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Long Term Bridge Performance Program: Objectives and Goals

Ali Maher, PhD[1], Hamid Ghasemi[2], PhD, John M. Hooks[3], and Andrew J. Foden, PhD[4]

[1] Rutgers, The State University of New Jersey – The Center for Advanced Infrastructure and Transportation, Piscataway, New Jersey, United States
[2] FHWA, USA
[3]Highway R&D Services, Cape Coral, Florida, United States
[4] Parsons Brinckerhoff, Princeton, New Jersey, United States

ABSTRACT: In April 2008, the Federal Highway Administration's (FHWA) Office of Infrastructure Research and Development launched a major new strategic initiative, the Long-Term Bridge Performance (LTBP) Program. This flagship research program is intended to be a 20-year undertaking, with the global objective of collecting scientific quality data from the nation's highway bridges. This will lead to a better understanding of bridge performance and improved bridge management practices. High priority bridge performance issues and knowledge gaps for which research is needed have been identified through bridge owner, stakeholder, and expert solicitation. Data collection techniques and protocols to address these performance issues are currently being evaluated in a pilot phase. The program objectives and methodology are discussed in this paper.

1 INTRODUCTION

Since the earliest of times, humankind has depended on bridges to span some feature that otherwise would impede or prevent passage from one point to another; early hunters may have used a fallen tree trunk to cross a narrow chasm and bring home game for food. Today cars and trucks move people and goods on modern highways spanning other highways and topographical barriers for purposes of employment and commerce and in pursuit of a variety of personal activities. The modern equivalent of the fallen tree may be a simple multi-span structure or a soaring signature cable-stayed bridge. Given the importance of movements of large numbers of people and large volumes of goods today, the performance of highway bridges of all types and sizes is critical to the transportation system and thus to the economy of the United States. Anytime the overall performance of a bridge or the performance of one of its critical features or components falls below a satisfactory level, some action – maintenance, rehabilitation, or replacement – is necessary to return the performance of the bridge to a satisfactory level. These actions usually entail some burden on highway users and on society in general. Disruption and delays in traffic flow, diminished productivity, increased fuel consumption, increased emissions, and expenditure of scarce public funds are typical results. Performance of bridges can suffer in different ways. The rare, catastrophic failure, such as the collapse of the I-35W bridge in Minneapolis, MN, captures the attention of the entire nation and often results in some significant change in bridge programs or engineering practice. But much more common is the poor performance of a key component of a bridge, such as a delaminated, patched deck or deteriorated beams. The impact of these poor performing components is significant but is limited to that one bridge. However, due to the prevalence of these types of problems, it represents a national problem of huge proportions.

2 THE FHWA LONG TERM BRIDGE PERFORMANCE PROGRAM

In 2008, the Federal Highway Administration (FHWA) launched the Long Term Bridge Performance (LTBP) Program, a 20-year research program which was authorized by the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The overall objective of the LTBP program is to collect, document, maintain, and study high-quality, quantitative performance data on a representative sample of bridges nationwide. This quantitative data will enable bridge owners to better understand how and why bridges deteriorate, how to best prevent or mitigate deterioration, how to best improve operational performance of bridges, and how to focus the next generation of bridge management tools.

The LTBP program is an undertaking of immense complexity owing mainly to the multitude of factors that influence bridge performance and the extreme diversity of these factors across the entire bridge population. There are literally dozens of factors and thousands of combinations of those factors that characterize the bridge population and influence the condition and performance of bridges in the United States. The multiple factors and the diversity of the bridge population are captured in the list below. For instance, in the National Bridge Inventory (NBI) there are 220 unique combinations of main material of construction and structure span type, such as prestressed concrete box beam and steel stringer multi-beam. Bridges are differentiated by:

- The type of structure, key design features, and the type and quality of material with which the bridge is built
- The various dimensions of the bridge, including span length(s), skew, and horizontal and vertical clearances
- The combination of live loads that the bridge experiences during its life span- trucks in the traffic stream plus possible loads from wind, seismic, and hydraulic forces
- Local environmental and climatic factors
- The type and scale of physical changes that occur on the bridge over time and the pace at which those changes occur
- The history of maintenance, preservation, and rehabilitation actions applied to the bridge

It is not unreasonable to conclude that each and every bridge represents a unique combination of these many factors.

