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Prefabrication Can Be a Cost-effective Answer for Thousands of Bridges in Need of Replacement

A standardized approach to prefabricated bridge elements opens the door to local builders and smaller agencies

The nation’s aging bridge inventory, increased traffic congestion, and work-zone safety concerns call for new approaches to traditional sequential “construct-in-place” methods. The industry must find smarter, faster ways to replace bridges using techniques that will provide economies of scale in manufacturing and construction, reduce traffic disruption, and increase safety. Prefabricated bridge elements have been used in a number of states, but to date, each design is unique and requires a high level of engineering and construction oversight. This toolkit provides standard design details, specifications, and a guide manual to enable any bridge owner to use prefabricated elements to accelerate bridge replacements more cost-effectively.

The toolkit was developed through the second Strategic Highway Research Program (SHRP2). It sets in place a standard design that can be used to create standard prefabricated elements that could become readily available and increasingly cost effective with repeated use.

Bridge Designs for Rapid Construction

The Solution

The Bridge Designs for Rapid Renewal product provides state and local departments of transportation with a design toolkit for prefabricated bridge projects. Standardized approaches streamline the activities required to get bridge replacement systems designed, fabricated, and erected in less time, and installed in hours or days, rather than weeks or months. It includes standard design plans for foundation systems, substructure and superstructure systems, subsystems, and components that can be installed quickly with minimal traffic disruptions. It provides design detail standards and design examples for complete prefabricated bridge systems. Although this toolkit does not eliminate the need for an engineer of record, it does make prefabrication design accessible to many more bridge owners at the state, county, and local levels.
The Benefits

► The toolkit capitalizes on the benefits of bridge prefabrication for rapid, cost-effective replacement of the thousands of small- to medium-sized deficient bridges across the country.

► Smaller agencies with fewer resources can use this toolkit to deliver prefabricated bridge construction.

► Prefabricated construction can be performed by local contractors, increasing competition and decreasing cost.

► No special equipment or construction techniques are required to use this toolkit.

► The toolkit can support the development of standardized prefabricated bridge elements, including substructure, superstructure systems, and foundations.

Who is using these tools?

The Iowa Department of Transportation (DOT) conducted the first pilot project of these methods in 2011, with the replacement of a bridge on US 6 over Keg Creek near Council Bluffs, Iowa. The replacement structure is a three-span steel/ precast modular bridge with precast bridge approaches. The bridge was demolished and replaced within 14 days using the standard plans developed as part of this project. These innovative bridge elements were showcased as part of the pilot:

► Prefabricated superstructure module: precast concrete deck on steel stringers

► Prefabricated substructure components: precast pier columns and caps and abutment stem and wing walls

► Prefabricated bridge approach: precast concrete panels and sleeper slab

The Vermont Agency of Transportation will go to construction this winter on the first of two bridges designed using the toolkit. Five additional bridges are in project development.

In 2013, the New York State DOT will pilot the application of lateral slide methods and concepts on a bridge replacement on I-84. These new concepts will be added to the ABC Toolkit and published in a future edition.

How can you learn more?

The report, *Innovative Bridge Designs for Rapid Renewal*, which includes research from the Keg Creek project, is available on the web at [http://www.trb.org/Main/Blurbs/167693.aspx](http://www.trb.org/Main/Blurbs/167693.aspx) and *Innovative Bridge Designs for Rapid Renewal Toolkit* is available online at [http://www.trb.org/Main/Blurbs/168046.aspx](http://www.trb.org/Main/Blurbs/168046.aspx). The toolkit will be updated next year to reflect the experiences of the New York and Vermont pilot projects. For more information, contact Shay Burrows at FHWA, sburrows@dot.gov or Kelley Rehm at AASHTO, krehm@aashto.org. A video of construction using these techniques can be viewed online at [http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/Pages/ABC_for_Everyday_Bridges_618.aspx](http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/Pages/ABC_for_Everyday_Bridges_618.aspx).

About SHRP2 Implementation

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Strategic Highway Research Program

U.S. Department of Transportation | Federal Highway Administration
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Next Generation Bridges Designed to Last Longer

Building a better bridge to deliver 100 or more years of service life

Bridge design standards lead to bridges with many components, each with a different design life. What if every component of the bridge, including bearings, decks, expansion joints, girders, columns, and piles each were designed for a specific design life to ensure that the overall structure can be maintained to reach a design life of 100 years? Not only does this extend the service life of the structure, but it may also limit overdesign on some bridge elements. Designing to a service life provides a more predictable asset management and maintenance program and will ultimately allow owners to keep their structures in service longer for better return on investment.

Service Life Design Guide for Bridges

The Solution

The Service Life Design Guide for Bridges (R19A) is a new reference document developed through the second Strategic Highway Research Program (SHRP2). It complements AASHTO specifications and equips designers to develop specific solutions for given conditions and constraints. The Guide addresses design, fabrication, construction, operation, maintenance, repair, and replacement issues and applies to both new and existing bridges. It includes standard plans, model specifications, detailed examples.

The Guide includes a fault tree flowchart that summarizes the factors that affect the service life of the bridge element or component under consideration. Each of these factors is thoroughly explained, resulting in an in-depth understanding of the important service-life-related factors for both new and existing bridges. The guide provides strategies and solutions to address the factors. Recognition of service life factors and options to manage these factors will allow your staff to develop an optimal, customized solution for your particular bridge.
The Benefits

► Provides longer service life by design through durable and state-of-the-art materials, construction techniques, and utilization of emerging technologies that are ideally suited for the bridge.

► Addresses service life issues at the design stage that will result in significant cost savings in maintenance and lower rehabilitation costs while the bridge is in service.

► Provides engineers with tools to select and design for longer-lasting bridge systems and subsystems for the appropriate environment. They result in longer-lasting bridge components that are easier to inspect and are better suited to their environment—factors that reduce maintenance, lane closures, and work zones.

Who is using these tools?

► Bridge engineers
► Materials engineers
► Design engineers
► Maintenance engineers
► State and local departments of transportation
► Public and private industry who own or operate bridge structures

How can you learn more?

For more information, contact Anwar Ahmad at FHWA, anwar.ahmad@dot.gov or Kelley Rehm at AASHTO, krehm@aashto.org.

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Strategic Highway Research Program

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Technical Advances Extend Bridge Life
To 100 Years

New bridge design approach can add years to service life

Bridge replacement is a major source of disruption to the nation’s transportation system, so bridge owners need ways to design bridges that last longer. Current bridge design practices consider the “ultimate limit behavior state” that prevents collapse. However, most bridge rehabilitation and reconstruction projects result from deterioration such as cracks, corrosion, and deformation. Knowledge of these “service limit states” is limited and largely based only on qualitative data and experience. Quantitative data from the element distress areas of bridges are needed to inform service-based design.

Design Guidance for 100-Year Bridges: Service Limit State Design

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), this research will create a quantitative framework to assess service limit states more accurately and provide actual performance data, component-based distress models, and specific guidance for common bridge elements. Products of this research will be packaged in a toolkit that includes:

- Framework for calibrating service limit state specifications
- Service limit state load and resistance factors
- Bridge design procedures and model specifications for service limit states
- Tools required for future service limit state improvements
- Model specification changes that include designing for durability

The toolkit allows for future improvements in service limit state calibration, particularly as data become available from projects that are currently under way (such as the Long-Term Bridge Performance Program). The toolkit contains databases, software tools used in the calibration (such as Monte Carlo spreadsheets), instructions for developing new or revised spreadsheets, deterioration models, and a user’s manual.
The framework will calibrate the following AASHTO service limit state design elements:

- Live load deflections
- Bearing movements
- Settlement of foundations and retaining structures
- Permanent deformations of compact steel components
- Fatigue of structural steel and the steel reinforcement in concrete (complementary research being conducted through National Cooperative Highway Research Program [NCHRP] 12-83)
- Slip-critical bolted connections
- Concrete approaches

**The Benefits**

The products resulting from this SHRP2 project add value by improving service limit state design, which can increase the service life of bridge components and enable designers to select bridge components based on expected maintenance and difficulty of replacement. The toolkit and framework establish a protocol by which future research and data collection fit easily into the approach to service limit state design. This approach will optimize future efforts by avoiding the collection of incomplete and inaccurate data on service limit state behavior.

**How can you learn more?**

The bridge design techniques are not yet in use because this product is a foundational study that fills a necessary gap in current bridge design practice. The enhanced bridge design guidance is expected to change how designers approach the bridge design process for service limit state checks. The final report, guidelines, toolkit, bridge specifications, and framework will be available in 2013 at [www.TRB.org/SHRP2/publications](http://www.TRB.org/SHRP2/publications). For more information, contact Lubin Gao at FHWA, [lubin.gao@dot.gov](mailto:lubin.gao@dot.gov) or Kelley Rehm at AASHTO, [krehm@aashto.org](mailto:krehm@aashto.org).

