Accelerating Infrastructure Innovations

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INSIDE

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U.S. Department of Transportation
Federal Highway Administration

An Innovative Solution for Rock Slope Stabilization

How do you stabilize surrounding rock slopes and protect drivers from rockfall hazards while preserving the scenic beauty of Virginia's George Washington (GW) Memorial Parkway? For the Federal Highway Administration's (FHWA) Eastern Federal Lands Highway Division office and the National Park Service, the innovative answer proved to be "rock glue."

After rocks from a 10.7-m (35-ft) high, 73-m (240-ft) long rock cut slope located along the GW Parkway in Arlington, Virginia, fell onto the road's shoulders and travel lanes in 2002, damaging sections of the curb and pavement and disrupting traffic, FHWA contracted with Schnabel Engineering to both investigate the slope failure and develop slope stabilization design alternatives. As traditional stabilization methods such as rockfall netting, rock anchors, and rockfall control barriers can have an unsightly impact on the visual appearance of rock slopes, something new was needed.

At the same time, FHWA's Central Federal Lands Highway Division office was investigating a technique known as rock gluing to achieve slope stabilization. Used since the 1960s in tunneling, mining, and dam projects to control water seepage and stabilize tunnel crowns, among other objectives, the technique involves injecting polyurethane resin (PUR) grout into a rock mass. The PUR hardens and adheres to the rock, bonding discontinuous individual rocks into a bigger, more stable, continuous mass and preventing water intrusion into the cracks. Any excess rock glue can be cleaned off, resulting in a natural-looking rock slope with greater structural integrity and slope stability. The Central Federal Lands Highway Division office's application of the technique was the first designed use of rock gluing for slope stability. More information on the technique can be found in FHWA's *Polyurethane Resin (PUR) Injection for Rock Mass Stabilization* (Pub. No. FHWA-CFL/TD-08-004), which is available online at www.cflhd.gov/programs/techDevelopment/geotech/PUR.

> The rock gluing technique not only improves the appearance of the rock slope but better supports the entire rock mass.

"This is not a new method but it was new to the transportation field," says Khalid Mohamed of FHWA. "It was particularly effective in this case because of the aesthetics of the roadway. The National Park Service did not allow the use of rockfall netting or barriers on the GW Parkway because of concerns with the historic and aesthetic nature of the Parkway." The rock gluing was supplemented by rock anchors in one location and horizontal drains that were installed to relieve groundwater pressure that could contribute to slope failure. The glue injection holes were spaced 3 m (10 ft) apart and drilled 4.6 m (15 ft) deep behind the rock

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Innovative Solution,

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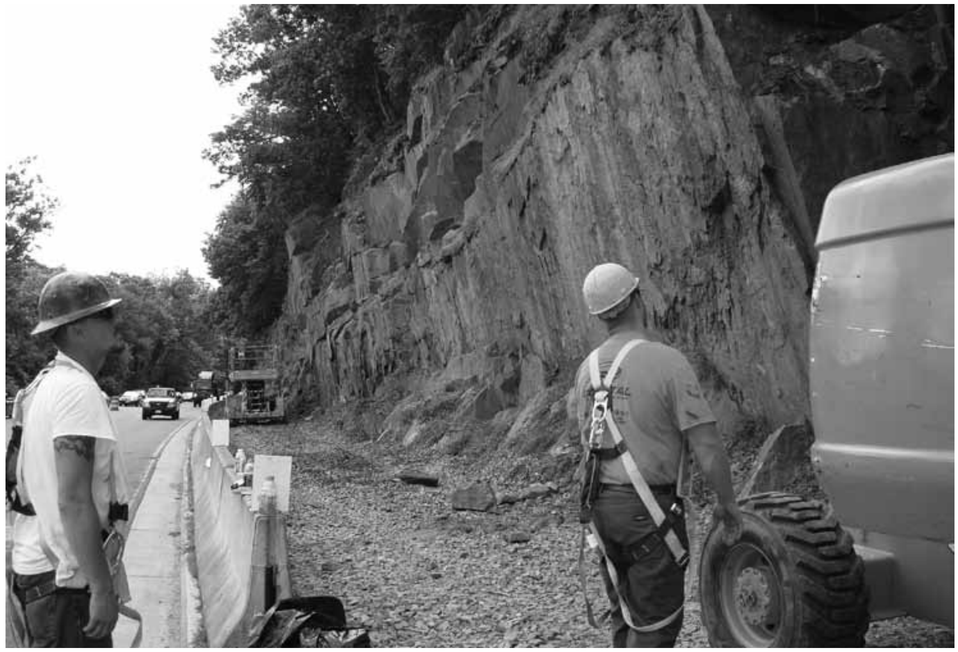
face. Schnabel determined the spacing and depth based on the spacing of the rock mass discontinuities and expected size of rocks in a rockfall.

