzuyang Yu, Associate Professor, Civil and Environmental Engineering – Project principle investigator and Institutional Lead at UML; overseeing all projects and working on nondestructive testing/evaluation and data interpretation with other RAs
- Dr. Susan Faraji, Professor, Civil and Environmental Engineering – Co-PI, bridge design and analysis

- 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
- Mr. Ruben Diaz, Jr., part-time undergraduate RA, Sophomore in Civil and Environmental Engineering – Manufacturing of laboratory specimens
- Mr. Jade Man, part-time undergraduate RA, Freshman in Civil and Environmental Engineering – Manufacturing of laboratory specimens

During the reporting period, the following participants have worked on the project at **WNEU**.

- Dr. ChangHoon Lee, Assistant Professor, Civil Engineering – Co-PI, concrete materials, design of pull-out test on reinforced concrete specimens
- Dr. Moochul Shin, Assistant Professor, Civil Engineering – Co-PI, data analysis and modeling
- Mr. Cameron Cox, part-time undergraduate RA, Sophomore in Civil Engineering – Preparing concrete cylinders and setting-up experiments
- Mr. Nicholas Pantorno, part-time undergraduate RA, Sophomore in Civil Engineering – Preparing concrete cylinders and setting-up experiments

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 location of on PC 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 obtain design information on Plain St. Bridge.
- On March 21, 2019, Ms. Clancy and Mr. Assenza visited our labs at UML to learn more about our NDT techniques and discuss other possible NDT applications for the City of Lowell.
- 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: (Component- and System-Level) Field Inspection/Measurements (UML: T. Yu and S. Faraji)

Task 2: (Meso-to-Macro Level) Development of Macro-Scale Mechanical Damage Model due to corrosion (WNEU: C. Lee and M. Shin)

Task 3. (System Level) Development of capacity reduction model for PC bridges due to corrosion (all members)

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.

References:

- ASTM A1096 / A1096M-15, (2015) *Standard Test Method for Evaluating Bond of Individual Steel Wire, Indented or Plain, for Concrete Reinforcement*, ASTM International, West Conshohocken, PA