ACCELERATED IMPLEMENTATION AND DEPLOYMENT OF PAVEMENT TECHNOLOGIES

2016–2017 ANNUAL REPORT

U.S. Department of Transportation
Federal Highway Administration

TURNING BEST PRACTICES INTO EVERYDAY PRACTICES

Today's highway users expect to travel on roads that are safe and smooth and cause the least possible delay. And they expect a high-quality traveling experience at the lowest possible cost.

One way the Federal Highway Administration (FHWA) is meeting the needs of the traveling public is through the Accelerated Implementation and Deployment of Pavement Technologies program. At its core, the program advances the latest and best practices and technologies for constructing and maintaining high-quality, long-lasting pavements.

As we reflect on our progress this year, we want to highlight various technology transfer and outreach efforts, which are central to the program. These activities deliver critical insights, experience, and practices to the pavement community through meaningful and cost-effective strategies, ranging from site reviews, demonstrations, and webinars to development of guidance documents.

This year a number of technologies are being implemented in new program areas, including performance-engineered asphalt mixtures, recycled concrete aggregates, thin asphalt overlays, and concrete overlays. And the program is having significant impacts on highway practices. For example:

- As a result of a demonstration project on density, seven of the ten participating States are revising their specifications to help improve asphalt pavement performance.
- Forty-four State highway agencies now allow use of recycled concrete aggregate for applications ranging from granular base and embankment fill to coarse aggregate.
- Thin asphalt overlays have been shown to be effective in preserving asphalt pavement structures while offering cost savings of up to 30 percent over traditional mixes.
- The use of concrete overlays continues to grow as a rehabilitation treatment for existing concrete and asphalt pavements, with more than 4 million square yards placed in 2016.

By partnering with highway agencies, industry, academia, the consulting community, and others, we're enabling stakeholders to manage the Nation's pavement assets more effectively, improve the condition of the roadway network, and make effective use of recycled materials and industrial byproducts in pavements.

I'm honored to share these highlights from our ongoing activities, and I look forward to further successes as together we continue to develop and deploy innovation on the Nation's roadways.

Sincerely,

Thomas D. Everett

Thomas D. Everett
FHWA Associate Administrator for Infrastructure

About the Program

Congress established the Accelerated Implementation and Deployment of Pavement Technologies (AID-PT) program in 2012 under the Moving Ahead for Progress in the 21st Century Act (MAP-21). The program's purpose is to document, demonstrate, and deploy innovative pavement technologies—including their applications, performance, and benefits.

In 2015, Congress continued the program in the Fixing America's Surface Transportation (FAST) Act, with funding available through fiscal year 2020. Through strategic partnerships with highway agencies and others across the paving community, FHWA is leveraging Federal investments to maximize the impact of the program, effectively amplifying the benefits to the traveling public.

The AID-PT program focuses on promoting, implementing, and deploying proven technologies and demonstrated practices. Specifically, the program encourages highway agencies to adopt and implement new technologies that have been shown to save money, enhance safety, improve performance, increase efficiency, and reduce delay.

This annual report documents FHWA's approach to achieve the six overarching goals Congress set for the program (see page 3).

The FAST Act Section 6003 calls for "a report on the cost and benefits from deployment of new technology and innovations that substantially and directly resulted from the program." The report may include the analysis of Federal, State, and local cost savings; improvements in project delivery time; reduced fatalities; and minimized impacts of congestion.

Due to the broad scope of the Federal-aid program and wide spectrum of Federal, State, and local stakeholders involved, it is difficult to quantify the overarching impact of the program and the costs and benefits directly attributable to it. Therefore, this report highlights case studies that discuss the anticipated long-term improvements in cost savings, project delivery time, congestion relief, enhanced safety, and pavement performance due to the program.

"The funding and workshop provided by FHWA were instrumental in WisDOT prioritizing an enhanced density demonstration project."

— Barry Paye,
Wisconsin Department of Transportation

The case studies in the following pages offer a snapshot of the exciting work that FHWA and its partners are doing to accelerate implementation and deployment of cutting-edge pavement technologies and practices.

Specifically, FHWA is engaged in a variety of efforts to improve paving materials and deliver guidance to help highway agencies design and construct both asphalt and concrete pavements more effectively. Examples of ongoing initiatives include the following:

- Encouraging implementation of the *Mechanistic-Empirical Pavement Design Guide*. Fourteen highway agencies have implemented the procedure for asphalt pavements, while another 31 plan to implement. For concrete pavements, 13 agencies have implemented and another 32 plan to do so.

- Increasing the use and application of recycled concrete aggregate and ground tire rubber in new and reconstructed pavements. These practices not only save on costs but also support an overarching focus on sustainability and reduce the impact of pavements on the environment.
- Improving construction processes for asphalt pavements, particularly in the use of more effective compaction practices that lead to longer lasting pavements at little to no additional cost.
- Advancing and promoting more performance-based approaches in the design of both asphalt and concrete pavement mixtures that focus on extended performance and long-term durability.
- Training highway agencies on the technological advancements associated with the *Mechanistic-Empirical Pavement Design Guide*, leading to tangible cost savings.

The AID-PT program is an outstanding example of FHWA operating under a shared vision with its teaming partners to implement and deploy critically needed products and technologies. With strong stakeholder support, the program is providing benefits ranging from shorter project delivery times and less congestion to cost savings and fewer roadway fatalities.

Source: National Asphalt Pavement Association.

"With the help of FHWA's pavement technology deployment programs, the Illinois Tollway now requires performance engineered mix designs and performance-related construction specifications for all newly constructed concrete pavements. These pavements are now being built with more sustainable concrete mixes with optimized gradations and with more supplementary cementitious materials to provide better durability or longer life."

— Steve Gillen, Illinois State Toll Highway Authority

Summary of How Recent FHWA Deployment Efforts Support the Goals of the AID-PT Program

AID-PT Goals [Title 23, United States Code, Section 503(c)(3)]	Selected FHWA Deployment Efforts									
	Sustainability	Mechanistic-Empirical Pavement Design	Ground Tire Rubber	Performance Engineered Concrete Mixes	Enhanced Density	Asphalt Binder Performance	Asphalt Overlays	Concrete Overlays	Performance-Based Mix Design	Recycled Concrete Aggregate
1. The deployment of new, cost-effective designs, materials, recycled materials, and practices to extend the pavement life and performance and to improve user satisfaction.	●	●	●	●	●	●	●	●	●	●
2. The reduction of initial costs and life-cycle costs of pavements, including the costs of new construction, replacement, maintenance, and rehabilitation.	●	●	●	●	●	●	●	●	●	●
3. The deployment of accelerated construction techniques to increase safety and reduce construction time and traffic disruption and congestion.					●			●		●
4. The deployment of engineering design criteria and specifications for new and efficient practices, products, and materials for use in highway pavements.	●	●	●	●	●	●	●	●	●	●
5. The deployment of new nondestructive and real-time pavement evaluation technologies and construction techniques.					●					
6. Effective technology transfer and information dissemination to accelerate implementation of new technologies and to improve life, performance, cost-effectiveness, safety, and user satisfaction.	●	●	●	●	●	●	●	●	●	●
See Page	4	7	10	13	16	19	22	25	27	30

Warm-mix asphalt, which was used when paving this stretch of scenic roadway in Yellowstone National Park, is an innovation that improves the sustainability of pavements by requiring about 20 percent less energy to produce. Source: FHWA.

Towards Sustainable Pavements

FHWA is supporting highway agencies as they work to meet environmental, social, and economic needs with their pavement structures.

How do paving materials affect the sustainability of a roadway? How can highway agencies adopt more sustainable designs and construction practices? What does sustainability mean within the highway and pavement environment? These are some of the questions that FHWA's Sustainable Pavements Program is on its way to answering.

The program defines a "sustainable" pavement as one that:

1. Achieves the engineering goals for which it was constructed.
2. Preserves and, ideally, restores surrounding ecosystems.
3. Uses financial, human, and environmental resources economically.
4. Meets basic human needs, such as health, safety, equity, employment, comfort, and happiness.

Further, sustainable pavements are context sensitive. That means they're designed to fit the location and climate, use locally available materials when possible, and meet the agency's design and performance goals.

With the help of a technical working group, FHWA's Sustainable Pavements Program is putting knowledge into action. Here's a look at some of the program's major activities.

FHWA Sustainable Pavements Program

Vision and Mission Statement

To advance the knowledge and practice of designing, constructing, and maintaining more sustainable pavements through:

- Stakeholder engagement.
- Education.
- Development of guidance and tools.

Engaging the Stakeholders

At the heart of the program is the Sustainable Pavements Technical Working Group. With 20 members representing Federal, State, and local transportation agencies, as well as industry and academia partners, and more than 300 "friends," the working group provides overall guidance for the program and helps raise awareness of sustainability issues among pavement professionals.

The group meets twice a year to share information through technical presentations, reviews of technical documents, and breakout and roundtable discussions. Recent meetings have covered topics including life-cycle assessment, product category rules (PCRs), environmental product declarations (EPDs), and pavement-vehicle interaction.

According to Leif Wathne, executive vice president of the American Concrete Pavement Association and a member of the working group, "the Sustainable Pavements Program has been exceedingly fruitful in bringing together stakeholders and engaging in meaningful dialogue on all issues related to pavement sustainability."

Defining the Playing Field

To provide best practices and hands-on guidance, FHWA has produced a variety of reference materials and training opportunities:

- A comprehensive reference document on sustainable pavement systems.
- A framework document on the use of life-cycle assessment (LCA) for pavement systems.
- A series of 25 technical articles.
- A compilation of technical resources.
- Five technical briefs on pavement sustainability topics.
- A series of webinars focusing on all stages of the pavement life cycle.

The program's hallmark deliverable is *Towards Sustainable Pavement Systems: A Reference Document* (FHWA-HIF-15-002). The document provides an overview of key concepts and advice on how to make paving practices more sustainable, such as:

- Consider the entire life cycle, from mining the materials and trucking them to the site through the design, construction, use phases, and end of the pavement's life.
- Recognize that there is no "one size fits all" approach to pavement sustainability.
- Embrace tradeoffs between economic, environmental, and societal factors.
- Aspire to improve sustainability from project to project over the long term.

