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: 10/01/2020~12/31/2020
Date: 12/28/2020

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 fully composite bridge to be installed in Hampden, ME has been identified for sensor instrumentation. In the past quarter, we installed integrated sensing textile with fiber optics and strain gauges (October 6, 2020) and measured baseline as a function of temperature (November 3, 2020). Table 1 provides our progress on individual tasks. Table 2 reports our budget progress. Due to the postponed construction schedule and an additional internal review procedure due to covid-19, live load testing on the Hampden bridge has been tentatively rescheduled to December 31, 2020.

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%

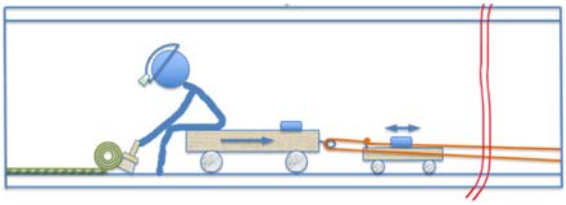
Table 2: Budget Progress

Entire Project Budget	Spend Amount	Spend Percentage to Date
$166,304 (Year 1)	$33,260 (TBD)	20%

Installation of Sensing Textiles on Hampden Bridge, ME

On October 6, 2020, we visited AIT Bridges and installed sensing textiles on three composite bridge girders. With a power generator and other logistic assistance provided by AIT Bridges (Anthony Diba and Wendell Harriman), we spent approximately 10 hours at AIT Bridges to install three sensing textiles and 28 strain gauges. Figure 1 shows two photos of the UML team installing sensing textiles at the parking lot of AIT Bridges.

Fig. 1. Installation of sensing textiles on three composite bridge girders (10/06/2020)



(a) Sensor installation scheme (top)
(b) Student installing sensors (middle)
(c) Installed sensing textile (right)

Fig. 2. Sensing textile installation scheme and result

Figure 2 shows our sensing textile installation scheme and result. Figure 3 illustrates our design of integrated sensing textiles (optical sensors and strain gauges).

On November 3, 2020, we went back to AIT Bridges for baseline data collection. Figure 4 shows the UML team and one installed sensing textile on a composite bridge girder. We also took the opportunity to check the condition of installed sensing textiles. Both optical sensor and strain gauge measurements were collected for baseline construction and temperature compensation. Figure 5 shows our laboratory setup of temperature test on strain gauges for developing a temperature compensation model.

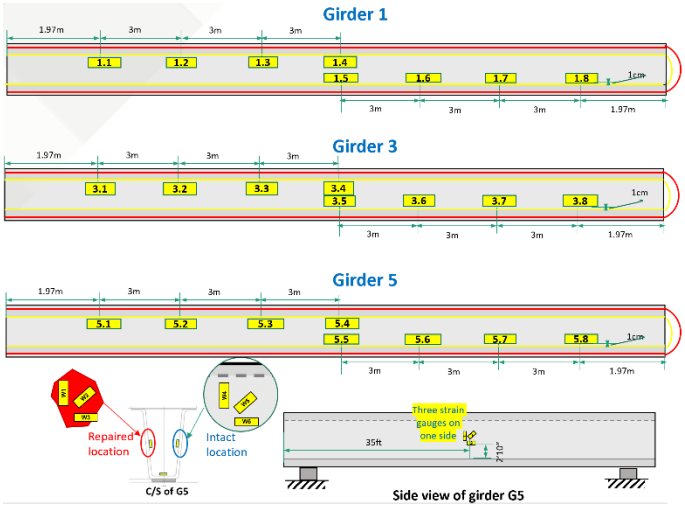


Fig. 3. Design of integrated sensing textiles

From this data collection activity, we have confirmed that each sensor has an updated baseline, mostly due to the change of boundary condition (e.g., epoxy). From the laboratory temperature test, we are able to remove the temperature effect on our sensors. From the field test on Nov. 3, 2020, we are able to determine different baseline states for each sensor.

Fig. 4. Baseline data collection (11/03/2020)

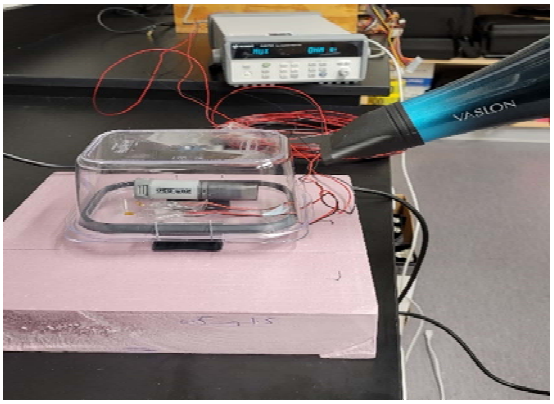


Fig. 5. Temperature test of strain gauges

Table 4: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**

Participants and Collaborators:

Table 5: 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 (PI) and Institutional Lead at UML; overseeing all project activities
Susan Faraji	Susan_Faraji@uml.edu	Civil and Environmental Engineering	Co-PI, bridge design and analysis
Xingwei Wang	Xingwei_Wang@uml.edu	Electrical and Computer Engineering	Co-PI, development of optical sensors
Zhu Mao	Zhu_Mao@uml.edu	Mechanical Engineering	Co-PI, dynamic health monitoring using motion videos
William Davids	William.Davids@maine.edu	Civil and Environmental Engineering	Co-PI, design and analysis of composite bridges
Ehsan Ghazanfari	Ehsan.Ghazanfari@uvm.edu	Civil and Environmental Engineering	Co-PI, data fusion and analysis

Table 6: 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
Harsh Gandhi		Ph.D.	Civil and Environmental Engineering	Manufacturing of laboratory specimens, data analysis and signal processing
Andrew Schanck		Ph.D.	Civil and Environmental Engineering	Finite element model construction and simulation
Andres Biondi Vaccarriello		Ph.D.	Electrical and Computer Engineering	Manufacturing and testing of optical sensors

Rui Wu		Ph.D.	Electrical and Computer Engineering	Manufacturing and testing of optical sensors
Celso DoCabo		Ph.D.	Mechanical Engineering	Assistance in the preparation for bridge field tests
Nashire Pelatra		B.S.	Civil and Environmental Engineering	Manufacturing of strain gauges
Abdulla Aljeboure		M.S.	Civil and Environmental Engineering	Field data collection

Table 7: 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	X
Saint-Gobain North America	Northborough, Massachusetts		X	X	X	X
MaineDOT	Maine	X		X	X	X

We have been communicating closely with our industry partners, Saint-Gobain North America (Camila Garces, Balaji Gopalan, Jackson Ivey) and AIT Bridges (Anthony Diba) and Maine DOT (Joe Stilwell, Garrett Kilfoyle, Dale Peabody) on our project activities during the past quarter whenever there is a need.

Changes:

1) Since last quarter, our laboratory tests were limited by i) access time (Phase 3 access), ii) social distancing (6 feet) and iii) the maximum number of students in each laboratory (SO130 and FA104). With team's health being our topic priority, we took extra care when performing any experimental work (indoor or outdoor). We would postpone or cancel scheduled laboratory or field test whenever there is a team member not feeling completely healthy in order to avoid the spreading of the pandemic on campus.
2) Doctoral student Sanjana Vinayaka will not continue her role on the project, due to personal health issue. A new member (Abdulla Aljeboure, Master's graduate) will join the team as doctoral student in next quarter.

Planned Activities:

At the end of this reporting period (Dec. 30~31, 2020), we plan to participate in the structural load test on Hampden Bridge, Maine and collect multiple sensor data.