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, 2020 to September 30, 2020
Submission Date: October 01, 2020

Overview:

Brief overview and summary of activities performed during the reporting period:
During this reporting period, the research team has been mainly focused on logistic preparations for the field test of the Devon railroad bridge located over Housatonic river between Milford and Stratford, CT (Figure 1). The tentative date for the field test is mid-October of 2020. The Finite Element (FE) modeling of Devon bridge was updated to mimic the planned field test and to validate the testing procedure (Figure 1). In addition, a significant amount of time was spent on processing and analyzing the data from the results from the tensile tests conducted on the materials from Devon and Cos Cob bridges in Connecticut. The research team has also been active in publishing and presenting of the findings from the research. Given below is a summary of activities performed by the research team during this quarterly report period:

- Railroad (RR) Contractor Safety Training has been completed by majority of the team members involved in the field test.
- RR Liability insurance and General Liability insurance has been prepared and is now under review from the Metro-North RR and University of Connecticut legal team.
- Detailed Work Procedure has been prepared and is now under review for approval from the Metro-North RR and Conn DOT.
- Preliminary field test logistics and budget for required equipment were analyzed and discussed with the interested parties.
- Efforts are ongoing to create an accurate FE model of Devon bridge to represent the harmonic response of the structures due the Shaker vibration. The FE model should mimic the planned field test and will be used to compare the field test result.
- A close collaboration with Conn DOT, Metro-North RR, Polytec Inc., and Maine DOT has been maintained. The Metro-North RR has been directly assisting the research team to obtain the Entry Permits for the desired bridges. The Conn DOT has been directly assisting the research team with required logistics and flag-man cost. The Polytec, Inc. has been directly assisting the team with part of the instrumentation and shaker. Maine DOT is providing steel bridge material samples for testing.
- The Team has presented has submitted the abstract and presented at the Transportation Infrastructure Durability Center (TIDC) 2020 virtual conference the paper “Preliminary Material Testing and Analysis of Two Old Railroad Steel Bridges” on August 12, 2020.
- The Team has submitted a Poster at the Transportation Infrastructure Durability Center (TIDC) 2020 Student Poster competition on August 30, 2020.
- The Team has submitted a paper to the Transportation Research Board (TRB) 2021 conference, the team has been accepted to present the paper “Tensile Test and Stress-Strain Behavior of Steel Material from a More than a Century Old Railroad Bridge” on January 2021.
- Microstructure and Chemical composition coupons have been cut and are ready to be tested and create more conclusions.
- The research team worked with Maine DOT (Contact: Mr. Dale Peabody) to have a few steel bridge material specimens they had collected from a bridge in Maine sand-blasted to get rid of any environmental health safety materials. The samples will be soon shipped to the research team at UConn to cut to the test specimens and tested.

How these activities are helping achieve the overarching goal(s) of the project:
The overarching goal of the project is to determine the structural health/condition and structural monitoring of old railroad bridges in the northeast corridor.

- The finite element analysis has and will help to determine the number of sensor and location for field testing. It will also help determine stresses, strain and deformation of the bridges analyze,.
- The work procedure prepared for the field tests will help to conduct the railroad bridge field test efficiently and collect essential data accurately. The field tests will allow the research team to update the FE model, and use this updated model to simulate different loading conditions of the bridge.
- The testing of material from Cos Cob and Devon bridge and the results have given insight into the current stress and strain behavior and help assessing the condition of the bridges material for their future durability.

