

FHWA BRIDGE ENGINEERING RESEARCH AND TECHNOLOGY – AN OVERVIEW

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Abstract

The Federal Highway Administration (FHWA) continues to support a robust and responsive research and technology program in the area of bridge engineering. Although funding for the program beyond the end of 2010 is currently unknown, the large number of research and technology needs identified by the bridge engineering community will essentially ensure that the FHWA continue to support a coordinated and strategic research and technology program in conjunction with a range of stakeholders that include State transportation agencies, industry, the consulting engineering community, and academia. This paper provides an overview of the current FHWA bridge engineering research and technology focus areas, and discusses some proposed strategic initiatives for the future.

Background

For many years, the Federal Highway Administration (FHWA) has conducted and supported a robust bridge engineering research and technology program. Research areas within this program have evolved and changed over time, as the needs of the industry have changed. The FHWA program has also been required to be responsive to special initiatives, often as a result of unanticipated problems, or catastrophic structural disasters. Yet, over this time, the core elements and focus of the program have remained relatively constant. Among these core areas are research and technology development in:

- structural engineering,
- geotechnical engineering,
- hydraulics and hydrology,
- aerodynamics,
- nondestructive evaluation (NDE) and infrastructure inspection technology,
- advanced structural materials,
- earthquake engineering, security research, and other extreme events,
- structural durability and deterioration science, and
- asset management and preservation.

These efforts have led to a number of significant advances in bridge engineering practice, and a more robust and resilient national highway bridge network in the United

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States. The research has addressed issues related to design, construction, operations, and maintenance, and has especially focused on the performance of highway structures subjected to both normal wear-and-tear, as well as natural and man-made extreme events. In the past few years, FHWA has partnered with a number of Federal and other agencies to develop solutions to address blast and other types of potential terrorism. This paper provides a snapshot of some of the unique research being conducted by the FHWA at this time.

Structural Systems and Advanced Structural Materials

FHWA has been a leader in research and development regarding advanced structural materials, and their application into highway infrastructural systems. Examples include the development of first generation high performance steels (HPS) and improvements in the use of high performance concretes (HPC) for bridges and other highway structures. Today, FHWA continues to support improvements in understanding the behavior and performance of these structural materials, while also supporting and conducting new research into other advanced materials and structural systems. Included in this is work on the application of nano-materials for cements and concretes, and both the materials characterization and structural applications for Ultra High Performance Concrete (UHPC).

Two examples regarding the work on UHPC include the continued development and deployment of the UHPC “Pi-girder” concept (see figure 1) and the use of UHPC as the primary element in a closure pour for prefabricated bridge deck slabs (see figure 2).



Figure 1 – UHPC Pi-girder during fabrication

Figure 2 – UHPC deck closure pour

With support and technical assistance from the FHWA, the Iowa DOT (IDOT) has taken the lead in the construction of bridges using UHPC. IDOT built the first UHPC bridge in the United States several years ago, when they used UHPC as a replacement material for conventional concrete in a typical prestressed I-girder structure. However,

this bridge did not take advantage of the unique material properties of UHPC (strength both in flexure and shear, minimized need for conventional reinforcing, and density and durability). More recently, IDOT completed construction of a Pi-girder bridge, and more are currently being planned.

Working with the New York State Department of Transportation (NYSDOT), FHWA has been assisting in the design and testing of deck closure pours, especially for prefabricated bridge deck systems, using UHPC. A number of static and dynamic tests have been conducted on several closure designs, including long-term fatigue under moist and salt-water ponding conditions, and the UHPC designs have exceeded all performance expectations.

Geotechnical Engineering

Although FHWA's geotechnical research program has focused on deep foundation research and tie-back systems research and development over the years, the current focus has shifted somewhat toward shallow foundation approaches for bridge construction. With the current emphasis on accelerated bridge construction, shallow foundations are a key element in helping to deliver bridges more rapidly, with a higher level of confidence. However, concerns about scour susceptibility and durability of shallow foundation systems must be addressed, due to the large number of bridges in the United States built over waterways, streams, or creeks.

One of the significant advances that FHWA has made, and is currently focusing on, in shallow foundation technology is in the application of geosynthetic reinforced soils (GRS) technology; and more specifically, the integration of GRS with the bridge super- and substructure in what FHWA terms the GRS-IBS (integrated bridge system) for bridge abutments. GRS is a fast, cost-effective bridge support method using alternating layers of compacted fill and sheets of geotextile reinforcement to provide bridge support. The use of a GRS-IBS system (see for example figure 3) eliminates the approach slab or construction joint at the bridge-to-road interface; can significantly reduce construction time (a complete bridge can be constructed in about 10 days) with common equipment and materials; has been shown to be on average 25% to 30% less costly than a standard pile capped abutment, and is easier to maintain. Facing elements are primarily architectural – the primary structural resistance comes from the alternating layers of soil and geotextile. Experiential data indicate that spans of up to approximately 40 meters (130 feet) can be accommodated by the GRS-IBS system. However, current FHWA research efforts on GRS-IBS are focused on mitigating scour concerns, and expanding the capability of the technology for longer spans and multi-span installations.



