Accelerating Infrastructure Innovations

FOCUS

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INSIDE

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U.S. Department of Transportation

Federal Highway Administration

Colorado Rockfall Simulation Program: Modeling Rockfall in 3D

Evaluate rockfall hazards surrounding roadways more effectively with the new 3D version of the Federal Highway Administration's (FHWA) Colorado Rockfall Simulation Program (CRSP-3D).

As development and traffic have increased in mountainous areas, the need to protect people, roadways, and building structures from falling rocks has become more important. Created in the mid 1980s for the Colorado Department of Transportation, the original CRSP program was a 2D model used to predict the behavior of rockfall; determine the need for rockfall mitigation measures such as constructing ditches, berms, fences, and walls; and aid in the design of these measures.

Modeling has helped engineers estimate how rockfall parameters such as bounce height, velocity, kinetic energy, and rollout distance change along the slope length. However, 2D modeling may not be as effective when simulating the rotation and slope interaction of nonspherical rocks, as different rock shapes have different modes of rotation depending on velocity. This may result in inaccurate estimates of rockfall properties, particularly rock rollout, dispersion along and below the slope, and bounce height.

CRSP-3D uses the Discrete Element Method, a numerical modeling approach that incorporates the equations of motion to more accurately model movement of rockfall on a slope surface, including impact, rolling, launching, and sliding. Different possible rockfall paths on a section of slope can be modeled, as well as the rotational movement of nonspherical rocks. Users can build rocks of several shapes, including spherical, cylindrical, and prismatic. The

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The highly weathered limestone escarpment above the Glenwood Canyon Viaduct in Colorado produces rockfall over an area too large to be assessed by conventional 2D methods. FHWA's new CRSP-3D software offers a more effective solution for evaluating rockfall hazards.

Showcasing an Advanced Motorist Warning System in Texas

On September 15, 2001, a tow boat pushing four barges struck the Queen Isabella Causeway (QIC) in Texas, a 3.9-km (2.4-mi) bridge crossing the Gulf Coast Intracoastal Waterway that connects South Padre Island to Port Isabel.

The structure consists of 147 concrete spans, 24-m (80-ft) each, with a 238-m (780-ft) steel section over the navigation channel. Two spans were knocked out by the barge, leaving a 48-m (160-ft) gap in the roadway.

Motorists driving from Port Isabel could see the missing spans just before the peak of the bridge and were able to stop in time. However, drivers coming from South Padre Island could not see the missing spans until after they had crested the peak of the bridge and were about 61 m (200 ft) from the edge of the gap. In the 15 minutes before emergency personnel received notification and closed the bridge, 10 cars drove off the bridge, resulting in 8 fatalities.

A similar accident occurred on May 26, 2002, near Webbers Falls, Oklahoma. A towboat pushing two empty asphalt tank barges on the Arkansas River veered off course and rammed a pier of the I-40 bridge, causing a 153-m (503-ft) section of the bridge to collapse and fall into the river and onto the barges below. By the time traffic could be stopped, eight cars and three truck-tractor semitrailer combinations had fallen into the river or onto the collapsed portion of the bridge, resulting in 14 fatalities and 5 injuries. Following the accident, the National Transportation Safety Board (NTSB) recommended the development of an "effective motorist warning system to stop motor vehicle traffic in the event of a partial or total bridge collapse."

After the QIC disaster, the Texas Department of Transportation (TxDOT) designed and launched a Collapse Warning System for the bridge in 2004. Maintained and monitored by TxDOT's Pharr District Office, the system was upgraded in 2007. It includes:

- A continuous fiber optic cable for signal transmission.
- A controller to monitor the signal.
- Traffic gates, dynamic message signs, and warning signs.
- A telephone auto-dial system.

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The Collapse Warning System on the Queen Isabella Causeway in Texas includes flashing red traffic signals.

