Thrust Areas/Business Needs
For Bridge Engineering

AASHTO Highway Subcommittee on Bridges and Structures

February 2000
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INTRODUCTION

The Highway Subcommittee on Bridges and Structures (HSCOBS) of the American Association of State Highway and Transportation Officials (AASHTO) has long recognized the benefit of research in helping its members meet their responsibility to design and manage the nation’s bridge infrastructure. Because of this recognition, HSCOBS strives to identify ways to fulfill the business needs of its members, and, to that end, annually reviews research problem statements. Some of these statements are recommended to the AASHTO Standing Committee on Research (SCOR) for consideration for funding under the National Cooperative Highway Research Program (NCHRP).

Because of this review and recommendation process, the subcommittee has obtained funding for various NCHRP projects that have benefited the bridge community. Nevertheless, it has become increasingly apparent to the subcommittee that a more structured procedure for prioritizing research is needed. At its 1999 meeting, a resolution was approved supporting the development of a strategic plan for bridge engineering research.

To provide essential input into a strategic plan, a steering committee, chaired by Mr. Malcolm Kerley, Chairman of the Subcommittee’s T-11 Committee (Research), was established to plan a workshop and select participants. The workshop was conducted February 14-16, 2000. Participants included AASHTO State Bridge Engineers, the Federal Highway Administration (FHWA), academics, consultants, and industry representatives (Appendix A lists the participants). The information developed in the workshop is a consensus of the participating bridge engineering professionals and will assist HSCOBS in identifying and giving priority to the major themes for a coordinated national bridge engineering agenda. HSCOBS will use the resulting agenda to evaluate and prioritize research problem suggestions to ensure a quality-based research program aligned with HSCOBS’ needs.

The products of the workshop are the six “thrust” discussions provided in this report. Each thrust focuses on a specific business need of the AASHTO bridge engineers. The unprioritized thrusts are as follows:

- Enhanced Materials, Structural Systems, and Technologies;
- Efficient Maintenance, Rehabilitation, and Construction;
- Bridge Management;
- Enhanced Specifications for Improved Structural Performance;
- Computer-Aided Design, Construction, and Maintenance; and
- Leadership.

Each thrust discussion starts with a paragraph giving general background on the thrust. A brief statement of the “business need” that would be satisfied with accomplishment of the thrust follows. After listing the thrust’s objective, the thrust discussion concludes with a list of “building blocks” (i.e., products or processes that must be available to satisfy the business need).
A list of research areas that complement the business needs of HSCOBS is provided in Appendix B. This list is included solely to illustrate the range of researchable topics that are of interest to bridge engineers.

This effort by HSCOBS is part of a broader effort by AASHTO and the Transportation Research Board (TRB) to establish a national highway research agenda. This report will be of immediate use to the Infrastructure Renewal working group of the National Research & Technology Partnership Forum. TRB’s study for a Future Strategic Highway Research Program (F-SHRP) will also benefit from the findings of this workshop.

This report is a working document. Thrusts and business needs are dynamic—they must be continually reviewed and revised to reflect the ever-changing societal and technical environment within which the highway system exists. HSCOBS is fully committed to the continued maintenance and improvement of this document and to applying the contents to the identification and prioritization of research.
BRIDGE ENGINEERING THRUST/BUSINESS NEEDS DISCUSSIONS

Enhanced Materials, Structural Systems, and Technologies

Bridges are subject to increasing traffic volumes and loads that degrade their long-term performance and increase their maintenance needs. The combination of an aging infrastructure and decreasing resources adds to the complexity of the problem. As the bridge community maintains, rehabilitates, and replaces deficient structures and designs new structures to enhance safety, mobility, and economic development, there is a growing need to use materials, structural systems, and technologies that will provide longer service life with lower maintenance costs.

The business need is to develop and apply sustainable materials, products, structural systems, and technologies that reduce life-cycle costs, extend useful life, and improve the constructability of bridges. This effort will build on previous work in the area of high-performance materials, durability research, and life-cycle cost. The development of new materials, structural systems, and technologies will be encouraged. Increased emphasis must be given to overcoming barriers to innovation.