"The glue used was high in tensile strength," says Mohamed. The technique not only improves the appearance of the rock slope but better supports the entire rock mass and prevents the potential for localized rockfall and raveling between rock anchors. While a high-strength PUR grout has a higher unit cost, use of the glue can help reduce overall project costs. The GW Parkway project costs included approximately $315,000 for rock stabilization measures, with the use of PUR accounting for about $150,000 of that.

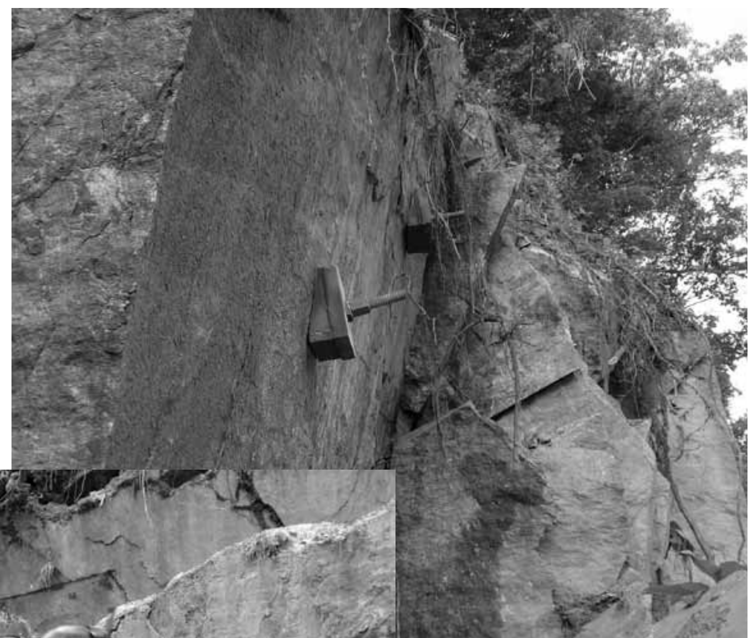
The technique has also been used by Federal Lands for a project in Great Smoky Mountains National Park in Tennessee and two projects currently under construction in North Carolina and Pennsylvania. "Its use has been very effective," says Mohamed. "Since the technique is new to transportation applications, however, quality control and quality assurance are very important."

Completed in 2009, the GW Parkway project was honored by the Association of Environmental and Engineering Geologists (AEG) as its 2010 Outstanding Environmental and Engineering Geologic Project. AEG cited the project for representing a "significant advancement for the engineering geology profession."

For more information about the GW Parkway rock slope stabilization project, contact Khalid Mohamed at FHWA's Eastern Federal Lands Highway Division office, 703-404-6347 (email: khalid.mohamed@fhwa.dot.gov). ✻



A rock cut slope on the George Washington Memorial Parkway in Arlington, VA.



Above: A view of installed rock bolts on the George Washington Memorial Parkway.

Left: Drilled holes are prepared for injection of polyurethane resin or "rock glue."

New FHWA Course Introduces the Asphalt Mixture Performance Tester

How well will your new asphalt pavement perform? Find out how to better predict the performance of an asphalt mix by attending the new course offered by the Federal Highway Administration's (FHWA) National Highway Institute (NHI), Asphalt Mixture Performance Tester (AMPT) (Course No. FHWA-NHI-131118). Development of the course was supported by FHWA and Transportation Pooled Fund Study TPF-5(178), "Implementation of the AMPT for Superpave Validation." Launched in 2008, the study offered States the opportunity to obtain and learn how to use the AMPT to evaluate asphalt mixtures.

The AMPT is a computer-controlled hydraulic testing machine capable of subjecting a compacted asphalt mixture specimen to cyclic loading over a range of temperatures and frequencies. The device evaluates asphalt mixture properties to assess potential performance. Transportation agencies can use the AMPT to develop inputs for the structural design of flexible pavements and obtain information helpful in monitoring mixes and performing quality assurance. Now available from several equipment vendors in the United States, the AMPT builds upon past efforts to develop a testing device for determining fundamental asphalt mixture performance properties. The current equipment and test methods have been developed to optimize both testing time and cost.

