TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

Bi-Monthly 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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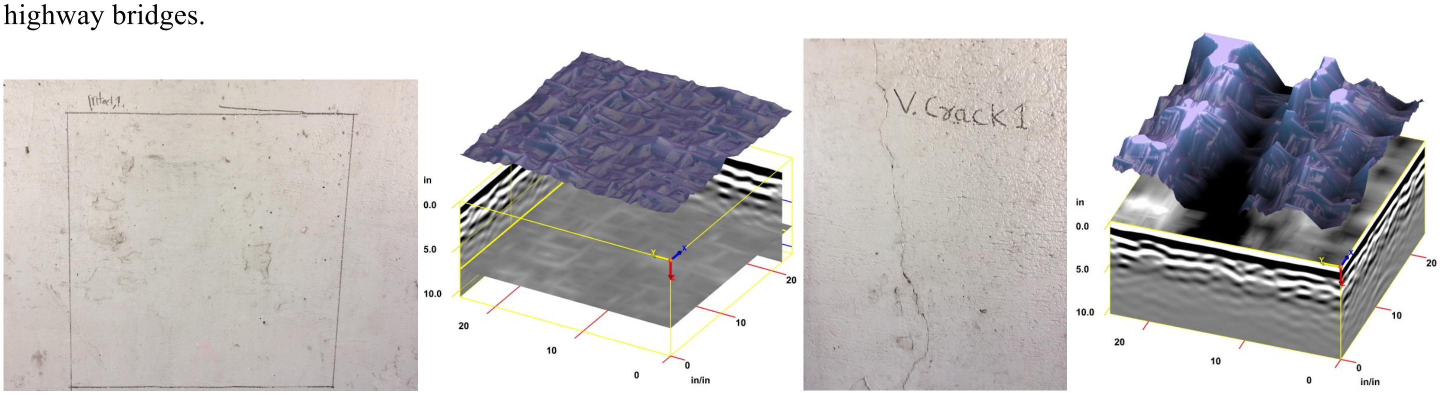
Co-PI(s): Susan Faraji (UMass Lowell), ChangHoon Lee (WNEU), Moochul Shin (WNEU)
Reporting Period: 6/1/2019 ~ 7/31/2019
Date: 7/31/2019

Overview:

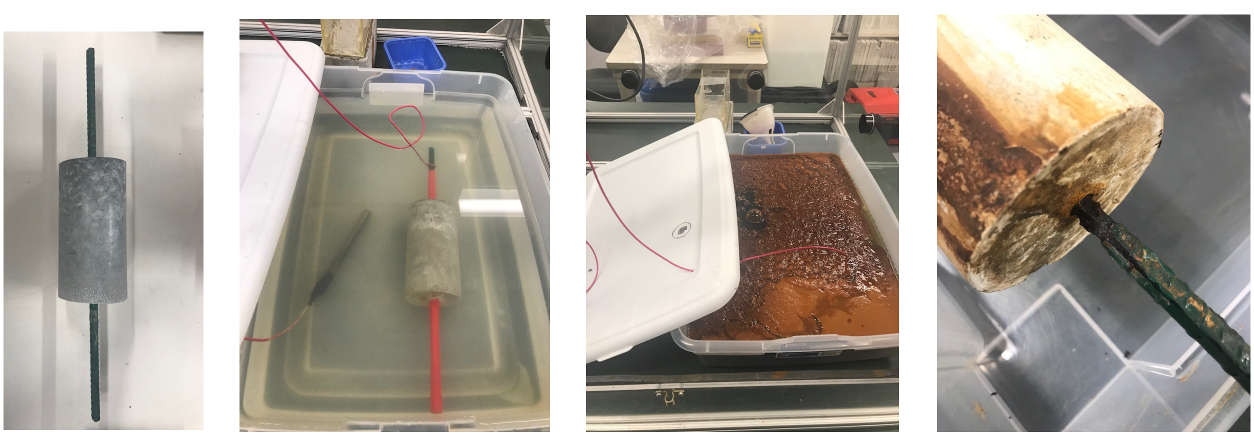
During the reporting period, we have been working on Tasks 1 and 2; **Task 1**: (Component- and System-Level) Field Inspection/Measurements and **Task 2**: (Meso-to-Macro Level) Development of Macro-Scale Mechanical Damage Model due to corrosion. In **Task 1**, we inspected one highway bridge on the Lowell Connector of I-93 in Lowell, MA, using a commercial radar sensor (ground penetrating radar or GPR) to image intact and damaged locations of the bridge abutment. Figure 1 shows the photos and radar images of intact and damaged locations of the bridge. From this result, we are confident that the use of electromagnetic sensors like GPR can help bridge engineers to better characterize defects and damages on highway bridges.



