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
PI: Tzuyang Yu (UML)
Co-PI(s): Susan Faraji (UML), Xingwei Wang (UML), Zhu Mao (UML), Bill Davids (UMaine), Ehsan Ghazanfari (UVM)
Reporting Period: 04/01/2020~06/30/2020
Date: 06/26/2020

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. Table 1provides our progress on individual tasks. Table 2 reports our budget progress. *Until the second quarter of the project, we have not started our project tasks in the laboratory, due to the delay of funds availability and the impact of covid-19 pandemic in Massachusetts.*

Table 1: Task Progress

Task Number	Start Date	End Date	Percent Complete
Task 1	01/01/20	02/28/20	10% (delayed)
Task 2	01/01/20	03/31/20	50% (delayed)
Task 3	01/01/20	07/31/20	0% (delayed)
Task 4	07/31/20	08/15/20	0%
Task 5	08/15/20	08/20/20	0%
Task 6	08/15/20	12/31/21	0%
Task 7	08/20/20	12/31/21	0%
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)	$0	0% (delayed)

Planning and design of a strain gauge monitoring system for Grist Mill Bridge (Hampden, ME)

Despite of lack of funding and prohibited access to our laboratories on campus, we have been communicating with Maine DOT (Dale Peabody, Joe Stilwell, and Jeffery Coffin) on the design of sensing systems for Grist Mill Bridge in Hampden, ME. Figure 1 shows the location and cross section of the bridge.

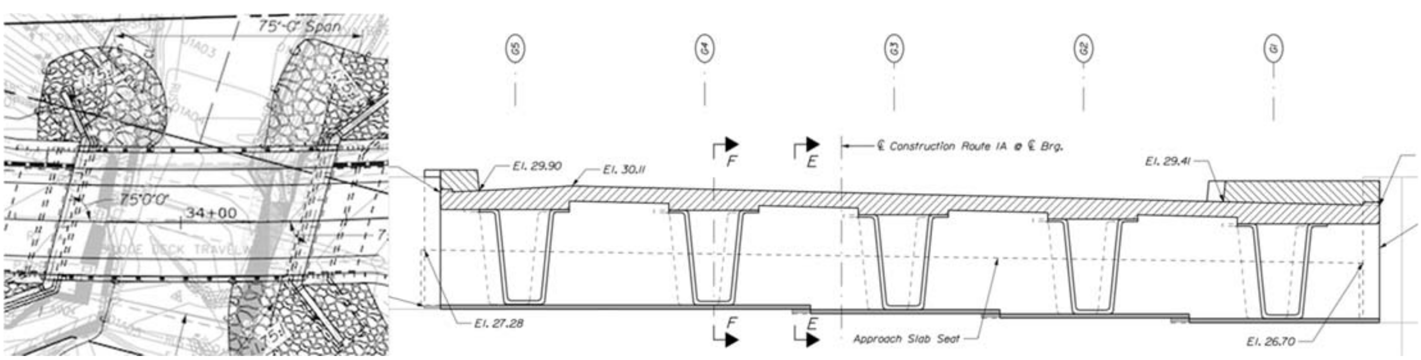

Fig. 1. Layout and cross section of Grist Mill Bridge (Hampden, ME) (Source: MaineDOT)

Figure 2 shows the detailed cross section view of one typical composite bridge girder. The bridge girder depth is 4'-2" and the width 3'-10". The bridge span is 75'.

Fig. 2. Detailed cross section of a composite bridge girder (Source: MaintDOT) and composite sample (by AIT Bridges)

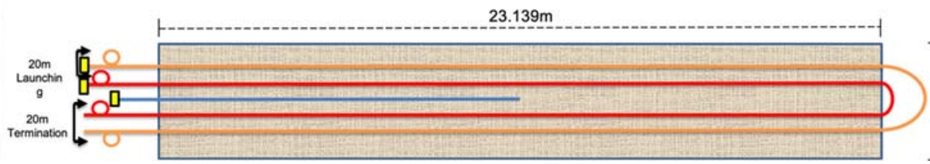

Fig. 3. Design of a distributed fiber optic sensing system

Since MaineDOT expressed a need to monitor a repaired section (at mid-span or 37’-6” from the support) on girder G5 in January 2020, we had started designing another strain gauge system comprising of six (tentatively) strain gauges on the interior of bridge girder G5. Until the end of this quarter, we have all items (e.g., stain gauges, data loggers, wires) identified, except the adhesives (epoxy) that needs to be tested on the composite material actually used in the bridge construction. We have received an approximately 1’-by-1’ composite sample from the bridge manufacturer Advanced Infrastructure Technologies (AIT) Bridges in Brewer, ME in May 2020. We will use a composite sample (provided by AIT Bridges) to experimentally determine the type of adhesive/epoxy for this bridge monitoring project.

