Semi-Annual 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 October 01, 2018 – March 31, 2019
Date: March 31, 2019

Overview:

Overview and summary of activities performed

Research work performed over this reporting period has been aligned with Task 1 and Task 2 of the proposal. Per task 1, information relevant to this project about railroad bridges in various New England states is to be gathered and analyzed. Thus far, thorough documents detailing project objected related information about railroad bridges in Connecticut, Maine, and Vermont have been compiled from Conn DOT (2012; Maine DOT (2018); and Vermont Agency of Transportation (2014). Some of the information that has been compiled for each bridge includes the bridge structure type, the deck type, the number of tracks and spans, the length of the spans, the total length of the bridge, the year they were built, their past bridge inspection ratings, their most critical members, what type of loading this member experiences, and max load capacities. A vast majority of the bridges in New England are around 100 years old or older, and many received poor ratings during their last inspection. In many cases bridges are rated at a number that is not acceptable and they are still overdue for their next inspection.

Another major part of the research work done has been related to task 2 that relates to collecting bridge material from around New England and performing tensile and fatigue testing on coupons to determine their material properties. With the support from Metro-North Railroad Company, the first batch of available railroad member material has been collected from the Cos Cob Bridge in Greenwich, CT (built 1904; 115 years old) on March 15, 2019 from the bridge site. Two pieces of brackets from the bridge repair have been collected, each piece weighing ~200 pounds and 7 feet long. One of them is e shown in Figure 1.

Figure 1: Brackets from Cos Cob Bridge in Greenwich, CT

The research team has done significant work in literature search and review of specifications and guidelines including ASTM standards, and other published literature on preparing/fabricating and, testing material for tensile stress-strain and fatigue, and reporting the results. The research team has been working to determine the best course of action for what parameters to set for the tensile and fatigue testing for the collected bridge material specimens. The research team is preparing to prepare and test coupons from the railroad bridge members retrieved for tensile stress-strain per ASTM E8/E8M-16a (2016) and for fatigue characteristics as per ASTM E466-15 (2015).

Thorough reviews have been performed on these documents from the New England DOT websites and the ASTM websites mentioned above. In addition to the reviews of the ASTM standards mentioned above, ASTM E606/606M-12 (2012) on Strain-Controlled Fatigue Testing was reviewed and compared to ASTM E466-15 (2015). It was decided that adopting ASTM E466-15 would be more applicable for the type of testing the team is focused on. ASTM E467-14 (2014) dealing with verification of constant amplitude dynamic forces in an axial fatigue testing system and ASTME468-04 (2004) dealing with constant amplitude fatigue test results for metallic materials" were reviewed to ensure test procedures are compliant with ASTM.

How these Activities are helping achieve the overarching goal of the project

The members collected from the Cos Cob Bridge (Greenwich, CT) are made out of A7 steel which has a yield stress of about 33 ksi and an ultimate tensile strength of 60-72 ksi. The plan is to test coupons from sections that have experienced no visual degradation as well as that with degradation and rust. This should provide a baseline comparative information how one should expect railroad members in similar environments to age and degrade.

Efforts have been collaborated with Metro-North Railrpad Company in Connecticut and Maine DOT. They have agreed to provide the removed steel members from their railroad bridge repairs this coming spring 2019 for the research team's use. If trends are observed across bridges for defective parts that prove to be performing below the standard they should, then this could be information of consideration in the ultimate effort to maximize the potential of the limited number of

sensors utilized in the structural health monitoring system being established. Parameters of interest that will be analyzed include the effects of the age of the member, its geographic location, and the type and usage of the bridge on the members' stress-strain behavior and fatigue characteristics. The goal is to develop a correlation between the stress-strain behavior of members and their life cycle based on fatigue and tensile testing. Ideally one would able to observe the stress of an active member under loading and based on its stress/strain, be able to predict its life cycle.

Accomplishments achieved under the project goals…

As described in the previous section, the research team has been working on the first two tasks.

- Thorough literature reviews have been performed on the available documents from the New England DOTs websites on their railroad bridges and the specification/guidelines available on ASTM websites and publications on the material tensile and fatigue testing
- Document have been prepared with project related information about railroad bridges in Connecticut, Maine, and Vermont have been compiled from Conn DOT, Maine DOT, and Vermont Agency of Transportation.
- Bridge members recently removed from Cos Cob railroad bridge (Greenwich, CT) have been obtained and coupons are being cut from them for tensile and fatigue testing

Compiling the information about railroad bridges in New England is aligned with the project objectives/goals. It is important to know design information, bridge usage, and in what condition they are to be able to develop a methodology for continuous structural health monitoring with a limited number of sensors. Performing testing on recently retired railroad bridge members will provide information relating to the aging and degradation of members, and how their stress-strain condition is related to their fatigue life.

Opportunities for training/professional development

Since the research results are still preliminary, no training/professional development opportunities have been provided yet.

Dissemination of research results

The project is still in its initial phase. However, some of the preliminary research results were disseminated during the TIDC workshop on November 8-9, 2018 in Portsmouth, NH. Additionally, on February 28, 2019 the research team met with Conn DOT in Storrs, CT and presented on the projects and shared the information currently achieved. As more results become available, the research team aims to dissemination research results via journal and conference publications, seminars/conferences/workshop presentations, and other appropriate avenues.

