

Bi-Monthly 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: June 01, 2019 – July 31, 2019

Date: July 31, 2019

Overview:

Overview and summary of activities performed during previous two months:

During this 2-month report period (June-July 2019), the following activities were performed and achieved;

(1) The team started off this reporting period with the preparation and presentations at the 1st annual TIDC conference at University of Maine in Orono, Maine from June 6 to June 7, 2019. At the Conference, the PI, Dr. Ramesh Malla presented an oral presentation and Graduate Assistant, Mark Castaldi a poster reporting the team's work involving testing of material from a 115-year old Cos Cob steel railroad bridge in Greenwich, CT. . They presented results from several tests obtained so far, conclusions drawn from testing, the methodology used in testing and methodology for the future work. The results were compared with the given material properties for A7 steel. The results showed that the A7 steel tested from the Cos Cob Bridge has maintained its Young's modulus, stress-strain condition before plastic deformation, and its yielding and strain hardening behavior. The team believes these results can be used as a baseline for how unstressed ~115 year old A7 steel material behaves

(2) With the help from TIDC Advisory Board member from Conn DOT, Mr. Andrew Mroczkowski, we were able to identify the Atlantic Street Railroad Bridge, Stamford, CT to collect more material samples for testing. The bridge was slated for demolition during the weekend of July 04th 2019 weekend. We decided to obtain material samples from the pier column, column header, girders, stringers, and a floor beam. Mr. Mroczkowski accompanied Graduate Assistant, Mark Castaldi to the construction site where they marked the members they wanted material samples. The material samples have been taken to the Conn DOT yard in Bridgeport, CT for cleaning.

(3) The team then had a productive meeting with 8 engineers from Connecticut Department of Transportation (Conn DOT) on June 28, 2019. The attendees from Conn DOT were several experts from the Bureau of Public Transportation, Office of Rail and others, including John Bernick, Assistant Rail Administrator; Edgardo Block, Manager, Research; Andrew Mroczkowski, TIDC Advisory Board member from Conn DOT; and other subject matter experts from the railroad division in attendance included Transportation Principal Engineer Jayantha Mather, Transportation Principal Engineer Richard Unkel, Transportation Supervising Engineer Rodney Armsrong Transportation Engineering Supervisor Haresh Dholakia, Transportation Engineer III Manesh Dodia, and others. This meeting truly opened up communication with Conn DOT and they are all aware of the focus of the research is to make the research outcome as valuable as possible for DOTs. It was decided that Mr. Haresh Dholakia from Rail bridge design and Mr. Manesh Dodia from field construction serve as the day to day contact and champion from Conn DOT for the project. .

(4) The research team needed to solve the issue of removing/abating lead paint from the old railroad bridge material being collected before bringing to the university campus. The team has had a substantial amount of communication for several weeks with the UConn Environmental Health and Safety (EHS) Department, ConnDOT, ATANE (contracted company for bridge demolition and replacement), and Metro-North Railroad Co. (MNRR) to solve the issue of older Railroad Bridges having lead paint on them. Our discussions and strong relationships with these groups resulted in MNRR generously offering to perform the lead paint abatement on all of the material we currently have.

(5) The current focus of the team's research continues to be evaluating the material properties of existing, old railroad bridge steel and trying to develop methodologies to relate fatigue to the aging of the members and any degradation of material properties such as Young's Modulus (higher observed strain for the same load).

- The team hopes to develop a methodology for determining remaining life of the whole bridge and its individual members based on observed (ni/Ni) ratios (accumulated fatigue at some stress level/total fatigue life at that stress level). Results from material testing will be used to determine if there is a relation between (ni/Ni) ratios at other stress levels. If this relation is empirically determined, then it is possible to test for a ni (to failure)/Ni ratio to obtain the remaining life ratio, and solve for what the remaining life of ni would be for another stress level (i.e. the stresses observed through field testing)
- Thorough literature reviews have been studied relating to fatigue evaluation of steel structures.
 - Miner’s rule is the most used tool for determining accumulated damage. Equations developed for evaluating different categories of member types are widely used. AASHTO detail category S-N plots have been studied. AREMA does not have S-N plots for their detail categories.
 - Using the AASHTO constants and the relevant equations, it is possible to determine an effective stress range for a variable amplitude stress range histogram (Kashefi, 2010).
 - Additional equations for calculating remaining life based on the material’s existing properties such as ultimate tensile strength and endurance strength (stress limit at which infinite life is assigned) were studied as well. (Yilmaz, lecture chapter 2_6 Fatigue).

