BRIDGE SAFETY: THE FOCUS OF FHWA'S BRIDGE AND STRUCTURES RESEARCH AND DEVELOPMENT PROGRAMS

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Abstract

With the passage of the Federal Highway Administration's current authorization legislation (known as MAP-21) by the U.S. Congress in the summer of 2012, FHWA's bridge and structures research program has redoubled its efforts to address gaps in knowledge and develop advanced tools that provide a high level of bridge safety for the traveling public. This paper provides an overview of the current bridge and structures research and development programs and projects, with a focus on bridge safety.

Introduction

Since the collapse of the I-35W Bridge in Minneapolis, Minnesota, in August of 2007, the citizens of the United States have had a higher awareness and concern about the condition of the U.S. bridge population. Although the Federal Highway Administration has issued its "Conditions and Performance" (C&P) report (FHWA, 2013) biannually (the first report was titled the *1968 National Highway Needs Report*), which provides a general condition-related description of the U.S. bridge inventory, little public attention had been paid to the information presented in the C&P report.

Historically, FHWA categorized bridges in four ways: in a "state of good repair," meeting all current standards and demands; functionally obsolete (in good condition, but some elements not meeting current *functional* design standards); structurally deficient (one or more major elements determined as having some level of damage or deterioration and needing repair or rehabilitation); and closed. Of these, only the last category (closed) was applied to bridges deemed unsafe for the public.

Bridge safety has therefore been the primary focus of FHWA's bridge and structures programs for many years. Efforts in this regard have been redoubled with the U.S. Congress's passage of the current surface transportation authorization legislation "Moving Ahead for Progress in the 21st Century" (P.L. 112-141, which was signed into law by President Obama on July 6, 2012, and is known as MAP-21). MAP-21 requires FHWA to develop and promote programs that provide for the continued improvement to bridge and tunnel conditions that are essential to protect the safety of the traveling public,

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and that facilitate the efficient movement of people and goods on which the U.S. economy relies. MAP-21 also requires the periodic inspection and inventory of all highway bridges and tunnels on public roads.

MAP-21 also established the principles and practices for a flexible, nationally-coordinated research and technology (R&T) program that addresses fundamental, long-term highway research needs, significant research gaps, emerging issues with national implications, and research related to policy and planning. It charges FHWA with national coordination of research and technology transfer activities, conducting and coordinating research projects, and partnering with State highway agencies and other stakeholders. All research activities conducted by FHWA must include a component of performance measurement and evaluation, should be outcome-based, and must be consistent with the FHWA's R&T strategic plan. And again, bridge safety is specifically called out within the R&T provisions of the authorization legislation.

Much of the research conducted within the FHWA bridge and structures R&D programs and project result in findings or recommendations that, if implemented, can improve not just bridge safety, but overall long-term bridge performance and reduced investments in bridge rehabilitation, maintenance, or replacement. As a result, quite often, FHWA bridge and structures R&D results become the basis for FHWA headquarters "technical advisories," guidance, or regulation.

This paper provides a brief review of some of the current FHWA bridge and structures R&D programs and projects, all of which have a primary objective of bridge safety. These are not inclusive of the whole FHWA R&D program. More information on the overall FHWA bridge and structures R&D program can be found on the FHWA Research and Technology website[2].

Bridge and Foundation Engineering

The FHWA Bridge and Foundation Engineering research program is focused on design and construction of bridges and other highway structures. FHWA research facilitates the use of innovative materials and structural concepts, assists with the refinement of design specifications, and provides guidance regarding the performance of specific structural elements and systems. Research related to bridge safety addresses:

- Uniformity and consistency of design specifications;
- Ensuring that innovative materials and systems are appropriately developed and applicable to the highway transportation sector; and
- Forensic investigation of unique structural performance issues.

[2] http://www.fhwa.dot.gov/research/tfhrc/offices/infrastructure/

Some examples of FHWA research in this area include:

- Development of geosynthetic reinforced soil systems and assessing shallow foundations for scour susceptibility as low-cost bridge foundation systems

- Development of innovative structural systems and prefabricated bridge element connections using ultra-high performance concrete

- Addressing shortcomings in the *AASHTO LRFD Bridge Design Specifications* related to lightweight concrete

- Developing revised specifications for shear stud composite connection details on steel girders

Infrastructure Management

The FHWA Infrastructure Management research program focuses on advancing knowledge and technology associated with infrastructure performance throughout the entire life cycle, inspection, rating, evaluation, nondestructive testing, corrosion and durability, sensor technology, data infrastructure, field instrumentation and testing, health monitoring, asset management, performance and program management. The FHWA Long-Term Bridge Performance (LTBP) program is administered within Infrastructure Management R&D.

