Quarterly Progress Report

Project Number and Title: C11 Development of a system-level distributed sensing technique for long-term monitoring of concrete and composite bridges
Research Area: Thrust 1: Transportation infrastructure monitoring and assessment for enhanced life
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Co-PI(s): Susan Faraji (UML), Xingwei Wang (UML), Zhu Mao (UML), Bill Davids (UMaine), Ehsan Ghazanfari (UVM)
Reporting Period: 07/01/2020~09/30/2020
Date: 09/30/2020

Overview:

The research problem we are trying to solve is the long-term monitoring problem of bridges (e.g., concrete and composite bridges), using multiple modes of sensing technology including fiber optic, video motion, and electromagnetic sensors. A full composite bridge to installed in Hampden, ME has been identified for sensor instrumentation. In the past quarter, we were designing, manufacturing, and testing distributed sensors, as well as sensor installation apparatus and procedure. Table 1 provides our progress on individual tasks. In Table 1, due to the postponed construction schedule and an additional internal review procedure due to covid-19, our sensor installation date has been rescheduled to tentatively October 2, 2020 (weather permitting) at AIT Bridges, with October 5, 2020 being our contingency date for sensor installation. Table 2 reports our budget progress. The funding for Project C11 became available at UML on September 22, 2020. Our spending percentage will catch up with research progress after the submission of several cost transfers. Fig. 1 shows our proposed installation procedure. Figs. 2~5 show our manufactured sensing textiles.

Table 1: Task Progress

Task Number	Start Date	End Date	Percent Complete
Task 1	01/01/20	02/28/20	50% (postponed)
Task 2	01/01/20	03/31/20	100%
Task 3	01/01/20	07/31/20	80% (postponed)
Task 4	07/31/20	08/15/20	50% (postponed)
Task 5	08/15/20	08/20/20	0% (postponed)
Task 6	08/15/20	12/31/21	0% (postponed)
Task 7	08/20/20	12/31/21	0% (postponed)
Task 8	01/01/20	12/31/21	5%

Table 2: Budget Progress

Entire Project Budget	Spend Amount	Spend Percentage to Date
$166,304 (Year 1)	$8,310 (TBD)	5%

INSTALLATION APPARATUS

Fig.1 shows how a sensing textile is installed onto a composite gride girder with one person sitting on an installer's cart. A strain gauge system and an optical fiber system using BOTDA were integrated into sensing textiles. First, optical fibers were sewed onto a fabric substrate by Saint-Gobain with their patented technology. Strain gauges were then integrated to form a sensing textile. Figures 2~5 illustrate one integrated

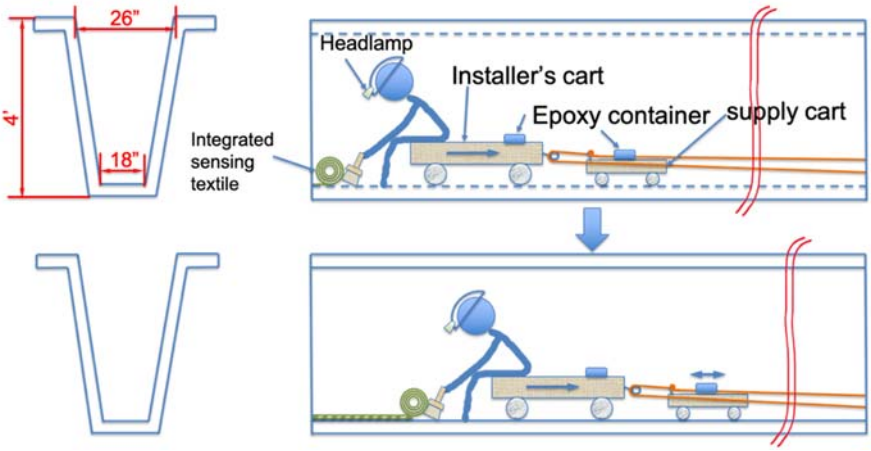

Fig. 1. Installation schematic

sensing textile as an example. Sensing textiles comprised of optical fibers, strain gauges, and fabrics are first rolled up into a spool configuration for transportation purpose.

