RUTGERS
Center for Advanced Infrastructure and Transportation

Project Overview Report

1. UTC Identifying Number

   DTRT13-G-UTC28

2. Center Identifying Number

   CAIT-UTC-NC39

3. Project Title

   Development of a Robust Framework for Assessing Bridge Performance using a Multiple Model Approach

4. Principal Investigator & Contact Information

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7. Project Description

   While there is consensus among stakeholders (FHWA, State DOT's, Academia, Industry) that better data on bridge performance is required, there is limited infrastructure in place to make the best possible use of the data. This is a considerable threat to the success and existence of the shift towards data-driven approaches. Data without a plan for extracting value quickly becomes a burden. One technique commonly used for deterioration modeling is to use non physics-based models to predict performance based on existing data. Each empirical model form (e.g., Markov chain, Artificial Neural Networks, etc.) comes with a particular set of strengths, weaknesses, biases and assumptions. Unfortunately, there is a lack of consensus on the best applications of model forms, or even a framework to select and use models. Beyond that, the complexity of influences on bridge performance make it very difficult to identify causal relationships between observable behavior and driving factors.

   The primary goal of this research is to establish a robust, flexible framework for integrating quantitative data collected from operating structures to provide reliable performance assessments and forecast remaining service life (i.e., descriptive relationships) for structures. This research will address the problem of model selection for bridge performance data through a multiple model framework that accounts for various model approaches, as opposed to excluding them. Over time, the proposed framework may be a viable approach for identifying causal relationships of bridge attributes and inputs to bridge performance.

   The proposed research will achieve the stated goal through investigating varying parameter sets within a given model form, as well as multiple model forms, and looking at the ability of the model(s) to predict bridge performance. This will help to address the gap between what is observable (i.e., condition, nondestructive evaluation, member actions, global movements, etc) and what is desired (i.e., capacity, remaining service life, etc). Each model or set of models will be updated based on the observations using a Bayesian model updating approach. For multiple model forms, a set of mathematical rules must be implemented to move between model forms. The process will implicitly weigh model forms and

parameter sets that are better predictors of the observed responses. From this population of multiple models, unobservable characteristics (like estimates of remaining service life) can be predicted in a probabilistic sense.

8. Implementation of Research Outcomes (or why not implemented)

   The proposed framework will be valuable not only for management decision-making for bridge owners at the state DOT level, but will also be valuable for research efforts into predictions of bridge performance. The research plan focuses on a demonstration effort first using synthesized data, and then applied to realistic bridge data. The results of this effort will be reported as part of this program, and shared via publication in related journals. Adoption of the approach by state DOTs is dependent on showing value, and integrating smoothly with their existing management workflow. To achieve this, it is important to target bridge management software providers as an implementation target, as most bridge data is managed and interacted with via a software application.

9. Impacts/Benefits of Implementation (actual, not anticipated)

   TBD

10. Dates and Budget

    Start Date: 8/1/2016
    End Date: 7/31/2018
    UTC (CAIT) Dollars: $ 96,499
    Cost Sharing: $ 111,663
    Total Dollars: $ 208,162

11. Keywords

    Bridge Performance; Performance Forecasting; Data-driven; deterioration modeling; multiple model approaches; Markov chain Monte Carlo

12. Web Links (Reports and Project Website)

    https://cait.rutgers.edu/cait/research/development-robust-framework-assessing-bridge-performance-using-multiple-model-approac