Semi-Annual Progress Report

TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

Project Number and Title: 1.1 Field Live Load Testing and Advanced Analysis of Concrete T-Beam Bridges to Extend Service Life
Research Area: Thrust Area 1
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Co-PI(s):
Reporting Period: 8/1/2018 – 3/31/2019
Date: 3/31/2019

Overview:

Provide overview and summary of activities performed during previous two months….

During the previous months, significant progress has been made toward the completion of the three tasks encompassing this project:

Task 1: Five skewed, reinforced concrete T-beam bridges were live-load tested under high levels of loading in August, 2018 (see Figure 1). This produced data which were used to assess these bridge's actual live-load capacities, which resulted in increasing HL-93 operating flexural rating factors to greater than 1.0 for three of the five bridges. Rating factors were increased significantly for the remaining two bridges.

Figure 1: *Skewed T-Beam Bridge Live-Load Testing*

Task 2: Detailed, linear finite element (FE) models were constructed for the purpose of investigating the phenomena behind the data recorded during live-load testing. This involved creating a base model of each bridge (Figure 2), applying loading equivalent to that used during testing, comparing the structural response of the model with that recorded on the actual bridges, and systematically modifying model parameters to bring their responses closer to the field-recorded response. For each bridge, a base model has been built, live-loading applied, and initial analyses performed. In addition, the process of model updating to better match field live-load testing has begun.

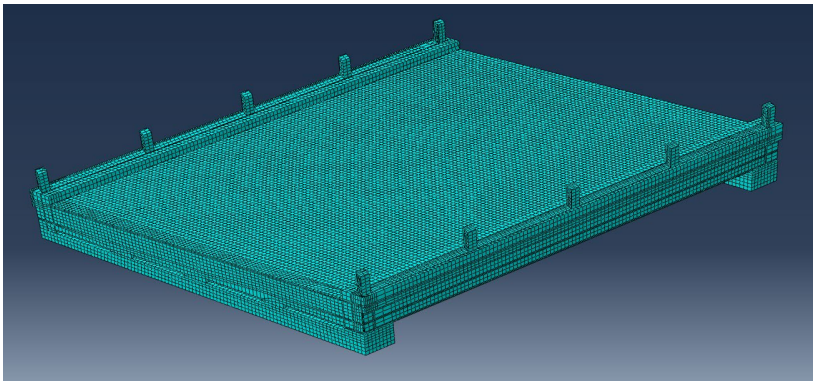

Figure 2: *Linear Base FE Model*

Task 3: A novel advanced FE modeling strategy has been developed (and remains under continued development) for analysis of bridges up to failure and including steel yielding and concrete cracking. This nonlinear modeling technique condenses the complicated, 3D constitutive behavior of reinforced T-beams into a collection of elastic and elastic-plastic materials that are straightforward to implement with FE software while realistically capturing girder ductility and load redistribution in the 3D structure. This strategy is continuing to be developed with emphasis on streamlining the modeling process and ensuring its applicability to skewed bridges.

Provide context as to how these activities are helping achieve the overarching goal of the project…
The previously described activities are in direct support of the project's overarching goal of extending the service life of existing concrete bridges. Through live-load testing, three of the five tested bridges had their live-load rating factors raised to above 1.0, indicating their ability to carry modern loading without repair. Linear FE modeling has laid groundwork for examining the differences in response between right bridges and skewed bridges possibly revealing either positive or negative effects skewness has on live-load capacity. Development of a nonlinear FE modeling strategy will lead to a useful tool for accurate live-load capacity assessment of other reinforced concrete T-beam bridges.

Describe and accomplishment achieved under the project goals…
The following are direct accomplishments under the three tasks listed in the project scope:

Task 1: Five skewed reinforced concrete T-beam bridges were tested under significant levels of live load.
Task 2: 3D FE models were built and are in development.
Task 3: A novel, nonlinear FE strategy has been developed and is currently being extended and improved.

Describe any opportunities for training/professional development that have been provided…
No significant opportunities for training or professional development have occurred as a direct result of the project within the current reporting time-frame.

Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period)…
The results of Task 1 (live-load testing and rating factor updating) have been drafted into a report for the Maine Department of Transportation (MaineDOT). This report recommends loosening the restriction of live-loads on three of the five bridges tested. In addition, a journal article describing much of the development of the nonlinear FE modeling technique developed through Task 3 has been submitted and is currently under review.

Participants and Collaborators:

What organizations have been involved as partners on this project?
MaineDOT has been a collaborating partner in many of the aspects of this project, in particular Task 1 in which MaineDOT equipment and personnel assisted in performing live-load testing.

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Have other collaborators or contacts been involved? If so, who and how?
No other collaborators have been contacted.

What students have participated in the project? (Include class standing, major, role in the research)
Two students, one undergraduate and one graduate, have participated in the project. The undergraduate, a Senior in Civil Engineering assisted in live-load testing. The graduate student, a M.S. student in Civil Engineering, managed and performed live-load testing, analyzed the resulting data, using it to update bridge rating factors, created and began further development of linear FE models, and developed the advanced nonlinear FE modeling technique.

Changes:

Discuss any actual or anticipated problems or delays and actions or plans to resolve them…

Two significant problems have arisen for which solutions are currently being pursued. First, during the course of live-load testing, three of the 24 reusable strain transducers used to monitor bridge response failed. This required amendments to be made to the original instrumentation plans to record all required data, as well as ordering replacements. Second, the recorded data indicated significant girder end restraint on four of the tested bridges, which was not present in the previously investigated un-skewed bridges. This has required significant additional development of the linear FE models not initially anticipated based on modeling of the previous bridges.

Discuss and changes in approach and the reasons for the change…
No major changes to approach have been required.

Planned Activities:

Description of future activities over the coming months.
Over the next few months, the following activities will occur:

- Development of the linear FE models will continue to the point that reasonable agreement between their results and field testing is achieved
- Results of live-load testing and linear FE analysis for skewed and un-skewed bridges will be compared to assess the significance of skew
- The nonlinear FE modeling technique will continue to be developed with the goal of streamlining and simplifying implementation and allowing for analysis of skewed bridges