The Collapse Warning System works by detecting the loss of a signal that is transmitted over fiber optic cable. A controller monitors the signal and activates motorist warnings if the signal is lost. A telephone auto-dial system then notifies TxDOT and emergency personnel. Primary motorist warning is accomplished through a series of flashing red traffic signals, which are configured to notify motorists who have not reached the site of the bridge collapse to stop and to allow those who have already passed the site to exit the bridge. Warning mechanisms also include signs alerting motorists when they approach the bridge, traffic gates, dynamic message signs, and preemption of nearby traffic signals. TxDOT conducts a full emergency alarm test each quarter to check the operation of the system and ensure that the auto-dial function is working. Potential system enhancements being considered include adding video surveillance cameras and additional communication lines for remote monitoring of the system.

On April 26, 2012, FHWA held a showcase meeting in South Padre Island, Texas, to learn more about the system, as well as other available commercial solutions. Participants included representatives from TxDOT, the Louisiana Department of Transportation and Development, Florida Department of Transportation, NTSB, and FHWA. Both Louisiana and Florida

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A traffic gate with a warning sign on the Queen Isabella Causeway in Texas.

have expressed interest in installing a similar system on their bridges.

"The system installed on QIC is an exemplary one that is operational and effective," said Raj Ailaney of FHWA. "The technology is readily available, and a unified advanced motorist warning system can easily be designed for a particular bridge location per individual State specifications."

In addition to showcasing TxDOT's system, the workshop provided an overview of existing commercial options for an advanced motorist warning system. In general, such systems contain a sensor mechanism and an integrated central control architecture. A sensor mechanism could be a continuity-type sensor such as the fiber optic cable used in TxDOT's system, a rotational or displacement sensor, or a combination of both to detect a tilt or shift in a structure that could be caused by an event such as a collision, seismic occurrence, storm, scour, or structure component failure. While sensing technologies to detect a failed bridge exist, as well as central control architecture that includes signal and barricade systems, a commercial unified system does not yet exist. However, separate sensing, signal, and barricade systems can be integrated to achieve a complete Advanced Motorist Warning System at an estimated cost of $200,000 to $250,000 for a 152-m (500-ft) long bridge.

For more information on the Collapse Detection and Warning System Showcase, contact Jesus Leal, Director of Transportation Operations for TxDOT's Pharr District Office, 956-702-6127 (email: jesus.leal@txdot.gov). To obtain a copy of the showcase report, contact Raj Ailaney at FHWA, 202-366-6749 (email: raj.ailaney@dot.gov). ✻

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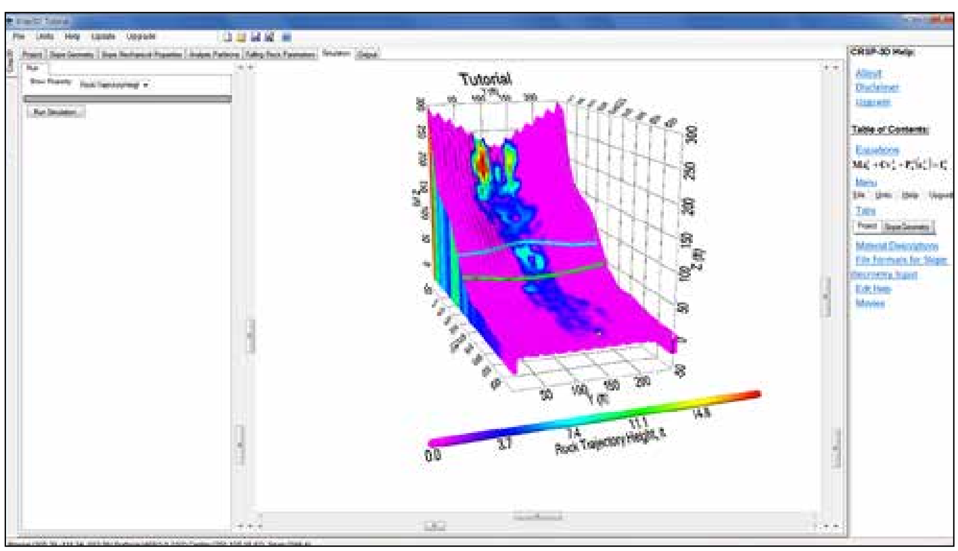
slope profile can be displayed in either 2D or 3D.

"The CRSP software is recognized by users around the world," said Matt DeMarco of FHWA's Federal Lands Highway Division. "While the previous version used a semi-empirical approach, this new 3D version uses an improved numerical modeling method."