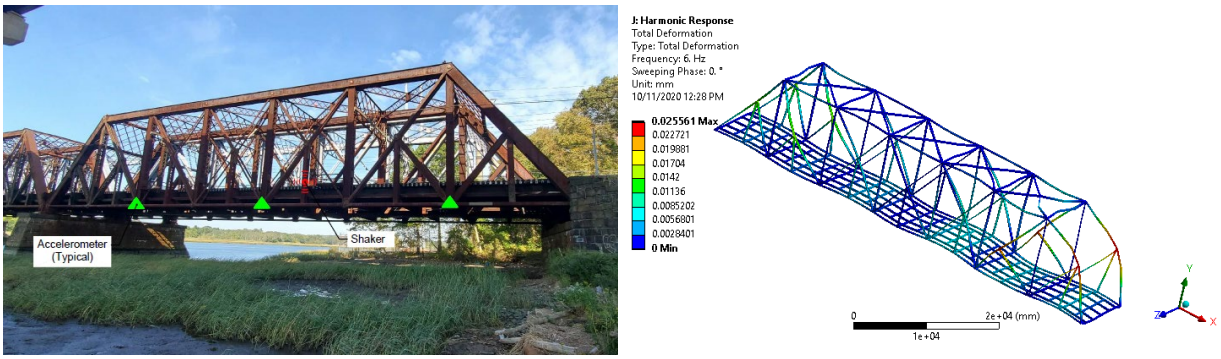

Figure 1 – Devon Bridge: Field Test Instrumentation Pan (Left) and FE ModelHarmonic Response (Right)

Detailed work procedure for the field test on Devon bridge has been produced during the same reporting period, this document contains relevant information related to work methodologies and safety requirements during the field testing and data collection of the selected bridges. This document has been shared with Connecticut Department of Transportation (Conn DOT) and Metro-North RR company.

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

- The detailed work procedure has been prepared and will be shared with the concerned parties.
- The FE model has been created to facilitate for effective field test on Devon bridge and optimum sensor location.
- Partnership with states DOT's and industry companies has been maintained. The ConnDOT, Metro-North RR, and Polytec Inc. provided vital support for the planned field test.
- The research team has disseminated research findings through conferences (posters and presentations) and journal publication, and also more draft paper/abstract has been prepared.

Table 1: Task Progress

Task Number	Start Date	End Date	% Complete
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	100%
Task 2: Existing railroad bridge material testing	January 1, 2019	September 30, 2020	55%[1]
Task 3: Finite Element (FE) modeling of railroad bridge	June 1, 2019	December 31, 2020	65%

1. Activity in delay due to COVID-19 (Coronavirus Pandemic)

Task 4: Determine optimal number and locations of sensor for effective bridge condition monitoring	December 1, 2019	January 31, 2021	20%
Task 5: Determine from the analytical and FEM analysis effects of vehicle speed/type on bridge response and DMF	June 1, 2020	August 31, 2021	0%
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	September 31, 2021	20%[1]
Final Report preparation and submission	June 1, 2021	September 31, 2021	0%
Overall Project:	October 01, 2018	September 31, 2021	60%

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 has completed the Metro-North Railroad Company Contractor Safety Training, required for all the personnel working under RR property. This is relevant for the field test of the railroad bridges

Activities involving the dissemination of research results:

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

Title	Event	Type	Location	Date(s)
Devon Railroad Bridge (CT) – Field Test Preparation	Meeting with Mr. Mario Pineda and Mr. Arend von der Lieth, from the Polytec Inc, Hudson, MA	Meeting	Virtual	September 11, 17, 23, 28, 2020
Preliminary Material Testing and Analysis of Two Old Railroad Steel Bridges	Transportation Infrastructure Durability Center (TIDC) 2020 virtual conference	Conference	Virtual	August 12, 2020
Micro structure analysis (characterization) of old railroad (RR) steel bridge materials	Meeting with Dr. Leslie Frame from Department of Materials Science & Engineering, University of Connecticut, Storrs	Meeting	Virtual	September 21, 2020

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Conference Presentation	Tensile Test and Stress-Strain Behavior of Steel Material from a More than Century Old Railroad Bridge	By Celso de Oliveira, Sachin Tripathi, Mark Castaldi, and Ramesh Malla *2021 TRB Annual Meeting*	January, 2021	Accepted for presentation
Poster Contest	Tensile Test of Two More than a Century Old Steel Railroad Bridges	By Celso de Oliveira, Sachin Tripathi, and Ramesh Malla *2020 TIDC Annual Student Poster Contest*	September, 2020	Submitted