The program also developed a framework for assessing the life-cycle environmental impacts of pavement systems. The *Pavement Life Cycle Assessment Framework* (FHWA-HIF-16-014) is an important first step in the implementation and adoption of LCA principles within the pavement community. This document is being used to help guide highway agencies and the transportation industry in developing LCA tools, PCRs, and EPDs.

For example, Dr. Amlan Mukherjee, associate professor of civil and environmental engineering at Michigan Technological University, used the document in preparing a PCR and EPD for the asphalt pavement industry. "The LCA framework identifies all the interrelated components that are relevant to design, construction, and maintenance of pavements," Mukherjee says. "When conducting the LCA for asphalt mixtures, the framework was used to consider all factors relevant to asphalt pavements. This ensures that asphalt EPDs can integrate seamlessly with other pavement LCA components and, in the long run, allows them to be used by agencies for pavement design and construction decision-making purposes."

A Road Map for the Future

FHWA recently developed a strategic *Sustainable Pavements Program Road Map* (FHWA-HIF-17-029) that provides a focused direction for the next 5 years. The road map highlights topics and deliverables that can have a meaningful effect on advancing sustainability considerations within the pavement community. The contents are organized into four broad goal areas, each of which includes processes and actions that advance the state of the practice toward sustainability.

Putting Knowledge Into Practice

Adopting more sustainable practices yields a variety of benefits, not just for the environment but also for agencies' bottom lines. For example, in the reconstruction of the Jane Addams Memorial Tollway (I–90), the Illinois Tollway documented the reuse of nearly 1.2 million tons of recycled materials, including aggregate and both asphalt and concrete pavements, from the project site. Similarly, the Illinois Department of Transportation documented the recycling of more than 2 million tons of materials during the 2015 construction season. Recycling and reusing materials reduces the demand for virgin materials and the related transport and energy costs.

Reusing materials also yields significant environmental benefits and cost savings at the national level. For example, it is estimated that during the 2015 construction season more than 74.2 million tons of reclaimed asphalt pavement and nearly 2 million tons of recycled asphalt shingles were put to use in new pavements in the United States, saving taxpayers more than $2.6 billion. Further, the American Road & Transportation Builders Association estimates that the use of fly ash—a byproduct of coal-burning power plants—in concrete paving mixtures saved $2.3 billion over a 5-year period.

The Sustainable Pavements Program will continue to support highway agencies as they incorporate sustainability considerations in their day-to-day operations. On the horizon, FHWA plans to produce additional guidance documents, create a simple LCA calculator, and develop case studies highlighting best practices for sustainable pavements.

For more information, visit www.fhwa.dot.gov/pavement/sustainability.

Goal Areas in FHWA's *Sustainable Pavements Program Road Map*

Source: FHWA/APTech.

Two-lift concrete paving, as shown here, uses a higher percentage of recycled or marginal aggregate in a thicker bottom layer, while reserving more durable material for the thinner surface layer, thereby improving the sustainability of the pavement without compromising performance. Source: APTech.

The Next Generation of Pavement Design Is Here Today

Highway agencies across the country are embracing a state-of-the-art design method that promises improved pavements for lower costs.

In the world of pavement design, a revolution is underway. For decades, pavements were designed based on empirical relationships reflective of limited conditions. Today, the ability to account for unique site conditions and material variations to obtain durable, long-lasting pavements has improved dramatically, thanks to one groundbreaking publication: the *Mechanistic-Empirical Pavement Design Guide* (MEPDG *Guide*).

Attendees listen to a technical presentation on mechanistic-empirical design at the National AASHTO Users Group meeting in Indianapolis, IN, held in December 2016. Source: APTech.

Developed under a National Cooperative Highway Research Program project and subsequently adopted by the American Association of State Highway and Transportation Officials (AASHTO), the *Guide* and its associated software, AASHTOWare Pavement ME Design, represent a quantum leap forward from the design procedures of the past. The software enables engineers to incorporate a variety of inputs—from materials to climate data to traffic loading—and predict in great detail how the resulting pavement will perform over time.

Although it represents a dramatic departure from its predecessors, the MEPDG procedure and the software's analytical capabilities already have won over many in the pavement design community. To assist highway agencies and their industry partners in making the transition from empirical methods to those in the *Guide*, FHWA provides training and workshops on the fundamentals and theory behind mechanistic-empirical (ME) design, offers practical guidance on implementation, and is facilitating productive interactions among users.

Indiana Sets the Pace

The Indiana Department of Transportation (INDOT) was one of the earliest adopters of the MEPDG and has realized significant benefits from its position at the forefront of implementation. One of the most significant benefits is the cost savings. INDOT developed dual designs using both its traditional approach, based on AASHTO's 1993 *Guide for Design of Pavement Structures*, and the MEPDG procedure. The comparison revealed that the MEPDG procedure reduced pavement thickness between 0.5 and 1.5 inches, resulting in lower construction costs.

Even more important is the MEPDG's ability to predict how a pavement will perform and avoid premature distresses. For example, in looking at failure modes for its designs, INDOT engineers can predict maintenance costs and work to minimize them by addressing the predicted distresses.

"The mechanistic-empirical design approach has been very effective for us because we now know how the pavement is going to perform," says Tommy Nantung, research manager for pavement, materials, and construction at INDOT. "We can target specific distresses and design, so they are kept to a minimum percentage."

Plus, he says, INDOT's design engineers now have a greater understanding of how pavements perform, so they can better calculate the costs of ownership and make data-driven decisions.

Paving the Way Forward

To provide a forum for sharing information, FHWA hosted five regional peer exchanges from 2013 to 2015. These meetings drew participants from 32 State highway agencies, two Canadian provincial highway agencies, six universities, the concrete and asphalt pavement industries, and consultants.

The States shared their experiences on a wide range of topics, including key design inputs, recommended threshold and hierarchical levels, ongoing calibration efforts, and implementation challenges. Each meeting ended with a discussion of key takeaways and lessons learned, which are summarized in the *FHWA AASHTO MEPDG Regional Peer Exchange Meetings: Final Technical Report* (FHWA-HIF-15-021).

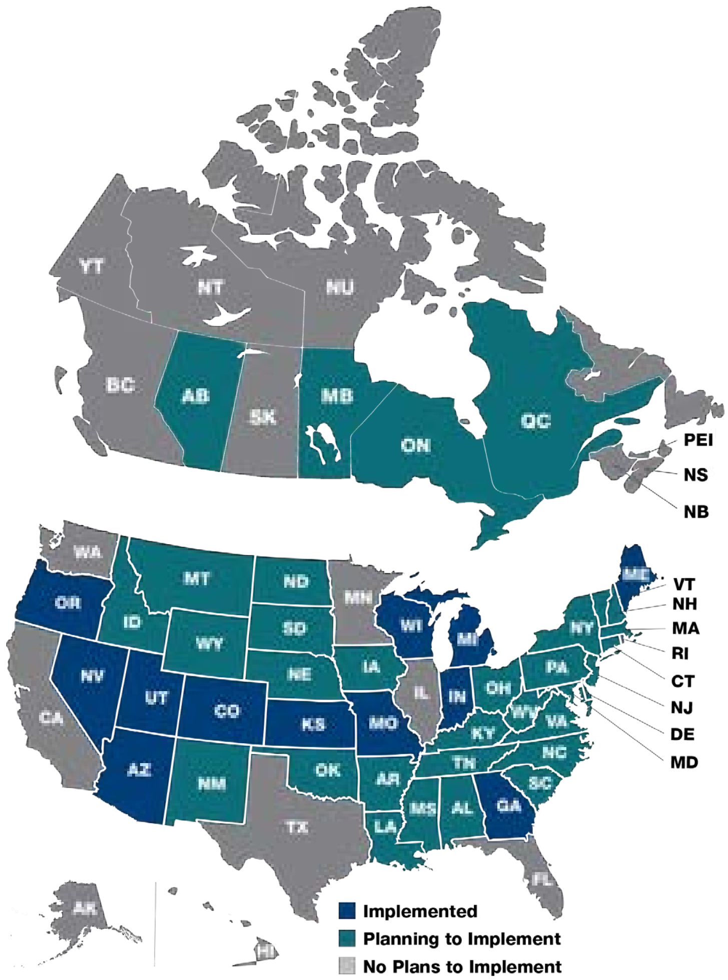
As a follow-up to the successful peer exchanges, FHWA assembled the National AASHTO Users Group to provide a forum for information exchange and facilitate a rapid adoption of the MEPDG and AASHTOWare Pavement ME Design software. The first meeting was held in Indianapolis, IN, over 2 days in December 2016, with 68 participants representing 30 States and four Canadian provinces. The meeting included updates on enhancements to the Pavement ME design procedure and software, demonstration-based training on the latest version of the software, presentations from several agencies on their implementation activities, and discussions on a variety of issues related to both the procedure and software.

ASPHALT

Summary of MEPDG Implementation Status for Asphalt Pavements and Overlays (2017)

IMPLEMENTED: 14
PLANNING TO IMPLEMENT: 31

Source: FHWA.



"A national forum for users of the Pavement ME Design software was several years overdue," says John Donahue, construction and materials liaison engineer with the Missouri Department of Transportation and a member of the National

AASHTO Users Group. "Pavement engineers from various States and Canadian provinces finally had the opportunity to listen to each other's stories about local calibration and implementation, and learn from the AASHTOWare product task force where the software development was headed."

One key takeaway from the meeting is the challenge associated with performing local calibration and validation, Donahue says. "Conditions for transitioning from calibration and verification to full implementation can never be absolutely ideal, and it's better to begin the journey sooner than later." Improved communication about upcoming changes to the software and development of an automated calibration tool were seen as beneficial ways of addressing the local calibration issue.

The next meeting of the National AASHTO Users Group is tentatively planned for fall 2017. The meeting will have a similar format, with continued emphasis on progress and experiences in agency implementation, software updates, and training. A greater emphasis on ME design activities, such as back calculation, local calibration, and distress modeling, also is expected.

