Deterioration Modelling of Bridges on BrM 5.2.3

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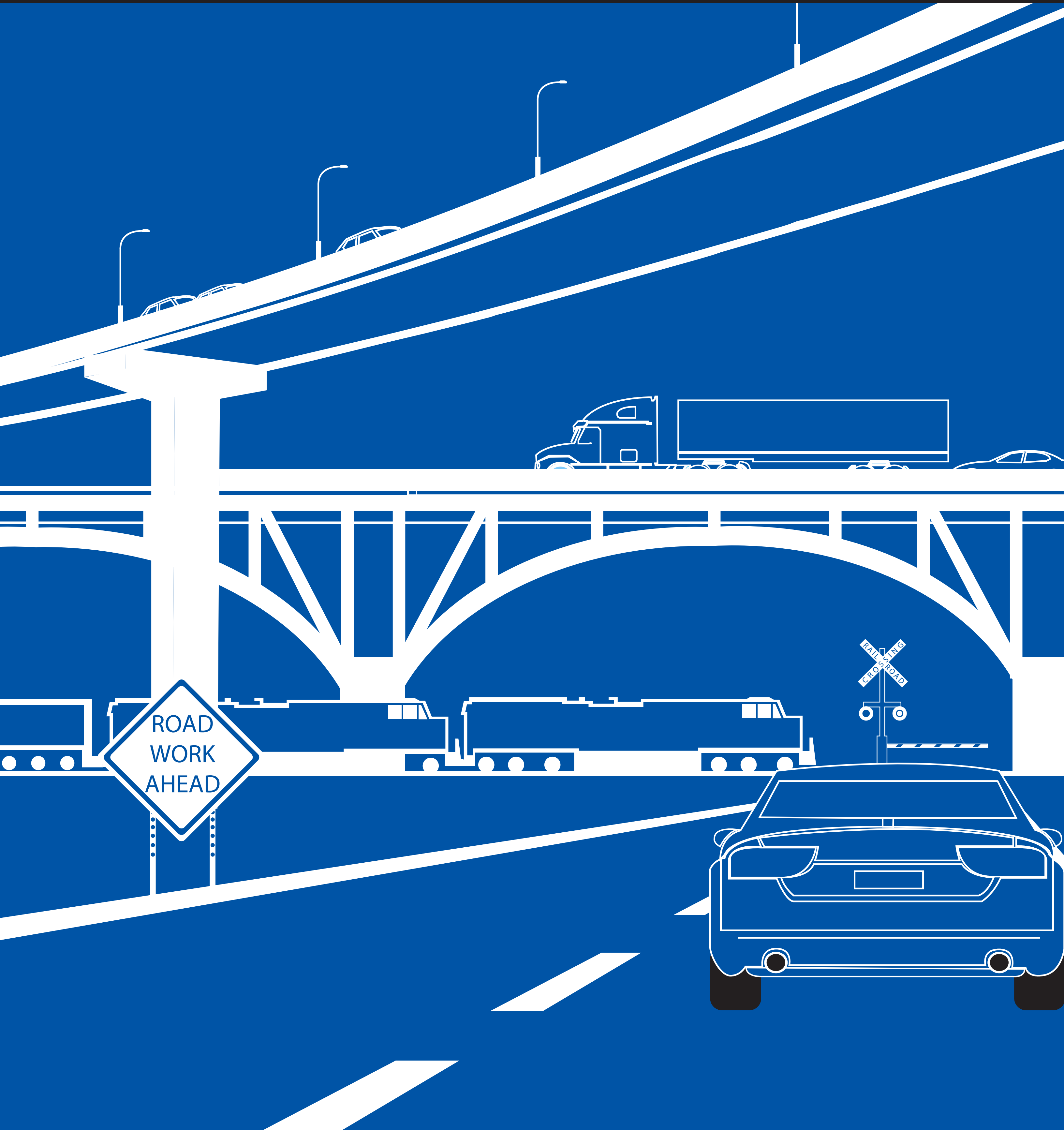

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College of Engineering, University of Kentucky, Lexington, Kentucky

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Research Report
KTC-19-02/SPR17-532-1F

Deterioration Modelling of Bridges on BrM 5.2.3

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16. Abstract
The Kentucky Transportation Cabinet (KYTC) initiated the study KYSPR 17-532, "Deterioration Modelling of Bridges on BrM 5.2.3," so it could receive assistance identifying and employing bridge deterioration and cost forecast modeling for its bridge maintenance program. The Kentucky Transportation Center (KTC) was to help coordinate KYTC in adapting BrM 5.2.3's deterioration and cost modelling features and update the existing guide material to reflect all changes for BrM 5.2.3. This study included acquiring access and becoming familiar with AASHTO Bridge Management (BrM 5.2.3) software. It was also to explore opportunities for any training on BrM and BrM 5.2.3's deterioration and cost modeling capabilities and adapt them to best meet KYTC's maintenance needs for four National Bridge Elements (NBE) — Reinforced Concrete Deck (12), Steel Open Girder/Beam (107), Strip Seal Expansion Joint (300), and Moveable Bearing (311). But the lack sufficient and reliable data for element-level deterioration modelling has proved a hindrance and impeded the completion of the research. As data points are collected, deterioration rates should be checked occasionally to see if they require calibration.