Among other updates, the program's definition of surface roughness has changed so that only one value is needed to model the surface roughness for all rock sizes. CRSP-3D also uses just one input value, the hardness coefficient, to model slope material properties. The hardness coefficient measures the elasticity of the collision between a falling rock and the slope, as well as how much tangential resistance the rock is subjected to when sliding on the slope.

The software is accompanied by the *CRSP-3D User's Manual* (Pub. No. FHWA-CFL/TD-12-007). The manual walks users through installing and operating the program. Included are three simulations designed to familiarize users with the software. The tutorial example highlights how to create a new project and enter the necessary data. A second example features a 3D simulation of rockfall using LIDAR (Light Detection and Ranging) data. LIDAR is a 3D mapping technology that uses a laser to rapidly scan and produce high-resolution images of areas such as rock slopes and outcrops. Also included in the User's Manual is a 2D simulation of rockfall using manually entered slope geometry data.

To download CRSP-3D at no cost, visit www.cflhd.gov/programs/techDevelopment/geotech/CRSP-3D. The software is compatible with Windows®-based operating systems. For more information on CRSP-3D, contact Roger Surdahl at FHWA's Central Federal Lands Highway Division, 720-963-3768 (email: roger.surdahl@dot.gov). For user support, contact Rick Andrew at Yeh and Associates, 303-781-9590 (email: randrew@yeh-eng.com). ✻



A typical CRSP-3D graphical representation when performing a slope analysis.

Assessing Highway Infrastructure Health Nationwide

How healthy is your highway infrastructure?

A new report from the Federal Highway Administration (FHWA) examines candidate methods to consistently and reliably assess infrastructure health, focusing on bridges and pavements on the Interstate Highway System. Also examined are potential tools FHWA and State departments of transportation can use to obtain key data that will provide a more complete picture of infrastructure health nationally.

Improving FHWA's Ability to Assess Highway Infrastructure Health (Pub. No. FHWA-HIF-12-049) looks at the process for categorizing bridges and pavements in good, fair, or poor condition. This begins with developing qualitative definitions for each category. For this study, the definitions relate solely to the condition of a bridge or pavement and do not consider other factors such as safety or capacity. For example, the definition of "good" used for the study was bridge and pavement infrastructure that is free of significant defects and has a condition that does not adversely affect its performance. Condition metrics and thresholds that can be used to systematically categorize assets based on these definitions should then be defined.

A new report from the Federal Highway Administration (FHWA) examines candidate methods to consistently and reliably assess infrastructure health, focusing on bridges and pavements on the Interstate Highway System.

Building off of previous work conducted by the American Association of State Highway and Transportation Officials, three separate tiers of performance measures were evaluated. Tier 1 measures are considered ready for use at the national level, while Tier 2 measures require further work before being ready for deployment. Tier 3 measures are generally still in the proposal stage.

Performance measures for bridges included Structural Deficiency (SD) (Tier 1) and Structural Adequacy Based on National Bridge Inventory (NBI) Ratings (Tier 2). A Tier 3 measure was not included for bridges. For pavements, performance measures included the International Roughness Index (IRI) (Tier 1) and Functional Adequacy Based on Highway Performance Monitoring System (HPMS) Distress Data (Tier 2). A Tier 3 measure of Structural Condition based on Tier 2 data and pavement deflection data was also included.

The performance measures were evaluated on I-90 in Wisconsin, Minnesota, and South Dakota. This corridor runs for 1,406 km (874 mi), with average annual daily traffic ranging from approximately 5,000 vehicles to 90,000 vehicles. While about 85 percent of the corridor is rural, it links such urban areas as Madison, Wisconsin; Rochester, Minnesota; and Rapid City, South Dakota. HPMS and NBI data for this corridor were used for the study. The participating State highway agencies also provided data, including documentation of their systems, processes, and corridor inventory and pavement management system data.

