Quarterly Progress Report

Project Number and Title: Project 1.2: Condition/Health Monitoring of Railroad Bridges for Structural Safety, Integrity, and Durability

Research Area: Thrust 1 -Transportation Infrastructure Monitoring & Assessment for Enhanced Life

PI: Ramesh B. Malla, Ph.D., F. ASCE, F. EMI, Professor, Department of Civil & Environmental Engineering, University of Connecticut, and **Institutional Lead** for US DOT Region 1 UTC-TIDC Program

Co-PI(s): N/A

Reporting Period: July 01, 2021, to September 30, 2021

Submission Date: September 30, 2021

Overview:

Brief overview and summary of activities performed during the reporting period:

During this reporting period, the research team has performed several material characterizations tests, such as tensile, and metallography. Additional samples and specimens from different bridges has been prepared and will be used to further evaluate the original material. The data collected using Single-Point Laser Doppler Vibrometer was analyzed and displacement-time domain was extracted, and it will be used to calibrate the Finite Element Model (FEM).

The Devon bridge FEM is almost in completion, and a significant progress has been made in modeling the Cos Cob bridge. The research team has been active in presenting the findings from the research.

Given below is a summary of activities performed by the research team during this quarterly report period:

- The research team worked and continue to work on material microstructure characterization and mechanical testing with emphasis in the metallographic analysis (Figure 1) and tensile test (Figure 2). Samples from Devon bridge and Cos Cob bridge in Connecticut, and Sheridan/Aroostook River bridge in Maine have been tested in tension, and more samples from these bridges, and Atlantic Street bridge in Connecticut, have been prepared to be evaluated in tensile, fractography and the hardness indentation test.
- A field test data collected from Cos Cob and Devon bridges in June 2021 has been processed and the displacement time-domain of the service train at the reading location has been successfully extracted (Figure 3).
- Devon bridge FEM is almost in completion, the natural frequencies, mode shapes, and the displacement-time domain behavior are aligned with the FEM, displacement magnitude need to be further evaluated (Figure 4). Significant progress has been made in modeling the Cos Cob bridge for FEM analysis.
- The research team continues to maintain close collaboration with the government and industry companies, such as Conn DOT, Metro-North RR and Polytec Inc.
- The research team has presented a recorded video at TIDC conference 2021 with the title “Dynamic Behavior of a More than Century Old Truss Railroad Bridges under Service Conditions” on July 28, 2021

Figure 1 – Microstructure image of Devon, bridge (CT) sample material, encircled in red are MnS intrusion

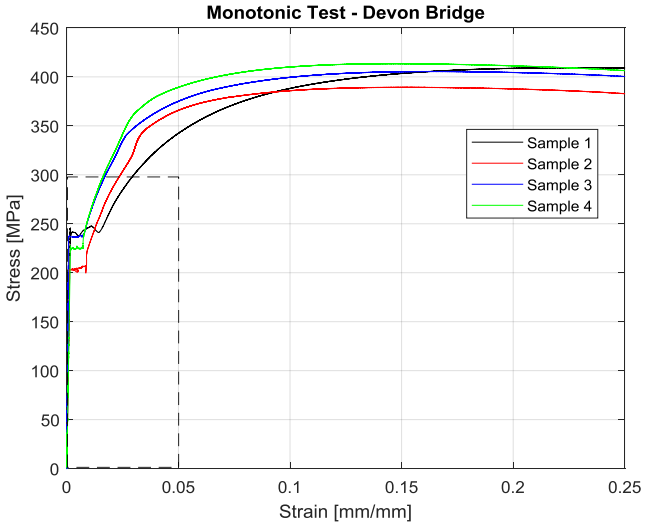

Figure 2 – Stress vs strain plot Devon Bridge (CT), Specimen 1, 2, 3 and 4 at a loading rate of 1mm/min

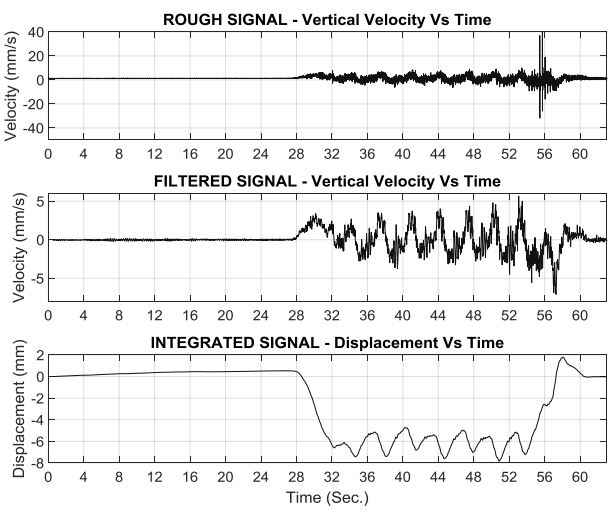

Figure 3 – Field data of M8 at 17 Mph crossing span 7 of Devon Bridge (CT): Data processing to displacement time domain at midpoint