Objective

To develop or enhance the following:

1. Materials that improve durability, reduce cost, and improve constructability;
2. Structural systems that improve performance and reliability;
3. Construction technologies that reduce construction or rehabilitation time and cost while ensuring safety; and
4. Policies, procedures, and methodologies that enable the acceptance and adoption of new technologies.

Building Blocks

1. Materials
   - High-strength, high-toughness, and durable steel plates and rolled sections.
   - High-performance concrete.
   - Fiber-reinforced polymers.
   - Corrosion protection systems for structural steel reinforcement, tendons, cables, and stays.

2. Structural Systems
   - Structural systems that span greater distances for less cost.
   - Self-maintaining bridge systems.
   - Modular construction.
   - Rapid replacement techniques.

3. Technologies
   - Training and certification programs for laboratory and field inspectors.
   - Test beds for evaluation of products and structural systems.
   - Deterioration models for life-cycle analyses.
   - Performance-based acceptance criteria.
   - Improved field welding processes.
**Efficient Maintenance, Rehabilitation, and Construction**

As the nation’s aging highway infrastructure experiences ever-increasing traffic volumes, more efficient maintenance, rehabilitation, and construction technologies must be introduced. Technological advances to increase work zone safety and to reduce construction time, costs, and public inconvenience are essential. In addition, new products and processes are needed in order to repair bridges so as to extend their useful lives. New products and procedures for preventive maintenance also are needed.

The business need is to identify, develop and apply efficient technologies, processes, and administrative methods that ensure quality and longevity, and enhance safety and that reduce construction and maintenance time, costs, and effects on the public.

**Objective**

To reduce construction, maintenance, and rehabilitation time and expense through the following:

1. Efficient contracting methods,
2. Efficient construction methods, and
3. Efficient inspection and monitoring methods.

**Building Blocks**

1. Improved QA/QC specifications and inspection processes.
2. Design/build contracting.
3. Automated and integrated design, fabrication, and construction processes.
4. Best practices, methods, and models for preventive maintenance in order to optimize service life.
5. Performance-based specifications.
6. Electronic design, fabrication, construction, and maintenance records.
7. Computer-aided design and drafting (CADD) automation for fabrication and inspection.
Bridge Management

Bridge management involves formalizing decision procedures that optimize public investment in new and existing bridges. These decisions have significant public safety and economic implications. Therefore, bridge program decisions should be based on the best available data and data-processing methodology. Significant efforts and resources have been, and continue to be, devoted to development and implementation of bridge management systems to assist coordinated and cost-effective maintenance, repairs, and rehabilitation or replacement of the nation’s bridge inventory. Although these initial efforts have been successful in gaining acceptance by owners and decision-makers, continued work is needed to enhance data collection and evaluation methods, economic analyses with “what if” scenarios, and readily usable, credible life-cycle cost analyses.

The business need is to improve the practices used by bridge owners, including the use of software systems such as PONTIS and BRIDGIT. This comprehensive effort will be directed toward all areas of bridge management, from inspection and data collection to using the data to manage public resources.

Objective

To develop bridge management practices that facilitate enhanced maintenance, repair, and rehabilitation through the following:

1. Continued support of existing bridge management systems to facilitate improvements,
2. Providing the bridge engineer with the best possible information on bridge conditions to support management decisions, and
3. Development of standardized processes for identifying project needs and ranking the projects once identified.

Building Blocks

1. Inspection and assessment techniques, including remote sensing, monitoring, and NDT.
2. Software development, including new and improved modules for bridge management systems such as geographic information systems (GIS) applications.
3. Data to support economic analyses and service life/life-cycle analyses.
4. Risk management and capital investment strategies.
5. Quality data and databases.
7. Methodologies to establish bridge needs.
Enhanced Specifications for Improved Structural Performance

Enhancement of design specifications, material specifications, design details, and construction practices could eliminate or forestall problems related to cost and/or time overruns during construction and could prevent premature problems with the serviceability and integrity of bridges and bridge components. Bridges that are more easily, quickly, and economically constructed would result. Maintenance problems would be diminished, and the difficulties and costs associated with maintenance and replacement of details or components would be minimized. In order to provide more efficient use of limited resources, simple, easily applied specifications are needed. These specifications should promote improved reliability, durability, maintainability, and constructability.