Design a distributed fiber optic sensing system for Grist Mill Bridge (Hampden, ME)

In the past quarter, we also designed a distributed fiber optic sensing system for Grist Mill Bridge, using a Brillion optical time domain reflectometer (BOTDR) and optical frequency domain reflectometry (OFDR). We have identified the type of optical fibers to be used in this distributed sensing system including a fabric substrate and three optical fibers. We will hold a virtual meeting with our collaborator Saint-Gobain (Northborough, MA) on the manufacturing schedule of our designed distributed fiber optic sensing system in the near future. Fig. 3 shows our current design of the distributed fiber optic sensing system.

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events

Title	Event	Type	Location	Date(s)

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status

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; overseeing all projects and working on radar imaging and interpretation
Susan Faraji	Susan_Faraji@UML.EDU	Civil and Environmental Engineering	Co-PI, bridge analysis and design

Xingwei Wang	Xingwei_Wang@UML.EDU	Electrical and Computer Engineering	Co-PI, distributed fiber optic sensors and sensing systems for structural health monitoring
Zhu Mao	Zhu_Mao@UML.EDU	Mechanical Engineering	Co-PI, video-based motion sensors for structural health monitoring
Bill Davids	William.Davids@MAINE.EDU	Civil and Environmental Engineering	Co-PI, design and analysis of composite bridges, structural loading test, finite element analysis
Ehsan Ghazanfari	Ehsan.Ghazanfari@UVM.EDU	Civil and Environmental Engineering	Co-PI, data analysis, data fusion

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Sanjana Vinayaka		Ph.D.	Civil and Environmental Engineering	Manufacturing of laboratory specimens, field radar imaging of structures, data analysis and signal processing
Ronan Bates		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests
Nasharie Peralta		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests
BiondiVaccariello, Andres M		Ph.D.	Electrical and Computer Engineering	Optical Fiber sensor design
Rui Wu		Ph.D.	Electrical and Computer Engineering	OFDR Sensor fabrication preliminary test
Lidan Cao		Ph.D.	Electrical and Computer Engineering	Preliminary data output format analysis

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**

Table 8: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
Maine Department of Transportation (MaineDOT)	Augusta, Maine				X	X
AIT Bridges	Brewer, Maine		X	X	X	X

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Since January, we have been communicating (via emails and virtual meetings) with MaineDOT and AIT Bridges on the Hampden bridge monitoring task by incorporating their input and needs in our research tasks. On June 26, 2020, co-PI Faraji visited AIT Bridges (Wendell Harriman, Timothy Kenerson) in Brewer, ME to preliminary assess the feasibility of our sensor installation plan.

Changes:

Due to the significant impact of covid-19 pandemic in Massachusetts, we have been prohibited from accessing our research facility, equipment, and specimens since March 6, 2020. While the Massachusetts State Government has issued a four-phase plan in early May, the UML researchers working on Project C11 still cannot resume our planned laboratory and field tasks until now (June 26, 2020). We have taken the following actions to prepare ourselves on getting ready to return to our laboratories in the past quarter:

1. Online covid-19 safety training at UML – Some UML researchers received a one-hour online training on June 3, 2020, required by the UML administration for everyone prior to returning to campus. Currently we are preparing a request form to apply for return to campus labs.
2. Acquisition of personal protection equipment (PPE) for all team members – We have ordered sufficient amount of PPE (e.g., face masks, latex gloves) in May 2020 such that we can resume our project tasks on campus and in the field.

On the other hand, we will continue our research meetings that have been converted to a virtual platform since last quarter. We will use the virtual meeting platform for our educational and outreach activities, as well as meeting with MaineDOT and AIT Bridges.

Planned Activities:

In the next reporting period, we plan to resume the following tasks:

Task 1: Development of a finite element model of a composite/concrete bridge for strain range and distribution
Task 2: Design of a distributed sensing system using strain and temperature
Task 3: Establishment and modal calibration of baseline measurements using fiber optic, video motion, and electromagnetic sensors
Task 4: Installation of distributed fiber optic cables on a composite/concrete bridge
Task 5: Structural loading test and data collection
Task 6: Monitoring of structural performance under service and environmental loads
Task 7: Data fusion, visualization, and interpretation
Task 8: Documentation, reporting, and dissemination