Accelerating Infrastructure Innovations

FOCUS on Structures Technology

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July 2004

INSIDE

U.S. Department of Transportation

Federal Highway Administration

LRFD: Achieving Greater Reliability and Service for Bridges

Call it the LRFD revolution. At least 46 States have fully or partially implemented the Load and Resistance Factor Design (LRFD) Specification for bridges, or are working with the Federal Highway Administration (FHWA) to develop LRFD implementation plans. This represents a giant leap from last year, when about half of States had not yet begun LRFD implementation.

The First Edition of the LRFD Specification was published by the American Association of State Highway and Transportation Officials (AASHTO) in 1994, as an alternate to the *Standard Specifications for Highway Bridges.* It incorporates state-of-the-art analysis and design methodologies for bridges with load and resistance factors based on the known variability of applied loads and material properties. The load and resistance factors are calibrated from actual bridge statistics to ensure a uniform level of safety. "With LRFD, you know what you're getting. There's greater reliability and a more uniform factor of safety," says Firas Ibrahim of FHWA's Office of Bridge Technology. "After using LRFD, States will find that their new bridges will result in either cost savings or cost increases, depending on the bridge geometrics and types, because of the unreliable and inconsistent factor of safety resulting from the old Standard Specifications. However, the more uniform service levels and bridge reliability should ensure superior serviceability and long-term maintainability for bridges."

AASHTO, in concurrence with FHWA, has set a deadline of October 1, 2007, for full LRFD implementation by all States. After this date, States must design all new bridges according to the LRFD Specifications. According to a 2004 AASHTO Oversight Committee survey, 12 States have already fully implemented the specifications. Another 34 States have partially implemented LRFD or are in the stage of developing implementation plans and designing pilot projects. To assist States in making the transition, FHWA is providing a range of resources, including:

- A team of structural, geotechnical, and research engineers who can meet with individual States and provide guidance in developing a State-specific LRFD implementation plan.
- A model State implementation plan.
- An LRFD resources list (including training courses, design examples, books, and software).
- Three LRFD Design Workshops (two for concrete and one for steel).
- Two comprehensive LRFD steel and concrete bridge design examples (deck to foundations).
- One LRFD steel girder design example in accordance with the Third Edition of the LRFD Specifications.
- An "Office Demonstration Project" to assist agencies with technical needs, such as completion of trial designs, interpreting Specification sections, "on the spot" training, and interpreting the results of different designs.

continued on page 2 ➢

LRFD,
continued from page 1

FHWA is developing two detailed training courses on using LRFD for substructures/foundations and superstructures. The substructure course will be available through FHWA's National Highway Institute (NHI) by the end of 2004, with the superstructure course available from NHI in 2005. FHWA will also be developing LRFD steel curved girder design examples and a training workshop, which will be available in early 2005.

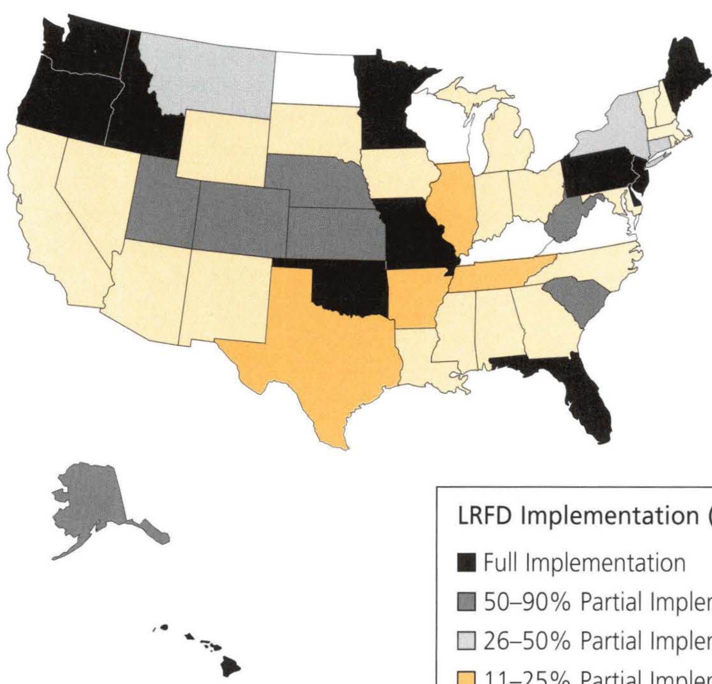
An obstacle to full LRFD implementation had been the geotechnical and foundations sections of the LRFD Specifications that address shallow and deep foundations, and earth retaining structures. "This impediment, although part reality and part perception, has now been overcome through a combination of NCHRP, AASHTO, and FHWA activities that have largely resulted in a complete rewrite that provides design and construction Specification guidance that is practitioner based, comprehensive, and current for geotechnical features," says Jerry DiMaggio of FHWA's Office of Bridge Technology. The final piece of this effort is the recently completed rewrite of Section 10 of the LRFD Specifications, which will be officially proposed for AASHTO Bridge Subcommittee adoption at next year's AASHTO annual meeting. In the interim, several States have volunteered to perform comparative designs and assess the results, which will be used to refine the proposed section. "The completion of this final task means that the structural and geotechnical highway features can now be seamlessly designed using LRFD procedures," says DiMaggio.