3 THE LTBP PROGRAM ROADMAP

The discussion above illustrates the challenges that the LTBP program must address in order to achieve its goals. Because of the many complexities of the subject and the intended 20-year duration of the program, a well designed roadmap for the program is essential.

Figure 1. LTBP Program Roadmap

The roadmap for the LTBP program, as shown in Figure 1, has seven major steps under which numerous activities are being conducted. These steps are:

1. Define bridge performance in terms of the issues that are of most importance to owners and highway users. These issues can be grouped in four broad categories: durability and serviceability of the bridge and its individual components, user safety and functional capacity of the highway on (and under) the bridge, structural stability and integrity, and costs incurred by the owner and the highway users.
2. Identify the factors that are most relevant to the identified performance issues and determine what high quality data should be collected in order to adequately study those issues. Determine the most economical and effective ways to collect that data.
3. Create a data management system that is capable of storing and managing bridge data from a variety of sources and in a variety of formats.
4. Design experimental studies that will assist in answering the key questions about these bridge performance issues.
5. Collect the desired data on representative samples of bridges as appropriate to the issue being studied.
6. Analyze data and create models that provide a better understanding of bridge performance.
7. Disseminate results that can be applied by the bridge community to improve bridge performance.

This represents a daunting challenge but one that is made more doable by the existence of a vast knowledge base of information about bridges in the collective experiences of bridge owners nationwide and in a national database of bridge information containing over twenty years of data on bridges.

4 STARTING WITH WHAT IS KNOWN

A very large body of knowledge about bridges in the United States is available in a unique resource, the National Bridge Inventory (NBI). This database, maintained by the FHWA, contains records on every bridge (minimum 20 feet in length) on all public highways in the US. The NBI contains a separate record for each bridge, with a variety of data fields within each record to identify the location of the structure, its year of construction, its type of construction and geometry, the identification and classification of the route that it carries, and features that it crosses. Further, the NBI contains temporal data regarding the condition and adequacy of the structure, which is generally updated on at least a biennial basis. These data include general condition ratings, load ratings, and postings, if applicable. Much of this information is derived from biennial visual inspections by trained inspectors. There are also indicators that relate to the functional performance of the structure, including appraisal ratings of the clear deck width, of the approach roadway alignment, and of the vertical and horizontal clearances, as well as estimates of the traffic the structure carries.

The NBI is an invaluable tool for beginning any examination of bridge performance and for identifying trends in bridge performance, as well as understanding relationships between performance and the factors that govern it. One simple example is parsing the data in the NBI to determine which types of bridges are most representative of bridges across the US. Table 1 shows the most prevalent combinations of material and span types in the bridge population in the US. These are the bridge types that will be the initial focus of the LTBP program.

Table 1. Most Common Bridge Material and Structural Types in the National Bridge Inventory

Material / Type	Number	Cumulative Area Million Sq. m.	Cumulative ADT Millions VPD
Simple Span Steel Stringer 1	03,836	469	704
Continuous Steel Stringer 4	6,491	720	618
Simple Span Concrete Slab	33,873	78	114
Simple Span Concrete Stinger 9,	988	51	44
Simple Span Concrete T Beam	21,162	87	121
Continuous Concrete Slab	31,565	132	190
Continuous Concrete T Beam 6,	247	53	102
Simple Span Prestressed Concrete Stringer	51,731	637	655
Simple Span Prestressed Concrete Multiple Box Beam	38,103	122	181
Continuous Prestressed Concrete Stringer	13,560	205	146
Totals 35	6,556	2,554	2,875

Using NBI data, it is possible to further examine bridge data to begin to match bridge types and bridge conditions with factors such as age, traffic (ADTT), environment, and so forth and begin to reveal relationships that may govern performance and should be studied further.