Figure 3 – A recently constructed GRS-IBS bridge

Structural Durability and Advanced Inspection Technology

Much of the recent focus within FHWA agency-wide has been on improving the state of knowledge and practice in the areas of highway system asset management and system preservation. In support of these initiatives, FHWA continues to support a robust research and technology program that helps to improve bridge inspection tools and programs through the evaluation of advanced nondestructive evaluation (NDE) technologies, along with sensors and systems that can monitor and report the on condition and performance of a bridge, or elements within it. Recent research has focused on fatigue crack characterization technology, but several ongoing studies are also looking at tools to “look inside” bridge systems and components – to obtain better data and decision-making information on the condition of embedded reinforcing materials and prestressing strand. An interesting study that is just now getting started involves several prestressed concrete I-girders that were salvaged from a bridge being demolished near the coast in Maryland (see figures 4 and 5).



Figure 4 – Damaged prestressed girders



Figure 5 – Close-up of recovered girder

Two damaged full size prestressed concrete girders, each 26 meters (85 feet) long, were shipped to FHWA's Turner-Fairbank Highway Research Center. They will be used during the course of a three-year study that will give us a better understanding of the corrosion phenomena; development and testing of NDE technologies to better diagnose condition of the embedded prestressed strands; experiment on corrosion mitigation and repair methods; and ultimately develop a systematic decision making protocol and maintenance manual for similar bridges throughout the United States.

Long-Term Bridge Performance

Launched in 2008 as a 20+ year research effort, the FHWA Long-Term Bridge Performance (LTBP) program continues to move forward in advancing knowledge of bridge performance. The LTBP Program is intended to inspect, monitor, and evaluate a large sample of bridges that represent the bridge inventory in the United States. LTBP is currently investigating the number and location of these bridges to be monitored over the next twenty years. The sample bridge size may include several hundred bridges. Current activities include:

- Detailed inspection of seven “pilot bridges” – In 2009, a pilot study was initiated to validate and refine the methods, protocols, and guidelines for data collection and monitoring, and to ensure that the objectives of the LTBP program are well defined before the program rolls out nationwide. The LTBP pilot study includes bridges that provide a broad representation of structural type, environmental conditions, and age. A variety of tools and cutting-edge NDE technologies are being employed at each pilot bridge to establish baseline characteristics and to monitor long-term bridge deterioration and performance under traffic loads and environmental effects.

- Bridge performance: The LTBP program has identified over 20 topics that address bridge performance that will be evaluated during the duration of the program. The performance topics are grouped into four categories which include deck, joint, superstructure, and substructure issues. A draft report highlighting the bridge performance study topics will be available in spring of 2011.
- The LTBP Bridge Portal: The LTBP program has developed an open, scalable, and extensible data management and analysis infrastructure. The system integrates LTBP data, legacy data, and other data from multiple sources including the FHWA National Bridge Inventory. When complete, it will be accessible via the web as the “LTBP Bridge Portal.” FHWA is currently beta-testing the portal internally, and will engage State Highway Agencies and others in the near future to test and use the portal.

A number of stakeholder groups and committees are being established to assist FHWA in the conduct and direction of the LTBP program. Among these are a formal LTBP Advisory Committee, which will be assembled and facilitated by the Transportation Research Board on behalf of FHWA; and a State Coordinators’ Committee, representing the 50 AASHTO States, along with the District of Columbia and Puerto Rico. The broader LTBP program will be rolled out nationwide upon completion of the pilot study, which is expected to be near the end of 2011.

Summary

These are just a small sampling of the broad topics and varied studies currently under way within the FHWA’s bridge and structures research and development programs. Some of the studies were initiated as a result of unique events (e.g., studies on gusset plate performance and rating, resulting from the collapse of the I-35W truss bridge in Minnesota in 2007); others as a result of a multi-year strategic plan that was developed with the assistance of a range of stakeholder groups.

The future of FHWA structures research is currently uncertain, however. The United States Congress passed the most recent “authorization” bill that supports agency-wide FHWA research and development programs in 2005, and the legislation was expected to expire in September 2009. Since then, the Congress has passed several short-term extensions of this authorization legislation, the most recent one taking us to the end of the calendar year 2010. It is unclear what will happen after December 2010, and therefore, unclear whether or how existing structures research and development roadmaps and long-term strategic plans will be continued, until Congress takes additional legislative action.

In the meantime, there are still a huge number of research and technology needs, as expressed by the bridge engineering community within the United States and internationally, and FHWA will continue to work in concert with our partners, customers, and stakeholders to address these needs.