"These types of outreach activities are instrumental in facilitating a more rapid adoption of the MEPDG," says Christopher Wagner, P.E., Manager of FHWA's Pavement and Materials Technical Service Team, "as agencies take this giant step forward in evolving their design practices and producing more cost-effective pavements for the traveling public."

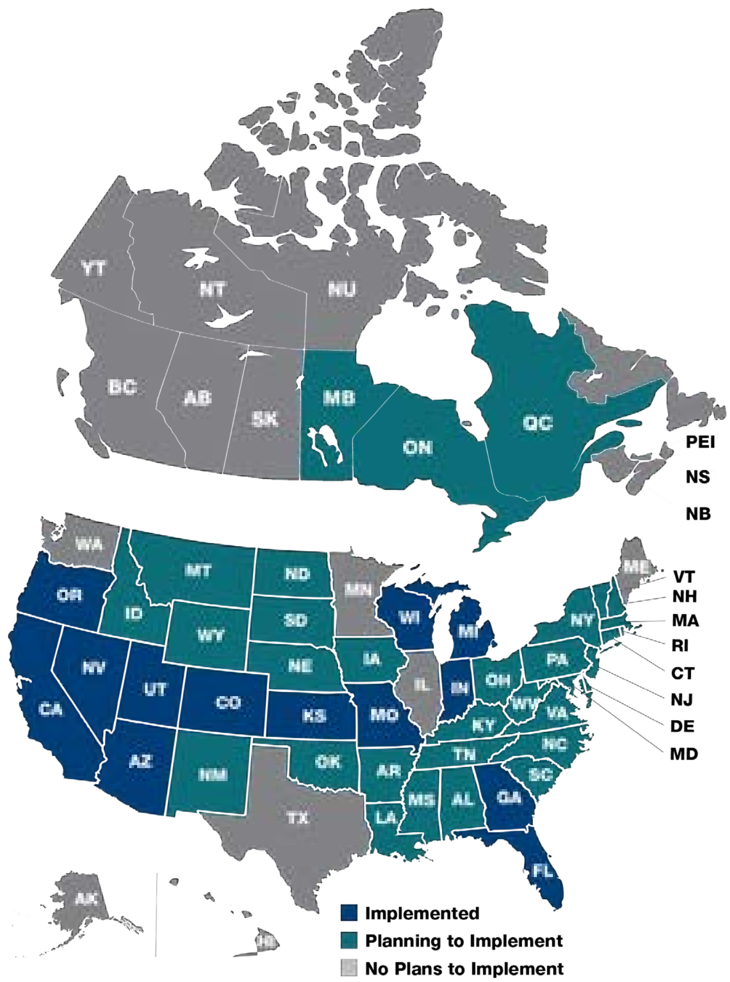
For more information, visit www.fhwa.dot.gov/pavement/dgit/index.cfm.

CONCRETE

Summary of MEPDG Implementation Status for Concrete Pavements and Overlays (2017)

IMPLEMENTED: 13
PLANNING TO IMPLEMENT: 32

Source: FHWA.



Waste tire piles like this one could dwindle as use of recycled rubber in pavement mixtures continues to grow in the United States. Source: © shutterstock.com, JCVStock.

Using Ground Tire Rubber in Asphalt Pavements

Agencies around the country are discovering the benefits of this resource-responsible paving solution.

This is a story about where the rubber meets the road. Literally. Every year the United States generates nearly 300 million scrap tires. Rather than consuming acres of landfill space, many highway agencies are repurposing old scrap tires by using ground tire rubber (GTR) as an asphalt modifier to the binder used in constructing asphalt pavements. The primary pavement applications have included chip seals, open-graded friction courses, stress-absorbing membrane interlayers (SAMIs), thin overlays, and structural overlays.

"The safe disposal of rubber tires is a major concern here in California," says Dr. Gary Hicks, former technical director of the California Pavement Preservation Center and an internationally recognized authority on asphalt rubber pavements. "Caltrans, CalRecycle, FHWA, industry organizations, and academia have all worked together to develop and promote environmentally friendly and cost-effective ways of incorporating GTR into hot-mix asphalt paving and hot-applied asphalt chip seal applications."

Using GTR in pavements not only can reduce the amount of solid waste sent to landfills but also can contribute to improved pavement performance.

> Highway agencies divert nearly **4.2 million scrap tires** away from landfills for paving projects every year.

Changing with the Times

Making scrap tires suitable for use in pavements requires processing to remove the steel and fiber, and then grinding the remaining rubber into small pieces. Highway agencies have been using rubber from discarded tires in asphalt pavements since the 1960s. But until recently, only a few States have used GTR routinely in their pavements.

According to a recent nationwide survey, more than half of the participating highway agencies reported allowing the use of GTR in their asphalt mixes. The primary reasons cited for incorporating GTR are improved performance (as compared to conventional mixes), overall cost-effectiveness, benefits to the environment, and recycling incentives.

Using GTR in pavement does present challenges related to mix design and processing. For example, there have been issues with compaction and raveling of mixes in cold climates. Also, highway agencies need to use slightly higher binder contents in the rubber-modified mixtures because of their open-graded aggregate structure typically required to accommodate GTR. These challenges can be overcome but underscore the need for engineering, performance testing, and quality control to ensure long-term performance.

Local, State, and Federal regulations have helped increase the availability of recycled tire rubber, driving a renewed interest in the material by the asphalt industry. FHWA continues to advance innovations with the goal of providing high-performing, long-lasting, cost-competitive, resource-responsible, and safe pavements.

What Are the Benefits?

In addition to diverting scrap tires from landfills, the use of rubber-modified asphalt offers other advantages, when properly engineered, designed, and constructed. The soon-to-be-released *Best Practices Guide for Rubber Modified Asphalt Technologies*, a publication being prepared collaboratively by FHWA and the National Asphalt Pavement Association (NAPA), cites the following potential benefits:

- Decreased temperature susceptibility of the asphalt binder.
- Improved resistance to reflective, thermal, and fatigue cracking.
- Improved rutting resistance.
- Reduced road maintenance.
- Improved driving safety during wet weather.
- Cost-effectiveness (when life-cycle cost analysis is used).

Ground tire rubber is delivered in 2,000-pound bags at this asphalt mixture production facility in Phoenix to produce field-blended, rubber-modified asphalt binder. Source: Mark Belshe, Rubber Pavements Association.

Expanding Usage Nationwide

Highway agencies in Arizona, California, Florida, and Texas are lead users of GTR technology and have incorporated it in their construction standards and specifications. In 2016, CalRecycle (the State's Department of Resources Recycling and Recovery) offered grants of up to $500,000 to local agencies for using asphalt rubber in qualifying pavement construction projects to reduce the number of landfill-bound tires in California. This program provides an example of one agency's approach to reducing tire disposal in landfills by incentivizing their reuse in other products and applications.

To increase the use of GTR for pavement applications, FHWA has played a key role in several ongoing implementation and deployment activities.

- Working with NAPA to develop the *Best Practices Guide for Rubber Modified Asphalt Technologies*.
- Producing a technical brief on *The Use of Recycled Tire Rubber to Modify Asphalt Binder and Mixtures* (FHWA-HIF-14-015).
- Cosponsoring, along with the Rubber Manufacturers Association, the 2016 Rubber Modified Asphalt Workshop in Ann Arbor, MI.
- Sponsoring the Binder Expert Task Group (ETG), which meets twice a year for technical presentations and discussions on construction and testing practices.
- Leading efforts in the Binder ETG to develop a testing draft standard for the concentric cylinder geometry for the dynamic shear rheometer for the American Association of State Highway and Transportation Officials.
- Using its Mobile Asphalt Testing Trailer for testing and evaluation activities—such as material characterization, replication of mix designs, and performance testing—at project sites involving rubber modified asphalt binder.
- Working with highway agencies and suppliers to implement best practices in design, production, and construction.

"FHWA remains an important partner to industry in fostering the greater use of GTR derived from scrap tires," says Mark Belshe, executive director of the Rubber Pavements Association. "While addressing a serious solid waste problem, pavements properly constructed with GTR have proven themselves with superior performance over and over in field applications. The highly anticipated best practices guide commissioned by FHWA in conjunction with NAPA will provide valuable information for expanding this market."

For more information, visit www.fhwa.dot.gov/pavement/pubs/hif14015.pdf.

Crews are placing an open-graded friction course overlay containing rubber-modified asphalt binder on a segment of plain jointed concrete pavement along Interstate 10 in Arizona. Source: Mark Belshe, Rubber Pavements Association.

A new materials specification is expected to improve the durability and longevity of the Nation's concrete pavements. Source: APTech.

Engineering Concrete Mixtures for Better Performance

With a renewed focus on long-term durability, FHWA and its industry partners have developed a new specification for concrete paving materials.

Today's concrete pavements take a beating from the ever-growing traffic loads on the Nation's roadways and extreme weather events, the coldest of which require heavy applications of deicers. Unlike earlier generations of sodium chloride deicers, today's products have a higher potential for deleterious effects on concrete pavements, particularly when used aggressively in both preventive and reactive applications. Together, these factors have created a set of severe exposure conditions that can affect a pavement's performance or even lead to premature failure, especially if the concrete's durability characteristics, such as its air void system or permeability, aren't up to par.

Although concrete pavements are inherently long-lasting and durable structures, their performance hinges on the use of effective mixtures designed for the prevailing traffic loads and environmental conditions. To ensure that tomorrow's concrete pavements stand up to modern demands, FHWA is working with highway agencies and industry partners to implement a new specification for concrete mixtures.

Building the Specification

A task group consisting of experts in concrete pavements and materials from highway agencies, industry, and academia are collaborating to develop the new specification. The expert group outlined a number of key factors for achieving good concrete mixture performance.

"At the heart of the specification is making sure that we are measuring the right things," says Peter Taylor, director of the National Concrete Pavement Technology Center. "We found that beyond concrete strength, most of the critical factors that we need for performance are durability related, and typically not captured in existing specifications."

The expert task group selected broad categories of properties for the basis of the new guidelines: strength, cracking tendency, workability, and durability. The specification needed to provide flexibility in implementation by including both prescriptive and performance options for highway agencies to choose from as they transition to a performance approach. The prescriptive approach provides specific guidance on target values and test methods for certain material properties, while the performance approach specifies target performance levels for each key material property identified. The specification also features a tiered approach, so highway agencies can impose tighter controls as the level of risk increases.