17. Key Words deterioration modelling, bridge maintenance, BrM	**18. Distribution Statement** Unlimited with the approval of the Kentucky Transportation Cabinet

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Executive Summary

The Kentucky Transportation Cabinet (KYTC) initiated the study KYSPR 17-532, "Deterioration Modelling of Bridges on BrM 5.2.3," so it could receive assistance identifying and employing bridge deterioration and cost forecast modeling for its bridge maintenance program. The Kentucky Transportation Center (KTC) was to help coordinate KYTC in adapting BrM 5.2.3's deterioration and cost modelling features and update the existing guide material to reflect all changes for BrM 5.2.3.

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Introduction

Decision making pertaining to bridge maintenance, rehabilitation. and replacement can be greatly enhanced by the use of deterioration and cost models that predict the condition/future service performance of major bridge components based on bridge/major element type, age, current condition, and traffic. As part of KYSPR 16-514, "Use of Bridge Element Level Condition Rating Data to Determine Effective Maintenance Activity Life Cycles," the Kentucky Transportation Center (KTC) was to develop a best practices guidance document for using BrM 5.2.2's modelling features. In addition, BrM 5.2.2's forecast modelling of deterioration rates were to be evaluated. The Kentucky Transportation Cabinet (KYTC) has updated to BrM 5.2.3, which has enhanced deterioration models and life cycle cost analysis tools. This information shall be beneficial in providing KYTC officials with estimates of future bridge needs/costs for planning and in targeting specific bridges for project-level actions that will extend the "dwell time" of bridge components at current condition states.

Element-level condition data can be used to benefit KYTC decision making at both the system and project levels. Currently, the 2013 *AASHTO Manual for Bridge Element Inspection* contains elements which are now rated on a uniform four-point scale. The ratings include quantities, which can be used to better develop bridge/culvert preventive maintenance, rehabilitation, and replacement plans and derive at more accurate action costs. For vital planning activities, it is necessary to predict the deterioration characteristics of those elements under present maintenance and service conditions (e.g., loading and applications of deicing chemicals). That data are believed to vary by factors including structure type, element age, route classification, ADT/ADTT, snow priority route, and location/district. Presently bridge element condition v. time data have not been determined, and key factors impacting performance have not been identified nor have their impacts been quantified.

Objectives

The current KYTC NBI element rating files were to be reviewed going back to their initial use on Kentucky bridges/culverts. Statistical evaluations were required to group element performance over time and to derive typical element performances for key factors (previously identified) to determine valid relationships. Deterioration rates were to be determined and element rating "hold times" at specific condition states identified. Models, including those provided in the forthcoming BrM bridge management software, were to be calibrated using KYTC inspection data.

KYSPR 2016-514, "Use of Bridge Element Level Condition Rating Data to Determine Effective Maintenance Activity Life Cycles," was a precursor to KYSPR 17-532, "Deterioration Modelling of Bridges on BrM 5.2.3," where deterioration models from BrM 5.2.2 were to be customized for KYTC maintenance needs. KTC will help coordinate KYTC's efforts in adapting BrM 5.2.3's deterioration and cost modelling features. KTC will update the existing guide material to reflect all changes for BrM 5.2.3.

To achieve those goals, KTC researchers addressed the following tasks from KYSPR 16-514 as part of this study:

1. A literature search to identify current options/practices for analyzing element-level condition rating for effective maintenance practices. Based on the literature search, identify appropriate mathematical analyses methods for application on KYTC bridge/culvert element data.
2. Acquire access to and become familiar with AASHTO Bridge Management (BrM 5.2.2) software. Explore opportunities for any training on BrM.
3. Identify, with help from KYTC, three to four NBEs or BMEs. Use identified elements to explore BrM 5.2.2's deterioration and cost modelling capabilities and adapt them to best meet KYTC's maintenance needs.
4. Apply basic mathematical/statistical analyses to validate results from Task 3.
5. Prepare guidance material to assist KYTC personnel in utilizing BrM 5.2.2's modelling module.