Aimed at pavement and materials engineers and technicians, the 2-day course will focus on using the AMPT to perform standard tests to measure the dynamic modulus and flow number of asphalt mixtures. Data from these tests can then be directly input into the American Association of State Highway and Transportation Officials' *Mechanistic-Empirical Pavement Design Guide*.

The asphalt mixture performance tester can subject a compacted asphalt mixture specimen to cyclic loading over a range of temperatures and frequencies.

Ultimately the course aims to move AMPT technology to standard practice and routine use, as specified by transportation agencies, industry, and contractors. On completion of the course, participants will know the procedure required to prepare AMPT test specimens, understand the operation of the AMPT equipment, and be able to review the data quality of dynamic modulus and flow number results. They will have also studied the procedure required to develop dynamic modulus master curves, as well as how to interpret flow number test results to evaluate mixtures.

Course sessions are currently scheduled for February 16–17, March 22–23, April 5–6, and May 3–4, 2011, in Auburn, Alabama. The fee is $400 per participant, with a minimum class size of 10 and a maximum of 15. Pooled fund participants will have priority in registering for these scheduled sessions, as membership in the pooled fund covers the cost of sending two staff members to the course. Prior to taking the course, participants should be familiar with the principles of hot-mix asphalt mixture design and analysis, including the Superpave volumetric mixture design system and associated practices and test methods.

Additional information on the course is available at www.nhi.fhwa.dot.gov (enter "AMPT" under "Search for a Course"). For more information on the course, AMPT pooled fund study, and pooled fund participant course registration, contact Jeff Withee at FHWA, 202-366-6429 (email: jeff.withee@fhwa.dot.gov). To learn more about the AMPT pooled fund study, visit www.pooledfund.org (search under Study No. TPF-5(178)).

Developing the Next Generation of Bridges: The Long-Term Bridge Performance Program

The Federal Highway Administration's (FHWA) Long-Term Bridge Performance (LTBP) program is leading the way toward a better future for bridge performance. Launched in 2008 and now in its pilot project phase, the LTBP program will collect, maintain, and study high-quality, quantitative performance data for a representative sample of bridges nationwide. These bridges will feature many structural types and materials, as well as variations in geometry, age, traffic volume, truck loads, and climatic conditions. "This innovative program will lead the way towards identifying high-value, state-of-the-art procedures and practices for assuring bridge performance from cradle to grave," said Firas I. Sheikh Ibrahim, Team Leader for Infrastructure Management in FHWA's Office of Infrastructure Research and Development.

"The data collected by the program will support a better understanding of how and why bridges deteriorate, how to best prevent or mitigate deterioration, and how to most effectively focus development of the next generation of bridge management tools," said Hamid Ghasemi, Manager of the LTBP program at FHWA.

The first phase of the LTBP program included identifying the relevant data types to be collected; establishing a data management and analysis architecture; and developing protocols for data sampling, collection, and quality assurance. Pilot studies are now being conducted at seven bridges across the country to validate the methods and protocols developed during the first phase of the program and to investigate various details about the program management, so that high quality data collection can be ensured while minimizing disruptions to bridge owners and users. These details include the time, effort, and cost of preparation, field work, and collection and analysis of data; the cost of instrumentation and data collection systems; and the cost of traffic maintenance. During the pilot phase, researchers are also looking at the time needed to coordinate with bridge owners and obtain the necessary permits for work.

FHWA's Long-Term Bridge Performance (LTBP) program is conducting pilot studies at seven bridges across the country, including a bridge in Sandstone, MN, that carries State Road 123 over the Kettle River.

Located in California, Florida, Minnesota, New Jersey, New York, Utah, and Virginia, the pilot bridges represent both a broad geographic distribution and a cross section of the bridges that will be the focus of the LTBP program. The program will concentrate on the types of bridges heavily represented in the U.S. bridge population, including highway and interchange overpasses and bridges over minor waterways. Primary selection criteria for the pilot bridges were superstructure type, age, type of deck, composite versus noncomposite design, deck condition, environmental factors, annual average daily traffic (AADT), and the percentage of trucks in the traffic stream.