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Strategic Highway Research Program

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Toolbox Resource for Non-Destructive Testing

Comprehensive guide on non-destructive testing procedures allows for smarter selection of the right technologies

A number of non-destructive testing (NDT) techniques have become available to the transportation industry in recent years. Some of these are commercially available, some are prototypes, but most are proprietary technologies. Overall, these technologies and techniques have generated faster and more effective ways to perform non-destructive testing on bridge decks, concrete tunnel linings, hot mix asphalt, and other structures and materials.

As part of the research conducted under the second Strategic Highway Research Program (SHRP2), an independent assessment of the many available NDT technologies was conducted to determine the capabilities and limitations within the range of products available.

Non-Destructive Testing Technologies Lead to More Rapid Reconstruction

The Solution

A new resource – the NDToolbox – is being created through SHRP2 as an electronic repository of NDT techniques and technologies, bringing together information and assessments derived from the research in an easily accessible and readily available format. Users will be able to use the NDToolbox to explore different NDT technologies, view their benefits, and learn how to use them effectively. The Toolbox will include information and descriptions of the technology; its applications, performances, and limitations; equipment, test procedures, and protocols; and sample results.

The SHRP2 research of NDT techniques assessed the strengths and limitations of applicable NDT technologies from the perspective of speed, accuracy, precision, and ease of use. Test procedures and protocols for the most effective application of NDT methods will be identified and available in the NDToolbox, as well as a comprehensive guide to the technologies available. The NDToolbox will allow transportation agencies to quickly review these non-destructive testing methods and more easily identify which method is best to use.

The NDToolbox will serve as a quick reference of validated methods for identifying deterioration on concrete bridge decks, as well as those for quality control of construction materials and pavements, and conditions assessment of pavements and tunnels. When completed, the NDToolbox will include results from six related NDT research projects and will provide recommendations regarding the best technologies to use for a particular deterioration detection application.
The Benefits

Many NDT technologies are available to owner agencies, however, each has its own set of applications, strengths, and weaknesses, and practitioners need clear information to help them select the best NDT method to evaluate the condition of a specific feature. The NDToolbox will provide an independent assessment to allow owner agencies to be confident in their choice of technology and method. The NDToolbox will allow owners to:

- Quickly and reliably provide information about the under-the-surface conditions of bridge decks without causing undue additional wear to the bridges themselves.
- Yield faster measurements in the field by using hand-held stereoscopic “fingerprinting” equipment for testing the quality assurance of materials.
- Use automated thermal profiling systems and other technologies to reliably prevent deterioration and segregation of hot-mix asphalt construction.
- Easily and efficiently detect the extent, depth, and severity of de-lamination in hot-mix asphalt pavements.
- Meet smoothness requirements for Portland cement concrete pavements more easily and less expensively by detecting surface irregularities in real-time before the cement hardens.
- Use continuous deflection measuring devices to determine the structural capacity of pavement with better spatial coverage and less impact on traffic.
- More thoroughly monitor the condition and deterioration of tunnel linings while providing less disruption of traffic.

How can you learn more?


For more information, contact Kelley Rehm at AASHTO, krehm@aashto.org.

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Recommended technologies to detect deterioration of concrete bridge decks

New technology allows field identification of concrete bridge deck deficiencies through nondestructive testing methods

The number of concrete bridge decks in poor structural condition is one of the biggest problems affecting bridges in the United States. Evaluating bridge deck conditions becomes increasingly critical as highway agencies work to optimize the effective timing, scope, and approaches for preventive maintenance, repair, and replacement.

Normal chain dragging, hammer sounding, and visual methods of identifying concrete bridge deck deficiencies do not accurately and safely provide the needed information to adequately maintain concrete bridge decks. Nondestructive testing (NDT) techniques have the potential to quickly and reliably provide the needed information about under-the-surface conditions of bridge decks, but independent evaluations are needed to determine their best use and to validate their effectiveness under a variety of conditions.

Identifying NDT Techniques to Identify Common Concrete Bridge Deck Deficiencies

The Solution

Through the second Strategic Highway Research Program (SHRP2), the web-based, open-source NDToolbox was created to identify and characterize testing technologies that are available to locate the primary deficiencies in concrete bridge decks. With the toolbox, users can explore different NDT technologies and examine their use in detecting deterioration for conditions relevant to the project. The NDToolbox describes the technology and the physical principle behind it, applications, performance, limitations, equipment, test procedures and protocols, and sample results. It also provides recommendations regarding the best technologies for a particular deterioration detection application.

The accompanying report identified the four most common types of deterioration affecting concrete bridge decks, as well as corresponding prioritized NDT techniques that are best suited to locating and identifying them. Based on their overall value in detecting and characterizing deterioration in concrete decks, the top technologies were ground-penetrating radar, impact echo, and ultrasonic surface waves. The report and web tool provide clear information about the advantages and limitations of each technology. However, the ultimate decision on which
equipment to acquire and which technology to use is dependent on the type of deterioration that is of the highest concern to the agency, and whether the evaluation is being done for network-level condition monitoring or for project-level maintenance or rehabilitation.

The Benefits

Comprehensive and accurate assessments of concrete bridge decks can reduce the frequency of detailed regular and follow-up inspections. This can reduce the number of congestion-related traffic interruptions, which, in turn, can provide shorter durations and frequencies of work zones during testing operations. In addition, a number of NDT technologies can generate data at production rates that are comparable to the current practice of chain-dragging and hammer-sounding. The cost of these techniques is also approaching traditional testing values.

Who is using these tools?

Field and laboratory validation testing was conducted in Virginia and Texas. State DOT and local agencies that own and maintain bridges as well as bridge construction contractors will benefit from these improved concrete deck testing technologies and the NDToolbox categorizing these technologies.

How can you learn more?

The final report, Nondestructive Testing to Identify Concrete Bridge Deck Deterioration, is available at http://www.trb.org/Main/Blurbs/167278.aspx. The spreadsheet tools will be available in 2013 at www.TRB.org/SHRP2/publications. For more information, contact Shay Burrows at FHWA, sburrows@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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New Applications of Technology Allow Identification of Materials in the Field

Materials verification without sampling delays

Verifying that construction materials meet project specifications can be a time-consuming and expensive operation. Quality control operations during construction are an important aspect of ensuring that all contract requirements are met and the project is built to last. Current procedures require extensive sampling and testing in a laboratory to ensure that the material used in construction will meet contract specifications. These procedures can be both time-consuming and expensive.

Evaluating Applications of Field Spectroscopy Devices to Fingerprint Commonly Used Construction Materials

The Solution

Through the second Strategic Highway Research Program (SHRP2), three new technologies have been studied to evaluate their ability to verify specific construction materials in real time and at the project site to determine if contract specifications are being met. These technologies are: Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Florescence (XRF), and Raman Technologies. In addition to evaluating these new technologies, the unique signatures found on many common construction materials used in transportation projects have been identified.

For the techniques that have proven capable, SHRP 2 has developed proposed standards of practice that can be considered by the American Association of State Highway and Transportation Officials (AASHTO). The proposed AASHTO standards will be useful to quality assurance and quality control personnel and research and material divisions in transportation agencies. Using these techniques, inspectors will be able to compare the materials’ signature in the field, rather than in the laboratory.

The ability to field-verify construction materials through matching their signatures to those on file using new portable equipment provides cost- and time-saving advantages. The ability to confirm that the material being used onsite meets contract specifications will allow real-time verification of construction operations and prevent costly rework to replace noncompliant material. Field verification will also allow contractors to proceed quickly to the next project operation without having to wait for results of laboratory analysis to verify the type and quality of the material used during construction.
The Benefits
State and local transportation departments, contractors, materials suppliers, and the public will benefit from these technological advancements. Identifying the quality of the materials used on highway projects in the field can lead to savings in both time and money. Field verification avoids costly sampling and laboratory analysis, which have been necessary until now to ensure material specifications are met. The portable equipment will be easy to use and affordable to purchase.

Who can use these tools?
Likely users of this new technology include materials suppliers, transportation contractors, and state and local agency construction staff. The project is currently developing agency-based specifications for using portable spectroscopy equipment in the field. Two state departments of transportation are being identified to pilot-test the specifications.

How can you learn more?
The report titled *Evaluating Applications of Field Spectroscopy Devices to Fingerprint Commonly Used Construction Materials* can be found at [http://www.trb.org/Main/Blurbs/167279.aspx](http://www.trb.org/Main/Blurbs/167279.aspx). For more information, contact Steve Cooper at FHWA, Stephen.J.Cooper@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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Infrared and Radar Technologies Test Temperature and Density of Asphalt Pavement Area

Real-time asphalt pavement testing technologies offer greater testing coverage and immediate feedback

The quality of an asphalt product is determined by the density of the asphalt pavement and the temperature of the mix at application. Specifications for both are very precise and testing of asphalt pavements is required to measure the temperature of the mix and the density achieved in the construction process. In contrast to current specified methods for detecting defects, new infrared and radar technologies offer a system of real-time testing of almost 100 percent of the pavement area. These new technologies improve the state of the practice for obtaining quality control data in hot- or warm-mix construction.