One of the highlights of the specification is the incorporation of new test methods and procedures developed in collaboration with partners from industry and academia. The tests under consideration include the Super Air Meter, the box test, the vibrating Kelly ball test, and formation factor.

Innovative tests represented in the new specification for concrete pavements.
Source: National Concrete Pavement Technology Center.

Pilot Testing

To help move the specification forward, FHWA identified nine highway agencies to serve as champions in pilot testing. The Indiana, Iowa, Michigan, Minnesota, Nebraska, South Dakota, and Wisconsin Departments of Transportation are participating, as well as the Illinois Tollway and the Manitoba highway agency in Canada. A number of these agencies received equipment to perform the new test methods proposed in the specification to see how field friendly they are. Initial testing also helped ensure the validity and reasonableness of some of the specification limits.

FHWA's Concrete Pavement Performance System will help highway agencies implement performance-engineered mixtures.

Establish FHWA CPPS Workgroup
- Offices of Asset Management, Pavements, and Construction
- Turner-Fairbank Highway Research Center
- Resource Center

Provide Guidance & Outreach on Performance-Engineered Mixture Testing
- Short video clips
- Technician training
- FHWA Mobile Concrete Trailer participation in shadow projects and pilot testing
- One-pagers/ deployment tools

Develop Concrete Pavement Quality Assurance Toolkit
- Plant approval
- Acceptance specifications
- Contractor quality control guidance

Conduct Workshops to Promote Use of Performance-Engineered Mixtures
- Implementation workshops for States and industry

Develop Other One-Pagers Related to Performance
- Lowering cement content
- Optimized gradation with spreadsheet tool
- Others based on input and feedback from stakeholders

Source: APTech.

Roadmap for Deployment

In November 2016, AASHTO approved the provisional specification and published it as AASHTO PP 84-17, *Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures*. A separate commentary document accompanies the specification to assist agencies in applying and implementing it.

FHWA will participate in a pooled-fund study for implementation activities and further research to promote the use of performance-engineered mixtures. One agency, the Illinois State Toll Highway Authority, already has embraced the specification and is working to implement it on all new paving projects.

Steve Gillen, deputy program manager of materials at the Illinois State Toll Highway Authority, credits FHWA's program based at the FHWA headquarters in Washington, DC, in collaboration with work being done at FHWA's Turner-Fairbank Highway Research Center in McLean, VA, for providing the support needed to adopt performance specifications.

"With the help of FHWA's pavement technology deployment programs, the Illinois Tollway now requires performance engineered mix designs and performance-related construction specifications for all newly constructed concrete pavements," Gillen says. "These pavements are now being built with more sustainable concrete mixes with optimized gradations and with more supplementary cementitious materials to provide better durability or longer life."

Gillen adds that in nearly a million square yards of new interstate concrete pavements built since 2015, bid prices for 13-inch jointed plain concrete pavement have dropped $15 to $20 per square yard when compared to several million square yards of similar pavement designs built under method specifications just 10 years ago.

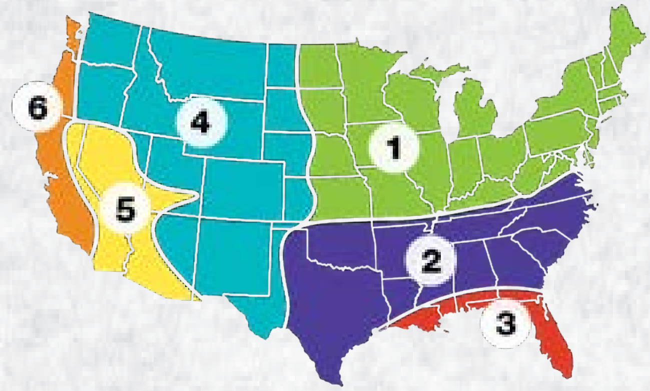
Implementing the provisional specification fits squarely within FHWA's new Concrete Pavement Performance System (CPPS), which is a coordinated effort to provide guidance and tools to help States and industry moved toward more performance-based quality assurance programs.

Through this range of support activities, highway agencies can work at their own pace to make the successful transition to a more performance-based approach for their concrete mix designs.

For more information, visit www.cproadmap.org/publications/MAPbriefJuly2017.pdf or www.cproadmap.org/publications/MAPbriefApril2017.pdf.

Concrete Pavement Exposed to 6 Regional Climates

Performance-engineered mixes can be customized to meet the varying demands of different climatic regions. Source: CP Tech Center.



1. **Warm to hot and humid summers with rain, and cold to very cold winters with snow**
2. **Hot, humid summers with rain, and mild to cool winters with occasional freezing rain and snow**
3. **Warm to hot and humid summers with rain and warm to cool winters**
4. **Arid to semiarid regions from cool to cold in winter, with light to heavy snow in mountainous regions**
5. **Very arid, hot regions with cool to cold nighttime temperatures**
6. **Wet and warm to very warm summers and wet and warm to cool winters**

The Pennsylvania Department of Transportation employed three vibratory steel wheel roller compactors operating in echelon to help achieve increased density targets for its demonstration test sections. Source: Victor (Lee) Gallivan, Gallivan Consulting Inc.

Improving Durability Through Increased Density

A 10-State demonstration project shows that higher levels of compaction can be achieved cost-effectively, leading to longer life and lower life-cycle costs for asphalt pavements.

Consisting of more than 9.6 million lane miles, the U.S. highway network is one of the country's largest assets. But keeping the system in good working order comes at a high cost. In its report to Congress, *2015 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* (FHWA-PL-17-001), FHWA estimates that the average annual investment needed between 2013 and 2032 to maintain the condition and performance of the Nation's highway system as a whole is $89.9 billion.

The Minnesota Department of Transportation used roller compactors equipped with intelligent compaction instrumentation to monitor the densification of its test sections. Source: MnDOT.

Any improvements in the performance of pavement structures would help reduce the magnitude of that required annual investment. For asphalt pavements, one simple, straightforward, and relatively low-cost means of improving performance is through the achievement of higher density levels during construction. Higher levels of asphalt density improve the pavement's durability, extend the service life, and delay future rehabilitation and reconstruction activities.

The Appeal of Compaction

Over the years, innovations and advancements in equipment, techniques, and technology have increased pavement performance and reduced costs. Now engineers know that combining controlled compaction with higher in-place pavement density can have a dramatic effect on the performance of asphalt pavements.

Studies have shown that increasing the density and reducing the air void content of asphalt pavements results in lower permeability, increased resistance to load-related cracking and rutting, and, ultimately, a longer pavement life. For example, studies have found that an increase in compaction resulting in a 1-percent decrease in air void content can provide an 8- to 44-percent increase in fatigue life and a 7- to 66-percent increase in rutting performance, based on both laboratory and field data.

Comparing the estimated life-cycle cost of an asphalt pavement overlay constructed at 92 percent of maximum theoretical density to a similar overlay constructed at 93 percent shows the potential savings made possible by increasing the minimum required in-place density by only 1 percent. Using a conservative 10-percent increase in service life, a recent FHWA-sponsored synthesis report cites a net present value cost savings of $88,000 on a $1 million paving project.

Contractors certainly have the ability to achieve higher densities through increased compaction, but there can be risks associated with excessive compaction that can damage the pavement. Fortunately, recent improvements such as warm-mix asphalt technologies (which provide mixture workability), intelligent compaction, high-tech pavers, and quality control processes have made it possible to achieve higher in-place density while avoiding those risks. And, unlike other methods to achieve increased pavement performance that involve costlier materials or construction practices, additional in-place pavement density doesn't have to add much to the cost to gain substantial additional performance.

FHWA Launches a Demonstration Project

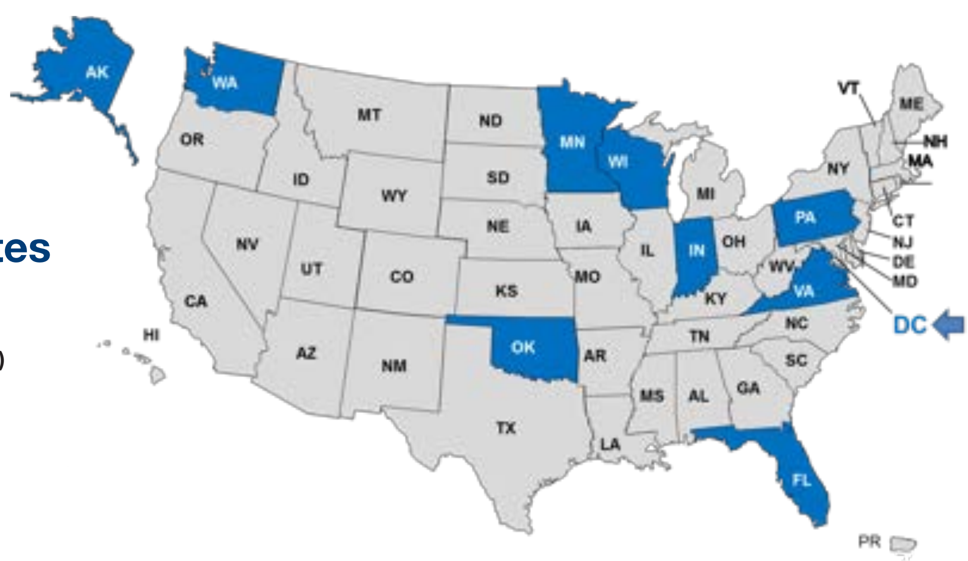
Recognizing the importance of in-place density in building cost-effective, long-lasting asphalt pavements, in 2016 FHWA initiated a demonstration project called "Enhanced Durability Through Increased In-Place Pavement Density." The objective was to demonstrate that the in-place density required to improve the performance of asphalt pavement could be achieved without a significant increase in construction cost. Through an application process, FHWA selected 10 States to construct test sections and participate in the demonstration.