The New Jersey Department of Transportation (NJDOT) has been using LRFD for all of its bridges since 2001. Its implementation efforts began about 2 years earlier with two pilot projects. The first project used LRFD for a steel superstructure in Newark, while the second employed the specifications on a prestressed concrete bridge on Route 9 over Nacote Creek in South Jersey. "Our original intent was to phase in the implementation, but the design and construction of the pilot projects went so well that we decided to go full bore on implementation," says Harry A. Capers, Jr., of NJDOT. "Using LRFD has resulted in more efficiently designed bridges, with cost savings of up to 8 percent."

The Washington State Department of Transportation (WSDOT) established an in-house LRFD Implementation Steering Committee in 1994 and began providing LRFD training for its personnel in 1995. In 1995 and 1996, WSDOT began designing simple-span concrete superstructures using the LRFD Specifications. Since 1999, both superstructures and substructures for steel and concrete bridges have been designed using LRFD. "While there was a little bit of a learning curve, as our staff started using LRFD, they realized it was not so difficult. Now they are appreciating LRFD because it is so comprehensive and detailed. They see it as a powerful new design tool," says Jugesh Kapur of WSDOT. Washington State developed its own software, QConBridge and PGSuper, to perform LRFD live load analysis and design precast, prestressed concrete girders. These programs are available free of charge at www.wsdot.wa.gov/eesc/bridge/software. Implementation of LRFD has not negatively affected WSDOT's bridge design and construction costs.

In Pennsylvania, implementation of LRFD began about 7 years ago, with full implementation achieved over the last 2 to 3 years. The primary cost has been putting into place new LRFD software. "We use our own software, which cost several million dollars to develop and put in place," says Scott Christie of the Pennsylvania Department of Transportation

continued on page 6 ➢



LRFD Implementation (as of April 2004)

- Full Implementation
- 50–90% Partial Implementation
- 26–50% Partial Implementation
- 11–25% Partial Implementation
- 1–10% Partial Implementation
- No Implementation

Bridge System Preservation and Maintenance: Scanning for Innovation

The goal of learning more about bridge system preservation and maintenance processes and technologies used abroad brought an international technology scanning tour panel to Europe, Scandinavia, and Africa from March 28 to April 13, 2003. Sponsored by the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA), the tour featured 10 participants representing AASHTO, FHWA, State and local transportation agencies, and academia. Participants met with highway agency representatives and bridge management and inspection technology practitioners and researchers from South Africa, Switzerland, Germany, France, Denmark, Sweden, Finland, Norway, England, and Wales. The tour also included site visits to observe preservation techniques and new construction practices intended to provide longer and more reliable bridge performance.

While all of the countries visited had a smaller number of bridges than those found in the United States, the composition (types of materials, structural systems, and typical number and length of spans) and average age of their bridge populations were similar. Also, nearly every country was experiencing the same types of structure problems as are found in the United States, including problems with construction quality control, premature deterioration caused by corrosion, insufficient staffing and funding resources to maintain aging bridge populations, and increasing truck volumes and loads.

Among the innovations and best practices observed was bridge inspection frequency. The current practice in the United States is to inspect every highway bridge at least once every 2 years (although this inspection frequency can be increased to 4 years in some cases). In contrast, most of the countries visited during the scanning tour base their bridge inspection frequency interval on a risk-based approach that accounts for specific factors such as type of structure, condition, and age. For example, Germany has defined four levels of inspection: superficial, general, major, and special. Superficial inspections, which are primarily a visual assessment, are performed by maintenance personnel every quarter. General inspections are performed every 3 years, while major inspections are conducted every 6 years. Special inspections are performed as needed to assess known deficiencies or damage. In France, the frequency and level of inspection vary with the condition of the structures, but typically range from 3 to 9 years. The 3-year inspections are more superficial, while indepth inspections are performed every 9 years.