Specifications for Using Rapid Infrared and Radar Technologies for Quality Control of Asphalt Pavements During Construction

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), this project is demonstrating two nondestructive techniques for detecting defect areas in asphalt pavements during construction. Both technologies (infrared and radar) test essentially 100 percent of the pavement area, providing much more inspection coverage than existing quality control methods.

The infrared technology focuses on the PAVE-IR equipment, which allows inspectors and paving crews to measure the real-time mat temperature and make adjustments. The ground-penetrating radar (GPR) technology measures pavement density after rolling, allowing for quicker turnaround and avoiding costly and time-sensitive nuclear testing.

A training video explaining how to use the technologies and interpret the data has been produced and model quality control specifications are currently under development and piloting. Products also include recommendations for equipment and testing protocols for using infrared and GPR for testing the entire surface area during new hot-mix asphalt construction.

New technologies provide almost 100 percent testing coverage for asphalt density

FOCUS AREA: Renewal (R06C)

Model quality control specifications and training video show how to use the technologies and interpret the data.

Save Money
- More inspection coverage helps avoid noncompliance penalties.
- Better quality control leads to smoother pavement for travelers and longer-lasting pavement for owners.
- Real-time density testing allows for quick and efficient field modification.
- Real-time temperature quality assurance and quality control allow for prompt adjustments to avoid costly corrections later.

Save Time
- Real-time testing results in time-savings during construction operations.
- Increased testing coverage area lessens need for corrective action due to low-density asphalt pavements.
The Benefits
Real-time temperature quality assurance and quality control allows for prompt adjustments by the paving crew, thereby minimizing segregation problems that can occur when the temperature is too low. Using GPR technology reduces the reliance on single-point density gauges and instead provides almost 100 percent pavement coverage. In addition to savings resulting from these innovations, near-term benefits include:

- More uniformly constructed hot-mix asphalt and warm-mix asphalt layers
- Better in-place field density
- Improved communication among paving crews, their supervisors, and transportation agency personnel
- Improved ride
- Reduced discrepancies between contractor and agency test data

In the long term, implementation of these commercially available products could result in longer-lived pavements, allowing agencies to stretch their funding further and decrease user costs.

Who is using these tools?
Two state departments of transportation (DOTs) will pilot the specifications. For maximum impact, these tools will require involvement and expertise from the U.S. Department of Transportation, state DOT pavement and material engineers, the state Associations of General Contractors, state asphalt pavement associations, local DOT project engineers and inspectors, and contractors and their quality assurance managers.

How can you learn more?
The final report, training material, and specifications for testing procedures will be available in 2013 at www.TRB.org/SHRP2/publications. For more information, contact Steve Cooper at FHWA, Stephen.J.Cooper@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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Improved Ability to Locate Delamination in Asphalt Pavements Using Non-Destructive Testing System

Identify delamination between asphalt pavement layers in single pass with full-lane coverage

Delamination between layers of asphalt is a key pavement failure that can result in multiple pavement distress issues. Asphalt pavement is generally laid in multiple layers of various thicknesses. To act as a single pavement structure, the various layers have to bond together; failure to bond properly creates problems for the roadway pavement.

Guidelines for Using NDT Methods to Identify Delamination in Asphalt Pavements

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), two new technologies make advances in the detection of subsurface delamination of asphalt pavement. Ground-penetrating radar (GPR) uses a lane-width multi-antenna array with frequency sweep that can be operated at speeds up to 40 miles per hour. The multiple pairs of hardware reduce the number of passes required to cover the lane width. The GPR also has an automated test frequency (every six inches) which accelerates the ability to acquire data. The impact echo (IE) and seismic analysis of surface waves (SASW) system completes data collection in less than one percent of the time required by manual point testing. The software has real-time display to monitor the quality of the data collection. The IE software can provide immediate results to identify suspect pavement conditions. This significantly reduces the time and safety issues associated with current manual testing of a surveyed grid within a lane closure.

The Benefits

Enhanced GPR technology is a significant step forward. This technology, which comes with a lane-width multi-antenna array to provide an accurate full-lane measurement, is an improvement over the current one- and two-antenna systems, which need several passes across a lane to obtain a complete measurement. This translates into time-savings and improved safety. The frequency sweep feature permits radar signal penetration into the pavement to examine the...
entire surface, base, and sub-grade in the same pass. Current GPR antennas are built for single-frequency operation that limits the antenna’s depth of field. Low-frequency antennas penetrate into the sub-grade, while high-frequency antennas identify more detail near the pavement surface. The improved technology allows the engineer or technician to narrow the manual analysis to identified locations where the GPR signal changed.

**Who can use these tools?**

This NDT equipment can be used by transportation agencies and pavement condition consultants to measure near-surface material and distress conditions. Two prototypes are still under development and guidelines for their use being determined. Pilot states will be needed to test the results.

**How can you learn more?**

The final report will be available in 2013 at www.TRB.org/SHRP2/publications. It is anticipated that the prototype equipment will be available for commercial use in 2014. For more information, contact Steve Cooper at FHWA, Stephen.J.Cooper@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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Real-time measurements help build smoother concrete pavements

**FOCUS AREA:**
Renewal (R06E)

Tools to measure concrete pavement smoothness during construction were evaluated. Model specifications and guidelines were developed.

**Save Lives**
- Eliminating pavement grinding and remediation means less exposure to work zone hazards for drivers and workers.

**Save Money**
- Measuring smoothness during construction avoids costly correction solutions such as grinding.

**Save Time**
- Correcting smoothness during construction prevents time-consuming rework in the future.

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**Tools to Detect Pavement Surface Irregularities During Construction**

*New tools measure concrete pavement smoothness*

Ride smoothness is an important performance measurement of user satisfaction, as well as a good measure of concrete pavement durability. Specifications used by state and local departments of transportation (DOTs) include this quality requirement for their concrete pavements. Measuring pavement smoothness during construction, rather than after the concrete sets, allows immediate remediation, resulting in a better quality product and reduced need for expensive grinding.

**Real-Time Smoothness Measurements on Portland Cement Concrete Pavements During Construction**

---

**The Solution**

A project of the second Strategic Highway Research Program (SHRP2) evaluated tools to measure concrete pavement smoothness in real time during construction and developed model specifications and construction guidance to expedite the implementation of these technologies.

These tools have the potential to improve process control. In addition, they allow adjustments of equipment and operations to correct surface irregularities while the concrete is still workable. The results are **higher quality, lower cost, and faster construction, with less impact on the traveling public.**

**The Benefits**

State and local DOTs, contractors, and the traveling public will benefit from these tools. Smooth concrete pavements have been shown to be more durable, with reduced maintenance and rehabilitation costs. In addition, DOTs recognize that smooth-riding pavements minimize collisions from vehicles losing control on rough pavements. **When contractors do not have to grind rough areas or replace sections of concrete pavement, costs, time, and driver delays are minimized.**

**Who has tested these tools?**

Seven potential measurement devices were identified and studied. Two of the devices were found to warrant subsequent evaluation and demonstration: the GOMACO Smoothness
Indicator and the Ames Engineering Real-Time Profiler. The devices were evaluated during concrete paving projects in Georgia, Arkansas, Texas, Michigan, and New York.

**How can you learn more?**

The final report for this project will be available through the TRB bookstore in 2013 at [www.trb.org/SHRP2/publications](http://www.trb.org/SHRP2/publications). For more information, contact Gary Crawford at FHWA, [Gary.Crawford@dot.gov](mailto:Gary.Crawford@dot.gov) or Greta Smith at AASHTO, [gsmith@aashto.org](mailto:gsmith@aashto.org).

**About SHRP2 Implementation**

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Strategic Highway Research Program

U.S. Department of Transportation | Federal Highway Administration
American Association of State Highway and Transportation Officials ● Transportation Research Board
Tunnel-Testing Technology Minimizes Traffic Disruptions

Rapid non-destructive testing of concrete tunnel lining is safe and effective in high-volume traffic conditions

Tunnel inspection is a challenging problem, but owners routinely need to test the integrity of the concrete lining of their tunnels to maintain and repair their assets. Tunnels typically service high-volume traffic and operate in aggressive environments. As a result, they are difficult to inspect for maintenance concerns or deficiencies such as leaks, concrete liner cracking, concrete spalling, delamination, and other debonding issues. Due to their close confinement and heavy use, and the often long detours needed when they are closed to traffic, tunnels pose a unique operational challenge that technology is poised to solve.