At each demonstration site, crews constructed one control section and one or two test sections with increased density. Each State took the opportunity to construct additional test sections to identify what other construction alternatives they should consider to achieve increased density. These alternatives involved many recent technology improvements, such as warm-mix asphalt, intelligent compaction, rolling density meter, and infrared imaging, as well as the more conventional changes in practice such as additional roller compactors, material transfer vehicles, and improvements to asphalt mixture design, material selection, and quality assurance plans.

A key to the success of the project was the partnership that FHWA established with industry, as well as the State highway agencies and contractors in the participating States. The National Center for Asphalt Technology and the Asphalt Institute provided workshop training, assistance with mixture designs and pre-construction meetings, construction monitoring, and documentation support. The primary goal of the workshops was to present best

States Hosting In-Place Density Demonstration Sites

Demonstration Projects (10)



Source: FHWA.

The Wisconsin Department of Transportation (WisDOT) is constructing experimental sections on State Highway 21, near Necedah, WI, as part of a demonstration project to evaluate the performance of asphalt pavements with increased compaction density. A material transfer vehicle helps move asphalt mixture from the delivery truck to the paver at a uniform temperature. Source: WisDOT.

practices for achieving pavement compaction, without resorting to use of additional compaction equipment or higher cost compaction technology. The 1-day workshops were so well received among the participating States that they were presented 18 more times in other States. Together, 1,431 participants from Federal and State government and industry organizations benefitted from the training.

What Did We Learn?

From all accounts, the demonstration project has been a major success. The key finding was that crews could effectively improve in-place density, with 8 of the 10 States achieving increased densities by at least 1 percent on their projects. The methods found to achieve increased density fell into five basic categories that can serve as a checklist for highway agencies to investigate:

1. Improving specifications to either include incentives or increase existing incentives for contractors to achieve higher in-place densities.
2. Adjusting mixture designs to obtain slightly higher asphalt contents.
3. Striving for greater consistency in mixture temperatures, paver speeds, and roller patterns.
4. Following best construction practices.
5. Employing new technologies such as warm-mix asphalt, infrared imaging, rolling density meter, and intelligent compaction.

"The funding and workshop provided by FHWA were instrumental in WisDOT prioritizing an enhanced density demonstration project," says Barry Paye, chief materials engineer at the Wisconsin Department of Transportation, one of the project participants. "The information gained from this demo enabled WisDOT to update our density specifications for the 2017 construction season, a year or two ahead of what we had originally planned. The 1- to 1.5-percent increase in density will result in 10 percent or greater gains in pavement life. The return on FHWA's $50,000 incentive and workshop will be great for Wisconsin."

A report documenting the findings of the 10-State demonstration is available on NCAT's Web site at http://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep17-05.pdf.

Making the Grade with Performance-Based Asphalt Binders

NEW TOPIC

Efforts to improve asphalt binder performance testing and specifications are helping the industry adapt to modern practices.

Asphalt binder is the liquid "glue" that holds together the rocks and sand in an asphalt mixture. The binder has a major effect on a pavement's performance. An ideal binder should be able to maintain stiffness and elasticity during high-temperature conditions, yet also remain flexible at intermediate and low temperatures. Unfortunately, some unmodified binders fail to meet these requirements, leading to problems like rutting, fatigue cracking, and cold-temperature cracking.

To overcome these performance issues, producers are turning to additives and modifiers to enhance the intermediate and low-temperature properties by making the asphalt binder more elastic and less susceptible to aging or improving the high-temperature properties and resistance to viscous flow.

Inadequate design, selection, testing, and performance in asphalt binders can lead to pavement distress like the rutting shown here. Source: APTech.

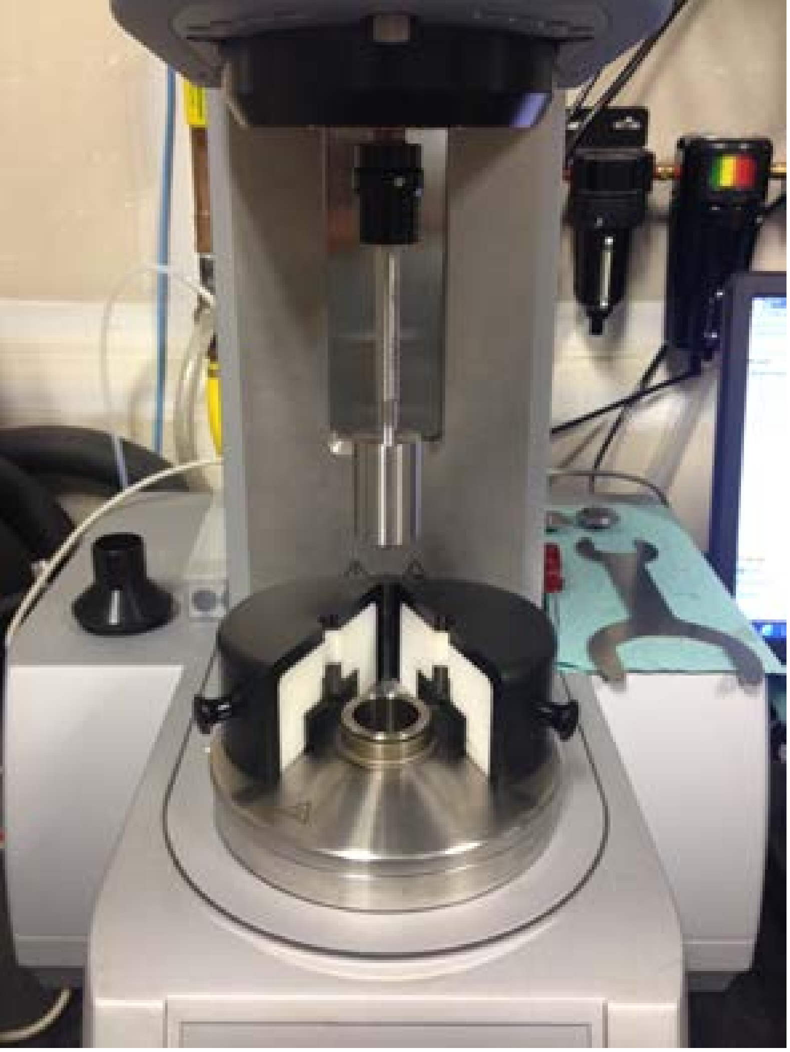
Increasing the use of performance-based asphalt binders can help minimize premature pavement distress like this transverse cracking. Source: APTech.

Over the years, binder specifications have evolved considerably, from empirical requirements with minimal relation to performance to well-defined rheological properties that are useful to pavement engineers designing based on cutting-edge technology and material science. Today, performance-graded binders are specified based on anticipated performance under the climatic and traffic-loading conditions to which the pavement will be exposed during its service life. Since the implementation of performance-graded binders, new screening techniques are being promoted that enable agencies to specify materials required to meet the performance needs, while discouraging practices that might result in allowing materials that meet the old specification yet fail to deliver long-term performance.

FHWA has played a key role in the move toward performance-based binders that are designed to control critical distresses, leading to more durable, longer lasting pavements.

Connecting Resources

FHWA has deployed a number of strategies to encourage State highway agencies to adopt performance tests for binders. For example, FHWA assembled subject matter experts from the private sector, academia, and State highway agencies to form the Asphalt Binder Expert Task Group (ETG) to advance protocols for next-generation, performance-graded asphalt binders. The ETG's efforts help identify knowledge gaps, highlight materials and testing innovations, usher performance tests into the mainstream, and develop problem statements to improve binder research.



The dynamic shear rheometer is a cutting-edge technology used to measure the elasticity and viscous flow of asphalt binders. Source: FHWA.

Similarly, FHWA develops partnerships with stakeholders, such as the Asphalt Institute and the North East Asphalt User/Producer Group, to conduct round-robin binder testing and to develop and disseminate technical guidance. This growing coalition of organizations and testing laboratories has accelerated equipment ruggedness testing for new test criteria, developing precision statements for test methods, and adoption of performance-based binder testing requirements and specifications.

Adoption of Standards and Specifications

One test in particular that contains new performance criteria is the Multiple Stress Creep Recovery (MSCR) procedure. The MSCR test correlates favorably with known rutting performance. FHWA developed a technical guidance document, *The Multiple Stress Creep Recovery (MSCR) Procedure* (FHWA-HIF-11-038), describing both the test and performance-related results, and shared it with State highway agencies to build their familiarity with the procedure.

Since then, FHWA has conducted companion testing with several State highway agencies, including Arizona, Oklahoma, and Virginia, and provided side-by-side comparison testing and training on equipment, leading to increased confidence in using the new testing criteria.

"As we implement new specifications, it is an advantage to have FHWA companion tests to compare criteria and enable the Oklahoma [Department of Transportation] to evaluate advanced testing parameters to improve our ability to predict performance," says Scott Seiter, materials engineer at the Oklahoma DOT.

These efforts by FHWA to promote specification advances led the American Association of State Highway and Transportation Officials (AASHTO) to adopt additional criteria for performance testing in AASHTO TP 70, a provisional standard for the MSCR test method using the dynamic shear rheometer, and subsequent improvements adopted as non-provisional standard AASHTO T 350. AASHTO adopted and included the MSCR criteria in AASHTO M 332, which establishes grading criteria for binders. AASHTO's technical subcommittee is evaluating the adoption of a new standard developed through the FHWA Asphalt Binder ETG for evaluating the elastic behavior of binders using the MSCR test.

As the work continues in performance-based binder specifications, FHWA also is leading a task force to develop a standard using the concentric cylinder (cup-and-bob) geometry to test binders modified with ground tire rubber using the dynamic shear rheometer. Binders modified with ground tire rubber present challenges to traditional testing and grading because of the size and quantity of rubber particles. The goal is to provide a performance-based specification that provides an avenue for suitable material characterization and, thereby, lead to AASHTO's adoption of an improved specification broadly applicable to binders modified with ground tire rubber.

Partners in regional user and producer groups and equipment manufacturers have committed to proof-test the criteria and, if successful, to support the adoption by AASHTO.

