# The FHWA Long-Term Bridge Performance Program

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An ever-growing volume of cars and trucks move people and goods on modern bridges spanning highways and topographical barriers for purposes of employment and commerce and in pursuit of a variety of personal activities. Given the importance today of movements of large numbers of people and large volumes of goods, 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. Activities such as maintenance, rehabilitation, or replacement that are necessary to return the performance of a bridge to a satisfactory level of service, result in disruption and delays in traffic flow, diminished productivity, increased fuel consumption, increased emissions, and expenditure of scarce public funds. Rare catastrophic failures such as the collapse of the I-35W Bridge in Minneapolis, Minn., do occur. But much more common is the poor performance of key components of a bridge such as a delaminated deck or deteriorated beams. The prevalence of these types of problems represents a national problem of huge proportions.

**The Long Term Bridge Performance Program**

In 2008, the Federal Highway Administration (FHWA) launched the Long Term Bridge Performance (LTBP) program, a 20-year-long research program 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, and how to better 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 these factors that characterize the bridge population and influence the condition and performance of bridges in the United States. These 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 materials of construction and structure span types such as prestressed concrete box beams and steel stringer multi-beams. 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 and highly variable 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.

**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-long duration of the program, a well designed roadmap for the program is essential.

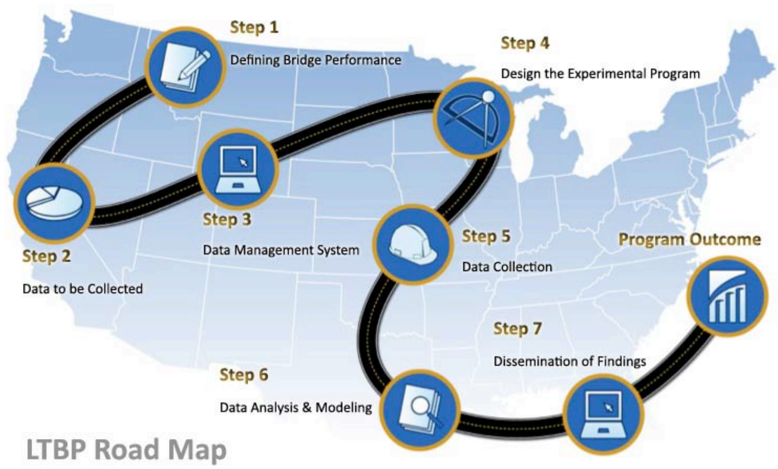


Figure 1 The LTBP Program Roadmap

The roadmap for the LTBP program 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 the costs incurred by the owner and by 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 the issues. Determine the most economical and effective ways to collect the 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 the 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 achievable by:

- the existence of a vast knowledge base of information about bridges in the collective experiences of bridge owners nationwide, and
- the NBI containing over 25 years of data.

**Starting with What is Known**

A very large body of knowledge about bridges in the United States is available in a unique resource, the NBI. This database, maintained by the FHWA, contains records on every bridge (minimum 20 feet in length) on all public highways in the United States. The NBI contains a record for each bridge, with a variety of data fields within each record that identifies the location of the structure, the year of construction, the 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 which 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 on the bridge.

The NBI is an invaluable tool for beginning the examination of bridge performance and for identifying trends in bridge performance as well as understanding relationships between performance and the factors that affect it. One simple example is parsing the data in the NBI to determine which types of bridges are most representative of all bridges throughout the United States. Table 1 provides data on the most prevalent combinations of material and span types from the NBI. These represent 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 | 103,836 | 469 | 704 |
| Continuous Steel Stringer | 46,491 | 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 | 356,556 | 2,554 | 2,875 |

Using the NBI, it is possible to further examine bridge data to match bridge types and bridge conditions with factors such as age, traffic (ADTT), environment, etc. to reveal relationships that may govern performance indicating the need for further studies.

**Focus Group Meetings**

Meetings were held with 15 state Departments of Transportation (DOT)s in order to glean more information on bridge performance problems in various areas of the country. A goal was to capture local knowledge and experience about programs and activities aimed at improving performance.  The focus group meetings helped identify the most critical performance issues faced by the geographically distributed DOTs (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 were to:

- Develop an understanding of how representative states manage and track bridge performance.
- Identify the most common concerns and the most costly activities of the representative states to maintain, repair, rehabilitate, and replace bridges.
- Determine what data the states currently collect and use for their decision-making processes and what gaps they see in their currently available data.
- Identify 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 substructures and foundations and 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, was developed.

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 |

**The Pilot Bridge Phase**

In a program as complex as this, there are multiple uncertainties that must be investigated in order to ensure collection of high-quality data while avoiding wasted efforts and money 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 plans 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 unnecessarily high levels of data quality 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 are 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 2-year 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 would ensure that the pilot bridges represent a cross section of the bridges that would be the focus of the LTBP program. The primary criteria in the selection of the pilot bridges were superstructure type, age, type of deck, composite or non-composite design, deck condition, environmental factors, overall traffic, and percent trucks in the traffic stream. Based on these criteria, six of the seven pilot bridges have been selected.