The good, fair, and poor analysis for bridges proved to be a viable approach, with NBI data sufficient for the performance management assessment. However,

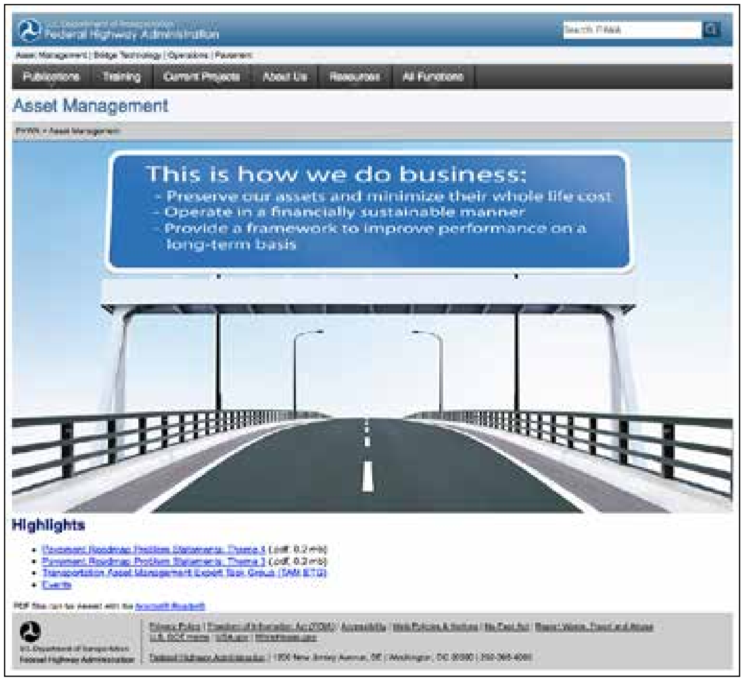
Improving FHWA's Ability to Assess Highway Infrastructure Health **looks at methods for consistently and reliably evaluating the health of bridges and pavements.**

a bridge's SD status was not as easily incorporated into the analysis. The report notes that a measure of structural adequacy based on NBI ratings would be a viable supplement to SD status as a national measure of bridge condition, although "implementation would require developing a general consensus on its definition."

The pilot study also demonstrated that the good, fair, and poor approach is feasible for pavements and implementable today using IRI as a Tier 1 measure. However, IRI does not fully represent the condition of a pavement, as it indicates little about the ability of the pavement structure to withstand traffic loadings. Implementation of the Tiers 2 and 3 pavement measures also proved to be feasible, although the study recommends data collection and processing improvements to advance the measures and achieve a more accurate picture of pavement health.

For example, collection of cracking data needs to be better defined, along with recommended quality control and quality assurance standards. Inconsistencies in collection and analysis of faulting data should also be resolved. The study suggests using FHWA's ProVAL software tool to analyze faulting may be a suitable first step in addressing these inconsistencies and standardizing the analysis of faulting data. ProVAL assists users in analyzing longitudinal pavement profiles.

The recommended next step in bridge assessment is for FHWA to develop a new measure of structural adequacy based on NBI ratings. This new measure could serve as an eventual supplement to SD as a national measure of bridge condition. In developing the new measure, two questions should be discussed:



To learn more about the new report on *Improving FHWA's Ability to Assess Highway Infrastructure Health* or other asset management resources, visit www.fhwa.dot.gov/asset.

1. Should the measure be based on the minimum condition rating or a weighted average?
2. What is the relative importance of the bridge deck as compared to the superstructure and substructure?

For pavements, the next steps include completing and implementing the good, fair, and poor indicator based on IRI data. Incorporation of additional selected distresses into the indicator should also be studied. These could include cracking and rutting in asphalt pavements and cracking and faulting in concrete pavements. FHWA's Pavement Health Track Analysis Tool should also be improved so that it can provide a more comprehensive measure of pavement condition. This tool can help determine the health of a pavement network in terms of the pavement's remaining service life.

The report recommends that FHWA consider developing a tool to automate creation of an infrastructure health report. This tool would enable users to select a corridor or network and view its condition. The tool should also allow users to incorporate the required HPMS and NBI data directly into the report. A prototype is discussed.