In order to glean more information on bridge performance problems in different areas of the country and to capture local knowledge and experience about programs and activities aimed at improving performance, a series of focus group meetings was held with 15 state Departments of Transportation (DOTs). These focus group meetings helped identify the most critical performance issues faced by DOTs across a geographically distributed selection of states (Figure 2). Additionally, to further clarify the most critical bridge performance issues that involve geotechnical considerations, the FHWA conducted a workshop with 47 bridge/geotechnical experts. Both of these efforts were intended to elicit advice on what were the most important issues in bridge performance. The objectives of the focus group meetings included:

- Developing an understanding of how representative states manage and track bridge performance.
- Identifying the most common concerns and the most costly activities of the representative states in maintaining, repairing, rehabilitating, and replacing bridges.
- Determining what data the states currently collect and use for their decision-making processes and what gaps they see in their currently available data.
- Identifying the aspects of bridge performance on which the states would like the LTBP program to focus.

The objectives of the geotechnical workshop were to identify key performance issues related to substructure and foundation and to identify data needs and gaps related to the key performance issues.

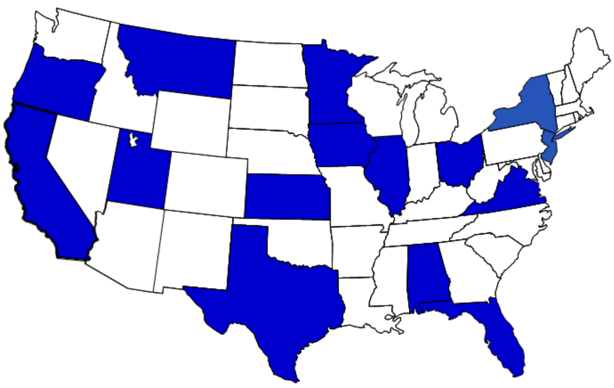

Figure 2. LTBP program Focus Group Meetings

Based on those outreach activities and other research done by the LTBP program research team, a list of high priority bridge performance issues, shown in table 2, were identified.

Table 2. High Priority Bridge Performance Topics

Category - LTBP Bridge Performance Topic
Decks -
Performance of Untreated Concrete Bridge Decks
Performance of Bridge Deck Treatments
Performance of Precast Reinforced Concrete Deck Systems
Performance of Alternative Reinforcing Steels
Influence of Cracking on the Serviceability of HPC Decks
Joints -
Performance of Bridge Deck Joints
Performance of Jointless Structures
Bearings -
Performance of Bridge Bearings
Concrete Bridges -
Performance of Bare/Coated Concrete Super- and Substructures
Performance of Embedded Prestressing Wires and Tendons
Performance of Prestressed Concrete Girders
Steel Bridges -
Performance of Coatings for Steel Superstructure Elements
Performance of Weathering Steels
New Construction -
Performance of Innovative Bridge Designs and Materials
Foundations & Scour -
Performance of Scour Countermeasures
Performance Issues at the Bridge Approach-Abutment Interface Material degradation/corrosion/deterioration (Durability of Substructure Components)
Performance of MSE Walls
Risk -
Risk and Reliability Evaluation for Structural Safety Performance
Functional -
Performance of Functionally Obsolete Bridges

5 THE PILOT BRIDGE PHASE

In a program as complex as the LTBP program, there are multiple uncertainties that must be investigated in order to ensure the collection of high quality data while avoiding wasted efforts and costs and minimizing disruption to the bridge owners and users. These uncertainties include:

- Costs associated with research personnel, including labor, travel, and subsistence plus costs for site preparation, equipment and supplies, safety and maintenance of traffic, data transmission, and data processing and analysis.
- The amount of time and effort necessary to conduct each element of the planned investigation.
- Coordination with bridge owners – considerable time and costs are necessary to coordinate with bridge owners to ensure that necessary permits are obtained, that plans for maintenance of traffic and safety of the research personnel meet the owner's requirements, and that the plans for testing the bridges are acceptable to the owner.
- Ensuring that the quality and quantity of data to be collected is consistent with the needs, as determined in the LTBP program experimental studies, without spending time and money on unnecessary data or on unnecessary levels of data quality and/or quantity.