The Oresund Bridge and Tunnel connects Copenhagen, Denmark, and Malmö, Sweden.

"The more risk-based approach to bridge inspection frequency we observed abroad was one of the most striking aspects of the trip to me," says team member Tom Everett of FHWA's Office of Bridge Technology. "The countries we visited also tie required inspector qualifications to the complexity of the bridge being inspected, rather than taking a one size fits all approach." Team member Ron Young of the Alcona County Road Commission in Michigan also found learning about the differences in bridge inspection frequency and inspector qualifications to be one of the most valuable aspects of the trip. "There are a wide variety of bridge types and complexities, which were reflected in the different levels of inspection frequency and inspector qualifications," says Young. "The trip was an excellent source of ideas. I have since shared some of my experiences with other local highway agencies."

The scanning team has recommended conducting a study to determine the relative risk of extending the inspection frequency for typical bridge types in the United States and to then develop a rational method for determining the required frequency, associated rigor, and required level of inspector expertise for bridge inspections for different classifications of bridges.

The team also observed that both Finland and Switzerland are developing corridor-based bridge management systems. Finland is developing a network-level management system known as "Hibris," which will be capable of analyzing and evaluating bridge and pavement needs in an integrated environment. Performance and planning indicators, including a repair index and a rehabilitation index, are being designed for the system. Switzerland, meanwhile, has designed a system that will provide management tools for maintaining highway assets, including pavements, structures, and electromechanical systems. In contrast, most bridge management systems in the United States currently operate independent of other highway asset management systems. Recognizing the value in a corridor-based management approach, the scanning team has recommended that a study be initiated to evaluate and promote corridor-based management princi-

continued on page 8 ➢

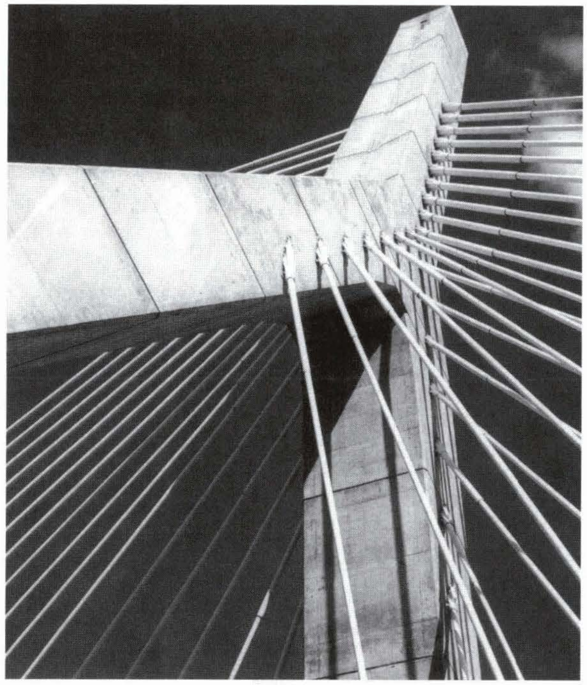
Steel Bridges: Partnering for Success

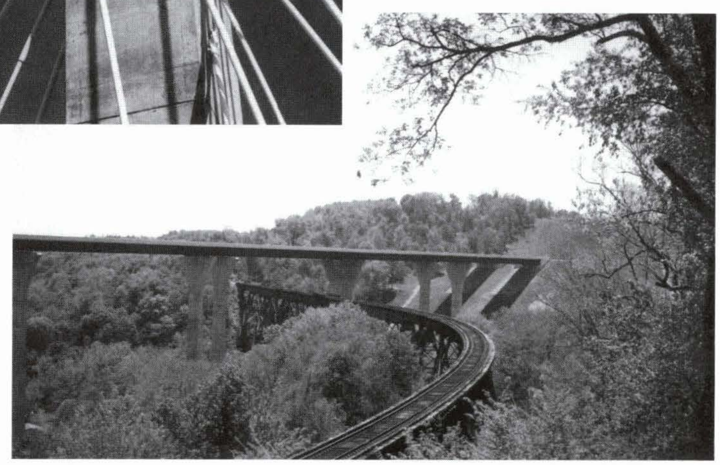
Improving the state-of-the-art for the design and construction of steel bridges brought 30 representatives from States, industry, and the Federal Highway Administration (FHWA) together in December 2003 for an inaugural partnership meeting at FHWA's Turner-Fairbank Highway Research Center in McLean, Virginia. "The main focus of the meeting was to get participants' ideas on how we can improve the design and construction of steel bridges, and the input received was very valuable," says Vasant Mistry of FHWA. The partnership is now paying dividends as participants collaborate on such activities as preparing a new design handbook.