The Solution

Non-destructive testing (NDT) methods are automated, quantitative, and rapid, and they provide complete coverage compared with conventional visual inspections. Through the second Strategic Highway Research Program (SHRP2), all the best NDT technologies available have been reviewed and analyzed for their use in tunnel lining assessments. Ground-penetrating radar (GPR), infrared thermography analysis, and impact echo technology were determined to be the most appropriate. The technology allows for vehicles to drive through the tunnel and conduct the inspection without the need to close lanes. A user’s manual was developed for selecting NDT technologies that can detect defects behind or within tunnel linings. The manual will include information on equipment, test procedures, inspector’s training requirements, data management procedures, data analysis procedures, limitations, and interpretation guidelines. Specific software called TUNNELCHECK has also been developed that supports the integration of GPR and video-collected data to identify problem areas in the tunnel more quickly.
The Benefits

The benefits to using these NDT methods in tunnels include:

- Avoids tunnel shutdown
- Requires no lengthy detours
- Uses safe procedures during testing
- Captures 100 percent coverage of tunnel walls

Who is using these tools?

This technology has been piloted for SHRP2 in tunnels in Colorado and Texas, and in the Chesapeake Bay area of Virginia.

How can you learn more?

The user’s manual and TUNNELCHECK software will be available in 2013 at www.TRB.org/SHRP2/publications. For more information, contact Shay Burrows at FHWA, sburrows@dot.gov or Kelly Rehm at AASHTO, krehm@aashto.org.

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GeoTech Tools

Easy identification of the best technologies for solving site-specific geotechnical issues

Fast-paced projects depend on having foundation solutions that allow innovative project construction in restricted space and unique soil and rock conditions. Many of these geotechnical solutions, although well developed and mature, are not widely understood or used. As a result, less appropriate techniques may be selected and the benefits of advanced techniques not realized.

By assembling all the information needed to select, design, specify, and monitor soil improvement technologies into one convenient and comprehensive system, GeoTechTools.org provides transportation agencies and their consultants and contractors with the information and tools needed to use these technologies with confidence.

Web-Based Technical Support Tool for Geotechnical Solutions

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), this web-based tool has identified more than 40 geotechnical solutions to common embankment, cut slope, structure foundation interface, and pavement foundation issues. This technology selection resource tool is currently in the beta-testing phase and is available at http://www.geotechtools.org. It contains extensive photographs, case histories, and examples from past practices that collectively can assist users to select and apply the most appropriate solution to site-specific problems and conditions. The tool helps a user decide among 46 technologies, design issues, and other complex variables to select a geotechnical solution. It offers a balanced level of content for both generalists and specialists so they can identify and apply potential new solutions to geotechnical issues.

The Benefits

This web-based tool can accelerate the design and construction process by providing practitioners with a convenient and efficient way to identify and apply geotechnical solutions to site-specific conditions and issues based on specific performance requirements. This benefit translates into cost, time, and safety for workers, agencies, and the traveling public.
Who can use these tools?
Many of the assembled technologies have consistently proven to be cost-effective and time-efficient, but they have been inconsistently used by federal, state, and local transportation agencies. Both designers and contractors whose projects need innovative geotechnical solutions can more confidently select and apply these techniques with this web-based tool.

How can you learn more?
The full report on the new technology will be available in 2013 at www.TRB.org/SHRP2/publications. For more information contact Silas Nichols at FHWA, silas.nichols@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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Options for Using Precast Concrete to Speed Construction

A solution for repairing roadways with faster project schedules, reduced congestion, and improved safety

Precast concrete pavement (PCP) segments can be quickly installed on a prepared foundation. PCP has application both in accelerated pavement reconstruction as a permanent surface over a wide area, as well as for temporary segments to allow more flexibility in construction phasing. There are great potential benefits to using PCP systems: they can speed up roadway reconstruction without sacrificing quality; once installed, the roadway can quickly be reopened; and traffic disruption during construction can be significantly reduced through use of unique phasing opportunities. In many cases, contractors have been able to repair the subgrade and return the roadway to full service within one construction shift.

Over the past 10 years, several transportation agencies have recognized the benefits of this technology and installed PCP systems in a variety of applications. Because it is a relatively recent technology, however, information on precast pavement practices and PCP performance has not been well documented. In addition, most PCP systems are proprietary, so state transportation departments have often found them difficult to specify.

The objective of the research from the second Strategic Highway Research Program (SHRP2) was to fill this gap in knowledge by developing guidelines and tools for public agencies to use in the selection, design, construction, installation, and maintenance of PCP systems, and to provide the tools for cost/benefit assessment in situations where the technology may apply.

The Solution

Because PCP systems are a recent technology, there was insufficient data on their use over an extended period of time, with gaps in knowledge regarding durability and performance at the joints and panels. Additionally, unrealistic expectations about PCPs as “super pavements” potentially could undermine the success of the technology. To address these issues, SHRP2 investigated 16 PCP projects at locations with a wide range of climates (from Michigan to Texas) and assessed how the PCP systems were used (on ramps, toll plazas, at-grade roadways, and airports). Field surveys included short, intermittent repairs as well as longer, continuous applications.
SHRP2’s research found that modular pavement technology is still evolving, but that over the 10 years it has been used, well-designed and well-constructed PCP systems can provide high-quality, long-term service and are often a good choice for rapid repair and rehabilitation of existing pavements. These new guidelines provide transportation agencies with tools that can match the PCP installation technology to the project, while providing clear specifications for PCP design, fabrication, and installation, as well as model specifications.

The Benefits

PCP pavement provides the opportunity for significantly reducing traffic impacts of roadway reconstruction projects, particularly on heavily traveled routes. The technology has applications both in small segments to allow flexibility in construction phasing, as well as use for corridor-wide pavement reconstruction. This tool will support the continued growth and understanding of the use of PCP for roadway construction. Some benefits are:

► Shorter installation time means reduced traffic impacts.
► Safety of drivers and construction workers improves due to reducing the frequency and duration of work zones.
► Pavement is ready for traffic upon installation—no curing time.
► Slabs are cast in place under ideal conditions for optimum quality.
► Installation can take place at night or under adverse weather conditions, extending the construction season.
► Durability can be similar to or better than traditional cast-in-place (CIP) solutions.

Who is using these modified pavement technologies?

PCP systems are in place across the country. Here are just a few examples:

<table>
<thead>
<tr>
<th>Agency</th>
<th>System</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caltrans</td>
<td>Precast, prestressed, and jointed PCP (Caltrans designed)</td>
<td>I-680 (prestressed system) I-15 (jointed system) and other locations</td>
</tr>
<tr>
<td>Illinois Tollway</td>
<td>Jointed PCP for repairs (Tollway designed and Fort Miller Co. systems)</td>
<td>Several projects in the Chicago area</td>
</tr>
<tr>
<td>Iowa Department of Transportation (DOT)</td>
<td>Precast, prestressed, and jointed PCP for approach slabs (Tollway designed and Fort Miller Co. systems)</td>
<td>Highway 60 near Sheldon, IA Iowa 43 near Denver, IA</td>
</tr>
<tr>
<td>New Jersey DOT</td>
<td>Jointed PCP for repairs (Fort Miller Co. systems)</td>
<td>Several projects along I-95 and other primary roadways</td>
</tr>
<tr>
<td>Utah DOT</td>
<td>Utah DOT-designed Fort Miller Co. systems</td>
<td>I-15 and other locations</td>
</tr>
<tr>
<td>Virginia DOT</td>
<td>Precast, prestressed (Virginia DOT designed) Jointed (Fort Miller Co. systems)</td>
<td>Fairfax County, VA; I-66 mainline (prestressed system); I-66 ramp (jointed system)</td>
</tr>
</tbody>
</table>

How can you learn more?

For more information, contact Sam Tyson at FHWA, styson@dot.gov, or Jameelah Hayes at AASHTO, jhayes@aashto.org. Additional resources include a project overview on the TRB website at http://apps.trb.org/cmsfeed/trbnetprojectdisplay.asp?projectid=2169 and a report, Precast Concrete Pavement Technology, available at http://www.trb.org/Main/Blurbs/167788.aspx.

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Strategic Highway Research Program
Guidance and Tools Support Wider Use of Composite Paving System Construction

*New guidance for constructing cost-effective, safe, and longer-lasting pavement systems*

Composite pavement systems have been shown in the United States and Europe to have a longer service life with excellent surface characteristics and structural capacity, while being economical and sustainable. Despite this, these composite pavement systems are not widely used in the United States because studies of their installation and use were inadequate. The purpose of the product developed through the second Strategic Highway Research Program (SHRP2) project was to document the behavior of composite pavements and provide models to be used for design, performance prediction, and life-cycle cost analysis.

**The Solution**

Two promising composite pavement systems: a thin, high-quality hot-mix asphalt layer over a Portland cement concrete (PCC) structural layer, and a thin, superior PCC surface over a second, less-expensive, recycled PCC layer were investigated as part of the research. The results of these tests, which were conducted in heavy-load highway and a variety of climatic conditions, were used to develop and validate models and design procedures to be used for design and construction of the new composite pavement systems. The new guidelines provide practical recommendations for construction specifications and techniques, life-cycle costing, quality management procedures, and training materials.