- Ensuring that the test protocols used for the LTBP program inspections are clear and are consistently applied, and that the spatial and temporal distribution of testing is sufficient for the LTBP program needs without being excessive.

In order to adequately address these issues, the initiation phase of the LTBP program was designed to have a two-year pilot phase during which seven bridges around the nation would be selected and used as field laboratories to obtain critical knowledge about the issues described above. The selection of the seven pilot bridges is being done according to a carefully developed set of criteria that ensure that the pilot bridges represent a cross section of the bridges that would be the focus of the LTBP program, including the most common superstructure types, typical physical bridge layouts (features carried and intersected), and a wide range of environmental conditions. The primary criteria in the selection of the pilot bridges are superstructure type, age, type of deck, composite or non-composite design, deck condition, environmental factors, overall traffic, percent trucks in the traffic stream, and logistical and site access considerations.

Based on these criteria, six of the seven pilot bridges have been selected. The bridges are located in California, Minnesota, New Jersey, New York, Utah, and Virginia. The selection of the seventh pilot bridge, to be located in the state of Florida, has not yet been made. These bridges cover a variety of environmental and operational conditions and include common structure types, such as single and multi-span steel girder, pre-stressed concrete beam, adjacent concrete box beam, pre-stressed post-tensioned continuous CIP box girder, and steel deck truss.

The ultimate goal of the pilot study phase is to make certain that all of the components needed to achieve the long-term objectives of the LTBP program are specified before starting the nationwide study on a larger sample of the bridge population. This includes validation of all the procedures for selecting, analyzing, inspecting, and testing LTBP program bridges, from selection of bridges that are accessible for the various onsite research activities, to validation of the LTBP program inspection and testing protocols, to analysis and interpretation of the data collected. The pilot phase provides an opportunity to examine the uncertainties noted above.

The pilot bridges are being subjected to a comprehensive regimen of analysis, inspection, and testing. Each bridge is analyzed using finite element modeling and a detailed visual inspection of each bridge is conducted. Live load testing and/or dynamic testing are also done on each bridge to provide a baseline for the structural behavior of the bridges. The deck of each bridge is inspected with several different nondestructive testing methods and cores are taken to help characterize the material qualities of the deck and the type and extent of any deterioration. The data collected from the pilot bridges will be evaluated to determine what adjustments in the LTBP program protocols are appropriate. The pilot phase of the LTBP program will be completed early in 2011.

The long term data collection phase of the program will begin early in 2011. Many valuable lessons are being learned from the combined experiences on these pilot bridges. The knowledge gleaned from the pilot phase will provide critical insight into the planning and implementation of the long term data collection phase.

6 CONCLUSIONS

The LTBP program is focused on producing high quality, quantitative data that will be used to address high priority bridge performance issues. It will provide the bridge community with a better understanding of bridge performance, better tools to determine how and why bridges deteriorate, improved knowledge of the effectiveness of various maintenance strategies, and improvements in bridge management practices. As of October 2010, the program is in the final stages of its pilot phase, whereby data collection protocols are tested on a small group of bridges representative of the types of bridges and field conditions likely to be considered during the LTBP program. This phase will be completed in early 2011; the long term data collection phase will follow. A sampling methodology is currently being finalized that will focus the next phase on evaluating the most widely used bridge types in the national bridge population. By studying the high priority bridge performance issues, identified in the program's initial phase, as they relate to these structures, the LTBP program will produce both near-term and long-term products that will aid bridge owners and practitioners.