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>
<thead>
<tr>
<th>Table 1: Task Progress</th>
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</thead>
<tbody>
<tr>
<td><strong>Task Number</strong></td>
</tr>
<tr>
<td>Task 3</td>
</tr>
<tr>
<td>Task 4</td>
</tr>
<tr>
<td>Task 5</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Table 2: Budget Progress</th>
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<tbody>
<tr>
<td><strong>Entire Project Budget</strong></td>
</tr>
<tr>
<td>$269,791.11</td>
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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
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visible 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 scattering 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 noteworthy 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

<table>
<thead>
<tr>
<th>Title</th>
<th>Event</th>
<th>Type</th>
<th>Location</th>
<th>Date(s)</th>
</tr>
</thead>
</table>

### Table 4: Publications and Submitted Papers and Reports

<table>
<thead>
<tr>
<th>Type</th>
<th>Title</th>
<th>Citation</th>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conference paper</td>
<td>FDTD Simulation of Near-Field Scattering Pattern of a Surface Crack in Plate-like Structures for Optimal Inspection Angle Determination</td>
<td><a href="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=a5731747-7sc7-52b6-5d04-2291e38a26e9&amp;sessionGUID=844dc623-8995-e1d5-28982b0852619b1&amp;spMailingID=6700208&amp;spUserID=NTE0Mjk3MTA3MDyS1&amp;spJobID=1220588403&amp;spReportld=MTlyMDU4ODQwMgS2&amp;_ga=2.197168167.924825082.1616347826-480614764.1616347826&amp;SSO=1">Link</a></td>
<td>March 22, 2021</td>
<td>Accepted</td>
</tr>
<tr>
<td>Journal paper</td>
<td>Electromagnetic detection of concrete cracking by using synthetic aperture radar and ground penetrating radar</td>
<td>NDT&amp;E International</td>
<td></td>
<td>To be submitted in April 2021</td>
</tr>
</tbody>
</table>

### Participants and Collaborators:

<table>
<thead>
<tr>
<th>Individual Name</th>
<th>Email Address</th>
<th>Department</th>
<th>Role in Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tzuyang Yu</td>
<td><a href="mailto:Tzuyang_Yu@UML.EDU">Tzuyang_Yu@UML.EDU</a></td>
<td>Civil and Environmental Engineering</td>
<td>Project principle investigator and Institutional Lead at UML; overseeing all projects and working on radar imaging and interpretation</td>
</tr>
</tbody>
</table>
Table 6: Student Participants during the reporting period

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Email Address</th>
<th>Class</th>
<th>Major</th>
<th>Role in research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tek Dhant</td>
<td></td>
<td>M.S.</td>
<td>Civil and Environmental Engineering</td>
<td>Laboratory radar imaging and data processing</td>
</tr>
<tr>
<td>Ronan Bates</td>
<td></td>
<td>B.S.</td>
<td>Civil and Environmental Engineering</td>
<td>Assistance in the preparation for bridge field tests</td>
</tr>
</tbody>
</table>

Table 7: Student Graduates

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Role in Research</th>
<th>Degree</th>
<th>Graduation Date</th>
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</thead>
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Table 8: Research Project Collaborators during the reporting period

<table>
<thead>
<tr>
<th>Organization</th>
<th>Location</th>
<th>Contribution to the Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts Department of Transportation (MassDOT)</td>
<td>Boston, Massachusetts</td>
<td>Financial Support</td>
</tr>
<tr>
<td>City of Lowell</td>
<td>Lowell, Massachusetts</td>
<td>In-Kind Support</td>
</tr>
<tr>
<td>Maine DOT</td>
<td>Hampden, Maine</td>
<td>Facilities</td>
</tr>
<tr>
<td>AECOM</td>
<td>Germantown, Maryland</td>
<td>Collaborative Research</td>
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<tr>
<td></td>
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<td>Personnel Exchanges</td>
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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 Aljebour 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