MPC-512
June 16, 2106

Project Title:
Pre-stress Losses and Development of Short-Term Data Acquisition System for Bridge Monitoring

University:
Utah State University

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Research Needs:

As a national trend, DOTs are faced with difficult financial decisions. The age of the infrastructure is increasing and deteriorating, needing maintenance and in some cases replacement. This does not include the additional needs of infrastructure expansion due to the population increasing. However, there simply is not enough money available to meet the required needs. As a result, judicious decisions need to be made based on accurate assessment of bridge performance.

Bridge performance is dependent on many factors and therefore is often different than the assumed designed behavior. Factors such as prestress losses, loading frequency and magnitude, load distribution, support conditions and environment are critical variables that can lead to changes in bridge performance.

The appropriateness of applying current design methods to calculate prestress losses needs to be evaluated. For example, elastic shortening and creep are two major components of the total prestress loss. With higher strength concretes available today, girders will almost certainly be more highly stressed than one made with conventional concrete, the magnitude of those loss components will probably increase. It is unknown whether this difference in prestress loss is adequately taken into account by present methods of analysis. In response to these concerns, several research projects have been performed in order to quantify the response of prestress concrete girder bridges fabricated with high performance concrete. Ahlborn et al. (1995) compared the AASHTO LRFD design provisions with the measured response of two long-span, high-strength composite prestressed bridge girders. They found that the design specifications overestimated the high-strength concrete modulus of elasticity resulting in under predicted elastic shortening losses and over predicted the creep and shrinkage losses. Roller et al. (1995) performed an experimental investigation with four high strength concrete bridge

girders. Two of the girders were used to evaluate the early-age flexural properties and the remaining two were used to determine the long-term behavior. The researchers concluded that prestress concrete girders made with high strength concrete can be expected to adequately perform if designed according to the AASHTO Standard Specifications. Kowalsky et al. (2001) instrumented four prestress high-performance concrete bridge girders in North Carolina. These researchers found that the elastic shortening and creep losses were major contributors to the total losses with shrinkage losses much less so. The larger than expected elastic shortening and creep losses were attributed to a lower modulus of elasticity than predicted. The total prestress losses ranged from 12.9% to 19.1% of the initial jacking stress. Other prestress loss bridge research can be found in Shams and Kahn (2000), Lopez et al. (2003) and Waldron (2004).

This second focus of the proposed research will be to obtain the critical bridge live load performance factors by developing a self contained, rapidly deployable data acquisition system that can be applied to a bridge and and monitor the required data. It is proposed that this system will be deployed on a bridge in northern Utah. The data gathered from this system will be compared with assumed design parameters. This information can aid engineers in determining actual bridge behavior. This information can aid in bridge maintenance and replacement decisions.

This research will work with two leading companies, Campbell Scientific and Bridge Diagnostic Inc. to obtain high-quality data to address these uncertainties in bridge behavior.

Research Objectives:

The focus of this research will be on two primary objectives:

1. Quantifying the prestress losses of a precast, prestressed concrete bridge made with deck bulb tee girders. The measured prestress losses will be compared with predictive methods that are recommended in the AASHTO LRFD Specifications.
2. Additionally the research will help to develop a self contained, structural health monitoring system that monitors critical bridge behavior over a short-term period. This system will not require external power or hard line communications. It will also obtain the required bridge performance data using a minimum number of sensors.

Research Methods:

The methodology that will be used for this project will be focused on measurements data from a prestressed concrete bridge. The bridge is located in northern Utah. Working with Campbell Scientific Inc., long-term instrumentation will be installed to monitor changes in strain at the centroid of the prestressing strand for and exterior and interior girder. These strain measurements will be used to calculate changes in prestressing force from casting through approximately the first two years of the service life of the bridge. The influence of deck casting and service conditions will be evaluated. The data will be used to compare with prestress loss recommendations in the AASHTO LRFD Specifications.

In addition to the quantifying prestress losses, researchers will work with Bridge Diagnostic Inc. on the development of a short term data acquisition system. This system will focus on quantifying bridge response due to live load, both in terms of changes in strain and dynamic

response, over a period of one week. This data acquisition system can help engineers with load rating and bridge management decisions.

Expected Outcomes:
The expected outcome of the research will be: 1) high quality data set of changes in prestress losses of precast, prestressed concrete bridge girders over an extended period of time, 2) comparison of measure and predicted bridge prestress values, 3) evaluation of the accuracy of the current AASHTO LRFD Methodology for predicting prestress losses and 4) the development of a short term data acquisition system that can aid state DOTs to effectively and economically determining the behavior of in-situ bridges.

Relevance to Strategic Goals:
This research will contribute in the strategic goal of State of Good Repair. An accurate understanding of the long-term performance of the bridge inventory in the United States is critical as available funding is insufficient to address all the present needs. Improved design methodologies in the AASHTO LRFD will also improve bridge performance. This research will address prestress loss calculations and bridge response due to live load. These are two critical design parameters.

Educational Benefits:
It is anticipated that one MS student will be employed on the project and an undergraduate will assist on an hourly basis. This research will also be incorporated into the Bridge Design Class I teach at USU.

Work Plan: The proposed research will be conducted in a period of 27 months with a starting date of May 1, 2016, and an ending date of July 31, 2018. Tasks will be carried out according to the following schedule:

Task	**Duration**
Literature Review	2 months
Prestress-Loss Data Instrumentation and Collection	16 months
Short-term Instrument preparation	4 month
Short-term Instrumentation of Bridge	1 month
Data Collection and Analysis	8 months
Effect on Design	3 months
Report Writing	3 months

- Note that several of these tasks will be conducted in parallel

Project Cost:
Total Project Costs: $220,181
MPC Funds Requested: $ 110,071
Matching Funds: $ 110,110 Source of Matching Funds: LTAP

TRB Keywords:
Bridges, Prestressed Concrete, losses, AASHTO LRFD, Data Acquisition

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