(6) The team has developed a number of planned tests to investigate the relations mentioned. The team is especially interested in how unstressed material’s fatigue life compares to that estimated by Miner’s Rule/S-N curve/AASHTO equations. Methods for determining and evaluating variable amplitude stress spectrum histograms have been previously researched (Morales, 2006). These methods generally require the evaluation of the current stresses incurred by the bridge’s current loading condition and using either Rainflow Counting Method or an effective stress range approach along with an estimate of traffic history to determine the accumulated fatigue.

(7) The team is currently waiting for material to be lead-paint abated.

- The team was able to go to the Atlantic Street Bridge in Stamford, CT and collected the material samples to be tested (Figure 1).
- The contracted construction company, ATANE, was kind enough to cut plates out of the webs of the members that can be used for testing. The member types include girders, stringers, a floor beam, a pier column, and a column header. A picture showing a girder that we marked for testing is shown in Figure 2. The team has saved pictures of each marked member for reference. Testing of the pier column and column header may reveal how effectively the bridge bearing was able to mitigate stresses.
- This material from the Atlantic Street Bridge in Stamford, material from the Cos Cob Bridge in Greenwich, and material from Devon Bridge (Stratford to Milford) are awaiting lead paint abatement at Metro-North’s Construction Yard in Bridgeport.

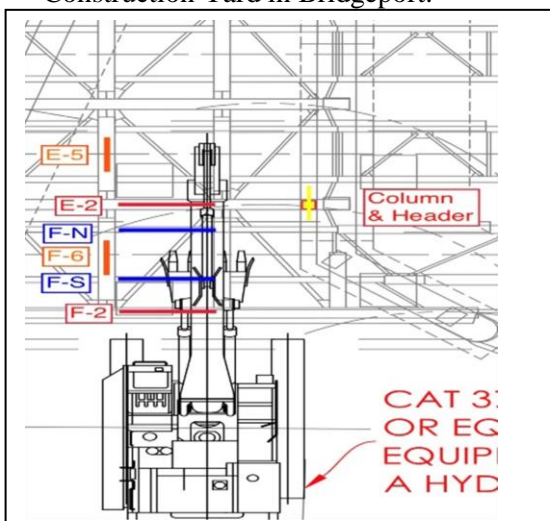


Figure 1: Atlantic Street Bridge Collected Material Locations

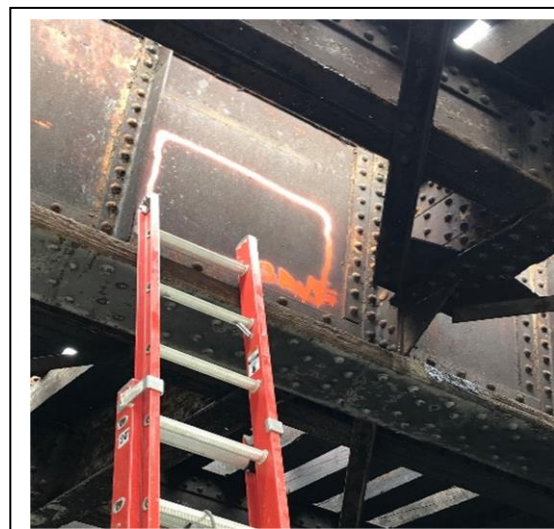


Figure 2: Atlantic Street Bridge Marked Girder Material

(8) Besides Connecticut DOT, the research team has written to other New England state DOTs requesting steel railroad bridge materials from their states for testing. They are in communication with them to obtain materials:

- Maine Department of Transportation (Contacts: Mr. Dale Peabody, Chari TIDC Advisory Board, and Mr. Brian Reeves, Director, Rail Transportation)
- Massachusetts Department of Transportation (Contact: Mr. Brian Clang, TIDC Advisory Board, State Bridge Inspection Engineer)
- New Hampshire Department of Transportation (Contact: Mr. Robert Landry, TIDC Advisory Board, Bridge Design Administrator)
- Rhode Island Department of Transportation (Contact: Dr. Kate Wilson, TIDC Advisory Board, Principal Engineer)
- Vermont Agency of Transportation (Contact: Dr. Emily Parkany, Ph.D., P.E., TIDC Advisory Board, Research Manager)