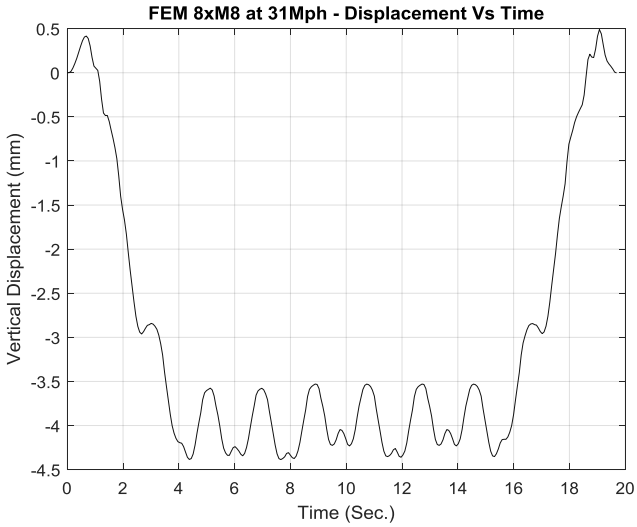

Figure 4 – Finite Element Model of M8 at 31 Mph crossing span 7 of Devon Bridge (CT): Displacement time domain at midpoint

How these activities are helping achieve the overarching goal(s) of the project:

The primary goal of the project is to develop an efficient and cost-effective methodology for the structural health/condition and structural monitoring of old railroad bridges in New England, highlighting the dynamic response due to experimental and numerical techniques of the structure under service.

- The material characterization tests from different old bridges will allow the research team to understand and evaluate the durability and actual condition of the old steel, in this case the ASTM-A7.
- The displacement time domain response obtained from the Single-Point Laser Doppler Vibrometer will is being used to calibrate and verify the accuracy of the FEM and different sensors, and to determine the ideal number of sensors for future field testing.
- The use of conventional accelerometers, standalone accelerometers, and One Point Laser Vibrometer will allow the research team to determine the most cost-effective method for future monitoring campaigns.
- The updated model will be used to simulate different loading conditions of the bridge, with emphasis in service scenario and different vehicles dynamic behavior.

Accomplishment achieved under the project goals:

Following accomplishments have been achieved and would help toward meeting the project goal:

- The research team has processed the data from the field test using a single-point Laser Doppler Vibrometer in Devon and Cos Cob railroad bridges located in Connecticut, where the time-domain displacement and vibration characteristics have been extracted.
- The original material from the Devon bridge, Cos Cob bridge and, the Sheridan/Aroostook River bridge members replaced in the past maintenance, has been tested under tension and the microstructure analyzed.
- The research results have been disseminated through conferences and has established a communication channel between the DOTs and various industries-railroad related and structural health monitoring equipment manufacturers.
- The research team has disseminated research findings through conferences (posters and presentations) and journal publication, and more draft paper/abstract has been prepared.
- The collaboration between the academic and industry institutions has been maintained.

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**% Complete (as of now)**
Task 1: Literature search and review; communication with New England state DOTs for railroad bridge material collection and information/data	October 1, 2018	December 31, 2020	90%
Task 2: Existing railroad bridge material testing	January 1, 2019	August 31, 2021	70%
Task 3: Finite Element (FE) modeling of railroad bridge	June 1, 2019	December 31, 2021	88%
Task 4: Determine optimal number and locations of sensor for effective bridge condition monitoring	December 1, 2019	January 31, 2022	25%
Task 5: Determine from the analytical and FEM analysis effects of vehicle speed/type on bridge response and DMF	June 1, 2020	May 31, 2022	10%
Task 6: Prepare procedure to field test and data collection by applying a limited number of sensors to bridge, collect field data, update FE Model, and verify that sensors give sufficient info to determine condition of bridge	October 1, 2020	May 31, 2022	50%
Final Report preparation and submission	January 1, 2022	June 30, 2022	0%
Overall Project:	October 01, 2018	June 30, 2022	80%

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date***
To be provided separately		

Include the date the budget is current to.

Opportunities for training/professional development that have been provided:
The research team members have been continuously trained by the School of Material Science from UConn to use their testing equipment's and data processing software.

- Tensile testing machine user: May 19, 2021, at Institute of Material Science Mechanical Testing Lab.

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events				
Title	**Event**	**Type**	**Location**	**Date(s)**
Dynamic Behavior of a More than Century Old Truss Railroad Bridges under Service Conditions (by Ramesh B. Malla, Ph.D., F. ASCE, F. EMI, M. CASE (Professor), Celso de Oliveira, Research Assistant (Ph.D. Student), and Santosh Dhakal, Research Assistant (M.S. Student)	TIDC Conference 2021	Conference	Virtual	July 28, 2021

Table 4: Publications and Submitted Papers and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
N/A				

Participants and Collaborators:

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
Dr. Ramesh B. Malla, Professor	Ramesh.Malla@UCONN.EDU	Department of Civil & Environmental Engineering, University of Connecticut, Storrs	Principal Investigator (PI)/ TIDC Institutional Lead, UConn
Dr. Lesley D. Frame, Assistant Professor	Lesley.Frame@UCONN.EDU	Department of Materials Science & Engineering, University of Connecticut, Storrs	Collaborator: Material characterization of the test specimens

Use the table below to list all students who have participated in the project during the reporting. (This includes all paid, unpaid, intern, independent study, or any other student that participated in this project.)

