

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

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Co-PI(s): N/A

Reporting Period: January 01, 2021 to March 31, 2021

Submission Date: March 31, 2021

Overview:

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

During this reporting period, the research team has performed a field test of the two railroad bridges, Devon bridge located over the Housatonic River between Milford and Stratford, CT, and the Cos Cob bridge located over the Mianus River between Cos Cob and Riverside, CT. The data collected using Standalone Accelerometers was partial analyzed and determined the natural frequencies of the bridge structure, and acceleration magnitude of the train. These dynamic parameters will be further verified using Finite Element Modeling (FEM) which is under development. The research team has been active in publishing and presenting the findings from the research.

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

- A field test on Cos Cob bridge was conducted on January 20, 2021 (Figure 1). For this test, the research team used Standalone Accelerometers to collect the dynamic response of the bridge under moving train (Figure 2). The Metro-North RR supported the research team with logistic during the testing and the University of Rhode Island assisted with Accelerometers.
- Similar field test was conducted on Devon bridge on January 23, 2021(Figure 3, 4). The research team received similar assistance from the Metro-North RR and the University of Rhode Island for this test as well.
- The preliminary analysis on collected data using Laser Vibrometer on Devon bridge, has been detailed processed, and the Natural frequencies are identified. This Laser Vibrometer test was performed on October 28, 2020. Polytec Inc. loaned Laser Vibrometer and provided technical support during the test.
- Significant progress has been made in modeling the Devon and Cos Cob bridge (Figure 5) for FEM analysis. The detailed models are in advance progress and the calibration process is ongoing.
- The research team welcomed two new senior undergraduate students into the team who will be doing independent study research on the bridge focusing on FE modeling and dynamic analysis of the bridge structure.
- The research team continues to explore on availability of different equipment on structural monitoring campaign. Polytec Inc., one of the collaborators for this research has loaned us One Point Laser Vibrometer. The research team plan to perform testing using this device on Devon and Cos Cob bridge in spring.
- The research team continues to maintain close collaboration with Conn DOT and Metro-North RR. The Metro-North RR has directly helped the research team with the bridge access and equipment logistics during the field test. The Conn DOT has been directly assisting the research team with required logistics and flag-man cost.
- The research team has presented a poster at Transportation Research Board 2021 Virtual Conference with the paper “Tensile Test and Stress-Strain Behavior of Steel Material from a More than a Century Old Railroad Bridge” on January 25-29, 2021.
- The research team provided the update on current research progress to the Technical Champions of the project from CT DOT and MetroNorth Railroad in a meeting held on March 18, 2021 and received valuable feedback and suggestions.



Figure 1 – Cos Cob Bridge: Train 4 during tests

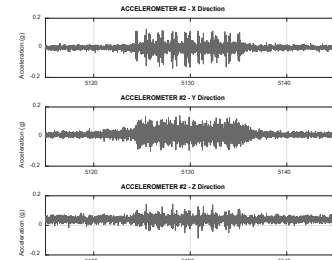


Figure 2 – Cos Cob Bridge: Train 4, acceleration time domain

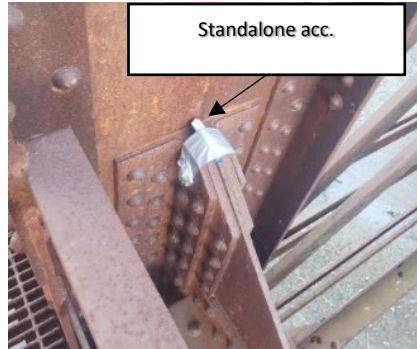


Figure 3 – Devon bridge: Standalone Accelerometer installation

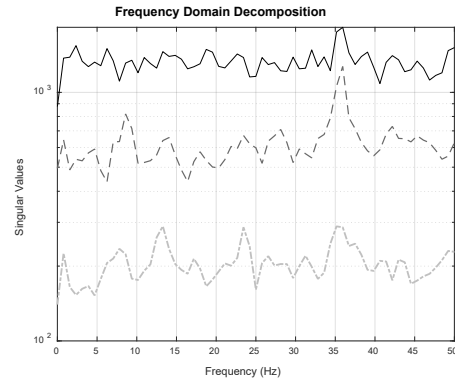


Figure 4 – Devon Bridge: Train 2, acceleration frequency domain

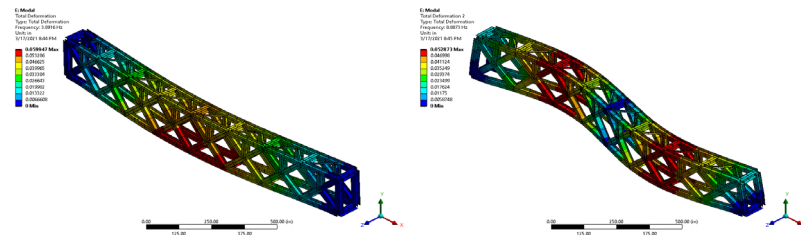


Figure 5 – Cos Cob Bridge: Preliminary FE model

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 acceleration frequency domain response from field test is being used to calibrate the FE model, and to determine the ideal number of sensors for field testing. The time domain response will be helpful to determine displacement, stresses, and strain of the bridges under service load.
- The use of conventional accelerometers versus standalone accelerometers will allow the research team to determine the most cost effective method for future monitoring campaigns.
- The field tests will allow the research team to update the numerical model. The updated model will be used to simulate different loading conditions of the bridge.

