U.S. Department of Transportation
Federal Highway Administration

**Federal Highway Administration (FHWA) Research and Technology Agenda**

# Meeting the Challenge: Infrastructure

The United States has one of the most extensive transportation systems in the world, representing trillions of dollars of public and private investment. To fulfill its role as the guardian of this critical highway infrastructure, FHWA is engaged in forward-looking research that supports safety and environmental sustainability while modernizing bridges and roads through better materials, new construction techniques, and consistent quality control. This research increases the highway system's productivity and performance, reduces operational and replacement costs, and ensures a world-class highway system long into the future.

The strength of the infrastructure in the United States depends on quality materials, sound construction techniques, and reliable maintenance practices. Infrastructure research explores emerging technologies that will improve the safety and reliability, structural integrity, and longevity of the Nation's bridges and roadways. A strong infrastructure must also be sustainable and environmentally sound. New pavement materials will have fewer impacts on air quality and ambient noise levels.

Consistent quality assurance methods developed through FHWA research are enhancing design, materials testing, construction, and inspection procedures for roads and bridges. These methods improve how programs are delivered.

**Objective: 1: Improve the security of highway infrastructure and reduce the number of fatalities attributable to infrastructure design characteristics and work zones.**

**Strategies**

- Develop and deploy hazard mitigation, adaptation, and restoration strategies and techniques.
- Develop and deploy methodologies and guidance for assessing safety of infrastructure after a hazard event.
- Develop and deploy best practices and opportunities to improve infrastructure safety performance.
- Develop and deploy technologies, standards, and test methods that optimize surface characteristics with regard to friction, texture, and splash and spray.
- Develop and deploy technical guidance to support infrastructure safety management programs.
- Develop and deploy construction administration practices that enhance safe operation of the highway system by reducing work zone exposure.

**Showcase Activities**

- Enhancing Hazard Mitigation and Adaptation Countermeasures
- Developing Rapid Post-Hazard Assessment Protocols and Techniques
- Pavement Friction Thresholds

## Enhancing Hazard Mitigation and Adaptation Countermeasures

Enhancing Scour Analysis Capabilities and Countermeasures for Inland and Coastal Bridges is among the projects FHWA is pursuing as part of its hazard mitigation and adaptation countermeasures initiative. Scour is the most common cause of bridge failure in the United States. Around bridge abutments or piers, water erosion can lead to scour, which undermines bridge integrity and could lead to instability and eventual bridge failure. FHWA continues to conduct research to better assess why, how, and when scour occurs around inland and coastal bridges. These research studies examine the use of field devices to determine soil erodibility around bridge foundations and the effects of different water pressures on bridge scour. The research will enhance current methodologies and technologies for predicting, evaluating, and mitigating bridge scour in different environments that, when applied, will improve the safety and stability of bridge infrastructure.

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### Additional Resources

- Materials Performance for Attack Countermeasures / Multihazard Mitigation Support on Bridges

### Developing Rapid Post-Hazard Assessment Protocols and Techniques

Developing guidelines to assess flooded pavements is among the activities FHWA is pursuing to advance rapid post-hazard assessment of infrastructure. Floods can cause significant damage to roadways. After floods occur, highway agencies need to assess the extent of damage quickly and make necessary repairs to ensure roadway safety and keep traffic moving. FHWA will conduct research on the effects of moisture on pavement performance. The Agency will work with the European Commission to identify pavement assessment technologies and techniques deployed in Europe that have potential for implementation in the United States. As a result of this research, FHWA will develop guidelines that highway agencies can use to assess the impacts of floods on pavements and how quickly damaged roads can be repaired.

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### Additional Resources

- Flooded Pavement Assessment Methods

### Pavement Friction Thresholds

Pavement friction is an important factor in pavement safety. FHWA initiatives to improve pavement safety include research to identify threshold values for pavement friction and demonstrate how those threshold values could be applied in a highway agency pavement friction management program. Ultimately, this research will enable highway agencies to more optimally allocate resources to improve pavement safety, resulting in safer highways.