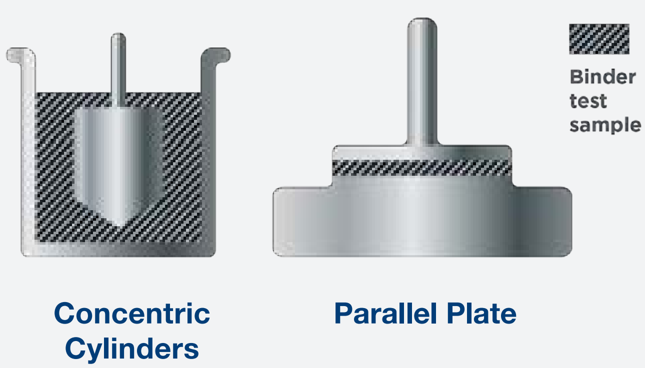
In addition, FHWA and the Asphalt Binder ETG have promoted new performance criteria for intermediate and low temperatures using the dynamic shear rheometer and bending beam rheometer. Recent studies have recommended extending the pressure-aging conditioning time used to simulate in-service stiffening and embrittlement of an asphalt binder as it ages. This would provide a more appropriate simulation of the field environment for the pavement's geographic location and help assess the binder's ability to resist aging and distress in the field.

A new 4-millimeter parallel plate testing geometry is being developed to evaluate low-temperature properties using smaller material samples to reduce sampling and testing costs. Studies have further demonstrated that supplementary material characterization can occur by comparing temperatures at which a binder meets a limiting stiffness value and develops adequate relaxation characteristics. The calculated difference in temperature has shown the potential to screen for binders that contain additives known to hinder optimal performance.

FHWA has leveraged efforts nationally to implement performance-based asphalt binder specifications by developing partnerships, promoting more robust testing procedures that acknowledge advantages in modified materials, and demonstrating testing that more closely predicts in-service performance attributes. Overall, using performance-based binder tests enables agencies to specify materials to meet each project need, while allowing producers to use innovative modifiers and additives to make the grade at the most efficient cost.

For more information on the Asphalt Binder ETG's efforts, visit www.fhwa.dot.gov/pavement/asphalt.

Dynamic Shear Geometries



The concentric cylinder geometry allows characterization of asphalt binders modified with ground tire rubber particles, minimizing the particle and specimen edge effects that could interfere with the test results, a typical problem when using the parallel plate geometry.
Source: APTech.

This concentric cylinder geometry is compatible with current dynamic shear rheometer equipment and facilitates the testing of binders containing suspended ground tire rubber particles up to 2 millimeters in diameter.
Source: FHWA.

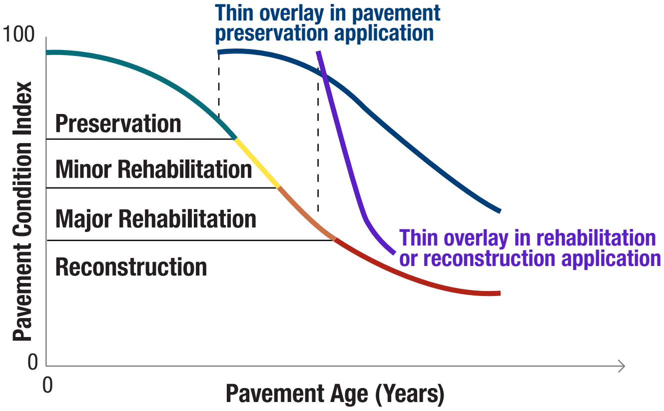
The availability of smaller maximum aggregate sizes makes thinner overlays possible. These workers in Erie County, NY, are installing a 1-inch overlay of warm-mix asphalt with a mixture containing a maximum nominal size aggregate of 0.25 inch. Source: New York Construction Materials Association.

NEW TOPIC

Thin Overlays on the Rise

More and more highway agencies are turning to thin asphalt overlays as a cost-effective alternative for pavement preservation.

FHWA and its industry partners encourage pavement preservation as a way for State highway agencies to protect their roads and make the most of their maintenance and rehabilitation budgets. In recent years, thin overlays have emerged as a viable preservation treatment for many asphalt pavements. As with other thin pavement preservation treatments that are sensitive to underlying defects, thin overlays perform best and are most cost-effective when applied to pavements that exhibit limited distress and maintain adequate load-carrying capacity. When applied as a preservation rather than a rehabilitation strategy, thin overlays can add years of service life, saving money and delaying more extensive rehabilitation and reconstruction activities.



Using a thin asphalt overlay in a pavement preservation application offers improved performance in terms of service life compared to using it in rehabilitation applications. Source: Applied Pavement Technology, Inc.

How Thin Is Thin?

A recent survey of highway agencies in all 50 States, the District of Columbia, Puerto Rico, and several Canadian Provinces, consultants, and contractors, documented a range in opinion as to what constitutes a thin overlay. Roughly 60 percent of respondents indicated a thickness between 1 and 2 inches, while the remaining 40 percent said less than 1 inch. As a general rule, the thicker overlays will consist of dense-graded asphalt mixes in which the nominal maximum aggregate size is 0.375 to 0.5 inch. The thinner overlays—especially those under 1 inch thick—will mostly consist of less conventional asphalt mixture surfaces, such as open-graded friction courses, ultra-thin bonded wearing courses, and fine-mix overlays.

Improved Performance

Recent advancements in asphalt mixture technology have improved the performance and cost-effectiveness of asphalt overlays of all thicknesses. The use of higher percentages of crushed aggregates has made thin overlays more rut resistant than older generation mixes, and intelligent compaction has proven to be a valid density specification alternative that supports agency acceptance practices. Greater attention to the uniform application of tack material has also significantly addressed issues with thin overlay delamination. These, along with better criteria on maximum aggregate size, more use of open- and gap-graded mixes, and greater use of additives and modifiers such as compaction aids, polymer, and rubber, have improved the performance and extended the applicability of thin overlays and made them a cost-effective treatment for pavement preservation and other applications.

Who Is Using Thin Overlays?

All State highway and most local agencies in the United States use thin asphalt overlays as maintenance or pavement preservation treatments on their highway and street networks. For example, the Ohio Department of Transportation has been using thin overlays to maintain its highways for years, focusing on structurally sound pavements in good condition. The department created a decision tree to help guide when to use thin overlays and has documented service lives of 10 to 12 years for its thin overlays.

Thin asphalt overlays commonly measure 1.5 inches or less, like this dense-graded asphalt overlay in Reno, NV. Source: Applied Pavement Technology, Inc.

Benefits of thin overlays as a pavement preservation treatment:

- Extends service life
- Renewed surface smoothness
- No loose aggregate (as compared to chip seals and other thin surface treatments)
- Carries traffic shortly after construction
- Withstands heavy traffic
- Easy to maintain

The Texas Department of Transportation (DOT) recently conducted research to improve its design and construction guidelines for thin, fine-graded overlays between 0.5 and 1 inch thick. Employing various mixtures including dense-graded, stone-matrix asphalt, and permeable friction courses, these thin overlay mixes often result in a savings of 30 percent, compared to traditional mixes. In Texas, "thin hot-mix asphalt overlays have shown very good performance in resisting both rutting and cracking," says Magdy Mikhail, pavement preservation engineer at the Texas DOT. "Also, the mixes can be placed on roadways with high traffic volumes."

In Louisiana, the Department of Transportation & Development (DOTD) expanded its pavement preservation toolbox by introducing the use of ultra-thin bonded wearing courses—a thin overlay requiring the use of an open-graded mix and specialized paving equipment. These bonded wearing courses apply a very thick layer of asphalt tack coat to the pavement, just in front of the paver screed. The thick layer and specific properties of tack, along with the open-graded mix, forms a strong bond with the existing pavement surface and has a relatively long service life. The Louisiana DOTD estimates this form of thin asphalt overlay could save $23,000 per lane mile compared to conventional dense-graded overlays, when applied under the right conditions.

Spreading the Word

Working through cooperative agreements and relationships with stakeholders, FHWA is advancing the use of new and innovative asphalt pavement technologies, including thin asphalt overlays.

- In partnership with The National Center for Asphalt Technology (NCAT), FHWA prepared a soon-to-be-released technical brief providing key design and construction guidance for thin asphalt overlays. In addition, NCAT has delivered instructor-led courses on asphalt technology and workshops on pavement preservation that feature thin asphalt overlays.
- In partnership with the National Asphalt Pavement Association (NAPA) and several State asphalt associations, FHWA initiated the publication of a new guide on thin asphalt overlays. The guide, which is scheduled for release this fall, will provide descriptions of the different types of thin asphalt overlays and document guidance on selecting the right applications, preparing mixture designs, using proper construction methods, and inspecting and troubleshooting.
- In partnership with the Asphalt Institute, FHWA developed and delivered a webinar for engineers on the use of thin asphalt overlays in pavement preservation, highlighting critical design and construction elements.

According to Mike Heitzman, assistant director of NCAT, "FHWA provided much-needed guidance and support to NCAT, NAPA, and the Asphalt Institute to document the proper selection and use of thin asphalt concrete surfaces as a pavement preservation alternative."

The growing awareness of the benefits of thin asphalt overlays, coupled with improved guidance on this technology, is helping ensure proper use for pavement preservation, and helping States make the best use of limited funding.

For more information, visit www.asphaltinstitute.org/thin-lift-asphalt-overlays-project-selection-design-and-construction-recording or www.asphaltpavement.org/thinlay.

(Above) This asphalt pavement core shows a fine-graded, 1-inch overlay on top of the original pavement structure. Source: National Center for Asphalt Technology.

(Below) Workers are constructing a 1-inch, ultra-thin bonded wearing course in Henderson, NV. The bonded wearing course preserves the underlying pavement structure and provides a new wearing surface for vehicle travel. Source: Applied Pavement Technology, Inc.

A bonded concrete overlay, shown here during construction, applies a new concrete layer to the surface of the existing pavement, increasing its total thickness. This reduces wheel load stresses and extends the life of the pavement. Source: Kurt Smith/APTech.

NEW TOPIC

Gaining Ground

Concrete overlays are growing in popularity as a sustainable, cost-effective solution for maintaining and preserving pavements.

