Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Low-Cost Modal Identification Sensors for Bridge Field Testing

Research Objectives

This project had one overarching objective: to provide a framework for experimental load rating of bridges via inclusion of low-cost vibration sensors and dynamic tests. More specifically, this project aimed to:

- examine and select cost-effective dynamic sensors for use during field tests;
- develop cost effective procedures for modal identification of bridges in Nebraska that will make experimental load rating more viable for owners; and
- develop protocols for performing bridge load tests that will potentially require limited traffic disruption.

Research Benefits

As mentioned earlier, currently 25% of bridges in Nebraska are posted for live load. About 99% of US bridges were posted using engineering judgement and/or simplified numerical analyses. To improve traffic flow, bridge owners need to decide to remediate a posted bridge via (i) rehabilitation, (ii) replacement, or (iii) other methods that can prove that sufficient additional capacity exists, with the most prevalent method being completion of a field test. Given that field tests can be costly the primary benefit of this project is reducing experimental load rating cost without sacrificing accuracy. This, in turn, facilitates data-enabled decision making for many bridge owners and improves bridge management and resource allocation. Development of the proposed framework also had the potential to be directly integrated into existing or new bridge health monitoring systems.

Principal Investigator

Daniel Linzell (P.I.)
Samira Ardani (Co P.I.)
Saeed Eftekhar (Co P.I.)
University of Nebraska

NDOT Lead TAC Member

Fouad Jaber, PE, Assistant State Bridge Engineer

Background

This project sought to provide a framework for experimental load rating of bridges via use of low-cost vibration sensors for dynamic testing. Currently 25% of bridges in Nebraska are posted for live load. According to National Bridge Inventory in 2012, of all posted bridges in the US, 93% were posted using analytical load ratings, 7% were posted using field evaluation and engineering judgement, and only 1% were posted using experimental load rating methods.

Instrumentation costs and traffic interruptions can be problematic when load testing is necessary to accurately assess in-situ bridge live load capacity. Recent advances in (i) sensing technology and (ii) numerical methods used to process load test data permit more cost-effective data-enabled decision making. According to the AASHTO Manual for Bridge Evaluation (MBE), vibration tests can be used for calibration of bridge numerical models and would enhance the value of a diagnostic test.

This study aimed to develop a procedure for selection and use of inexpensive, off the shelf vibration sensors for dynamic testing of typical bridges in Nebraska.

Conclusion

This report provided a framework for experimental load rating of bridges via inclusion of low-cost dynamic sensors and dynamic tests. Currently 25% of the bridges in Nebraska are posted for live load. According to the National Bridge Inventory (NBI) in 2012, 93% of all postings in the US were based analytical load ratings, 7% were posted using field evaluation and engineering judgement, and 1% were posted using experimental load rating methods.

Instrumentation costs and traffic interruptions can be problematic when load testing is necessary to accurately assess in-situ bridge live load capacity. Recent advances in (i) sensing technology and (ii) numerical methods used to process test data permit more cost-effective data-enabled decision making. According to the AASHTO Manual for Bridge Evaluation (MBE), dynamic tests can be used for calibration of bridge numerical models which could enhance the value of a diagnostic load test. This project helps engineers select and use inexpensive, off the shelf dynamic sensors for dynamic testing and load rating of bridges in Nebraska and elsewhere.

To help identify low-cost dynamic sensors suitable for Operational Modal Analysis (OMA), a set of bridges featuring various construction materials, span lengths, and structural systems were selected for vibration tests. Via tests conducted on the bridges, two low-cost sensors were down selected from five initial candidates. To ensure applicability of vibration tests to perform experimental load ratings, bridges were chosen as test beds for conducting vibration-based load ratings under operational conditions with results compared to data produced from strain measurements from controlled live load testing using. It was shown that vibration tests conducted using low-cost sensors and OMA can help engineers accurately complete bridge load ratings.

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Interested in finding out more?
Final report is available at:
NDOT Research Website

NDOT Recommendations Based Off of Research Project

This research proved the feasibility of using Low-Cost Modal Identification Sensors for Bridge Field Testing. When fully investigated, Bridge Engineers will use this research as alternate screening method of potentially for field Assessment as more economical method of traditional field sensors, such as:

1. 2019 Flood extreme events, the Low-Cost Modal Identification Sensors will assist the Engineers to assess the substructure condition, without the risk of underwater inspections. So then, the owners can open the bridge to the public without closing the structures for further assessment and delay.
2. Asses the capacity of bridges without plans.

- *As provided by Fouad Jaber, Lead TAC Member*

Research Readiness Level (RRL) Assessment

Level : Proof of Concept

RRL 2

Technology Transfer

Principal Investigator does not have any technology transfer for this research project at this time.

This brief summarizes Project SPR-P1 (20) M105
"Low-Cost Modal Identification Sensors for Bridge Field Testing"
Nebraska Department of Transportation Research Program