Delays experienced during reporting period:

The team spent about 3 weeks communicating with EHS at UConn and reviewing the standards and regulations required by OSHA and the EPA. Graduate Student Mark Castaldi had planned to do the lead paint abatement. However, the environmental controls and monitoring along with the human monitoring required is outside of the team's budget and is not practical for the amount of lead paint they will be needing to remove. After much discussion with EHS, ConnDOT, and MNRR, it was decided that MNRR would generously perform the lead paint abatement for all of the available material. The Cos Cob Bridge members were taken from the university to the Bridgeport MNRR construction yard along with the material from the Atlantic Street Bridge construction site in Stamford.

How these activities are helping to achieve the overarching goal of the projects:

- The team is close to getting a lot of lead-free material samples back from MNRR.
- The team has strengthened the collaboration with Conn DOT, MNRR, and ATANE which will be very valuable as we continue to try to collect material.
- The team has planned a number of tests focusing on developing relations through testing and statistical analysis. Most of the railroad bridges that the team will study are at least 100 years old. Thus most of them will be made from A7 steel. Gaining reliable, consistent, baseline test results from the Cos Cob Bridge foot bridge braces is valuable because this material can be treated as an unstressed material to compare stressed material even from other bridges. An unstressed material from the Atlantic Street Bridge (built 1896) should have nearly the same fatigue life as an unstressed member from Cos Cob (1904) or Devon (1905). Thus they would have the same (Ni) if we test the fatigue life of a girder from Atlantic Street bridge and determine its number of cycles to failure (ni); then we will have a (ni/Ni) remaining life ratio. The team is expecting this (ni/Ni) can be related to (ni/Ni) at other stress levels. Also, the middle of the girder being one of the most stressed areas on the bridge, we can confidently assign a remaining life to the bridge based on the fatigue behavior of that girder.

Accomplishments achieved under the project goals:

- A closer working relationship with the Conn DOT has been develop to make sure that the work preformed under the project will be of much value to the state DOTs.
- The team has strengthened the collaboration with the biggest transportation construction agencies in Connecticut.
- The team has reached out to the other DOTs in New England requesting bridge material and looked forward to collaborate with them as well. Some of the TIDC advisory board members who work for the state DOTs have already responded and it is apparent that the team will have opportunities for acquiring more material samples from other states.
- Additional railroad bridge material samples are being collected

Opportunities for training/professional development that have been provided:

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

Activities involving the dissemination of research results:

The research team accomplished dissemination of research results through several avenues during this reporting period.

(a) Conference Presentation and attendance:

- PI Dr. Ramesh B. Malla presented an oral presentation titled “Condition/Health Monitoring of Railroad Bridges for Structural Safety, Integrity, and Durability at the TIDC conference at University of Maine from June 6, 2019 to June 7, 2019.
- Graduate Student Mark Castaldi presented a poster titled “Material Testing of 115 Year old Steel from Cos Cob Railroad Bridge in Greenwich, CT” at the TIDC conference at University of Maine.
- PI Dr. Ramesh B. Malla gave a presentation as a Keynote Lecture at the 12th ASNEngr Annual Conference in Chicago, July 27-29, 2019. The title of the presentation is “Response Monitoring of a Very Old Truss Railroad Bridge for High Speed Trains.”
- PI, Dr. Malla attended the ASCE Engineering Mechanics Institute (EMI) Conference held at the California Institute of Technology (Caltech), Pasadena, CA during June 18-21, 2019. This conference is held every year and is internationally prominent and highly respected conference that has many technical sessions related to transportation infrastructure areas. The PI learn from others as well as share his own knowledge on the current state-of-the-art knowledge and technology, know-how and current trend that have direct impact and benefits to the UTC-TIDC project topics at UConn.
- Dr. Malla also attended the 2019 Northeast Connected and Automated Vehicle (NECAV) Summit held in Hartford, CT; July 12-13, 2019. He had discussion with the Commissioner of Connecticut DOT, Mr. Joseph Giulletti, several engineers from DOTs, and industry personnel about the UTC-TIDC projects and had opportunity to learn about the current needs in this area that will help strengthen the practical application the projects done at UConn under TIDC.