Topics covered at the 1-day meeting included technology and research needs, technology transfer, high-performance steel (HPS), load and resistance factor design, corrosion protection, nondestructive testing, and steel bridge fabrication and erection.

The need for further education for bridge engineers and designers emerged as a predominant theme at the meeting. To help bridge engineers better do their job, participants advocated for the development of a new design handbook for steel bridges that would cover everything from A to Z. FHWA is collaborating with the National Steel Bridge Alliance (NSBA) to make this goal a reality, and work on the new guide is underway. To further the collaborative effort, "we want to get specialists across the country involved in reviewing chapters of the new guide," says Mistry. The guide is expected to be available in 2006.

Meeting participants stressed the importance of accelerating bridge construction through such methods as prefabrication. Prefabricated bridge elements, ranging from small components such as deck panels to large spans, can be manufactured either on- or off-site, under controlled conditions, and brought to the construction location ready for installation. Using prefabricated elements can increase construction zone safety, minimize the traffic impacts of bridge construction projects, and improve constructibility. It can also reduce construction time from years to a matter of months or even days. To learn more about prefabricated bridge elements and systems, visit www.fhwa.dot.gov/bridge/prefab. More information about accelerated bridge construction technologies is available at www.fhwa.dot.gov/bridge/accelerated.





Innovative new steel bridges include the Leonard P. Zakim Bunker Hill Bridge in Boston, MA (above), and the Mingo Creek Viaduct in Washington County, PA (right).

Participants also discussed technology transfer and research needs for HPS. Stronger and tougher than conventional steel, HPS also offers greater resistance to cracking. Although 42 States are now using HPS for bridges, participants noted that many still view HPS as experimental and that its use needs to be more widely publicized. To aid in technology transfer, a variety of material on HPS is now available on FHWA's Web site (www.fhwa.dot.gov/bridge/hps.htm), including a designer's guide, technical advisories, and information on welding and standards details/best practices.

FHWA is planning to hold a second partnership meeting later this year. "Attendees felt that the meeting was a very important start and that it was vital to keep the dialogue and the effort continuing," says Mistry. "Everyone agreed to work together more closely," noted Conn Abnee of NSBA. "The meeting was also useful in disseminating new ideas and techniques. There is particularly strong interest in the forthcoming new design handbook."

To learn more about the partnership meeting or steel bridge technologies, contact Vasant Mistry at FHWA, 202-366-4599 (email: vasant.mistry@fhwa.dot.gov).

Balsi Beam Goes on Tour

Meet the new star of the summer road. Developed by the California Department of Transportation (Caltrans), the Balsi Beam is a mobile work protection system that uses a modified semi-trailer that is transported by a tractor (see January/February 2004 *Focus*). The system hit the road recently to visit numerous States on its way to and from the American Association of State Highway and Transportation Officials (AASHTO) Maintenance Conference in Bismarck, North Dakota. "We wanted to give States the opportunity to see the vehicle and find out more about it," says Jerry Jones of the FHWA Resource Center. "The tour allowed us to show it to the highway community and get feedback on how they see it being used."

The Balsi Beam on display in Bismarck, ND.

Each side of the trailer consists of high-strength steel box section beams that are capable of extending an additional 3.6 m (12 ft). Using hydraulic power, each beam can rotate to either side (left or right), depending on which side of the road a protective barrier is needed. The trailer then extends to provide a 9.1-m (30-ft) secure work zone.

En route to the AASHTO conference, the Balsi Beam visited Oregon, Washington, Idaho, and Montana in late June. In Washington State, for example, demonstrations were held in Vanouver, Olympia, and Seattle for Washington State Department of Transportation (WSDOT) and FHWA personnel. Members of WSDOT's Work Zone Safety Task Force attended the demonstration in Olympia. "We are very interested in finding better ways to protect our workers," says Pat Moylan of WSDOT. "We saw it being deployed and then the demonstrators showed us how to prepare the device for transport." Rose Willis of Caltrans notes that, "we got a variety of people at the demonstrations, including management, engineering, and maintenance staff. Attendees have talked to us about the various applications for the device, including night work, surveying, patching, and sign work."