To download *Improving FHWA's Ability to Assess Highway Infrastructure Health*, visit www.fhwa.dot.gov/asset/pubs/hif12049/hif12049.pdf. For more information on the report, contact Nastaran Saadatmand at FHWA, 202-366-1337 (email: nastaran.saadatmand@dot.gov). ✻

A Guide to Performance Contracting for Construction

Every day transportation agencies across the country face the challenge of carrying out high quality construction projects on time and within budget, all while meeting the expectations of the traveling public.

As agencies contend with aging highway infrastructure, increased congestion, and shrinking budgets, they continue to look for new methods to meet these challenges and complete projects better, faster, safer, and more cost effectively.

Performance contracting offers agencies an alternative to standard low-bid contracts with detailed specifications, allowing for increased innovation and problem solving. Under a performance contract, agencies specify performance goals and contractors have flexibility in how they carry out the work to meet those goals.

"The agency can clearly communicate to the contractor what they are trying to achieve with the project, and the contractor shares the risks and rewards through incentives and disincentives," said Jerry Yakowenko of the Federal Highway Administration (FHWA).

FHWA's newly updated *Performance Contracting for Construction: A Guide to Using Performance Goals and Measures to Improve Project Delivery* offers State and local transportation departments a valuable reference, walking them through the process for using performance contracting on a typical reconstruction or rehabilitation project.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The mid-section of the precast superstructure for a bridge on M-115 is placed as part of the Michigan Department of Transportation's performance contracting project.

Originally developed in 2006, the 2012 update includes lessons learned and sample materials from a successful performance contracting pilot project conducted by the Michigan Department of Transportation (MDOT).

The guide includes recommended processes and sample materials for:

- Project selection.
- Performance goals.
- Measurement methodology, including associated incentive and disincentive fee structures.
- Sample enhanced low-bid and best-value awards.
- Applications for FHWA's SEP-14 program (special experimental projects using alternative contracting techniques). Performance contracts that are awarded on a best-value basis (considering both price and non-price factors) must be approved under the SEP-14 program. This does not apply to performance based design-build contracts. For examples of SEP-14 best-value work plans, visit www.fhwa.dot.gov/programadmin/contracts/sep14list.cfm.

Each section in the guide describes a suggested process to follow, presents lessons learned from real-world contracts, and provides sample materials for project solicitations. When selecting performance contracting projects, for example, considerations include whether an agency can legally use an award process other than low-bid,

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Using performance contracting, the Michigan Department of Transportation rehabilitated an 8.9-km (5.56-mi) stretch of M-115 in Clare County.

Highway Technology Calendar

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

2012 Industrial Materials Conference
November 28–29, 2012, Indianapolis, IN

The conference will feature best practices in the use of high-volume recycled materials in sustainable pavement systems. Conference sponsors include the Federal Highway Administration (FHWA), Industrial Resources Council, and Indiana Department of Transportation.

Contact: Lee Gallivan at FHWA, 317-226-7493 (email: victor.gallivan@dot.gov), or visit www.industrialresourcescouncil.org.

Transportation Research Board (TRB) 92nd Annual Meeting
January 13–17, 2013, Washington, DC

More than 11,000 transportation professionals from around the world will gather to share perspectives on developments in transportation research, policy, and practice. The theme for 2013 is "Deploying Transportation Research—Doing Things Smarter, Better, Faster."

Contact: For information, visit the TRB Web site at www.trb.org (click on "Annual Meeting"). Questions about the meeting can be emailed to trbmeetings@nas.edu.

2013 Design-Build in Transportation Conference
March 18–20, 2013, Orlando, FL

Join transportation leaders in discussing lessons learned in the use of the design-build project delivery method for transportation projects. Discussions will cover choosing the right delivery method, contracting approaches, innovative financing solutions, risk allocation, and performance contracting.

Contact: Jerry Yakowenko at FHWA, 202-366-1562 (email: gerald.yakowenko@dot.gov), or visit www.dbtranspo.com.

Seventh National Seismic Conference on Bridges and Highways
May 20–22, 2013, Oakland, CA

Conference sessions will focus on understanding and mitigating damage to the Nation's highway infrastructure from earthquakes and other natural hazards. Sponsors include FHWA; the California Department of Transportation; TRB; American Association of State Highway and Transportation Officials; University at Buffalo, The State University of New York; and the Multidisciplinary Center for Earthquake Engineering Research.