**The Benefits**

With the new guidance, models, techniques, and specifications, state and local departments of transportation and other organizations can have confidence that the composite pavement systems they install and maintain will be long-lasting and have predictably low life-cycle costs. Agencies will no longer need to develop construction specifications and quality management guidelines on their own, but can instead consider using these. The training tools and case studies include all relevant design and construction issues and are essential to widespread adoption and use of composite pavements.
How can you learn more?

Implementation is expected in 2014.


For more information, contact Steve Cooper at FHWA, stephen.j.cooper@dot.gov or Jameelah Hayes at AASHTO, jhayes@aashto.org.

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Strategic Highway Research Program

U.S. Department of Transportation | Federal Highway Administration
American Association of State Highway and Transportation Officials ● Transportation Research Board
Using Existing Pavements to More Quickly Reconstruct Highway Projects

New guidelines help agencies use existing pavement for rapid and cost-effective reconstruction

State and local transportation agencies continue to seek innovative ways to speed up the delivery of needed infrastructure improvements at lower costs. New research from the second Strategic Highway Research Program (SHRP2) offers new guidance for incorporating existing pavement into pavement rehabilitation projects with cost-effective results.

The new guide identifies the optimal conditions for using existing pavements and the best approaches for ensuring they last longer when they are incorporated. These pavements have the potential to serve 50 years and can reduce the need for more costly and time-consuming reconstruction projects using all new materials. The end results are longer-lasting pavements that cost substantially less, use substantially less new material, and can be constructed more quickly.

The Solution

This web-based scoping tool and accompanying report, Using Existing Pavement in Place and Achieving Long Life, provide much-needed guidance for deciding where and under what conditions to use existing pavement as part of roadway renewal projects. The products include approaches for using existing pavements in-place to ensure longer service life for roadways using asphalt, concrete, and other innovative materials. They also identify new alternatives to renewal approaches. In addition, they can provide realistic scoping assessments; they document successful practices; and they provide model specifications.

Reconstructing the nation’s busiest roads faster with less new material

Focus Area: Renewal (R23)

Web-based scoping tool and easy-to-follow guide with model specifications and case studies for incorporating existing pavements into rapid renewal road construction projects.

Save Lives

- Shorter construction periods reduce risks and enhance safety for the traveling public and construction workers.

Save Money

- Reusing existing pavement reduces costs, including hauling and dumping costs, and shrinks construction timelines.

Save Time

- Projects are accelerated by reusing existing pavement, alleviating the need to remove and dispose of it offsite.
- The traveling public experiences fewer traffic delays because of shorter construction windows.
The report and accompanying materials describe:
► The range of approaches for using existing pavement in renewal projects;
► The advantages and disadvantages of each approach and under what circumstances each should be considered;
► Construction techniques; and
► The method for integrating recycled concrete with adjacent materials and road structures.

The Benefits

The web-based tool can complement an agency’s existing processes to encourage design and construction using onsite materials. Other benefits:
► Time savings based on rapid reuse of existing materials;
► Cost savings from reduced need for new pavement and a shorter construction phase;
► Shorter construction time, resulting in reduced exposure of travelers and construction workers to work zone hazards;
► A better return on investment for the public based on a longer pavement service life; and
► Reduced environmental footprints, based on decreased use of new materials.

How has this strategy been used by states?

The Washington Department of Transportation estimates it will realize a 30 percent cost savings over the life of the new pavement and a 50 percent reduction in user delay by applying this method. This approach delivers long-lasting value by promoting durable and dependable roads.

How can you learn more?

The TRB report, Using Existing Pavement in Place and Achieving Long Life, will be available in early 2013. For more information, contact Steve Mueller at FHWA, steve.mueller@dot.gov; or Greta Smith at AASHTO, gsmith@aashto.org.

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Strategic Highway Research Program

U.S. Department of Transportation | Federal Highway Administration
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Select Proven Preservation Techniques to Treat High-Volume Roads

New guide helps engineers select lower-cost pavement preservation over high-impact reconstruction for heavily traveled roadways

Relatively small investments in preserving existing pavement can forestall the need for major reconstruction projects. Many effective pavement preservation techniques exist, but until now they have been used, especially in urban settings, primarily for low-volume roads.

A comprehensive report developed through the second Strategic Highway Research Program (SHRP2) shows that many conventional techniques—and some new ones as well—can be used to extend the life of high-traffic-volume roads and avoid disruptive and costly major rehabilitation and reconstruction projects. Derived from an extensive literature review and a detailed survey of transportation agencies, the report and the guide document successful current practices and provide selection matrices to help match specific high-volume-traffic situations with the best available treatments.

Preservation Approaches for High-Traffic-Volume Roadways and Guidelines for Preservation of High-Traffic-Volume Roadways

The Solution

Preservation Approaches for High-Traffic-Volume Roadways and its companion guidelines are the first systematic and comprehensive documents to provide the technical background and decision-making framework needed to bring proven preservation strategies widely into play for high-volume roads.

The guide clarifies key factors that affect preservation treatment decisions, including traffic levels, pavement conditions, climate conditions, available work hours, and treatment performance and cost. Preliminary and final feasibility matrices for hot mix asphalt and Portland Cement Concrete-surfaced pavements allow engineers to quickly zero in on a particular treatment type (such as crack fill) and see whether it is recommended for particular distress types and severity levels. Example decision matrices simplify the complex factors involved and give steps for weighing technical inputs. Appendices summarize treatments and give examples of how the matrices have guided treatment selection.

Focus Area: Renewal (R26)

Decision matrix, treatment guide, and examples outline best practices and support the selection of the right option for your travel conditions.

Save Lives

- Shorter construction periods reduce risks and enhance safety for the traveling public and construction workers.

Save Money

- Preserving existing pavement reduces need for major reconstruction projects.
- Selecting the best preservation strategy reduces financial risk.

Save Time

- This guidance helps decision makers quickly target techniques most likely to work in a given high-volume-traffic situation.
The Benefits

By helping engineers to more quickly and confidently select the right treatment at the right time for a given pavement, the guide can help transportation agencies embrace preservation instead of rehabilitation or reconstruction, thereby saving scarce transportation dollars. And by focusing on more than 20 treatments that have proven cost-effective, these documents also help save money by reducing the risk of choosing preservation over reconstruction.

Follow-on benefits to choosing preservation over reconstruction include reducing congestion and increasing worker and driver safety. Small problems can be fixed before they become big problems, and the public can enjoy a smoother ride sooner. In the long run, selecting the right preservation techniques with help from the guide could help increase economic viability, since good roads underlie good business.

Who is using preservation techniques on high-volume roadways?

► Georgia Department of Transportation (DOT) has used crack seals, single-course microsurfacing, overlays, and mill/overlays on urban roadways.

► Texas DOT uses crack seals, polymerized chip seals, and ultrathin overlays as well as other treatments on rural roads.

► South Dakota DOT uses fog seal, ultrathin bonded wearing course, and cold in-place recycling on rural roads.

“This tool is about opportunity. This tool gives the states a portfolio of options and choices. I think it will help us redefine how we do our decision making in terms of infrastructure management.”
Andrew Williams, Ohio Department of Transportation

“If you can keep your treatment costs down for a longer period of time and push out those major rehabs, then you’ve saved very real dollars.”
Judith Corley-Lay, North Carolina Department of Transportation

How can you learn more?

The report and companion guide, Preservation Approaches for High-Traffic-Volume Roadways and Guidelines for the Preservation of High-Traffic-Volume Roadways, are available for online viewing at http://www.trb.org/Publications/Blurbs/165280.aspx and http://www.trb.org/Publications/Blurbs/164965.aspx, respectively, or for purchase from the TRB Bookstore at http://www.trb.org/Finance/Bookstore.aspx. For more information, contact Thomas Van at FHWA, thomas.van@dot.gov; Jameelah Hayes at AASHTO, jhayes@aashto.org; or Jason Richins at AASHTO, jrichins@aashto.org.

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Strategic Highway Research Program
Management Practices that Reduce Worker Fatigue

Guidelines and training to reduce worker fatigue in rapid renewal projects

Reconstruction projects that require accelerated schedules often generate additional pressures on the workforce, requiring longer day shifts, night and weekend work, and work conducted in protected zones adjacent to traffic. These conditions—which can affect laborers, superintendents, and management—can result in worker fatigue, which, in turn, can lead to possible increases in worker accidents. State and local transportation department managers need to better understand the factors associated with workforce fatigue and stress in the rapid renewal environment so that the risks to worker safety can be reduced.

Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), this project examined the causes of fatigue and stresses experienced by workers during rapid renewal projects, which resulted in the development of guidelines and training to increase worker safety. Outcomes and products include the following:

- An integrated set of rapid renewal workforce fatigue risk factor definitions, and fatigue risk management practices and techniques;
- A toolkit with procedures for state and local transportation departments to comprehensively manage workforce fatigue in the rapid renewal environment; and
- Model training and outreach materials to assist in future implementation.