Accomplishment achieved under the project goals:

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

- The research team has successfully completed field testing using standalone accelerometers on both Devon and Cos Cob bridge.

- The time domain (Figure 3) data collected using these devices has been successfully transformed into frequency domain (Figure 4). Doing so, the research team has been able to determine approximated natural frequencies of both the Devon and the Cos Cob bridge.
- Significant progress has been made in updating and validating the FEM of both Devon and the Cos Cob bridge (Figure 5). Once the FEM is completed, the natural frequencies and the mode shapes obtained from the field test will be compared with FE model using Model Assurance Criterion (MAC).
- The research team continue to get support from the ConnDOT, Metro-North RR, and Polytec Inc. during field testing.
- The research team is working on logistics to start working on material testing. Considerable progress could not be made on material testing during this reporting period because of the inconvenience caused by the Covid 19 Pandemic.
- 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	100%
Task 2: Existing railroad bridge material testing	January 1, 2019	August 31, 2021	55%
Task 3: Finite Element (FE) modeling of railroad bridge	June 1, 2019	December 31, 2021	75%
Task 4: Determine optimal number and locations of sensor for effective bridge condition monitoring	December 1, 2019	September 31, 2021	25%
Task 5: Determine from the analytical and FEM analysis effects of vehicle speed/type on bridge response and DMF	June 1, 2020	September 31, 2021	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	September 31, 2021	30%
Final Report preparation and submission	January 1, 2022	September 31, 2021	0%
Overall Project:	October 01, 2018	September 31, 2021	70%

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:

N/A

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

Title	Event	Type	Location	Date(s)
Devon and Cos Cob Railroad Bridges (CT) – Field Test Preparation	Meeting with Mr. Mario Pineda and Mr. Arend von der Lieth, from the Polytec Inc, Hudson, MA	Meeting	Virtual	January 14, January 22, February 12, February 26, March 12, 2021
Tensile Test and Stress-Strain Behavior of Steel Material from a More than a Century Old Railroad Bridge	Transportation Research Board 2021 Virtual Annual meeting/conference	Conference	Virtual	January 25-29, 2021
Technical Champion Meeting	Meeting with Messrs. Hareesh Dholakia and Manesh Dodia of CT DOT and Mr. Warren Best, and Ms. Hong McConnell of MetroNorth Railroad Company.	Meeting	Virtual	March 18, 2021

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 a Century Old Railroad Bridge (Poster)	By Celso de Oliveira, Sachin Tripathi, Mark Castaldi, and Ramesh Malla; Transportation Research Board (TRB) 2021 Annual Meeting/ conference (Virtual); Washington D.C.	January 25-29, 2021	Presented

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	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
Hernan Cortez		Undergraduate	Civil Eng.	Student
Andrew Schroder		Undergraduate	Civil Eng.	Student
Supporting Role				
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 (<i>Technical Champion</i>) (2) Mr. Manesh Dodia- Transportation Engineer III (<i>Technical Champion</i>)	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 (<i>Technical Champion</i>) (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		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
Warren Best, Assistant Deputy Director- Structures		Metro-North Railroad Company, Bridgeport, CT	Technical Champion
Hong McConnell, Senior Structural Engineer		Metro-North Railroad Company, Bridgeport, CT	Review work procedure for field test on bridges
Mario Pineda, Territory Manager		Polytec Inc., Hudson, MA	Part of the field test Equipment (Laser Vibrometer and Shaker) and help conducting field test
Arend Von der Lieth, Application Engineering Manager		Polytec Inc., Hudson, MA	Part of the field test Equipment (Laser Vibrometer and Shaker) and help conducting field test
Other Acknowledgements			
Dr. K. Wayne Lee, P.E. Professor and Director of URI Transportation Center	leekw@uri.edu	University of Rhode Island, Civil and Environmental Engineering, Kingstown, RI	Assisted with providing Standalone Accelerometers to evaluate the feasibility and suitability of their use in the bridge vibration monitoring
Dr. Christopher Baxter, Ph.D., P.E. Professor and Graduate Director	cbaxter@uri.edu	University of Rhode Island, Civil & Environmental Engineering and Ocean Engineering, Kingstown, RI	

Technical Champion for this project:

Name: Mr. Haresh Dholakia, P.E.

Title: Transportation Engineering Supervisor`

Organization: Connecticut Department of Transportation

Location (City & State): Newington, CT

Email Address: HareshKumar.Dholakia@CT.GOV

Name: Mr. Manesh Dodia,P.E.

Title: Transportation Engineer III

Organization: Connecticut Department of Transportation

Location (City & State): Newington, 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 research team could not proceed with the laboratory material testing in this quarterly period because of the restrictions and limitations imposed due to the Covid-19. The material test laboratory is not yet into operation, so the research team is waiting to continue with material testing after the laboratory is open for service.
- The research team has to reschedule the Devon and Cos Cob bridge field testing in two different occasions due to the weather condition and unavailability of the safety personnel.
- The equipment evaluation such as accelerometers, data acquisition system and other relevant related to the field test measurements have continued 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 January 20, 2021 and January 23, 2021, respectively.
- The research team will finalize the FE model of the Devon bridge and continue working on the FE model of the Cos Cob bridge.
- The research team is preparing to conduct Single Point Laser Vibrometer test on both the Devon and the Cos Cob bridges in April/May.
- The research team will continue to work on finding more industrial collaborators who can support research directly with the testing equipment and logistics in th.
- 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 spring 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.