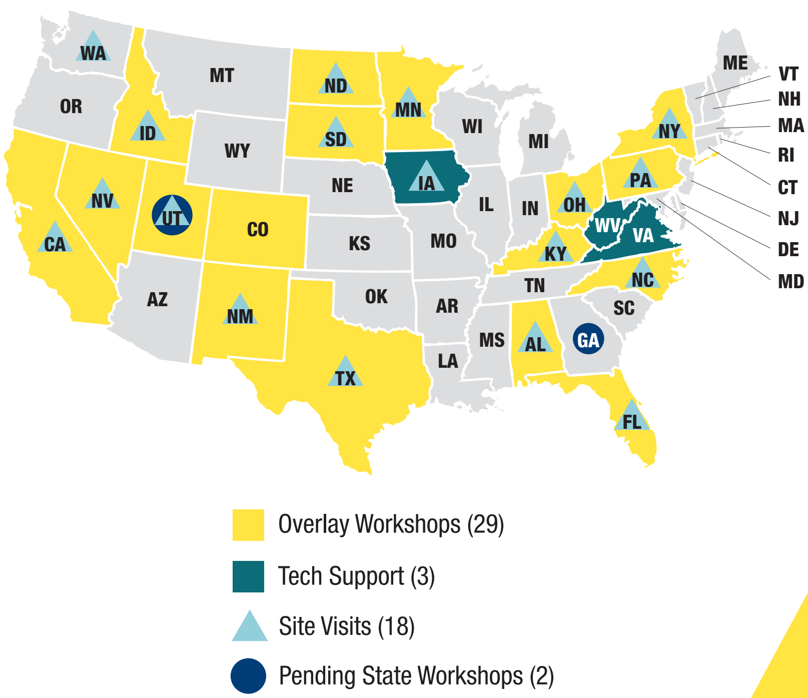
Using a concrete overlay to rehabilitate an existing pavement offers many benefits: extending service life, increasing structural capacity, reducing maintenance, and lowering life-cycle costs. But how do you determine when and where to use a concrete overlay? What are the design and construction considerations? FHWA answers these and other questions through its Concrete Overlay Field Application Program, administered by the National Concrete Pavement Technology Center (CP Tech Center) at Iowa State University.

“The goal of the program is to provide technical assistance to agencies in the overall concrete overlay process, from the selection of candidate projects through the design and construction of the project itself,” says Dale Harrington, a civil engineer at Snyder and Associates, who oversees the program for the CP Tech Center.

Another goal is to increase awareness and knowledge among State DOTs and local agencies, contractors, and engineering consultants regarding how to apply concrete overlays successfully. Many highway agencies across the country have participated and reaped the rewards since the program’s launch.

The Concrete Overlay Field Application Program has provided workshops, technical support, and site visits across the United States.

Source: Dale Harrington, CP Tech Center.

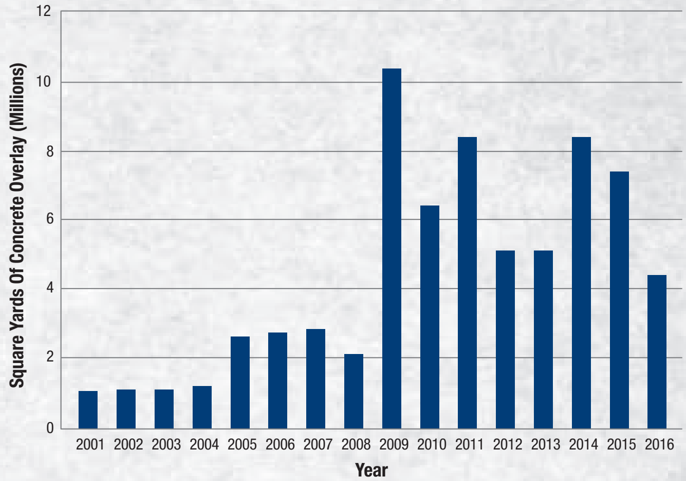


Types of Overlay Solutions

Crews can apply either bonded or unbonded concrete overlays on top of existing asphalt, composite, and concrete pavements. If the existing pavement is in good structural condition, bonded concrete overlays can eliminate surface distress or add structural capacity. This approach requires that specific steps be taken to bond the new overlay to the existing pavement so it behaves as a single structure.

On the other hand, if the existing pavement has moderate to severe deterioration, unbonded concrete overlays are used to restore structural capacity. The new overlay is separated from the existing pavement to ensure that the distress in the underlying pavement does not affect the performance of the new overlay.

Use of concrete overlays has increased significantly since 2009.



Source: Dale Harrington, CP Tech Center.

Results

Participants in the Concrete Overlay Field Application Program gain firsthand knowledge of overlay solutions, enabling their agencies to reap both technical and financial dividends.

"The Concrete Overlay Technical Assistance Program reviewed a 17-mile project on I-85 in North Carolina," says Clark Morrison, State pavement design engineer with the North Carolina Department of Transportation (NCDOT). The existing pavement was a 50-year-old jointed concrete with numerous asphalt patches for which NCDOT had selected an unbonded concrete overlay. The team from the CP Tech Center visited the site and conducted a workshop with NCDOT engineers, with two of the recommendations resulting from the workshop—to leave most of the existing asphalt patches in place and to use drainage fabric in lieu of permeable asphalt drainage course—resulting in significant savings in both construction costs and time. Morrison estimates that the cost savings in full-depth repairs alone were at least $3.25 million.

Adoption of concrete overlays is on the rise in other highway agencies too, Harrington says. "In the last several years, we've seen a significant increase in the use of concrete overlays. From September 2013 through September 2016, 11 different State DOTs who received the concrete overlay training constructed more than 115 concrete pavement overlay projects, representing more than $750 million in construction costs." As more agencies gain a working knowledge of concrete overlay technology, its use as a pavement preservation and rehabilitation alternative is expected to grow.

Ready to Learn More?

There are a number of resources that are available to assist highway agencies in evaluating and applying concrete overlay solutions. Guide books, technical briefs, documentation of case studies, and training are just some of the resources available that cover all aspects of concrete overlays, from selection to design to construction, and for a range of applications, including highways, urban streets, and parking lots.

Could your agency benefit from more information about concrete overlays? The Concrete Overlay Field Application Program wants to help. Contact the program for technical assistance or to discuss scheduling a site visit or workshop.

For more information, visit www.cptechcenter.org/research/research-initiatives/overlays.

HMA pavements placed today are exposed to increasing loads and varied climatic conditions. Design processes need to anticipate the conditions and predict how materials will respond in service. Source: APTech.

NEW TOPIC

Performance-Engineered Asphalt Mixtures

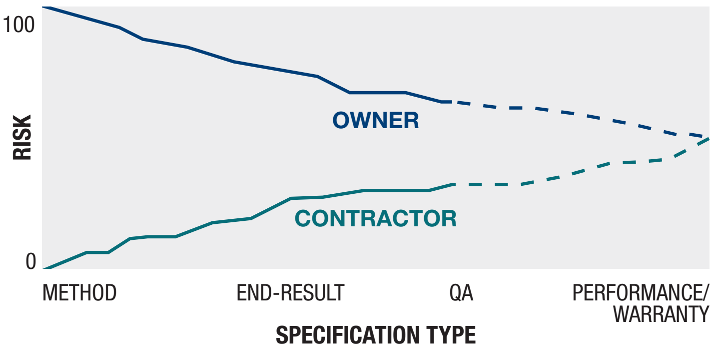
The next generation of asphalt pavement mixtures will better account for climatic conditions, traffic, and resistance to rutting and cracking throughout the pavement's life.

For many years, the design for asphalt mixtures was largely driven by State departments of transportation (DOTs). The recipes replicated the basic material qualities and size distributions of successful mixtures, and paving contractors matched those proportions by volume for the air, asphalt binder, and aggregate. Under these *method-based* specifications, contractors had to follow specific steps during production, and quality testing was tightly controlled. A consequence of this approach was development of recipes that differed from State to State, leading to significant variation across the country.

Later specifications required contractors to design mixtures based on the properties of the source materials to meet the same criteria the owner used. Quality acceptance tests verified that the mixture produced at the contractor's plant was comparable to the designed mixture and the volumetric proportions were within specified limits. This *end-result* type of specification shifted some risk and responsibility to the contractor to produce quality mixtures that conformed to design tolerances, but this approach did not always guarantee long-term performance. Later, *quality assurance* (QA) specifications further balanced risks and responsibility toward the contractors but did not necessarily improve the reliability of the design to represent future field performance.

Therefore, FHWA and its State DOT and private sector partners are pushing for a move toward *performance-related* and *performance-based* specifications as the next steps in the evolution of high-performing pavements.

Specification Risk Profile



Shown here is the relative risk sharing profile between contractors and owner agencies for the various specification types. Source: FHWA.

Sharing the Risk

Experience has shown that modifying specifications to give contractors a sizable stake in the quality of the final product incentivizes them to produce mixtures that resist cracking and rutting and deliver long-term performance. Toward that end, the Asphalt Mixture and Construction Expert Task Group (ETG), sponsored by FHWA and consisting of a panel of leaders from industry, academia, and State DOTs, proposes implementing *performance-engineered* asphalt mixtures to achieve higher performing mixtures and improve long-term performance and durability.

"Performance-based mix design requires the contractor to better understand mixture performance," says Shane Buchanan, asphalt performance manager at Oldcastle Materials and chair of the Asphalt Mixture and Construction ETG. "Volumetric checks are still completed, but the design is established by performance testing. The contractor can then estimate what changes or modifier additions are necessary to move from the current mixture performance level to the required performance level, and also determine the most cost-effective way to meet the required performance."

Performance-engineered mixture design is a win-win for owner agencies and contractors. Agencies get to share more of the risk with their contractors and expedite the rewards of longer lasting pavements, while contractors can take advantage of the opportunity to innovate and differentiate themselves in the marketplace by designing and constructing high-performance mixtures.