Research related to bridge safety includes:

- Development and enhancement of bridge inspection and condition assessment technology;
- Enhancing bridge durability through corrosion prevention and mitigation; and
- Optimizing bridge maintenance, repair, and preservation strategies.

Some examples of infrastructure management research are as follows:

- FHWA's LTBP program will collect periodic bridge condition and exposure data on over 1,000 bridges nationwide, and conduct studies to improve our understanding of bridge performance and deterioration over time.

- The LTBP Bridge Portal is a stand-alone web-based application that will house not only LTBP data, but bridge data and meta-data from numerous sources. It provides a visual indication of network and corridor-based bridge condition.

- In 2013, the Infrastructure Management research program developed a

Non-Destructive Evaluation (NDE) strategic vision and research and technology roadmap. The roadmap identifies and prioritizes national infrastructure NDE and structural health monitoring research needs.

- Similarly, in 2014, the Infrastructure Management research program developed an FHWA bridge corrosion research and technology roadmap. The roadmap identifies and prioritizes more than 50 research and technology studies intended to reduce the damaging effects of corrosion on bridge structural, reinforcing, and prestressing steels. A summary report documenting the roadmap will be available in the spring of 2015.

Hazard Mitigation

The FHWA Hazard Mitigation program focuses on developing new knowledge and technology associated with the design and performance of highway bridges and other highway structures under extreme events. Among these are infrastructure-related performance issues associated with earthquakes, floods, hurricanes and other high-wind events, blast, fire, and other types of extreme events. The program also administers an R&D program associated with materials such as wood and advanced polymer composites in highway construction.

Virtually all research within the Hazards Mitigation program directly relates to bridge safety. Studies currently underway include the following:

- In the area of bridge hydraulics, the program is studying the effects of wave forces including drag and lift on bridge cross-sections, and scour on bridge piers and culverts.
- Under the aerodynamics R&D program, the effects of wind vibrations on bridges are being assessed through field monitoring, wind studies in TFHRC wind tunnels, and via high-performance computational fluid dynamics analyses.
- A new focal area is termed foundation characterization. The focus of this R&D program is to find methodologies and techniques to help identify and fully characterize existing foundations and their components, most of which are subsurface and difficult to access.
- FHWA's bridge security research is currently focused on steel suspension bridge towers and cables. Using components recovered from the recent demolition of major suspension bridges, we are assessing the performance rivets (as opposed to bolts) when subjected to blast forces, cables and suspenders are being looked at for their vulnerabilities both with and without retrofits, and we are developing countermeasures to resist terrorist threats.

Specialized Studies

In addition to the studies being conducted at Turner-Fairbank Highway Research Center, a number of other studies are being conducted by others within FHWA that span the continuum from research through development through deployment and training – many of which also have a primary focus on bridge safety. Included in these are the following:

- FHWA and the International Association of Foundation Drilling (ADSC) are collaborating on a study developing technical guidance for the post-grouting of drilled shafts in highway design and construction. The focus is on improvement mechanisms and the repeatability, consistency and control of the grouting process in relation to performance improvements, and to develop practical methods for design and construction within the AASHTO *Load and Resistance Factored Design* methodology.

- Due to the loss of foundation support resulting from corrosive soil-based degradation of steel H-piles supporting the Leo Frigo Memorial Bridge near Green Bay, Wisconsin, FHWA supported the Wisconsin DOT in investigating the impacts of corrosive soils and developing guidance to shore up and restore bridge functionality.

- Another major bridge problem occurred near Wilmington, Delaware, in the spring of 2014, when a large stockpile of improperly stored waste material caused the foundation of the I-495 bridge to shift and rotate. FHWA investigated and issued an advisory to bridge owners throughout the United States to review and screen, in order to avoid similar occurrences.

- FHWA is a co-sponsor of a study being conducted by the National Academy of Science's Committee on Geological and Geotechnical Engineering of the Board on Earth Sciences and Resources, to update guidance for seismic-induced foundation liquefaction.

Summary

The projects described above are only a snapshot of the bridge safety studies currently underway within FHWA. At any given time, there are more than 50 such studies being conducted to address both short-term and longer-term highway infrastructure needs, and to develop new innovative tools and technologies that will help deliver and maintain a high-performing, cost efficient highway system within in the United States.

References

FHWA, 2013. "2013 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance, Report to Congress" Federal Highway Administration.