The business need is to develop and implement design specifications, design details, material specifications, and construction specifications that enhance durability, constructability, and maintainability while maintaining safety. These standards should address component-specific performance requirements and regional considerations.

Objective

To improve bridge durability, constructibility, and maintainability through the following:

1. Full implementation of load and resistance factor design (LRFD),
2. Technical training of the bridge engineering workforce in use of LRFD specifications,
3. Specification provisions for high-performance materials and composite materials, and
4. Rationalized design provisions for extreme events.

Building Blocks

2. Specifications for composite materials.
3. Design and construction concepts for rapid replacement and repair.
5. Durability standards.
6. Education opportunities for engineers on current design practices.
Computer-Aided Design, Construction, and Maintenance

Considerable advances have been made during the past decade in the computer-automation and communication technologies. Current bridge design, construction, and maintenance processes can be greatly enhanced by integrating computer-aided-design and drafting (CADD) with computer-integrated manufacturing (CIM) and construction techniques. Geographic information systems (GIS) also can enhance the project development process. The application of these computer and communication advances provides great benefits in reducing costs and project delivery time while enhancing the quality of the final product.

The business need is to improve and streamline the project development process for the design, plan preparation, and construction of bridges or other highway structures. This need can be addressed with automated bridge analysis and rating systems, such as VIRTIS/OPIS and BRASS, and the development of LRFD and other structure-related software. Robust databases and seamless data transfer are required in order to develop the project from inception to construction. Integrated manufacturing processes are also required.

Objective

To improve and to streamline the project development process through the following:

1. Implementing advanced computer automation and data communication technology to enhance productivity in bridge design, fabrication, construction, rating, maintenance, and management;
2. Using communications technology to support the transfer of data from design through construction, including official project documents;
3. Using interactive computer-based training to implement new specifications and to bring newly hired engineers up to speed;
4. Promoting seamless transfer of data from design through plan preparation to construction in order to accelerate and enhance quality project delivery; and
5. Using computer-based communications technology to provide bridge-related information to the public.

Building Blocks

1. Computer automation and communication.
   - Software verification/validation.
   - Software tools to validate/compare proposed specification changes.
2. Systems to integrate bid estimating, project management, and construction management.
3. Enhanced CADD/automation to integrate manufacturing, erection, and construction process.
4. Systems for public access to transportation-related information.
Leadership

Better uses of resources result when all types of expertise are brought to bear on policy decisions. Therefore, there is a need for bridge engineers to be concerned not only with the technical aspects of designing, constructing, and maintaining, but also with the process of policy formulation, planning, and budgeting. Bridge engineers need to fully participate by providing technical input to policy decisions. This participation will lead to more efficient use of resources and to more effective use of the transportation system by the public.

The business need is to encourage bridge engineers to seek opportunities to become engaged in the overall policy and budgetary processes within their organizations and to demonstrate the enhancement of policy and budgetary decisions by input from bridge engineers.

Objective

To engage engineers fully in policy formulation, planning, and budgeting through the following:

1. Equitable application of resources to bridge infrastructure through participation in budgetary and management policy decisions and
2. Enhancing the public’s understanding of DOT decisions regarding structures.

Building Blocks

1. A professional articulation of safety risk implications of design alternatives.
2. A structural viewpoint on the following:
   Aesthetics investment,
   Environmental sensitivity investment,
   Preventive maintenance investment,
   Bridge alignment, and
   Construction methods.
3. Application of bridge management expertise to the department’s asset management process.
4. Enhanced public perception of the department.
5. Leadership and management training for bridge engineers.
APPENDIX A

Workshop Participants
Workshop Participants (*Steering Committee Members)

Ralph E. Anderson, Illinois DOT  
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APPENDIX B

Research Areas Complementing
The AASHTO Thrusts/Business Needs
RESEARCH AREAS COMPLEMENTING THE AASHTO THRUSTS/BUSINESS NEEDS

During the course of the planning workshop, numerous suggestions were made for research work that might support the business needs of the AASHTO Highway Subcommittee on Bridges and Structures (HSCOBS). A listing of these suggestions follows. Readers are cautioned that these items do not necessarily represent topics that will receive endorsements for funding from HSCOBS. They merely illustrate the wide range of research topics which, if suitably interpreted in a detailed problem statement, could be of interest to HSCOBS.