Participants and Collaborators:

The main contributors to the core of this project are:

- Prof. Ramesh B. Malla, Ph.D., Principal Investigator
- Mark Castaldi, Ph.D student, Mechanical Engineering

Although not directly funded under the UTC-TIDC project due to limited funds available, the following students are receiving research and educational experience in the areas of the railroad bridge research topics related to this UTC -TIDC program under Professor Malla's supervision:

- David Jacobs, Ph.D. student, Civil / Structural Engineering working on research related to the impact factor of railroad bridges (formerly, Manager at Metro-North Railroad Company)
- Suvash Dhakal, Ph.D student, Civil/Structural Engineering working on research related to monitoring railroad bridges (also currently with A. DiCesare Associates, P.C, Bridgeport, CT.),
- Francis Almonte, Graduate Student, Materials Science & Engineering (in-charge of the Materials Science lab that will be utilized for tensile and fatigue testing)
- Stephanie Kreitler, Undergraduate Junior, Civil Engineering (independent study research on moving load analysis of a railroad bridge.)
- Sean Doolittle, Undergraduate sophomore, Chemical Eng. (Honors' project on railroad bridge truss analysis)
- Liam Gerety, Undergraduate Sophomore, Material Science and Eng. ((Honors' project on railroad bridge truss analysis)

Organizations involved as partners on this project

- Maine Department of Transportation (Maine DOT) (Contacts: Mr. Dale Peabody, Director, Transportation Research, Augusta Maine, Mr. Brian Reeves, Rail and Freight Project Manager)
- CT Department of Transportation (Conn DOT) (Contacts: Mr. Andrew Mroczkowski, TIDC Advisory Board)
- Metro-North Railroad Company (Contact: Mr. David Jacobs, formerly Manager of Metro-North)

Discussion with the following have been initiated

- Amtrak (Contact: Mr. Paul L. DelSignore, Deputy Chief Engineer-Structures, Amtrak, Philadelphia, PA)

- Providence and Worcester Railroad company (Contact: Mr. Todd Dragland, VP Engineering, GWRR NE Region, Stamford, CT)

Other collaborators or contacts

UConn's machine shop has advised on how to make coupons from the huge members collected from the Cos Cob bridge. The plan is for them to train Graduate Student, Mark Castaldi to be able to use plasma and arc cutters, manual mills and lathes and a CNC mill.

Changes:

Problems/ delays and actions/ plans to resolve

No major delays, except that occurs in any new research project and the time taken in revision and re-revision of the project proposal as required by TIDC. Mark Castaldi, Graduate student, started new in this project. It has taken some extra time to identify and obtain railroad bridge members available for the research team's use. Maine DOT and Metro-North have indicated that they have several rehabilitation projects scheduled for the upcoming months. This should yield adequate different types of bridge member materials to test.

The original proposal contained goals of studying the effects of resonance and cancellation speeds as well as some further dynamic magnification factor (DMF) investigation. Based on feedback from the proposal review team (TIDC Advisory Board, specifically Maine DOT) suggesting the investigator perform testing on existing railroad bridge material, the current Task number 2 (existing bridge material testing) was added and some of the tasks relating to resonance and DMF investigations were excluded.

Planned Activities in the Near Future:

During the next semi-annual reporting period, mainly the following research activities are planned:

1. The members collected from the Cos Cob Bridge are big members weighing ~200 pounds and 7 feet long each. So extra time, effort and steps are needed to prepare the test samples. Sections have been outlined for plasma cutting. The plan is manufacture 5 fatigue coupons and 5 tensile coupons each from i) rusted sections ii) partially rusted sections and iii) seemingly non rusted sections. After the sections are plasma cut, then the coupons will be cut and shaped by a waterjet cutter per the ASTM standards. Then tensile and fatigue testing will be performed on coupons cut from rusted sections, partially rusted sections, and non-degraded sections.
2. It has been communicated to Maine DOT and Metro-North that the research team would like to have any railroad members they remove. This arrangement will be made with other railroad lines and DOTs as needed. The research team will continue to collect recently retired railroad bridge members from around New England and test coupons to gain knowledge of their current stress-strain and fatigue conditions. This knowledge will be utilized when developing a methodology for an efficient structural health monitoring system.
3. The research team will continue to compile information about the railroad bridges of each New England state. Additionally, the research team is planning to send out a survey to the DOTs in New England for any information the research team cannot find from the customary literature search. The research team plans to request from the DOTs any field data and records of inspection and repair that they might have.

The goal is to compile as much information about the bridges in New England as possible. All of this information is of significant importance to the research team's development of an efficient continuous structural health monitoring system.

References:

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ASTM (2012). "ASTM E606/E606M-12 Standard Test Method for Strain-Controlled Fatigue Testing." ASTM International, West Conshohocken, PA, 2012, https://www.astm.org/Standards/E606 (Date Accessed: Feb. 22, 2019)

ASTM (2014). "ASTM E467-14 Standard Practice for Verification of Constant Amplitude Dynamic Forces in an Axial Fatigue Testing System." ASTM International, West Conshohocken, PA, 2014, https://www.astm.org/Standards/E467.htm (Date Accessed: Feb. 23, 2019)

ASTM (2015). "ASTM E466-15 Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials." ASTM International, West Conshohocken, PA, 2015, https://www.astm.org/Standards/E466.htm (Date Accessed: Feb. 23, 2019)

ASTM (2016), "ASTM E8/E8M-16a Standard Test Method for Tension Testing of Metallic Materials." ASTM International, West Conshohocken, PA, 2016, https://www.astm.org/Standards/E8.htm (Date Accessed: Feb. 11, 2019)

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Maine DOT (2018). "Maine Public Bridges Inventory." MaineDOT Bridge Maintenance, Augusta, ME Oct. 2018, https://www.maine.gov/mdot/bridges/ (Date Accessed: Mar. 1, 2019)

Vermont DOT (2014). "Rail Bridge Management Program." Vermont Agency of Transportation, Montpelier, VT, Version 2.2. Jun. 2014, https://vtrans.vermont.gov/sites/aot/files/rail/VTrans%20Rail%20Bridge%20Management%20Program_V2.2-sm.pdf (Date Accessed: Mar. 11, 2019)