In Oregon, demonstrations were held in Portland and Salem for Oregon Department of Transportation and FHWA staff. "The demonstration was very hands-on and informative. I think that everyone who saw the device was impressed and thought that it could provide some real tangible safety benefits," says Jeff Graham of FHWA's Oregon Division Office. "One area of interest was using it for bridge maintenance, as those workers are basically between the traffic and a bridge rail."

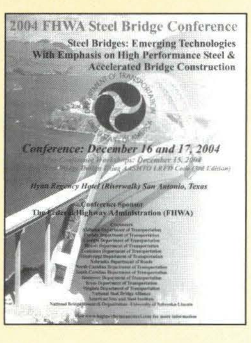
After being on display at the AASHTO Maintenance Conference from June 27–July 1, the Balsi Beam then made appearances in South Dakota, Nebraska, Wyoming, Colorado, Utah, and Nevada. "We're also hearing from other States who are interested in hosting demonstrations," says Chris Kundert of Caltrans.

To learn more about the Balsi Beam, contact Kris Teague at Caltrans, 916-227-9608 (fax: 916-227-9711; email: kris.teague@dot.ca.gov). For more information on the Balsi Beam tour, contact Jerry Jones at FHWA, 817-978-4358 (fax: 817-978-4666; email: jerry.jones@fhwa.dot.gov).

Emerging technologies will be the focus at the 2004 FHWA Steel Bridge Conference, to be held December 16–17 in San Antonio, Texas. Workshop sessions will particularly emphasize high-performance steel (HPS) and accelerated bridge construction, with such featured topics as the material characteristics of HPS, future plans for development of HPS, innovative methods for reducing construction time, and in-service inspection issues of bridges built with accelerated construction methods. Numerous case studies will also be featured. Three pre-conference workshops will be held on December 15:

- Steel Bridge Design Workshop: Using 2004 AASHTO LRFD Bridge Design Specification
- Accelerated Bridge Construction Workshop
- Curved I-Girder Bridge Design Workshop.

For more information, contact Vasant Mistry at FHWA, 202-366-4599 (fax: 202-366-3077; email: vasant.mistry@fhwa.dot.gov), or Atorod Azizinamini at the University of Nebraska–Lincoln, 402-472-3029; (fax: 402-472-5178; email: atorod@highperformancesteel.com). Information is also available online at www.highperformancesteel.com.



No Excuses in the Mixing Bowl

The successful use of an innovative contracting strategy is helping the Virginia Department of Transportation (VDOT) and Federal Highway Administration (FHWA) ensure the timely completion of Virginia's Springfield Interchange project, also known as the "Mixing Bowl."

The strategy, called a "No Excuses Incentive," involves offering the contractor a significant bonus (typically 2 to 10 percent of the contract's value) if "substantial completion" of the project is achieved by a set date. "Substantial completion" is typically defined in the contract, and the project engineer is usually authorized to make this determination. The incentive is known as "No Excuses" because the date established to receive the incentive will not be extended due to any delays that arise during construction, even though such delays are normally granted extensions under traditional contracting methods. These delays include those caused by work disruptions, utility conflicts, design changes, right-of-way issues, permitting issues, and weather conditions.

One of the first locations where this form of incentive saw use in State highway projects was in Florida during the mid 1990s. These projects covered the gamut from lane additions to resurfacing, bridge repair, intersection improvement, and highway reconstruction.

In the case of the Springfield Interchange, VDOT and FHWA opted to offer a No Excuses Incentive for Phases 2 and 3 of the 8-year project, which is aimed at redesigning a complicated and historically congested interchange in the vicinity of Springfield, Virginia, involving I-495 (the Washington Beltway), I-95, and I-395. Approximately 430,000 vehicles a day travel through the interchange. The incentive amounted to $10 million if the work was completed on or before August 18, 2001, with the amount dropping to $5 million if completed on or before November 17, 2001, with the contract fixed date for completing these project phases being June 1, 2002.