These products provide state and local transportation departments with the tools needed to manage workforce fatigue and increase worker safety.
The Benefits

Reducing worker fatigue in rapid renewal environments will benefit transportation departments, workers, and the public. Numerous benefits flow from having fewer worker injuries due to fatigue. Fewer worker injuries increases project productivity, which reduces project costs, lessens traveler delay, and keeps projects on time and within budget.

Who can use these tools?

The anticipated users for this material include state and local transportation departments and workers at multiple levels involved in highway construction projects using rapid renewal techniques.

How can you learn more?

The final report, guidelines, and training material will be available in 2013 at www.TRB.org/SHRP2/publications. For more information, contact Bryan Cawley at FHWA, bryan.cawley@dot.gov or Jason Richins at AASHTO, jrichins@aashto.org.

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Performance-Based Specifications Promote Innovation and Accelerate Project Delivery

This approach motivates contractors to come up with better ways to deliver projects

Many transportation agencies are using performance specifications, particularly on accelerated construction projects, to promote innovations and capture cost savings. Performance specifications focus on outcomes, rather than methods, to motivate contractors to find new and better ways to accelerate project delivery, minimize disruption, and build a better project. However, limited resources are available to support state and local departments of transportation (DOTs) in writing specifications for their projects and many have used trial and error to derive the best performance specification language to achieve the results they are looking for. This research captures the best practices, lessons-learned, and proven results to provide performance specifications that DOTs can use on their projects.

Performance Specifications for Rapid Renewal

The Solution

New implementation guidelines and model performance guide specifications help agencies get the quality and innovation they are seeking on pavement and structural construction projects. The new specifications support faster construction and improved quality, and cover an array of project delivery methods such as design-bid-build, design-build, design-build-warranty, and design-build-operate-maintain. By clearly defining how a product should perform in service, these specifications promote innovation and reduce prescriptive method requirements. They concentrate, instead, on measuring those factors that are critical to the performance of the final product.

Guide performance specifications are provided in the areas of hot-mix asphalt, Portland cement concrete, concrete bridge decks, embankment/pavement foundations, other geotechnical application areas, work zone traffic control, and quality management.
As applicable, the guide specifications have been tailored to specific delivery approaches (design bid-build, design-build, warranty, and design-build-operate-maintain), recognizing that the chosen approach can significantly affect how much performance risk can be placed upon the private sector.

Performance guide specifications provide a template for developing project-specific performance specifications. The guide also addresses issues related to project selection, specification development, procurement, and the other cultural and organizational changes necessary to successfully deliver rapid renewal projects. Guidelines for ranking important project parameters (time, quality, cost, risk, and complexity) and specifications for different highway renewal scenarios (road, bridge, structures, traffic control) are provided. The implementation guidelines include a procedural manual to help managers understand risk and make better decisions with regard to their specifications. It also provides a flexible framework for assessing whether performance specifications are a viable option for a particular project and provides step-by-step instructions for developing performance specifications.

The Benefits

Clearly specifying the desired performance goals for accelerated road and bridge projects can encourage contractors to apply greater control and ingenuity, reduce costly construction oversight, and apply construction management resources more efficiently. This product provides the tools to owner agencies to reduce claims, reduce inspection costs, accelerate construction, and improve project quality.

Who is using these specifications?

- Missouri DOT tested geotechnical performance specifications on its Route 141 Roadway Improvement Project.
- Virginia DOT tested the use of performance specifications for a hydraulic cement concrete bridge deck using construction parameters related to performance on its Lake Anna Bridge Rehabilitation project.
- Louisiana DOT’s US 90 Frontage Roads project will evaluate the use of non-destructive, roller-integrated compaction monitoring technology and mechanistic-based in situ point measurements on a new pavement section.

How can you learn more?

The final product will be available in April 2013. Specifications will also be available in electronic format. For more information, contact Jennifer Balis at FHWA, jbalis@dot.gov, or Greta Smith at AASHTO, gsmith@aashto.org.

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Strategic Highway Research Program

U.S. Department of Transportation | Federal Highway Administration
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Managing Risk on Rapid Renewal Projects

New suite of tools helps agencies build precision in their risk management processes

Highway projects come in a variety of sizes and utilize various financing mechanisms and delivery methods. Work on such projects often involves the potential for schedule delays, budget over-runs, and other unexpected problems or “risks” that affect project performance. The risks of underestimating cost, schedule, or disruption can negatively affect budgets, increase delays, undermine public confidence, and necessitate expensive changes. Managing a project by anticipating and planning for these risks can significantly improve its outcome, both for the transportation agency and the traveling public.

Traditional risk assessment and mitigation activities used by transportation agencies today often lack rigor and formality in the project planning, design, and delivery continuum. Failure to adhere to a formal risk analysis process can result in unanticipated problems, delays, and costs because finding solutions during later phases of a project can be more difficult and costly. The new guide developed by the second Strategic Highway Research Program (SHRP2) provides practical tools and techniques to optimize innovation, minimize schedule and budget risks, and build better projects.

Next Generation Guide for Managing Risk

The Solution

Managing Risk on Rapid Renewal Projects (R09) helps managers quantify risks and provides guidance on the level of risk management needed. It presents a formal risk management process that optimizes performance for accelerated reconstruction on projects, offering practical methods for identifying, assessing, mitigating, allocating, and monitoring risk. It fills the gaps that current risk management practices do not address by adding project performance measures, and different project delivery and construction methods.

The report provides a complete risk analysis process that allows the user to factor in project scope, strategy and conditions, structuring, risk identification, risk assessment, risk analysis, risk management planning, and risk management implementation. It also provides objective guidance that can be applied to various types and sizes of rapid renewal projects, as well as other rehabilitation efforts. Implementation tools include...
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The Benefits

The benefits of improved risk management through the use of this product all focus on improved project performance. This product can be applied to highway projects of varying sizes and types to help project managers proactively identify, plan for, assess, and manage their projects to reduce the risk of schedule and cost impacts. This product will help transportation agencies better anticipate and understand the range of performance outcomes that may occur during a project’s lifecycle. A better understanding of the potential risks leads to better financial management of agency capital budgets, fewer changes due to unanticipated issues, and more disciplined decision making regarding crucial project matters in the context of all other risks.

Who is using these tools?

Managing Risk in Rapid Renewal Projects was one of several SHRP2 products selected for 2013 FHWA/AASHTO Implementation Assistance Program. In the first round, two “proof of concept” incentives were awarded: the Florida Department of Transportation (DOT) for its Gateway Express Project and the Georgia DOT for its SR 96 Corridor Project.

The risk assessment workshops were also piloted during the research phase. Representatives from Washington, Minnesota, Nevada, Virginia, and North Carolina participated.

How can you learn more?

The Guide for the Process of Managing Risk on Rapid Renewal Contracts is available at http://www.trb.org/main/blurbs/168369.aspx. For information, contact Carlos Figueroa at FHWA, carlos.figueroa@dot.gov, or Jason Richins at AASHTO, jrichins@aashto.org.
**Innovative Strategies for Managing Complex Projects**

*Management tool leads to better decisions that address all aspects of planning of a complex project earlier in project life*

Complex highway projects come in a variety of sizes and utilize various financing mechanisms and delivery methods. Work on such projects often involves navigating complex logistics, new construction methods, controversial stakeholder issues, and restrictive regulations that require careful planning and execution. Similarly, underestimating cost, schedule, or disruption can negatively affect budgets, increase delays, undermine public confidence, and necessitate expensive changes.

Project management has long focused on three elements—cost, schedule, and technical (scope, design, quality, and integrated delivery), but complex projects, particularly those in the rapid renewal area, need something more robust to be successful.

Moving beyond traditional approaches requires stronger partnerships among transportation agencies, contractors, consulting engineers, and external stakeholders. Better strategic planning and execution must occur from startup through construction. This new guide developed by the second Strategic Highway Research Program (SHRP2) provides practical tools and techniques to optimize innovation, minimize schedule and budget risks, and build better projects.

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**The Solution**

The guidebook, *Project Management Strategies for Complex Projects*, expands the three-dimensional analysis typically used by departments of transportation and creates a model that facilitates project management in five areas—cost, schedule, technical, financial, and context. Methods for assessing complexity factors will help managers make rational resource allocations and guide planning and implementation.

The complex management product is a methodology that takes a project through a deliberative process that begins with an overview of complexity mapping and then follows five distinct steps for addressing the five dimensions. The steps are: 1) define critical project success factors, 2) assemble project team, 3) select project arrangements, 4) prepare early cost model and finance plan, and 5) develop project action plans.
The guidebook also contains 18 case studies, forms, and other application tools that will assist transportation agencies in using the product. The companion training program will assist state and local transportation agency staff in obtaining the skill-sets necessary to follow the process.