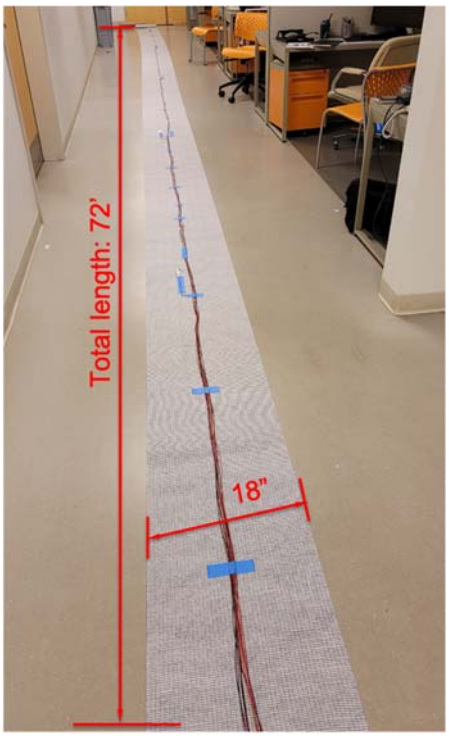

Fig. 2. Unfold integrated sensors

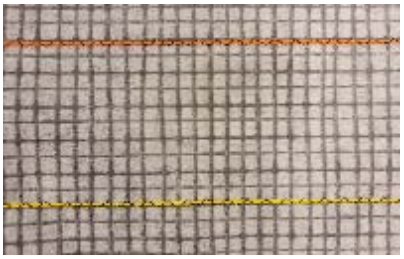

Fig. 3. Sensing textile.

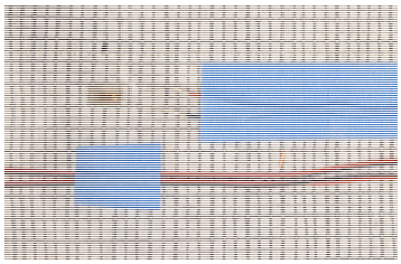

Fig. 4. Strain gauge on sensing textile

Fig. 5. Rolled up integrated sensors

Two installation carts were designed and manufactured; an installer's cart and a supply cart. Surface dimensions of the installer's cart are 15"x 3'. A mat composed of 4 layers of different thicknesses of sponges was made to make the cart more comfortable to be sat on. The size of the supply cart in Fig. 7 is 15"x 15".

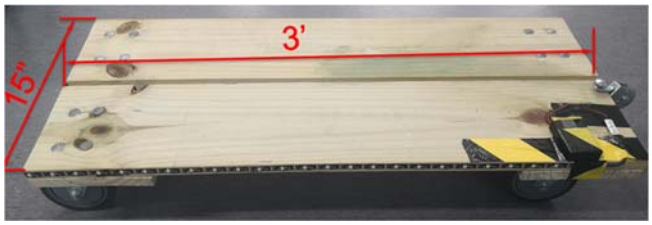

Fig. 6. Installer's cart

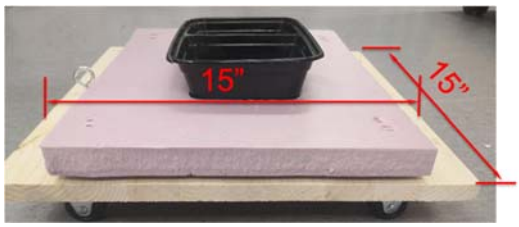

Fig 7. Supply cart for epoxy supply.

Figure 8. Mat on installer's cart

An 8-ft long 1:1 scale mock-up bridge girder model was made with foam boards for the preparation of sensor installation. It was used to practice installing sensing textiles and the design of installation carts.

Figure 9. Composite bridge girder at AIT Bridges (Brewer, ME)

Figure 10. Mock-up bridge girder at UML

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**
Sensing systems prep for Hampden bridge monitoring	TIDC Annual Student Poster Contest	Contest	Online	October 2020

Participants and Collaborators:

Table 4: 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

Table 5: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Jianing Wang		Ph.D.	Civil and Environmental Engineering	Manufacturing of installation apparatus, data analysis and signal processing
Sanjana Vinayaka		Ph.D.	Civil and Environmental Engineering	Manufacturing of installation apparatus, data analysis and signal processing
HarshNareshkumar		Ph.D.	Civil and Environmental Engineering	Manufacturing of laboratory specimens, data analysis and signal processing
Nashire Pelatra		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests
Rona Bates		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests

Table 6: Research Project Collaborators during the reporting period						
Organization	Location	Contribution to the Project				
		Financial Support	In-Kind Support	Facilities	Collaborative Research	Personnel Exchanges
AIT bridges	Brewer, Maine			X	X	X
Saint-Gobain North America	Northborough, Massachusetts		X	X	X	X

We have been communicating closely with our industry partners (Saint-Gobain and AIT Bridges) and Maine DOT on our project activities and held several teleconference calls during the past quarter whenever there is a need.

Planned Activities:

In the next reporting period, we plan to install sensors on three composite bridge girders and collect baseline data at AIT Bridges' parking lot on October 2, 2020 (weather permitting).