The project planners chose to use a No Excuses Incentive because they wanted to proceed with construction even though certain preparations typically made prior to construction had not been completed. When the project was advertised for bid in September 1998, 55 right-of-way parcels still needed to be procured, and much of the utility relocation work had yet to be completed. Any contractor bidding on the project would need to work around the utilities and unprocurred lots. It was determined that a No Excuses Incentive was the optimal method for encouraging the contractor to remain on schedule despite these difficulties, says Bob McCarty of FHWA's Virginia Division Office. The incentive worked: even though the contractor did not have full access to the construction site until right of entry had been obtained for the final parcel in March 1999, and many utilities had to be relocated during construction, the project phases were completed on schedule.

The contractor, Shirley Contracting Corp., received the full $10 million incentive. "There was some extra work added to the project, which delayed completion to June 2002, but as this additional work was not in the original contract, the contractor was not penalized," says McCarty. "The No Excuses incentive did help to complete the job quicker and with less total traffic disturbance."

For more information on the use of the No Excuses incentive for the Springfield Interchange Project, contact Bob McCarty at FHWA, 804-775-3349 (email: bob.mccarty@fhwa.dot.gov), or Larry Cloyed at VDOT, 703-313-6686 (email: Larry.Cloyed@VirginiaDOT.org). For more information on the project in general, visit www.springfieldinterchange.com.

LRFD,

continued from page 2

(PennDOT). PennDOT has found that the new specifications provide more explanation of what's needed for a design, though Christie notes that the agency is still working on fixing some problems in using the specifications for substructures.

"Thanks to PennDOT and other States who pointed out this problem to FHWA and have been working with FHWA and the Technical Committee of AASHTO to fix the problem," says Ibrahim. "As a result, newly rewritten foundation specifications were developed and will be balloted by AASHTO in 2005. These new specifications represent a state-of-the-art foundation design practice that has never been done in the geotechnical area before."

The New York State Department of Transportation (NYSDOT) is using LRFD for about half of its bridges now. "We started implementation about 5 years ago. It has been a learning curve, but we are finding that the results are comparable to what we were achieving with the standard specs," says Art Yannotti of NYSDOT. "One advantage is that LRFD does provide better consistency in designs." New York also has not seen any difference in costs using LRFD.

For more information on LRFD or FHWA's LRFD resources, contact Firas Ibrahim at 202-366-4598 (email: firas.ibrahim@fhwa.dot.gov). Information is also available online at AASHTO's LRFD Bridge Specifications Web site (lrfd.aashtoware.org).

Highway Technology Calendar

The following events provide opportunities to learn more about products and technologies for accelerating infrastructure innovations.

Second National HERS-ST Conference
August 19–20, 2004, Chicago, IL

The conference will provide practical assistance to highway agencies using the Highway Economic Requirements System–State Version (HERS-ST) software, as well as other agencies considering its use. HERS-ST is an engineering/economic analysis tool designed to evaluate the implications of alternative programs and policies on the conditions, performance, and user cost levels of highway systems.

Contact: David Winter at the Federal Highway Administration (FHWA), 202-366-4631 (email: david.winter@fhwa.dot.gov), or Francine Shaw-Whitson at FHWA, 202-366-8028 (email: francine.shaw-whitson@fhwa.dot.gov). More information and online registration is available at www.fhwa.dot.gov/infrastructure/asstmgmt/hersconf.htm.

Seminar on Design and Construction of Segmental Concrete Bridges
August 30–31, 2004, Orlando, FL

The seminar focuses on the design and construction of precast and cast-in-place segmental bridges constructed using the cantilever and span-by-span methods. Also addressed are cable-stayed bridges.

Contact: Cliff Freyermuth at the American Segmental Bridge Institute, 602-997-9964 (email: asbi@earthlink.net). Visit www.asbi-assoc.org for more information (select "Menu" and then "ASBI Events").

2004 National Hydraulic Engineering Conference
August 31–September 3, 2004, Asheville, NC

Conference topics will include hydrology, modeling, environmental issues, coastal engineering, stream stability, and scour. The event is sponsored by FHWA and the North Carolina Department of Transportation.

Contact: Cynthia Nurmi at FHWA, 404-562-3908 (email: cynthia.nurmi@fhwa.dot.gov).

Ninth Annual Eastern Winter Road Maintenance Symposium and Equipment Expo
September 8–9, 2004, Knoxville, TN

The symposium will feature best practices and new products and equipment for winter maintenance. Sponsoring the event are FHWA, the Tennessee Department of Transportation, and the Tennessee Transportation Assistance Program.