**The Benefits**

This method represents an evolution in current project management practices. This product can be applied to highway projects of varying sizes and types to help project managers proactively identify, plan for, and manage their projects to reduce the schedule and cost impacts. It changes the context for projects from linear to dynamic by encouraging innovation and relational partnering and emphasizing that each complex project has its own distinct set of performance goals.

The complex management product is very amenable to “self-implementation” after project managers or facilitators have been trained in the methodology. This product is scalable and adaptable to projects of all sizes and nature. It will also guide managers through a process to fully integrate project teams across the entire life cycle, a foundation of project success. Projects using this approach may also consider utilizing the Guide for Process of Managing Risk on Rapid Renewal Projects (R09) at the appropriate point in the project development process, since the two products are complementary in nature.

**Who is using these tools?**

*Managing Complex Projects* was one of several SHRP2 products selected for the 2013 FHWA/AASHTO Implementation Assistance Program. In the first round, five “lead adopter” incentives were awarded to Georgia, Massachusetts, Michigan, New Mexico, and the Federal Lands Highway in Montana.

Several training sessions and workshops were piloted during the research phase. Training sessions were held in California, Colorado, Florida, Iowa, Minnesota, New York, Ohio, and Texas. Pilot workshops were conducted in Colorado and Michigan.

**How can you learn more?**

The report, *Guidebook: Project Management Strategies for Complex Projects*, is available at [www.trb.org/Main/Blurbs/167481.aspx](http://www.trb.org/Main/Blurbs/167481.aspx). For information, contact Carlos Figueroa at FHWA, carlos.figueroa@dot.gov, or Jason Richins at AASHTO, jrichins@aashto.org.

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**About SHRP2 Implementation**

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**Strategic Highway Research Program**

U.S. Department of Transportation | Federal Highway Administration
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New Tool to Evaluate Construction Impacts From a Network Perspective

*Integrated framework enables better decisions*

The impacts of construction on congestion and work-zone traffic control are routinely considered by transportation agencies at a project level. Less common, however, is consideration of how a multitude of projects being constructed at the same time can affect traffic flow on a system-wide basis. Yet in today’s environment, higher traffic volumes often mean that adjacent projects being constructed simultaneously within a network have a greater impact than ever before. Insufficient program-level considerations of scheduling and phasing, poor staging on contracts, failure to use innovative technologies and techniques, and inadequate work-zone traffic management can amplify traffic disruption across the network for an extended period of time, with unsatisfactory results all around.

Transportation agencies need tools to help determine the optimal sequencing of renewal projects where multiple projects are occurring within a system or network. Tools are also needed to help determine, from an operational or safety perspective, the cost-effectiveness of sequencing strategies for the minimization, management, and mitigation of road user costs.

*WISE, Workzone Impact and Strategy Estimator Software*

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), the *Workzone Impact and Strategy Estimation Tool* (WISE) software analyzes the impacts on road users of multiple, concurrent work zones across a network or complex corridor. This tool will help agencies assess the optimal sequencing of renewal projects, and help determine the efficiency (cost-effectiveness) of strategies for the minimization, management, and mitigation of road user costs from safety or operational perspectives. The WISE tool is flexible, and can be used at a planning level as well as the operational level.

The Benefits

WISE benefits users by filling an observed gap in currently available products. This software provides an integrated framework for users to evaluate planning decisions and operational strategies, which will reduce the overall cost by avoiding repetitive model-building using different software. With the integrated framework, planning-level decisions can be based on network- and corridor-level impacts. Users can import traffic networks from existing travel demand models so
that large networks can be easily imported and evaluated. The tool has an optimization routine that will recommend efficient staging strategies. WISE can evaluate the impact of changes in route choice behavior, as well as impacts from intelligent transportation systems.

**Who is using these tools?**

The WISE software is fully developed. It is being tested in Iowa and Arizona using historical data to validate its parameters. In addition, future pilot tests in New York and Florida will use the software to analyze projects currently in the planning phase.

**How can you learn more?**

The final report and WISE software will be available in 2013 at [www.TRB.org/SHRP2/publications](http://www.TRB.org/SHRP2/publications). For more information, contact Tracy Scriba at FHWA, [Tracy.Scriba@dot.gov](mailto:Tracy.Scriba@dot.gov) or Greta Smith at AASHTO, [gsmith@aashto.org](mailto:gsmith@aashto.org).

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Locating Underground Utilities – the Difference between On-Time Delivery and Costly Construction Delays

New tools improve utility location practices contributing to time and money savings

Locating and identifying underground utilities are major sources of concern for the transportation industry. It is important not only to locate, but also to identify what type of utility is potentially in an area of construction activity. This information is crucial to the safe, timely, and cost-effective delivery of major construction projects.

Encouraging Innovation in Locating and Characterizing Underground Utilities

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), the software tool SAULT (Selection Assistant for Utility Locating Technologies) provides users with a web-based selection support tool to identify the most appropriate technologies for locating underground utilities at specific site locations. The companion SHRP2 report provides a comprehensive list of documented technologies for locating underground utilities. The report characterizes the methods for identifying existing utilities and for marking new utilities that are currently being constructed for future location. The case studies highlight utility location and marking technology. The report also documents widespread examples of successful use in the field.

The Benefits

By identifying underground utilities prior to construction, potential conflicts can be avoided during the project construction phase. Avoiding these conflicts can prevent costly delays and rework stemming from encountering unknown utilities in the field. Maintaining a delivery schedule is important to contractors, utility companies, and transportation agencies. Avoiding impacts on these schedules allow construction contractors to offer more appropriate bids that reflect lower risks, and ensure that costly user delays are avoided. Identifying technology that can be used to locate underground utilities, or that can mark new utility locations for future use, minimizes gas and electric facility impacts and prevents serious accidents to either workers or public users. Safety for all concerned on construction projects is always a priority.
Who should use these tools?

The intended users of this product include state and local transportation agency designers, utility coordinators, construction staff, consultants, and contractors, as well as utility owners and their respective technical staff.

How can you learn more?

Encouraging Innovation in Locating and Characterizing Underground Utilities and Development of the Selection Assistant for Utility Locating Technologies are available on the web at www.TRB.org/SHRP2/publications. The SAULT web-based selection tool is available at http://138.47.78.37/sault/home.asp. For more information, contact Amanda Rutherford at FHWA, amanda.rutherford@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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Strategic Highway Research Program

U.S. Department of Transportation | Federal Highway Administration
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3D Modeling Helps Transportation Agencies Design Optimum Transportation Solutions

New technology makes storing and retrieving 3D data for underground utilities a reality

With the ever-changing and increasing use of underground utilities, it is becoming more critical for state and local transportation agencies to identify and track the locations of new and existing underground facilities. The large amounts of existing data identifying these locations need efficient storage and retrieval technology so the data are available for future use.

Technologies to Support Storage, Retrieval, and Use of 3D Utility Location Data

The Solution

Developed through the second Strategic Highway Research Program (SHRP2), this state-of-the-art 3D storage and retrieval data model will accommodate large volumes of data, interface with existing design software, and provide designers with a tool to use captured data on underground utilities. The data provide horizontal and vertical location of the facility, as well as information regarding the type of utility that is buried at the location. This information is valuable both for design around the location and for coordinating with the utility owner. Once stored in the system, the underground utility location data are available for future reference.

The Benefits

Storing and easy retrieval of underground utility location data provide numerous benefits in the design, field data collection, and construction areas of transportation projects. Designers can change designs to accommodate extensive utility locations, thus avoiding costly utility moves. The ability to collect data in a single operation can minimize costs of data collection efforts. Contractors can avoid encountering unknown utilities in the field, preventing lengthy and costly modifications to the project.

Who can use these tools?

State and local transportation agencies and consultants are the first line of use with contractors and utility companies also accessing this information.
How can you learn more?

The data model and guidelines for integration and use are in development and will be available from the Transportation Research Board website in late 2013. For more information, contact Amanda Rutherford at FHWA, amanda.rutherford@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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Finding Underground Utilities with Technology

Combining multiple technologies on one platform to locate underground utilities in a single pass

The number and variety of underground utilities can hinder utility location. Underground utilities can be made from many different types of materials and can be located at random depths in soil conditions ranging from silty clay to sandy loam. Because of this constantly changing pattern of interference, it may take several different technologies to locate and identify unknown utilities.

Utility-Locating Technologies

The Solution

New research developed through the second Strategic Highway Research Program (SHRP2) has created a prototype multi-sensor platform that combines several types of technologies to locate utilities in one pass. Multi-channel ground-penetrating radar, electromagnetic imaging, and seismic systems are some of the new technologies employed on this platform.

The Benefits

Using cost-effective technologies to streamline the location process can benefit both the private firms that conduct utility location work and the state and local government agencies that pay for this service. Saving time, increasing accuracy, and improving overall success rates provide additional benefits when the designer uses this information to engineer site-specific project solutions. The contractor benefits from having accurate utility location information and fewer surprises, which translates into savings in time and money.