Selected pilot bridges include one that carries Southbound U.S. Route 15 over Interstate 66 in Prince William County, Virginia. Constructed in 1979, this two-span steel haunched girder bridge has a cast-in-place concrete deck and carries an AADT of 16,500 vehicles, with six percent trucks. Both the steel superstructure and the concrete deck are showing a significant degree of deterioration. The Minnesota pilot bridge, meanwhile, carries State Road 123 over the Kettle River in the town of Sandstone. Constructed in 1948, the steel deck truss bridge carries an AADT of 2,050, with eight percent trucks. And in New Jersey, the pilot bridge carries Eastbound Interstate 95 over Sharon Station Road near Allentown, New Jersey. This single span multi-beam steel girder bridge with a cast-in-place concrete deck was constructed in 1969 using stay-in-place forms. The bridge carries an AADT of 25,000 vehicles.

The final pilot bridge to be studied carries Westbound State Road 430 over the Halifax River in Daytona, Florida. Built in 1997, the precast segmental box girder structure has multiple spans.

Researchers have conducted a detailed visual inspection of each bridge and analyzed the bridges using finite element modeling. Live load testing or dynamic testing were also performed to obtain baseline data on the structural behavior of the bridges. The deck of each bridge was inspected using several nondestructive testing methods, and cores were taken to help characterize the material qualities of the deck and the type and extent of any deterioration.

The data collected from the pilot bridges are now being evaluated to determine if any adjustments in the LTBP program protocols are needed. The pilot phase will be completed by the fall of 2011, with the regular long-term data collection phase of the program beginning this summer.

"The ultimate goal of the pilot study phase is to make certain that all of the components needed to achieve the long-term objectives of the LTBP program are specified before starting the nationwide study on a larger sample of the bridge population," said Ghasemi.

For more information on the LTBP program, visit www.fhwa.dot.gov/research/topics/infrastructure/bridges/subindex1.cfm (select "Long Term Bridge Performance"), or contact Hamid Ghasemi at FHWA, 202-493-3024 (email: ltbp@dot.gov). ✻

Additional pilot bridges for the LTBP program include ones that carry Southbound U.S. Route 15 over Interstate 66 in Prince William County, VA (top); Eastbound Interstate 95 over Sharon Station Road near Allentown, NJ (middle); and Westbound State Road 430 over the Halifax River in Daytona, FL (bottom).

Highway Technology Calendar

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

First Transportation and Development Institute Congress: Integrated Transportation and Development for a Better Tomorrow
March 13–16, 2011, Chicago, IL

Organized by the Transportation and Development Institute of the American Society of Civil Engineers, the conference will bring together transportation and development researchers, engineers, planners, designers, construction managers, and contractors to discuss integrated strategies for smart development. Discussion topics will include transportation operations and safety, pavement and transportation materials, advanced technologies in transportation systems, airport planning and design, and smart development and sustainability. The conference will also feature a technical tour to an engineering project in the Chicago area.

Contact: Sam Tyson at the Federal Highway Administration (FHWA), 202-366-1326 (email: sam.tyson@fhwa.dot.gov), or visit www.tdi-congress.org.

2011 Design-Build in Transportation Conference
March 28-30, 2011, Kansas City, MO

Join transportation leaders in discussing lessons learned in the use of the design-build project delivery method for transportation projects. The discussions will cover choosing the right delivery method, contracting approaches, risk allocation, and performance contracting. The conference is cosponsored by FHWA, the American Association of State Highway and Transportation Officials, and various industry groups.

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

Tenth International Conference on Low-Volume Roads
July 24–27, 2011, Orlando, FL

Sponsored by the Transportation Research Board, the conference will feature the latest information about low-volume road management, design, construction, safety, maintenance, and other topics. Attendees will also have the opportunity to participate in a half-day field trip to observe and study low-volume road issues.

Contact: For more information, send an email to TRBMeetings@NAS.edu.

Second International Conference on Warm Mix Asphalt
October 11–13, 2011, St. Louis, MO

Sponsored by the National Asphalt Pavement Association and FHWA, the conference will provide a progress report on the implementation of warm-mix asphalt. Featured topics will include mix design, long-term performance, accelerated performance testing, effects on binder properties, and innovative temperature reduction processes. The conference will be of interest to engineers, researchers, contractors, and transportation agency personnel.

Contact: Matthew Corrigan at FHWA, 202-366-1549 (email: matthew.corrigan@fhwa.dot.gov).

