Semi-Annual Progress Report

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
PI: W. Davids, UMaine
Co-PI(s): (N/A)
Reporting Period: 4/1/2019 – 9/30/2019
Date: 9/30/2019

Overview: (Please answer each question individually)

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

During the previous months, significant progress has been made toward the completion of the two remaining tasks (Tasks 2 and 3) encompassing this project.

Task 2: Data recorded during live-load testing of skewed T-beam bridges (Task 1) has been analyzed and compared with the results of similar previous testing on un-skewed T-beam bridges. This has resulted in the identification of specific ways in which the behaviors of these bridges differ. Specifically, it has been observed from strain data recorded in individual girders at midspan that skewed bridges tend to distribute load much less evenly than un-skewed bridges, leading to higher concentrations of recorded strain in the vicinity of an applied load than at points distant from load application. In addition, relatively large negative strains were recorded at the ends of girders from skewed bridges that were not present on un-skewed bridges. This indicates that skewed bridges have a higher tendency to exhibit unintended support fixity than similar un-skewed bridges. These hypotheses are supported with the results of field-updated, linear finite element models of each bridge, which show similar patterns of load distribution and indicate torsional displacements of skewed bridges that could lead to apparent support fixity.

Task 3: Development of the novel, advanced FE modeling strategy developed to determine T-beam bridge capacity has continued. The technique has been shown to be effective in determining skewed T-beam bridge capacity with similarly accurate results as for un-skewed bridges and has been used to load-rate the skewed bridges tested as part of Task 1. The technique has also been used to simulate previously performed, full-scale destructive tests of both a T-beam bridge and prestressed I-girder bridge (Burdette and Goodpasture 1971), both with good results. Plots comparing the reported and predicted load-deflection behavior of both bridges are seen in Figure 1.

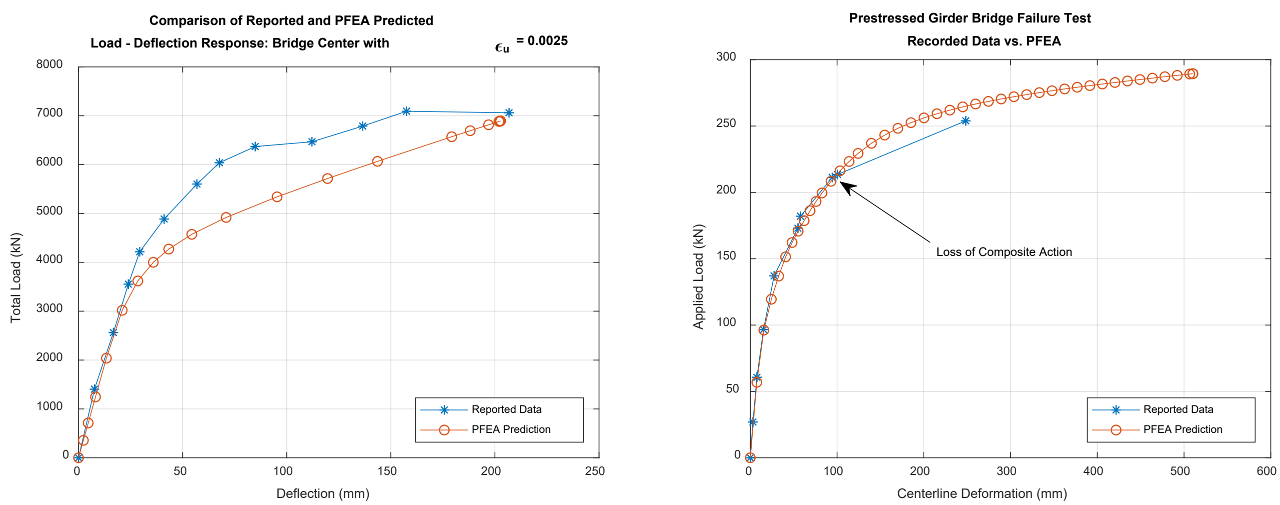

Figure 1: *Load-Deflection Prediction by Finite Element Analysis*

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. Comparative analysis of data recorded while live-load testing both skewed and un-skewed bridges has led to the identification of behaviors that differ between the two classes of bridge which, due to their otherwise similar geometric and material design, are most easily attributed to the inclusion of skew. The results of linear finite element analyses have provided additional confidence that these differences are indeed due to skew. This knowledge can be used to better inform decisions on maintenance and capacity rating for skewed bridges as compared with similar un-skewed bridges, such that their service life can be improved. Further development and testing of the novel finite element analysis technique has led to additional utility of the technique for load-rating T-beam bridges and other types of bridges, and additional confidence of the technique's veracity has been provided my simulating previous full-scale bridge tests to failure. This confidence will lead to the ability to determine bridge's capacity much more accurately with the use of this tool.

Describe any accomplishments achieved under the project goals…

The following are direct accomplishments under the two remaining tasks listed in the project scope:

Task 2: Comparative analysis of strain data recorded during live-load testing of skewed and un-skewed bridges has led to the identification of specific behaviors where these bridges differ. Linear, 3D finite element analysis has provided further evidence that these differences are indeed due to the presence of skew.
Task 3: The novel, nonlinear FE strategy has been further developed to handle the capacity rating of skewed T-beam bridges, as well as prestressed concrete girder bridges. The accuracy of the technique has also been demonstrated by simulating real tests of two bridges up to failure.

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)…

During the reporting period, the results of Tasks 1 and 3 (up to the date of presentation) were presented at both the UMaine Student Research Symposium and Transportation Infrastructure Durability Center Annual Conference, where they were available to the engineering community and general public, and were also displayed internally as part of the Advanced Structures and Composites Center's annual research poster competition. The development of the novel FE analysis technique has also been described in a journal article which has been submitted and is currently under review. An abstract has been accepted for presentation at the ASCE Structures Congress in St. Louis in April, 2020.

Participants and Collaborators:

List all individuals who have worked on the project.

Dr. William Davids, UMaine (Project PI)
Andrew Schanck, UMaine
Joshua Clarke, UMaine
Scott Tomlinson, UMaine
Garrett Kilfoyle, MaineDOT (Project Technical Champion)
Sam Maxim, Maine DOT
MaineDOT Bridge Maintenance Personnel

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List all students who have participated in the project. (Include name, email address, class standing, major, and role in the research)

Two students, one undergraduate and one graduate, have participated in the project. The undergraduate, Joshua Clark (joshua.e.clarke@maine.edu) a Senior in Civil Engineering assisted in live-load testing. The graduate student, Andrew Schanck (amdrew.schanck@maine.edu) a Ph.D. 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.

What organizations have been involved as partners on this project? What was their role?

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.

Have other collaborators or contacts been involved? If so, who and how?

No other collaborators have been contacted.

Changes:

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

A mistake in the formulation of the novel, FE analysis technique was identified which required changes. However, these changes have been made and require no additional action to resolve. The mistake caused previous results to be on the conservative side. Dissemination of results from the point of problem resolution have reflected these changes.

Discuss any changes in approach and the reasons for the change…

NA.

Planned Activities:

Description of future activities over the coming months.

Over the next few months, the following activities will occur:

- A report on the results of Task 2 and the current status of Task 3 will be drafted and delivered to MaineDOT
- The novel, advanced FEA technique will continue to be developed. Potential next steps will be expansion to additional types of slab-on-girder bridge and/or continuous bridges.
- The additional development of the advanced FEA technique to this point and beyond will be disseminated to the greater engineering and academic community.

Burdette and Goodpasture. (1971). *Final Report of Full-Scale Bridge Testing*. University of Tennessee, Knoxville, TN.