Who can use these tools?

This prototype technology is mainly geared for private-sector utility locators. It also has application for utility companies and state and local government agencies that do their own locations for underground utilities.
How can you learn more?

The prototype sensor platform is ready for commercial use. The full report on the new technology will be available in 2013 at www.trb.org/SHRP2/Publications. For more information, contact Amanda Rutherford at FHWA, amanda.rutherford@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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New Technology Locates Underground Utilities at Deeper Depths

Device will identify the precise placement of utilities in a sea of existing facilities

The shallow underground horizon is fast filling up with a multitude of ever-expanding utility facilities. The need to find room in this underground landscape leads utility companies to even deeper locations. In the transportation environment, utility companies are constantly challenged to find the locations of deep utility facilities. For new placements, it can be difficult to provide traceable signals to identify and tag the locations for future purposes.

Innovation in Locating Deep Utilities

The Solution

Deep utility construction places a premium on technology solutions to correctly identify, tag, and locate these locations. New technologies such as active and passive acoustical signatures, electronic scanning techniques to capture utility material signatures, Long-Range IFD tagging techniques, seismic reflectivity, and accurate mapping systems all play a role in finding the locations of deeper underground utilities. A new device is being developed as part of the second Strategic Highway Research Program (SHRP2), which will go beyond the shallow underground utility location technologies and expand the locatable zoom capability needed to find deep utilities.

The Benefits

Knowing the type and location of utilities that are placed deep underground is important for designers of transportation projects and contractors alike. The new device will enable transportation planners to design projects that avoid these utilities, since they can be very expensive to relocate. In addition, by knowing where these utilities are located, accidental damage to unidentified utilities can be circumvented, avoiding costly repair costs for contractors.

Who can use these tools?

Although the prototype equipment is still under development, expected users include utility companies, utility locating companies, contractors, and the transportation design community. Reports are expected in 2013.
How can you learn more?

The full report on the new technology will be available in 2013 at www.trb.org/SHRP2/Publications. For more information, contact Amanda Rutherford at FHWA, amanda.rutherford@dot.gov or Greta Smith at AASHTO, gsmith@aashto.org.

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Strategic Highway Research Program

U.S. Department of Transportation | Federal Highway Administration
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Identifying and Managing Utility Conflicts for Optimal Efficiency

A comprehensive methodology and tools to identify, mitigate, and resolve utility conflicts in highway rights-of-way

State departments of transportation (DOTs) and local agencies have developed many innovative approaches to minimize construction-related delays and congestion. Unfortunately, costly changes related to utilities continue to plague owner agencies, slowing construction and adding significantly to project costs. Locating buried utility lines in the right-of-way and relocating aboveground wires, poles, and equipment often cause costly delays for construction projects and expensive rework for utility companies.

New tools developed through the second Strategic Highway Research Program (SHRP2) to document and manage utility conflict data will help alleviate many of these problems.

Identification of Utility Conflicts and Solutions

The Solution

The Utility Conflict Matrix (UCM) and its companion report, Identification of Utility Conflicts and Solutions, provide concepts and procedures to identify and resolve utility conflicts that public agencies and utilities can use to help improve the highway project development process. Two versions of a unified conflict matrix have been developed: a stand-alone, spreadsheet-based matrix (“UCM lite”); and an advanced UCM prototype that enables the management of conflicts in a database environment. These matrices enable users to organize, track, and manage the conflicts that can frequently arise when utility lines are located under highways. They are scalable, support a range of project sizes and conditions, and generate easily accessible information to help all parties make more informed decisions. The tools feature a description of best practices from selected DOTs already using Utility Conflict Matrices as well as training materials, a procedural manual, and implementation guidelines. This SHRP2 Solution includes data from surveys of DOTs and utility companies and offers successful practices and case studies that identified prevailing issues and proven solutions.
The Benefits

The immediate benefits of the UCM process are simplified and earlier identification of conflicts and solutions. By offering more transparency to all parties and earlier identification of conflicts, the UCM can foster greater communication among affected parties. Together, these improvements lead to a more efficient process. Ultimately the benefits of using a utility conflict matrix on roadway and bridge construction include:

- Fewer contractor change orders and delay claims;
- Reduced costs from construction delays;
- Improved project development procedures based on anticipating and resolving utility conflicts early in the process;
- Better communication among transportation agencies and utilities; and
- Reduced impacts on the public from construction-related delays.

What states are using various types of utility matrices?

- Georgia DOT uses a utility impact matrix on every project involving utilities and offers programs to train designers in utilities coordination.
- Both Florida DOT and Georgia DOT have developed protocols for Electronic Plan Transfer, the use of electronic files and file transfer protocols to communicate highway project status to affected utility companies and to maintain archives.
- Wisconsin has developed a statewide common Transportation Utility Management System (TUMS) for tracking, locating, and managing systems.
- Texas DOT also developed a tool showing each activity of the right-of-way acquisition and utility adjustment process with the corresponding responsible parties separated into three categories: TxDOT Right of Way (ROW) Division, TxDOT ROW district, and project associates. This tool helps in planning activities and keeps participants updated on the process. It also offers a method and format for recording data. North Carolina DOT is collecting similar data.

How can you learn more?

Both the standalone UCM and the data model and database are available at http://www.trb.org/main/blurbs/166731.aspx along with companion documentation that describes their structure and usability. For more information, contact Amanda Rutherford at FHWA, arutherford@dot.gov, or Greta Smith at AASHTO, gsmith@aashto.org.

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Putting Project Coordination between Transportation Agencies and Railroads on a Fast(er) Track

Tools to better guide projects involving railroads and their rights-of-way

Each year construction of hundreds of public agency highway projects cross over, under, or parallel railroad rights-of-way, requiring extended coordination between these organizations. Although most go smoothly, delays in development or construction do occur. Railroads must carefully evaluate public transportation agency projects in terms of safety, engineering, and operational impacts both during construction and for decades later. For the public agencies, delays while waiting on railroad reviews and agreements can increase project costs and extend renewal needs for users.

Strategies for Improving the Project Agreement Process Between Public Agencies and Railroads

The Solution

The collection of model agreements, sample contracts, training materials, and standardized best practices developed through the second Strategic Highway Research Program (SHRP2) will allow public agencies and railroads to identify and circumvent sources of conflict. The tools reflect research that takes into account both the railroad and public agency perspectives, processes, budgets and funding, and acknowledged best practices.

The report, Strategies for Improving the Project Agreement Process Between Highway Agencies and Railroads, outlines recommended practices and offers eight different model documents to expedite negotiations. They include:

► Partnering Memorandum of Understanding – a nonbinding agreement that can drive development of shared understandings, vocabulary, and definition of success, as well as expected performance.

► Master Project Agreement – a legally binding agreement with “boilerplate” provisions that both parties can incorporate by reference into all following agreements. It also lays out funding responsibilities in partnering, particularly how the public agency will compensate the railroad for required reviews and related activities, a common source of conflict.
Preliminary Engineering Agreement – brief project details can be inserted into this standard preliminary engineering (PE) agreement to quickly authorize engineering reviews by the railroad, and expedite PE for the public agency.

Resurfacing Agreements – two model agreements, one for federally funded projects and one for state-funded projects, that reflect the common needs of public agencies and railroads when resurfacing highway sections at railroad crossings, including railroad-specific issues and solutions to deliver the necessary smooth transitions to the adjacent pavement sections.

Highway Overpass Agreement – a standard agreement with provisions that reflect safety and operational requirements critical to this type of project.

Warning Devices Agreement – a standard agreement specific to projects involving installation, maintenance, improvements, and replacement of warning devices such as gates and lights.

Pipe and Wire Agreement – a type of agreement required for installation, construction, or maintenance of drainage pipes, pipelines, utility lines, and other linear structures that intersect a railway. The frequency of pipe and wire projects has led to standardized agreements and approaches to construction and maintenance.

Training materials for both the recommended practices and the model agreements/sample contracts are in development.

The Benefits

With railroad volumes projected to continue to grow, pressures for more project coordination activity will continue to increase. Cementing mutual understanding and streamlining the process involved will save money and time for both railroads and public agencies. In turn, road users will see the positive results of more rapid highway renewal on facilities and budget. The model agreements also lay out standardized construction and operational needs—enhancing safety for workers and reducing delays for users.

Who will benefit?

State and local public agencies, Contractors, Railroads, Designers, Project Managers, Taxpayers

How can you learn more?

The full report and model agreements are available online and from the TRB Bookstore at www.trb.org/Publications/Blurbs/164283.aspx, including:

Strategies for Improving the Project Agreement Process Between Highway Agencies and Railroads (SHRP 2 Report, Issue S2-R16-RR-1)

For more information, contact Joe Taylor at FHWA, joseph.taylor@dot.gov, or Greta Smith at AASHTO, gsmith@aashto.org.

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