The first pilot bridge, shown in Figure 1, carries Southbound U.S. Route 15 over I-66 in Prince William County, Va., about 38 miles west of Washington, D.C. The bridge, constructed in 1979, is a two-span continuous, built-up haunched steel girder bridge with a cast-in-place concrete deck and carries an AADT of 16,500 vehicles with 6% truck traffic. Prominent factors in the selection of this bridge included location (within easy drive of the FHWA's Turner-Fairbank Highway Research Center), significant degree of deterioration in the concrete deck and the steel superstructure and the relatively high degree of skew (approximately 17 degrees).

The second pilot bridge, shown in Figure 2, carries Southbound I-15 over Cannery Road near Perry, Utah. The bridge, constructed in 1976, is a single span of American Association of State Highway and Transportation Officials (AASHTO) precast, prestressed concrete beams with integral abutments. The CIP concrete deck has a membrane and asphalt overlay . This section of I-15 carries an AADT of 22,250 vehicles with 29% truck traffic. Prominent factors in the selection of this bridge included the type of concrete superstructure, the high percentage of truck traffic, the deck with asphalt overlay and the proximity of a nearby weigh station for obtaining live load data.

Figure 1 Virginia Pilot Bridge

Figure 2  Utah Pilot Bridge

The third pilot bridge, shown in Figure 3, carries I-5 over Lambert Road about 30 miles south of Sacramento, Calif.  The bridge, constructed in 1975, is a 2-span, post-tensioned continuous cast-in-place concrete box girder bridge and carries an AADT of 24,500 vehicles with 21% truck traffic.  Prominent factors in selection of this bridge included the type of concrete superstructure and the high percentage of truck traffic.

The New Jersey pilot bridge, shown in Figure 4, carries eastbound I-195 over Sharon Station Road near Allentown, N.J.  The bridge, constructed in 1969, is a single-span, multi-beam steel girder bridge with a cast-in-place concrete deck that was constructed using stay-in-place forms.  The bridge carries an AADT of 25,000 vehicles.  Prominent factors in selection of this bridge included the deck construction with stay-in-place forms and the location of weigh-in-motion and weather stations nearby.

Figure 3 California Pilot Bridge

Figure 4  New Jersey Pilot Bridge

The New York pilot bridge, shown in Figure 5, is the Karr Valley Creek Bridge on Route 21 in Almond, N.Y.  The bridge, constructed in 1990, consists of two simple spans of adjacent precast, prestressed concrete box beams made continuous for live load using a continuity diaphragm over the center pier.  The bridge carries an AADT of 8,700 vehicles with 8% truck traffic.  Prominent factors in selection of this bridge included the type of bridge, the 24-degree skew and a problematic shear key detail between adjacent boxes.

The Minnesota pilot bridge, shown in Figure 6, carries State Road 123 over the Kettle River in the town of Sandstone, Minn. The bridge, constructed in 1948, is a steel deck truss, 400 feet in length with a main span of 200 feet. The bridge carries an AADT of 2,050 vehicles with 8% truck traffic. Prominent factors in selection of this bridge included the type of bridge, the age of the bridge, and some deterioration of the structural members.

Figure 5 New York Pilot Bridge

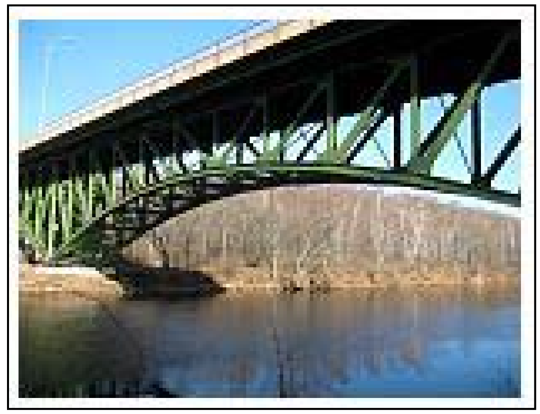

Figure 6 Minnesota Pilot Bridge

The final selection of the seventh pilot bridge, in the state of Florida has not been made.

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 included validation of all the procedures for selecting, analyzing, inspecting, and testing LTBP program bridges starting with selection of bridges that were 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 provided an opportunity to examine the uncertainties noted above.

The pilot bridges were subjected to a comprehensive regimen of analysis, inspection, and testing. Each bridge was analyzed using finite element modeling and a detailed visual inspection of each bridge was conducted. Live load testing and/or dynamic testing were also conducted on each bridge to provide a baseline for their structural behavior. The deck of each bridge was inspected with several different nondestructive testing methods and cores were 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 evaluated to determine what adjustments in the LTBP program protocols are appropriate. The pilot phase of the LTBP program will be completed by September 2011.

The long-term data collection phase of the program will begin 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.