To achieve those goals, KTC researchers addressed the following tasks for KYSPR 17-532:

1. Acquire access to and become familiar with AASHTO Bridge Management (BrM 5.2.3) software. Explore opportunities for any training on BrM.
2. Use previously identified elements to explore BrM 5.2.3's deterioration and cost modeling capabilities and adapt them to best meet KYTC's maintenance needs.
3. Apply basic mathematical/statistical analyses to validate results from Task 2.
4. Prepare guidance material to assist KYTC personnel in utilizing BrM 5.2.3's modeling software.

Research Approach

This objective of this research project was to assist KYTC with the identification and employment of bridge deterioration and cost forecast modeling for its bridge maintenance program. It was to provide KYTC officials with bridge element performance prediction tools to enable assessment of future/pending trends in bridge/culvert element condition, primarily on a service life basis (with accommodation for other factors impacting element performance). This information was to be used in calibrating/creating bridge condition forecasting models. The data can be combined with condition-based preventive maintenance, rehabilitation, and replacement guidelines to identify structures requiring those actions, estimating when the future actions will be needed and for estimating quantity-based maintenance/replacement costs. This information was to be useful in addressing FAST Act requirements and in seeking funding necessary to maintain Kentucky's bridges/culverts.

KYSPR 2016-514, "Use of Bridge Element Level Condition Rating Data to Determine Effective Maintenance Activity Life Cycles," was a precursor to KYSPR 17-532, where deterioration models from BrM 5.2.2 were to be customized for KYTC maintenance needs. Due to KYTC updating and rolling out BrM 5.2.2, KTC postponed getting access to BrM until late into the fiscal year in which KYSPR 17-532 was proposed. Once KYSPR 17-532 was approved, KYSPR 16-514 was rolled into KYSPR 17-532. KYTC was in the process of rolling out BRM 5.2.3 and once KTC gained access, condition data for the four National Bridge Elements (NBE) – Reinforced Concrete

Deck (12), Steel Open Girder/Beam (107), Strip Seal Expansion Joint (300), and Moveable Bearing (311) — were to be investigated.

A University of Kentucky statistics professor volunteered to look at the data and analyze them for modelling. An initial analysis during the first quarter of FY 2018 of KYTC NBI data for NBE 12 showed a health index in the 90s (Figure 1). The figure also indicates there were not enough data points for modelling different condition states, especially condition states 3 and 4. During a discussion with the Study Advisory Committee (SAC) in the second quarter of FY 2018, it was decided to source element-level data from other states to fill in the KYTC data gaps for the abovementioned conditions. During 2018 National Bridge Preservation Conference organized by Transportation System Preservation Technical Services Program (TSP2) inquiries with DOTs regarding their management of element-level data and deterioration modelling rates resulted in many officials stating their agencies did not have enough data points to dwell into more detailed modelling of those elements. An FHWA Resource Center Structures Team member was contacted to get data from other states for modelling in the third quarter of FY 2018. Data from other states could not be obtained in a timely manner for KTC to proceed further. At the SAC meeting in the first quarter of FY 2019, members were made aware of the various issues of having to model with limited data. It was decided by SAC members to terminate this project at this point with a possibility of re-addressing it at a future date when sufficient and reliable data have been gathered.

Conclusions

This goal of this research project was to help KYTC identify and employ bridge deterioration and cost forecast modeling for its bridge maintenance program. It was to provide KYTC officials with bridge element performance prediction tools to enable assessment of future/pending trends in bridge/culvert element condition primarily on a service life basis (with accommodation for other factors impacting element performance). The unavailability of sufficient and reliable data for element-level deterioration modelling has proved to be a hindrance and impeded completion of the project. As data points are collected, deterioration rates should be checked occasionally to see if they require calibration.

Recommendations

KYTC should continually calibrate the current modelling rates being used as more element-level data become available.

Figures

Figure 1 Health Index for NBE 12

Year	Count	CS1	CS2	CS3	CS4	HI
2005	21	74.48	22.00	3.52	0.00	90.32
2006	148	95.05	3.95	1.00	0.00	98.02
2007	1543	86.59	10.96	2.44	0.00	94.72
2008	2680	86.18	12.10	1.72	0.00	94.82
2009	2435	83.87	14.91	1.22	0.00	94.22
2010	2742	85.95	13.23	0.82	0.00	95.04
2011	2589	84.95	14.42	0.63	0.00	94.78
2012	2672	85.84	13.69	0.47	0.00	95.13
2013	2608	86.46	13.00	0.54	0.00	95.31
2014	2730	84.73	14.60	0.67	0.00	94.69
2015	2755	79.07	18.76	2.14	0.03	92.29
2016	2624	77.76	19.51	2.68	0.06	91.65