Contact: Mark Sandifer at FHWA, 708-283-3528 (email: mark.sandifer@fhwa.dot.gov). Information is available online at www.easternsnowexpo.org.

Second National Prefabricated Bridge Elements and Systems Workshop
September 8–10, 2004, New Brunswick, NJ

The workshop will look at how the use of prefabricated bridge elements and systems enables bridge owners, designers, and construction contractors to "Get in, Get out, and Stay out." The event is sponsored by FHWA, the American Association of State Highway and Transportation Officials (AASHTO), New Jersey Department of Transportation, and Rutgers University, in cooperation with the Midwest Transportation Consortium.

Contact: For information on registration or abstract submission, contact Hani H. Nassif at Rutgers University, 732-445-4414 (fax: 732-445-8268; email: nassif@rci.rutgers.edu). For information on travel support scholarships available for State highway agencies, contact Harry A. Capers, Jr., at the New Jersey Department of Transportation, 609-530-2557 (fax: 609-530-5777; email: Harry.Capers@dot.state.nj.us). For general information on the workshop, contact Helene Cook at FHWA, 609-637-4230 (fax: 609-538-4913; email: helene.cook@fhwa.dot.gov). Information can also be found online at www.fhwa.dot.gov/bridge/accelerated.

Structural Materials Technology: NDE/NDT for Highways and Bridges 2004
September 14–17, 2004, Buffalo, NY

Participants will learn about the state-of-the-art in nondestructive evaluation (NDE) and nondestructive testing (NDT) technologies. The event is sponsored by The American Society for Nondestructive Testing, Inc., New York State Department of Transportation (NYSDOT), Transportation Research Board (TRB), FHWA, and the Structural Engineering Institute.

Contact: Hamid Ghasemi at FHWA, 202-493-3042 (fax: 202-493-3442; email: hamid.ghasemi@fhwa.dot.gov), or Sreenivas Alampalli at the NYSDOT, 518-457-6827 (email: salampalli@dot.state.ny.us; Web: www.fhwa.dot.gov/bridge/smt.htm).

Second International Conference on Accelerated Pavement Testing
September 26–29, 2004, Minneapolis, MN

The conference will present research findings on accelerated pavement testing topics, including bridge decks, fatigue, instrumentation, performance, stabilization material, and permanent deformation. Conference sponsors include AASHTO, FHWA, the Minnesota Department of Transportation (Mn/DOT), TRB, and the University of Minnesota's Center for Transportation Studies.

Contact: Ben Worel at Mn/DOT, 651-779-5522 (fax: 651-779-5616; email: ben.worel@dot.state.mn.us), or Kenneth Fults at the University of Texas, 512-232-3081 or 512-310-2933 (email: kenfults@yahoo.com). Information is available online at www.cce.umn.edu/engineering/accelerated_pavement.

FOCUS

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Its primary mission is twofold: (1) to serve the providers of highway infrastructure with innovations and support to improve the quality, safety, and service of our roads and bridges; and (2) to help promote and market programs and projects of the various offices of FHWA's Office of Infrastructure.

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Bridge System Preservation and Maintenance,

continued from page 3

ples for bridge preservation and project decisions.

Another practice of particular interest to the scanning team was the use of bridge deck protective strategies, as bridge deck deterioration is one of the most costly aspects of maintaining this country's bridge inventory. Many European countries rely heavily on the use of waterproofing systems and membranes to provide protection for concrete bridge decks in order to retard and prevent deterioration. Typically, the membrane is then protected with a concrete or asphalt wearing surface. However, the primary practice in the United States has been to use other deck protection strategies, such as epoxy coated reinforcing steel and thicker concrete cover requirements, rather than waterproofing and membrane systems. The team has therefore recommended that a study be done to review U.S. and European practices and to compare the effectiveness of waterproofing and membrane systems to other deck protection approaches currently in use in the United States.

The team noted that several countries are making advances in concrete permeability evaluation technology. Switzerland, for example, has developed a vacuum-based method that pulls air through pores in the concrete member. As other countries, including the United States, are also conducting research and development studies on permeability testing, the scan team recommends that a more focused study be conducted to collect and assess information from a number of countries.

For more information on the scanning tour, contact George Romack at FHWA, 202-366-4606 (email: george.romack@fhwa.dot.gov), or Ken Hurst at the Kansas Department of Transportation, 785-296-3761 (email: kenh@ksdot.org). A scan report is expected to be released later this year.

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