(b) Peer reviewed Journal Publication:

Research team member David Jacobs and PI Dr. Ramesh B. Malla, who have been studying impact factors of railroad bridges and the potential of allowing high speed trains to travel on the existing bridges in the New England area, have published the following peer reviewed paper in the International Journal of Rail Transportation:

Jacobs, W. and Malla, R. B. (2019) On live load impact factors for railroad bridges, International Journal of Rail Transportation, DOI: [10.1080/23248378.2019.1604182](https://doi.org/10.1080/23248378.2019.1604182)

(c) Meeting with DOT:

Results, conclusions, advanced methodologies, and future activities were discussed with Conn DOT on June 28, 2019 during a meeting with the Rail Division. As mentioned, the Conn DOT team made suggestions for specific focuses in material testing such as testing material around bridge bearings. The Conn DOT team also worked with the research team to address the lead paint issue.

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, the following students are receiving research and educational experience in the areas of the railroad bridge research 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 (Custodian of the Materials Science lab that has been utilized for tensile and fatigue testing)
- Stephanie Kreitler, Undergraduate Junior, Civil Engineering (independent research study on moving load analysis of a railroad bridge.)

Organizations involved as partners on this project

- CT Department of Transportation (Conn DOT) (Contacts: Mr. Andrew Mroczkowski, TIDC Advisory Board, Transportation Engineer III; Mr. Haresh Dholakia, Transportation Engineering Supervisor; Mr. Manesh Dodia, Transportation Engineer III; Mr. Edgardo Block, Manager, Research unit; John Bernick, Assistant Rail Administrator)

- Maine Department of Transportation (Maine DOT) (Contacts: Mr. Dale Peabody, Director, Transportation Research, Augusta, Maine, and Mr. Brian Reeves, Director, Rail Transportation)
- Metro-North Railroad Company (Contact: Warren Best, P.E., Assistant Deputy Director-Structures, Mr. Nick Watert, Engineering Supervisor- Structures)
- ATANE Consulting (Contacts: Mr. Kevin Conroy, P.E.)
- The research team is also currently in communications and is collaborating with all other New England DOT to acquire steel bridge material for testing through the respective TIDC Advisory Board representatives:
 - Vermont Agency of Transportation (Contact: Dr. Emily Parkany, Ph.D., P.E., TIDC Advisory Board, Research Manager)
 - Rhode Island Department of Transportation (Contact: Dr. Kate Wilson, TIDC Advisory Board, Principal Engineer)
 - New Hampshire Department of Transportation (Contact: Mr. Robert Landry, TIDC Advisory Board, Bridge Design Administrator)
 - Massachusetts Department of Transportation (Contact: Mr. Brian Clang, TIDC Advisory Board, State Bridge Inspection Engineer)

Planned Activities:

Description of future activities over the coming months.

- The team will continue to collect railroad bridge material as it becomes available and procure coupons for testing.
- The team will perform combinations of tensile and fatigue testing aimed at developing relationships between fatigue and observed changes in material properties.
- Existing fatigue evaluation methods from AASHTO equations and Miner's Law will be compared to observe fatigue life from testing.
- Rainflow counting methods will be compared to effective stress range calculation methods
- (ni/Ni) ratio will be studied.
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References:

- 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)
- ASTM (2017), "ASTM E1049-85 Standard Practices for Cycle Counting in Fatigue Analysis." ASTM International, West Conshohocken, PA, 2017, <https://www.astm.org/Standards/E1049> (Date Accessed: May 7, 2019)
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- Morales, M., and Bauer, D. (2006). "Fatigue and Remaining Life Assessment of Steel Bridges More Than 50 Years Old." *The International Conference on Short & Medium Span Bridges*, 7, 1–9.
- Yilmaz, İ. H., Duyura, and Dosya. (n.d.). "Fatigue Life." *ME215_6B Fatigue Life*, Adana BTU, <https://web.adanabtu.edu.tr/Files/iyilmaz/Duyuru/dosya/ME 207 – Chapter 6 P2.pdf> (Date Accessed: Jun. 13, 2019).