Enhanced Materials, Structural Systems, and Technologies

1. Development of improved field welding processes.
2. Evaluate and develop corrosion protection systems for bridges and bridge elements.
4. High-strength and toughness-rolled steel with enhanced weldability and corrosion resistance.
5. Durability of portland cement mixes with pozzolans and admixtures.
6. Connection of fiber-reinforced polymers (FRPs) to concrete or steel structures.
7. Ductility requirements for FRP structural applications.
10. Cable cross-section to prevent aerodynamic vibrations.
12. Development of methodologies for determining the structural reliability (φ factors) for new materials and systems.
14. Accelerated tests for materials and/or systems.
15. Rapid replacement techniques.
16. Compatibility of hybrid material systems.
17. Development of self-maintaining bridge systems.

Efficient Maintenance, Rehabilitation, and Construction

1. Development and implementation of improved quality assurance/quality control (QA/QC) specifications and inspection processes.
3. Digital documentation for design, fabrication, and construction.
4. Robotics in maintenance, fabrication, and inspection.
5. Use of improved traffic controls in work zones.
6. Remote structure monitoring techniques and systems for scour detection, substructure movement, cracking, seismic damage, corrosion, and overloads.
7. Effective thin overlays compatible with rapid installation.
8. Materials to mitigate alkali-silica reaction.
9. More rapid tests for reactive aggregate.
10. Environmentally acceptable means of cleaning structures.
11. Alternatives for lead paint.
12. Repair methods for deteriorating foundations.
14. Promotion of design concepts amenable to rapid repair.
15. Development of enhanced materials and techniques for rapid installation in various environmental conditions.
16. Development of joints that are easily repaired and/or replaced.
17. Development of best practices, methods, and models for preventive maintenance that optimize service life.
18. Development of durable environmentally sensitive and easily applied coatings and sealants.
19. Development of modular components for rapid and easy repairs.

Bridge Management

1. Development and implementation of new inspection and assessment techniques, including remote sensing, NDT, and monitoring.
2. Development of new modules and improvement of existing modules for bridge management systems.
3. Collection of data to support economic analyses and service life/life-cycle analyses.
6. Improvement of quality of data and databases.

Enhanced Specifications for Improved Structural Performance

1. Code clarification for foundation design.
2. Clarification of extreme event loads and load combinations.
3. Software development.
4. Provision of continuous support for refining and expanding LRFD specifications.
5. Test suites and software tools for specification verification/comparison.
6. Development of design parameters regarding rehabilitation materials and techniques.
10. Education opportunities for engineers regarding current design practices (LRFD).
12. Promotion of design concepts that are amenable to rapid replacement and/or repair.
13. Development of feedback/communications requirements between design construction and maintenance forces.
14. Development of improved specifications for extreme events and combinations of extreme events.
15. Fully implement LRFD.
16. Development of acceptability criteria for various limit states, in particular serviceability limit states, and extreme limit states (determine corresponding target reliability level(s)).
17. Development of guide specifications covering areas of design and practice not currently covered, in particular specification provisions for composite and high-performance materials.
18. Research and implement findings on system and component behavior.
19. Development of simple, less prescriptive design procedure specifications.
20. Enhancement of current design specifications for improved durability and development of durability standards

**Computer-Aided Design, Construction, and Maintenance**

1. Development of systems to integrate bid estimating, project management, and construction management.
2. Enhancement of CADD/automation to extend to integrated manufacturing, erection, and construction processes.
3. Development of computer programs that link data between related design components.
4. Development of enhanced systems (e.g., GIS) to provide public access to transportation-related information.
5. Establishment of suitable protocols for storing and managing project data and documents.
6. Development of interactive Internet training modules, including LRFD, BMS, and inspection.
7. Development of protocols for “on-line” access to AASHTO specifications and transportation guides.
8. Continued support of design and analysis tools.
9. Test suites for software verification/validation.