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## Objective: 2: Improve the management of infrastructure assets and advance the implementation of a performance-based program for the National Highway System.

**Strategies**

- Develop and deploy reliable performance prediction models and practices in the design, construction, and management of the highway infrastructure.
- Develop and deploy sound measures and practices to assess infrastructure condition and assure data quality in infrastructure management and performance predictions.

**Showcase Activities**

- Understanding Infrastructure Performance
- Improving Infrastructure Condition Monitoring and Data Management
- Quantifying Pavement Albedo
- Application and Validation of Remaining Service Interval Framework to Pavements Using State Highway Agency Pavement Management Data

### Understanding Infrastructure Performance

FHWA's Long-Term Pavement Performance (LTPP) and Long-Term Bridge Performance (LTBP) programs are critical to advancing the understanding of infrastructure performance. The LTPP program was initiated in 1987 as part of the original Strategic Highway Research Program, and has been managed by FHWA since 1992. The program's mission is to explain how and why pavements perform as they do. Since data collection was initiated in 1989, the LTPP program has accumulated data documenting the structure, materials, service conditions, and performance of 2,509 inservice pavement test sections throughout the United States and Canada. As of 2014, performance monitoring of 745 test sections is ongoing. The LTPP data, as well as supporting and derivative information, are housed in the LTPP Information Management System (IMS), and disseminated to the public via the LTPP InfoPave Web portal. Building on the success of LTPP, FHWA sought and received authorization via the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Extension Acts to initiate the LTBP program. The LTBP program is intended to provide quality scientific data, knowledge, and tools to improve

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program is intended to provide quality scientific data, knowledge, and tools to improve maintenance and preservation practices for the more than 600,000 bridges in the United States and new bridge design and construction standards that will provide a longer life for bridges in the future. The LTBP program initiated its data collection efforts with a focus on bridge decks (the bridge component on which States currently spend the majority of their maintenance and rehabilitation funds) and is intended to expand to all other major bridge components in the future.

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**Additional Resources**

- Long-Term Pavement Performance Program Web Site
- Long-Term Bridge Performance Program Project

## Improving Infrastructure Condition Monitoring and Data Management

Timely and accurate condition data are essential to effective infrastructure management. FHWA is exploring a variety of ways to improve the monitoring of infrastructure conditions and management of the collected data. Overall, this research will support more effective transportation agency planning for pavement maintenance, repair, and rehabilitation that leads to increased public safety, reduced user delays and costs, improved ride quality, and long-lasting pavements.

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**Additional Resources**

- Low-Powered Wired Sensors for Asset Management or Health Monitoring of Structure and Pavements
- Remote, Ultra-Low Power Wireless Sensing System for Multimetric Self-Powered Monitoring of Bridge Components
- Demonstration of Network Level Pavement Structural Evaluation with Traffic Speed Deflectometer
- High-Speed Deflection Measurements for Use in State Highway Agency Pavement Management and National Performance Management

## Quantifying Pavement Albedo

Pavement surface albedo is an important factor influencing urban heat island effect as well as temperature-related changes in pavement response and material characteristics. However, currently available information is inadequate to support its proper use and consideration. To address this gap, FHWA has undertaken research to provide objective and well-founded information concerning the effect of pavement albedo on urban heat island effect, as well as pavement design and how it changes with time for all pavement types.

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**Additional Resources**

- Quantifying Pavement Albedo Project

### Application and Validation of Remaining Service Interval Framework to Pavements Using State Highway Agency Pavement Management Data

Because pavement deterioration is a complex phenomenon that is manifested in a variety of ways, it is challenging to identify a single, easily understood measure of condition that supports an overall assessment of network condition and comparisons among different pavements. Although the Remaining Service Life (RSL) concept has long been used for this purpose, there is no single, clear, and widely accepted definition of RSL. Moreover, there is a great deal of uncertainty associated with the definition, especially with the use of the term "life" to represent different points in a pavement's construction history. In addition, when communicated, the meaning of "life" is lost and it is interpreted differently by stakeholders. To overcome these deficiencies in the RSL terminology, a recently completed FHWA research project recommended adoption of a new terminology of time remaining until a defined construction treatment is required--RSL is replaced by "Remaining Service Interval," or "RSI." Ongoing research will critically evaluate the RSI concept by applying it with pavement management system data from two or more States and the Highway Performance Monitoring System (HPMS) 2010+ data. Through these two real-world applications, this research will also develop and refine the associated RSI analyses methodologies.