Fifth Asphalt Shingle Recycling Forum
October 27–28, 2011, Dallas, TX

Organized by the Construction Materials Recycling Association, the forum will cover all aspects of the opportunities offered by shingle recycling. Using recycled asphalt shingles in hot-mix asphalt and other construction applications can save money and conserve natural resources, while maintaining quality.

Contact: Audrey Copeland at FHWA, 202-493-3097 (email: audrey.copeland@fhwa.dot.gov), or visit www.shinglerecycling.org.

Diagnosing and Mitigating ASR in Transportation Structures

A new report from the Federal Highway Administration (FHWA) is designed to assist engineers in diagnosing and mitigating alkali-silica reaction (ASR), which can lead to expansion and cracking of concrete elements and the premature deterioration of concrete structures. *Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures* (Pub. No. FHWA-HIF-09-004) details the necessary steps for detecting and evaluating ASR in a highway structure. The report was developed through FHWA's ASR program, which launched in 2006 with the goals of increasing concrete pavement and structure durability and performance and reducing life-cycle costs through the prevention and mitigation of ASR.

A concrete median barrier affected by ASR is examined.

ASR occurs when silica in some aggregates and alkalis in concrete combine with water to form a gel-like substance. As the gel absorbs water and expands, it causes the concrete to crack. Over time, the cracks enable other modes of distress to occur, such as freeze thaw damage or corrosion.

Diagnosing ASR begins with a condition survey to evaluate the presence and severity of distress.

As the report describes, diagnosing ASR begins with a condition survey to evaluate the presence and severity of distress. This condition survey is followed by a second level of investigation to document information, measure the cracking index (CI), obtain samples, and conduct a petrographic examination. A third, more detailed level of investigation is then conducted to determine the current rate of concrete expansion and cracking, the potential for future expansion, and the risks posed by the presence of ASR. The third level of evaluation includes both in-situ investigations, such as examining surface cracking and taking expansion and deformation measurements, and laboratory tests.

The report looks at the success of various proposed mitigation measures for ASR. These measures are grouped according to whether they are intended to treat the causes of ASR or the symptoms of the reaction. Measures to treat the causes include using lithium compounds to halt expansion in the concrete and applying sealants to reduce moisture. Measures aimed at treating the symptoms of ASR, meanwhile, include crack filling techniques and the confinement of an ASR-affected member by using nonreactive concrete around it and other strategies.

Engineers and practitioners will also benefit from the resources provided in the report's appendices, which include guidance on identifying the visual signs of ASR, step-by-step instructions for determining the CI, and details on recognizing the petrographic symptoms of ASR. Also included is information on various test procedures, including the procedure to determine the water-soluble alkali content of concrete. Photographs are provided to aid in conducting condition surveys and petrographic analysis.

To download the report, visit www.fhwa.dot.gov/pavement/concrete/asrprotocols.cfm. For a printed copy or to obtain additional information on the ASR program, contact Gina Ahlstrom in FHWA's Office of Pavement Technology, 202-366-4612 (email: gina.ahlstrom@fhwa.dot.gov). Details on FHWA's ASR program are also available at www.fhwa.dot.gov/pavement/concrete/asr.cfm. *

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Design-Build in Transportation on Display at Annual Conference

Get started using design-build or take your experience to the next level at the 2011 Design-Build in Transportation Conference, to be held March 28–30, 2011, in Kansas City, Missouri. Cosponsored by the Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials, Design-Build Institute of America, and other industry groups, the conference will look at lessons learned in the use of the design-build project delivery method for transportation projects.

Featured topics will include choosing the right delivery method, contracting approaches, risk allocation, and performance contracting. Scheduled sessions look at design-build projects in Louisiana, Minnesota, Missouri, North Carolina, Utah, and other States. The conference also offers the opportunity to discuss design-build experiences and questions with hundreds of attendees, including representatives from the public and private sectors.

With the design-build project delivery process, a project owner executes a single contract for both architectural/engineering services and construction (see June 2010 *Focus* at www.fhwa.dot.gov/publications/focus/10jun/01.cfm). The design-builder may be a single firm, a consortium or joint venture, or other organization. Design-build can promote innovation, streamline coordination between the design and construction teams, reduce project costs, and result in time savings. Approximately 45 States currently have full or limited statutory authority to use the design-build project delivery method.

For more information on the conference, visit www.designbuildtransportation.com, or contact Jerry Yakowenko at FHWA, 202-366-1562 (email: gerald.yakowenko@fhwa.dot.gov).