Contact: Phillip Yen at FHWA, 202-366-5604 (email: wen-huei.yen@dot.gov), or visit http://7nsc.info.

Second National Covered Bridge Conference
June 5–8, 2013, Dayton, OH

The FHWA National Historic Covered Bridge Preservation Program is sponsoring the conference in partnership with the National Park Service and U.S. Forest Service. Themes include research and rehabilitation projects, best practices for rehabilitation, and continuing threats and challenges to covered bridges, including damage caused by Hurricane Irene and Tropical Storm Lee in 2011. Participants will have the opportunity to tour several historic covered bridges.

Contact: Everett Matias at FHWA, 202-366-6712 (email: everett.matias@dot.gov), or visit www.woodcenter.org/2013-national-covered-bridge-conference. ✻

Infrastructure Innovation Webinars

This free Webinar provides a quick introduction to the latest infrastructure innovations and technologies.

Federal Highway Administration (FHWA) Load and Resistance Factor Rating (LRFR) Implementation Webinar Series

Application of Load Testing in Bridge Load Rating

December 6, 2012, 1–4 p.m.
(eastern standard time)

The Webinar will provide participants with the latest information on using the load testing technique to evaluate live load carrying capacity of bridges. Among the highlights will be resources available and lessons learned. The session will focus on experiences in North Carolina and Rhode Island, as well as load testing of bridges at Logan Airport in Boston, Massachusetts.

The target audience for the Webinar is bridge and structures staff from local, regional, and State transportation agencies; FHWA staff; and consultants. Participants will have the opportunity to download Webinar presentations.

Registration for the Webinar is available at https://connectdot.connectsolutions.com/loadtest02/event/registration.html. For more information, contact Lubin Gao at FHWA, 202-366-4604 (email: lubin.gao@dot.gov). ✻

FOCUS

Focus (ISSN 1060-6637), which is published monthly by the U.S. Department of Transportation's Federal Highway Administration (FHWA), covers the implementation of innovative technologies in all areas of infrastructure.

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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if a contractor will be allowed flexibility in its approach to the project, if an agency has adequate resources to conduct performance measurement, and whether the project risks are balanced by adequate rewards. As noted in the guide, performance contracting can be applied to any size contract, not just large projects.

The guide includes sample performance measures developed for use on highway construction projects. Categories include safety, construction congestion, quality, time, cost savings, customer satisfaction, environmental sustainability, and innovation. Each performance measure has five levels of performance. "While agencies will need to develop a set of goals that suit their specific project, this sample menu will provide a head start and help to accelerate the process," said Yakowenko.

Also featured are details on the process used for MDOT's $3.8-million pilot project on M-115 in Clare County. The pavement on this rural 8.9-km (5.56-mi) stretch of a two-lane highway was in poor condition, and two bridges needed significant reconstruction. Michigan received $1 million in project funding from FHWA's Highways for LIFE (HfL) program and used HfL's Performance Contracting for Construction Implementation Framework. This framework was developed with input from several State highway agencies, the Associated General Contractors of America, and the American Road and Transportation Builders Association.

Performance goals for the 2008 project focused on the measures MDOT and its stakeholders wanted the project to achieve in the following categories: date open to traffic, completion of construction and related cleanup, pavement performance, worker safety during construction, work zone crashes, and motorist delay.

MDOT awarded the project to the contractor whose proposal represented the best value considering price, goals, and proposed innovations. Contractor innovations used for the project included prefabrication of the new bridge decks and installation of a 3.3-m (11-ft) wide temporary traffic lane that provided two-way traffic during major construction stages. A 24-hour roadside patrol also offered motorist assistance within the construction zone. Project successes included reopening the roadway to traffic 20 days early.

To download a copy of *Performance Contracting for Construction: A Guide to Using Performance Goals and Measures to Improve Project Delivery,* visit www.fhwa.dot.gov/construction/contracts/pcfc_2012/pcfc00.cfm. The HfL Performance Contracting for Construction Implementation Framework is available at www.fhwa.dot.gov/hfl/framework. For more information on performance contracting, contact Jerry Yakowenko at FHWA, 202-366-1562 (email: gerald.yakowenko@dot.gov).