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**Additional Resources**

- Application and Validation of Remaining Service Interval Framework Project Information

**Objective: 3: Improve the ability of transportation agencies to deliver projects that meet expectations for timeliness, quality, and cost.**

**Strategies**

- Develop and deploy expanded and consistent use of the elements of a quality assurance program to improve infrastructure design, materials testing, construction, and inspection procedures.

**Showcase Activities**

- Providing Guidance and Tools to Improve the Core Elements of State Quality Assurance (QA) Programs

### Providing Guidance and Tools to Improve the Core Elements of State Quality Assurance (QA) Programs

Transportation agencies must use quality assurance standards to control, monitor, and assess the construction quality of bridges, pavements, and other highway infrastructure. FHWA is developing best practices and standards to strengthen and improve core areas of agencies' quality assurance programs, such as independent assurance, dispute resolution, data validation, and acceptance procedures. Research initiatives supported by FHWA also investigate the state of the practice to identify effective strategies and tools that provide quality assurance in program delivery. FHWA shares the results of these research efforts with transportation agencies by providing training and technical assistance opportunities and by producing guidance and additional resources. As a result, transportation agencies can deliver programs more effectively and consistently to ensure high quality, safe, and reliable infrastructure construction.

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**Additional Resources**

- Guidance and Tools to Improve the Core Elements of State Quality Assurance Programs
- Analysis of Construction Quality Assurance Procedures on Federally Funded Local Public Agency Projects
- Traffic Signal System Management

**Objective: 4: Reduce user delay attributable to infrastructure system performance, maintenance, rehabilitation, and construction.**

**Strategies**

- Develop and deploy construction, inspection, maintenance, preservation, and rehabilitation practices that minimize impact to users.

**Showcase Activities**

- Accelerating Infrastructure Construction and Preservation

### Accelerating Infrastructure Construction and Preservation

FHWA has a number of projects underway to accelerate infrastructure construction and preservation. Improving Connection of Precast Concrete Bridge Deck Elements to Steel Bridge Superstructures is one such project that includes use of precast concrete bridge deck elements with steel beam superstructures to accelerate bridge construction. To achieve composite action, pockets must be formed in the deck elements to allow shear connectors to be welded and grouted onto the beam top flanges. Fit-up issues often develop in the field due to mismatched connectors and pockets in the deck elements. Limiting the longitudinal spacing of connectors to the current American Association of State Highway and Transportation Officials' design limit of 24 inches increases the number of formed pockets in the deck elements, and the likelihood of misalignment and fit-up issues. To address this, FHWA is conducting research to investigate the static and fatigue behavior of clustered shear connectors at extended spacings of 36 and 48 inches. The results of the research will assist engineers and other transportation decision makers to utilize precast elements more effectively and efficiently, leading to improved bridge safety, integrity, and performance, as well as reduced construction delays.

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### Additional Resources

- Quantification of Cost, Benefits, and Risk Associated With Different Quality and Project Delivery Systems
- Accelerated Bridge Construction Web Site

**Objective: 5: Improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations.**

**Strategies**

- Develop and deploy approaches to effectively and systematically preserve and improve highway infrastructure condition and performance.
- Develop and deploy design and preconstruction technologies and innovations to improve infrastructure condition, durability, service life, and constructability.
- Develop and deploy methods that will improve the quality of materials and systems used for highway infrastructure.
- Develop and deploy alternative project delivery methods, construction approaches, and specifications where the emphasis is on the long-term performance of the infrastructure system.

