Research Agenda for Transportation Infrastructure Preservation and Renewal: Conference Report

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Many elements of the nation’s surface transportation infrastructure are deteriorating as a consequence of aging and increasing stresses. The American Recovery and Reinvestment Act of 2009 (the stimulus package) provided an initial infusion of funds for transportation infrastructure renewal and restoration, but these resources are not sufficient for rebuilding and sustaining the condition and performance of that infrastructure. Under these circumstances, it is particularly important to develop and deploy the best methods and technologies to support effective management of transportation infrastructure.

To respond to this challenge, the U.S. DOT Research and Innovative Technology Administration sponsored a conference organized by the Transportation Research Board that brought infrastructure owners and decision makers together with researchers to consider problems, needs, and achievements and to define the directions for essential research to manage and preserve the nation’s surface transportation infrastructure. Participants at the November 2009 conference outlined the challenges and opportunities facing the highway, public transit, and rail systems and developed a road map to guide future research that builds on those opportunities and meets those challenges.

The conference focused on four research areas believed by the planning committee to be key to successful preservation and renewal of surface transportation infrastructure. The research priorities in those areas are summarized here; the complete road map is posted at http://onlinepubs.trb.org/onlinepubs/conferences/2009/Infrastructure/ResearchAgenda.pdf.

Inventory and condition assessment methods, with research thrusts in these areas:

- Develop new and enhanced sensing and data collection technologies, including assessment methods for currently uninspectable facilities (e.g., mechanically stabilized earth walls, gusset plates); hardened sensors for field deployment; a comprehensive database on sensors and their applications; and data collection methods to support deterioration modeling.
- Create new assessment methods, including rapid testing of new materials and designs; improved bridge management systems; and integration of inspectability and maintainability into infrastructure design.
- Modernize inspection policies, standards, and procedures, including development of risk-based assessment policies; inspection policies for all transportation assets (not only bridges and pavements); and uniform inventory and assessment standards.
- Estimate the value of infrastructure preservation and monitoring to support resource allocation decisions.

Innovative and environmentally responsible materials and methods for preservation, restoration, and reconstruction of transportation infrastructure. Examples of priority research include:

- Assess long-term performance of traditional, recycled, and advanced infrastructure materials.
- Determine technical and economic feasibility of using biorenewable resources as alternatives to petroleum-based materials.
- Evaluate feasibility of improving the current cement manufacturing process to minimize energy usage.
- Develop standards and life-cycle cost estimates for application of recycled materials.
- Investigate self-healing cementitious and steel materials.
- Promote practical applications of embedded sensors such as fiber optics, nanopowders, and piezo-composites for building intelligence into materials.
- Develop innovative materials to generate energy from and for infrastructure system operation, including heat to prevent bridge deck freezing.

Strategies for rapid repair and rehabilitation, including six themes:

- Develop materials and methods for accelerated construction, such as prefabricated replacement systems and rapid repair techniques and materials (e.g., composites, rapid-set concrete).
- Integrate life-cycle resource costs in rehabilitation decisions, including techniques to measure benefits (impacts) of renewal
4. Address organizational barriers to the application of new decision support tools, including the political process, risk-averse decision makers, fragmented infrastructure ownership, hierarchical decision processes, and challenges of bidding requirements. Specific research areas include:
   a. Develop improved policies and processes to integrate data and decision making, more effective communication strategies, and better ways to achieve buy-in through demonstrations, prototypes, and partnerships.
   b. Establish education and training programs to prepare professionals to use advanced analysis and decision support tools.

The development of research recommendations in these areas led to six cross-cutting research themes listed below. The first five of these themes address key barriers to implementing new concepts, and thus investments in these topics are likely to produce broad and important impacts on the field. The sixth—advancing technologies for condition and performance monitoring—aims to improve the quality and cost-effectiveness of information for infrastructure management decisions.

Methods for Rapid Testing of New Materials and Designs. Implementation of new materials and methods is commonly slowed by uncertainties about the effectiveness and efficiency of long-term performance. Reliable accelerated testing techniques will help overcome uncertainty about such innovations. Such techniques must be sensitive to the effects of environmental, utilization, and aging factors on component and system condition and performance. These techniques should target new and recycled materials, innovative designs, and construction methods.

Responsive and Flexible Standards and Specifications for New, Advanced, and Recycled Materials, Designs, and Systems. An important barrier to innovation and implementation is reliance on standards and specifications grounded in traditional materials and methods. A new concept may be rejected because there is no specification to support it, rather than because of inherent limitations. Updated and performance-based standards and specifications will help to advance innovation in infrastructure preservation and renewal.

Updated Inspection Standards and Policies. The value of advanced sensor and monitoring technologies is limited by outdated inspection policies. Modern and more flexible assessment criteria are needed to make effective use of new sensors and automated continuous monitoring capabilities, to manage inspection based on risk and condition, and to cover new materials and additional components of the transportation system.

Valuation Methods to Support Infrastructure Management Processes. Reliable and credible information on the value of infrastructure options is needed to support more informed investment and management decisions. Research is needed to develop objective, quantitative, and monetary methods and models to estimate life-cycle values for (1) automated monitoring technologies and methods; (2) preservation and renewal actions; and (3) keeping transportation facilities and systems in a state of good repair.

Training and Education. Limitations of knowledge about and skills for new materials and methods slow innovation in infrastructure renewal and preservation, creating a critical need to
invest in transportation infrastructure education and training in universities, private entities, and public agencies. While training is not a research function, knowledge transmission is an integral part of the research process, both in academic institutions that have this dual mission and in research organizations that have a mandate to move products into practice. The training challenge is exacerbated by the need to renew the transportation infrastructure workforce at both the professional and technical levels and by the rapid rate of development of new technologies.

**Continued Development of Infrastructure Condition and Performance Sensors.** While there has been much progress on new, automated sensors and remote monitoring technologies, a variety of enhancements are needed. In particular, sensors are needed to monitor a broader range of transportation system components extending beyond pavements and bridges. Advanced technologies that can monitor hidden and inaccessible components represent special needs. New sensors that can be easily deployed with minimum disruption to operations, are hardened for long life, and are responsive to new materials and designs are also needed.

This research road map can serve as a guide for both research investors and producers in the deployment of resources and talent to ensure the condition, performance, safety, and security of the nation’s transportation system in the years ahead.