(a) Intact surface and its radar image (b) Damaged surface and its radar image

Figure 1: Photos and radar images of intact and damaged surfaces on a highway bridge in Lowell, MA.

In **Task 2**, we performed an accelerated corrosion test (ACT) on laboratory reinforced concrete (RC) cylinders in order to artificially create macro-scale mechanical damage to RC specimens. Photos of our ACT on one of the RC cylinders are shown in Figure 2. From the experimental result of ACT, we found that the integral of current over time is proportional to the corrosion level of RC specimens, under laboratory-controlled conditions (e.g., temperature). On the other hand, due to the electrochemical reaction in steel corrosion during our ACT experiment, galvanic products were generated and released into the corrosion reactor, resulting in a brown-color solution shown in Figure 2 (c). Meanwhile, cracking of concrete cylinder was also observed, as shown in Figure 2 (d).



(a) RC cylinder (b) Beginning of ACT (c) End of ACT (d) Corroded RC cylinder

Figure 2: Photos and radar images of intact and damaged surfaces on a highway bridge in Lowell, MA.

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The WNEU team has been working on the calibration of a pull-out test, specifically focusing on the selection of the grippers, as shown in Figure 3. The UTM at WNEU is equipped with the gripper, of which capacity is 10 kN (2,250 lb) (left figure of Figure 3 (b)). However, the research team expects the maximum load for the pull-out test specimen with 6 inches of embedded length is about 45 kN (10,000 lb). Thus, WNEU requested to the vendor to manufacture a new gripper (right figure of Figure 3 (b)) and the associated connectors.

(a) (b)

Figure 3: (a) Apparatus of pull-out test and (b) different types of grippers for the pull-out test.

Besides, WNEU has also been developing the multi-physics model for estimating degradation of the bond-slip performance due to corrosion for the PSC girder bridges. To achieve this goal, it is imperative to understand the mechanism of the chloride attack, which can be simulated by solving the mass-transfer equation. Figure 4 shows the analysis results for three different concrete mixtures that can likely be used for the PSC structures. While the results from software Life 365 (by NIST) is beneficial to obtain the solution of the mass transfer analysis, as shown in the figure, concerning temperature, mixture proportion, and the dimension of the member, the result doesn't provide further information of the degradation of the structural performance.

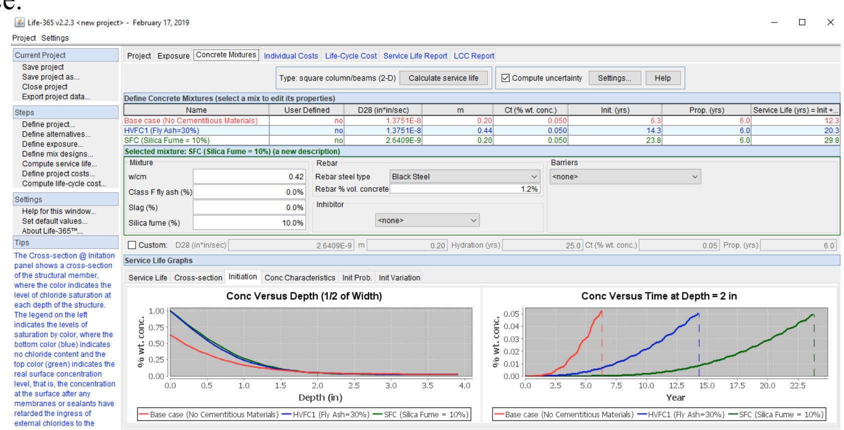

Figure 4: Analysis to compare time-dependent chloride concentration in (1) Normal concrete (No cementitious materials, (2) High volume fly-ash concrete (30% of fly ash replacement), and (3) Concrete with Silica Fume (10% of silica fume replacement)

Participants and Collaborators:

During the reporting period, the **UML** participants working on the project include Dr. Tzuyang Yu (PI), Dr. Susan Faraji (co-PI), Mr. Ahmed Alzeyadi (doctoral RA), Mr. Harsh Gandhi (Master's RA), and Ms. Sanjana Vinayaka (doctoral RA). The **WNEU** participants include Dr. ChangHoon Lee (co-PI), Dr. Moochul Shin (co-PI), Mr. Isaias Colombani (undergrad RA), Mr. Cameron Cox (undergrad RA), and Mr. Nicholas Pantorno (undergrad RA). Collaboration with MassDOT and the City of Lowell – We visited one highway bridge in Lowell, MA for field measurements using GPR.

Changes: N/A.

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)