**Showcase Activities**

- Evaluating Innovative Materials and Systems to Improve Infrastructure Durability and Longevity
- Development of Reliable Analysis Methodology and Tools for Evaluating Pavement Performance Under Movement of Superloads

### Evaluating Innovative Materials and Systems to Improve Infrastructure Durability and Longevity

Geosynthetic reinforced soil (GRS) composite structures are among the innovative materials and systems FHWA is pursuing in support of infrastructure innovation. Geosynthetic reinforced soil is soil that has been strengthened with the addition of synthetic materials such as geotextile fabric sheets. The solution is used to create Integrated Bridge Systems, where the reinforced soil replaces conventional bridge abutments. Bridges built with this technology are durable, cost-effective, and exceed American Association of State Highway and Transportation Officials' bridge-design loading requirements. FHWA is researching the performance of geosynthetic reinforced soil by applying different loads to blocks of geosynthetic reinforced soil. The resulting deformations are evaluated to better understand the performance of geosynthetic reinforced soil composites. Through this research, FHWA will build a database of geosynthetic reinforced soil material properties, assess how different loading conditions affect the soil, and validate methodologies to assess the stability of the soil. This research will assist engineers, designers, and other transportation stakeholders in understanding the conditions in which geosynthetic reinforced soil performs best.

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| | Email: jennifer.hicks@dot.gov<br><br>**Additional Resources**<br><br>• Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS)<br>• Ultra-High Performance Concrete |
| **Development of Reliable Analysis Methodology and Tools for Evaluating Pavement Performance Under Movement of Superloads**<br><br>Traditional pavement analysis methods are intended for repeated loading and accumulated fatigue damage based primarily on strain response. However, permit requests for one-time movement of superloads require strength analysis that considers the risk of instantaneous failure. FHWA is pursuing research to develop analysis methods and tools to conduct factor of safety analysis based on load demand and strength of the pavement and subsurface materials. | **Activity Contact**<br><br>**Nadarajah (Siva) Sivaneswaran**<br>FHWA Office of Infrastructure Research and Development<br>Tel: 202-493-3147<br>Email: nadarajah.sivaneswaran@dot.gov<br><br>**Additional Resources**<br><br>• Develop Reliable Analysis Methodology and Tools for Evaluating Pavement Performance Under Movement of Superloads |
| **Objective: 6: Reduce the life-cycle environmental impacts of highway infrastructure (design, construction, operation, and maintenance).** | |
| **Strategies**<br><br>• Advance and increase the use of renewable, reusable, and recycled materials in highway-related infrastructure. | **Showcase Activities**<br><br>• Advancing the Use of Renewable, Reusable, and Recycled Materials to Achieve Durable Highway Infrastructure |
| **Advancing the Use of Renewable, Reusable, and Recycled Materials to Achieve Durable Highway Infrastructure**<br><br>Optimizing the Use of Recycled Asphalt in Pavement Infrastructure is one of many FHWA projects advancing the use of renewable, reuseable, and recycled materials. The costs of construction materials are rising, as is public concern for the environmental impacts of transportation construction. It is becoming increasingly important to identify and utilize cost-effective and sustainable roadway construction materials, such as recycled asphalt pavements. Incorporating recycled asphalt into pavement mixtures, and producing the material at low temperatures, result in decreased asphalt consumption and improved air quality, although the performance of recycled asphalt pavements is not fully understood. FHWA is building and testing full-scale pavements that contain FHWA levels of recycled asphalt content to assess performance. This research also will help to identify optimal temperature conditions for production of recycled asphalt pavements and ideal ratios for recycled content in pavement mixtures. | **Activity Contact**<br><br>**Nelson Gibson**<br>FHWA Office of Infrastructure Research and Development<br>Tel: 202-493-3073<br>Email: nelson.gibson@dot.gov<br><br>**Additional Resources**<br><br>• Advance Use of Recycled Asphalt in Flexible Pavement Infrastructure: Develop and Deploy Framework for Proper Use and Evaluation of Recycled Asphalt i<br>• Asphalt Sustainability Issues: Evaluation of Long-Term |

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| | Performance of Recycled Additives, Including Recycled Motor Oil, Reclaimed Asphalt Pavements,<br>• Pavement Recycling |