Journal publication	Live-Load Response of Eyebars on a 110-Year-Old Steel Truss Railroad Bridge	By David W. Jacobs, Suvash Dhakal, and Ramesh Malla *ASCE Practice Periodical on Structural Design and Construction* https://ascelibrary.org/doi/10.1061/%28ASCE%29SC.1943-5576.0000523	September, 2020	Published online

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	Civil & Environmental Engineering, University of Connecticut, Storrs	Principal Investigator (PI)/ TIDC Institutional Lead, UConn
Dr. Nicholas Eddy		Institute of Material Science, University of Connecticut, Storrs	Mechanical Testing Lab
Dr. Lesley D. Frame, Assistant Professor		Department of Materials Science & Engineering, University of Connecticut, Storrs	Material characterization of the test specimens

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
Sachin Tripathi		Ph.D.	Civil Eng.	Graduate Assistant
David Jacobs		Ph.D.	Civil Eng.	Graduate Student
Suvash Dhakal		Ph.D.	Civil Eng.	Graduate Student

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
Vermont DOT Contact person: Dr. Emily Parkany- TIDC Advisory Board, Research Manager	Barre, VT					X
Polytec, Inc. , Hudson, MA Contact Person: Mr. Mario Pineda, Territory Manager	Hudson, MA		X		X	X

Table 9: Other Collaborators

Collaborator Name and Title	Contact Information	Organization and Department	Contribution to Research
Haresh Dholakia, Transportation Engineering Supervisor		Connecticut Department of Transportation (Conn DOT), Newington, CT	Technical Champion
Manesh Dodia, Transportation Engineer III		Connecticut Department of Transportation (Conn DOT), Newington, CT	Technical Champion
Mr. Warren Best, Assistant Deputy Director- Structures		Metro-North Railroad Company, Bridgeport, CT	Technical Champion
Mario Pineda, Territory Manager		Polytec Inc., Hudson, MA	Potential field test Equipment (Laser Vibrometer and Shaker) and help conducting field test
Arend Von der Lieth, Application Engineering Manager		Polytec Inc., Hudson, MA	Potential field test Equipment (Laser Vibrometer and Shaker) and help conducting field test

Technical Champion for this project:

Name: Haresh Dholakia
Title: Transportation Engineering Supervisor
Organization: Connecticut Department of Transportation
Location (City & State): Newington, CT

Name: Manesh Dodia
Title: Transportation Engineer III
Organization: Connecticut Department of Transportation
Location (City & State): Newington, CT

Name: Warren Best
Title: Assistant Deputy Director- Structures
Organization: Metro-North Railroad Company Location (City & State): Bridgeport, CT

Changes:

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

Limited material collected on Cos Cob, Devon and Atlantic Street bridges still left, and tensile and fatigue coupons are ready to be tested. The team was not able to do material testing since February 2020 due to the University shut down because of the COVID-19 (Coronavirus) pandemic. The lab personnel are gradually accepting new specimens for testing, the team hopes that the next quarterly, the research will ramp up.

Planned Activities:

- The accurate finite element (FE) model of Cos Cob and Devon bridges will continue to be developed and calibrated. The moving train load simulation with different speeds will be applied on each model.
- The research team will continue to work with Conn DOT, Metro-North RR and Polytec Inc. through the final logistics of scheduling-controlled field testing to test its sensor placement and data collection methodologies.
- The Research team and the Polytec Inc, Hudson, MA will use Laser Vibrometers and accelerometers to validate the result. Based on the results of this experience, the team will opt to use the best method for future short-term monitoring. The use of Laser Vibrometer presents significant advantages in comparison with the classic accelerometers, mainly in safety and productivity. A Shaker will be placed on the bridge to create a controlled vibration, this device will allow to have a forced vibration with sinusoidal waves that oscillate maximum 10Hz with maximum input load of 450N. Laser Vibrometers will be used and placed along boat launch area, all targeting strategic sections of the bridge. The Polytec Inc, Hudson MA will provide Laser Vibrometers and Shakers for the planned field test on the Devon Bridge.
- The research team will continue to maintain communication with CT and other New England DOTs , Metro-North Railroad company, and Polytec, Inc. and other railroad related organization, e.g. Amtrak so that the research will be relevant and of value to the DOTs and industry.