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Celso de Oliveira		Ph.D.	Civil Eng.	Graduate Assistant
Santosh Dhakal		M.S.	Civil Eng.	Graduate Assistant
Kelly Voong		Undergraduate	Civil Eng.	Student
Supporting Role				
Donghyun Kim		Ph.D.	Material Science	Graduate Student
Sachin Tripathi		Ph.D.	Civil Eng.	Graduate Assistant
David Jacobs		Ph.D.	Civil Eng.	Graduate Student
Suvash Dhakal		Ph.D.	Civil Eng.	Graduate Student

Use the table below to list organizations have been involved as partners on this project and their contribution to the project.

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
Conn DOT Contact persons: (1) Haresh Dholakia- Transportation Engineering Supervisor *(Technical Champion)* (2) Mr. Manesh Dodia- Transportation Engineer III *(Technical Champion)*	Newington, CT		X	X	X	X
Maine DOT Contact Persons: (1) Dale Peabody- TIDC Advisory Board, Director Transportation Research (2) Brian Reeves- Director of Rail Transportation	Augusta, ME		X	X	X	X
Metro-North Railroad Co. Contact persons: (1) Warren Best-Assistant Deputy Director- Structures *(Technical Champion)* (2) Ms. Hong McConnell, Senior Structural Engineer	Bridgeport, CT		X	X	X	X
Polytec, Inc., Hudson, MA Contact Person: Mr. Mario Pineda, Territory Manager	Hudson, MA		X	X	X	X

Table 9: Other Collaborators

Collaborator Name and Title	Contact Information	Organization and Department	Contribution to Research
Haresh Dholakia, Transportation Engineering Supervisor	HareshKumar.Dholakia@CT.GOV	Connecticut Department of Transportation (Conn DOT), Newington, CT	Technical Champion
Manesh Dodia, Transportation Engineer III	Manesh.Dodia@CT.GOV	Connecticut Department of Transportation (Conn DOT), Newington, CT	Technical Champion
Warren Best, Assistant Deputy Director-Structures	Best@MNR.ORG	Metro-North Railroad Company, Bridgeport, CT	Technical Champion
Hong McConnell, Senior Structural Engineer	McConnell@MNR.ORG	Metro-North Railroad Company, Bridgeport, CT	Coordinator for logistics for field test on bridges
Mario Pineda, Territory Manager	M.Pineda@POLYTEC.COM	Polytec Inc., Hudson, MA	Providing part of the field test Equipment (Laser Vibrometer) and

			advice conducting field test
Arend Von der Lieth, Application Engineering Manager	A.Vonderlieth@POLYTEC.COM	Polytec Inc., Hudson, MA	Providing art of the field test Equipment (Laser Vibrometer) and advice conducting field test
David Damiani, Application Engineering	D.Damiani@ POLYTEC.COM	Polytec Inc., Hudson, MA	Providing part of the field test Equipment (Laser Vibrometer) and advice conducting field test

Technical Champion for this project:
Name: Mr. Haresh Dholakia, P.E.
Title: Transportation Engineering Supervisor, Rail Design`
Organization: Connecticut Department of Transportation
Location (City & State): Newington, CT
Email Address: HareshKumar.Dholakia@CT.GOV

Name: Mr. Manesh Dodia
Title: Supervising Rail Officer, Rail Construction
Organization: Office of Rail – Constructions, Connecticut Department of Transportation
Location (City & State): New Haven, CT
Email Address: Manesh.Dodia@CT.GOV

Name: Warren Best, P.E.
Title: Assistant Deputy Director- Structures
Organization: Metro-North Railroad Company
Location (City & State): Bridgeport, CT
Email Address: Best@MNR.ORG

Challenges and Changes:
Actual and anticipated problems or delays and actions or plans to resolve them:

- The FEM calibration in structural transient analysis has proven to be time and resources consuming.

Planned Activities:

- The research team will continue to perform in-depth processing of the data collected from both the Cos Cob and the Devon bridges field tests performed on last summer.
- The research team will continue to work on material characterization. Tensile testing is expected to be completed by next reporting period, metallography, fractography and the hardness indentation test to be followed then.
- The research team will continue to calibrate the FE model of the Devon bridge with the result obtained from the files testing and continue working on the FE model of the Cos Cob bridge.
- The research team will continue to work on finding more industrial collaborators who can support research directly with the testing equipment and logistics in the coming days.
- The research team will continue to work with Conn DOT, Metro-North RR, and Polytec Inc., preparing for the future Controlled field test on earlier fall on Cos Cob bridge.

- The research team will continue to maintain communication with CT and other New England DOTs, Metro-North Railroad company, and Polytec, Inc., so that the research will be relevant and of value to the DOTs and industry.