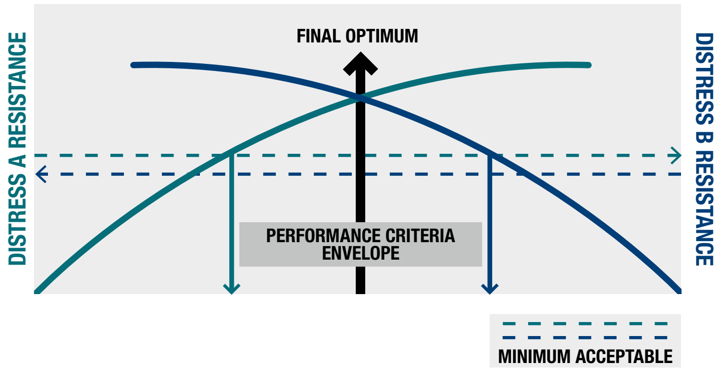
Implementing Performance Testing

Performance-engineered mixture design uses testing to determine the resistance of HMA mixes to rutting and cracking under different climatic and traffic conditions as part of a performance specification. FHWA not only endorses adoption of performance specifications but also participates in developing, refining, and testing devices that measure fundamental engineering properties related to performance.

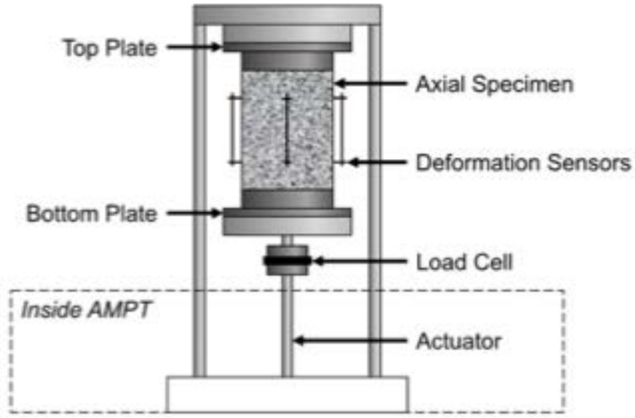
Designers can select an optimum design value from a range of measured engineering properties established through field performance. Although previous design processes considering only volumetric properties have produced asphalt mixtures that resist rutting, they may sacrifice resistance to cracking when paired with production and testing tolerances and variability. Performance-engineered mixture design seeks to provide resistance to multiple failure modes.

Through applied research, FHWA and its partners have shown that a commercially available device, the Asphalt Mixture Performance Tester (AMPT), and its associated testing and evaluation protocols can successfully relate engineering properties to

Performance-Engineered Mixture Design Concept



Performance-engineered mixture design considers the resistance to pavement distresses in determining the optimum design criteria for a mixture. Source: Dr. Y. Richard Kim, North Carolina State University (NCSU).



The Asphalt Mixture Performance Tester (AMPT) measures stiffness and resistance to deformation and cracking in a computer-controlled test system in accordance with accepted protocols and standards. Source: Dr. Y. Richard Kim, NCSU, for AASHTO TP 107 Standard Method of Test for Determining the Damage Characteristic Curve and Failure Criterion Using the Asphalt Mixture Performance Tester (AMPT) Cyclic Fatigue Test.

pavement performance and distress to advance performance specifications. The AMPT measures stiffness, deformation, and cracking resistance as loads are applied at various temperatures, and values calculated from the test can be entered directly as parameters for pavement design. Owner agencies also can compare the values to desired limits for rut and crack resistance during the design process and as a quality check for mixtures during construction.

The Mobile Asphalt Testing Trailer is one tool FHWA uses to encourage interaction with State DOTs, introducing innovations, new technology, and test methods to pavement engineers across the United States. Source: FHWA.

Getting the Word Out

Using its Mobile Asphalt Testing Trailer, FHWA has conducted demonstration projects, seminars, and technical assistance within the past year in seven States to familiarize State DOT personnel with using the AMPT apparatus, preparing samples, and interpreting the results to compare performance.

In addition, FHWA has published three TechBriefs on the device:

- *Asphalt Material Characterization for AASHTOWare® Pavement ME Design Using an Asphalt Mixture Performance Tester (AMPT)* (FHWA-HIF-13-060)
- *Asphalt Mixture Performance Tester (AMPT)* (FHWA-HIF-13-005)
- *Testing for Fatigue Cracking in the Asphalt Mixture Performance Tester (AMPT)* (FHWA-HIF-16-027)

In collaboration with AASHTO's Subcommittee on Materials, FHWA also has spearheaded developing or revising eight standards that specify methods for conducting analysis with the AMPT, as well as an equipment specification for the device.

- PP 60 – Standard Practice for Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor (SGC)
- TP 79 – Standard Method of Test for Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)
- PP 61 – Standard Practice for Developing Dynamic Modulus Master Curves for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)
- TP 107-14(R2016) – Determining the Damage Characteristic Curve of Asphalt Mixtures from Direct Tension Cyclic Fatigue Tests
- TP 107-XX – Determining the Damage Characteristic Curve and Failure Criterion Using the Asphalt Mixture Performance Tester (AMPT) Cyclic Fatigue Test
- PP XX – Standard Practice for Preparation of Small Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor (SGC) and Field Cores
- TP XXX – Standard Method of Test for Determining the Damage Characteristic Curve and Failure Criterion Using Small Specimens in the Asphalt Mixture Performance Tester (AMPT) Cyclic Fatigue Test
- TP XXX – Standard Method of Test for Determining the Dynamic Modulus for Asphalt Mixtures Using Small Specimens in the Asphalt Mixture Performance Tester (AMPT)
- MP XX – Standard Specification for the Asphalt Mixture Performance Tester (AMPT)

FHWA continues to lead implementation of performance-engineered mixture design by collaborating with State DOT and industry experts, developing and refining standards based on applied research, and demonstrating innovative practices to standardize the tests relating to long-term performance. Ultimately, the aim for these activities is to develop innovative contracting practices and advance performance specifications that result in longer lasting pavements that maximize the return on investment for taxpayers.

For more information, visit www.fhwa.dot.gov/pavement/asphalt.

FHWA is leading efforts to increase the recycling and reuse of demolished concrete pavement on highway projects. Source: APTech.

NEW TOPIC

Breaking It Down: Recycled Concrete Aggregates

Crushing old concrete to produce aggregate for use in highway construction is a smart, sustainable, and cost-effective choice.

Aggregates are a basic building block of highway construction. Unfortunately, in many parts of the country, the volume of good quality aggregates is dwindling, as many sources have been exhausted and suppliers face challenges acquiring permits for new quarries or mines. As a result, State highway agencies are finding compelling economic and environmental motivators to make use of old, worn-out pavements as a source for aggregate materials.

The practice of crushing old concrete for use as aggregate in roadway construction isn't new. States have been doing it for more than 70 years. Today, an estimated 140 million tons of concrete are recycled annually from all sources in the United States. The process produces a granular material known as recycled concrete aggregate (RCA). Crushed to selected sizes and properly engineered, RCA can substitute for virgin aggregate materials and achieve equal or greater performance in a range of applications, including concrete pavement mixtures, pavement base and subbase layers, and embankments and shoulders.

At least 44 State highway agencies allow the use of RCA in various applications. However, a number of barriers—including limited technical understanding of RCA properties and behavior and rigid specifications that exclude RCA materials—currently restrict the more widespread use of this resource. That's why FHWA is working with its highway agency partners to demonstrate the usefulness of RCA in roadway applications as a means to offset the need for virgin aggregates, while reducing construction costs and eliminating the need for landfilling old pavements.

Benefits of Using RCA

The two primary benefits of using RCA in roadway construction are economic and environmental. From the economic perspective, aggregates represent a significant component of construction costs, and using RCA helps reduce those costs by eliminating or minimizing the need for virgin aggregates. RCA can be particularly beneficial in regions where high-quality aggregates are scarce and agencies pay top dollar to purchase and transport those materials to jobsites. Moreover, the contractor can improve construction efficiencies by using RCA and reducing material hauling costs and impacts on traffic.

In addition, recycling old pavements eliminates the cost for disposal of the old concrete, helping agencies realize time savings and production efficiencies by reusing old materials onsite. The cost savings from recycling concrete pavement varies based on regional factors and site-specific conditions, but the California Department of Transportation reported savings as high as $5 million on a single project.

RCA affords important environmental benefits as well, as it conserves virgin aggregate sources and reduces the energy use and emissions associated with aggregate production and transport. Onsite recycling also reduces fuel consumption associated with hauling the old pavement materials away to landfills. These benefits are increasingly important as agencies seek more sustainable solutions.

Documenting Successful Applications

Several highway agencies have documented both the economic and environmental benefits of using RCA in their pavement systems, even when the original pavement contained nondurable aggregate. For example, on a reconstruction project on U.S. 59 near Worthington, MN, the existing two-lane concrete pavement was exhibiting durability cracking distress. Crews broke up the pavement to produce both coarse and fine RCA for reuse onsite. The Minnesota Department of Transportation (MnDOT) estimates that recycling the concrete resulted in a 27 percent cost savings and a fuel savings of more than 150,000 gallons.

As another example, the Illinois Tollway identified $50 million in savings by using RCA rather than virgin aggregate in pavement base courses, and recycled more than 775,000 tons of concrete in 1 year alone on a major reconstruction of I–90 west of Chicago.

And, in Wisconsin, crews reconstructing a 1.5-mile section of the Beltline Highway in Madison produced nearly 9,900 cubic yards of RCA for use as a base course and embankment fill, saving approximately $130,000 in initial construction costs. The entire recycling effort for the project achieved significant reductions in energy use (13 percent), water consumption (12 percent), carbon dioxide emissions (13 percent), and hazardous waste generation (9 percent) when compared to construction using virgin materials.

(Above) A close-up of coarse RCA.
(Below) This stockpile of RCA beside a road is ready for reuse.
Source: APTech.

FHWA Leading the Way

Through a cooperative partnership with the National Concrete Pavement Technology Center (CP Tech Center), National Concrete Consortium (NCC) member States, and the concrete industry, FHWA is leading an effort to promote greater use of technologies to recycle concrete pavement. As part of this initiative, FHWA and the CP Tech Center formed a technical advisory committee consisting of 10 NCC member States (California, Illinois, Kansas, Minnesota, North Carolina, Oklahoma, Pennsylvania, Texas, Utah, and Washington) to help demonstrate and expand the use of concrete recycling techniques and technologies.

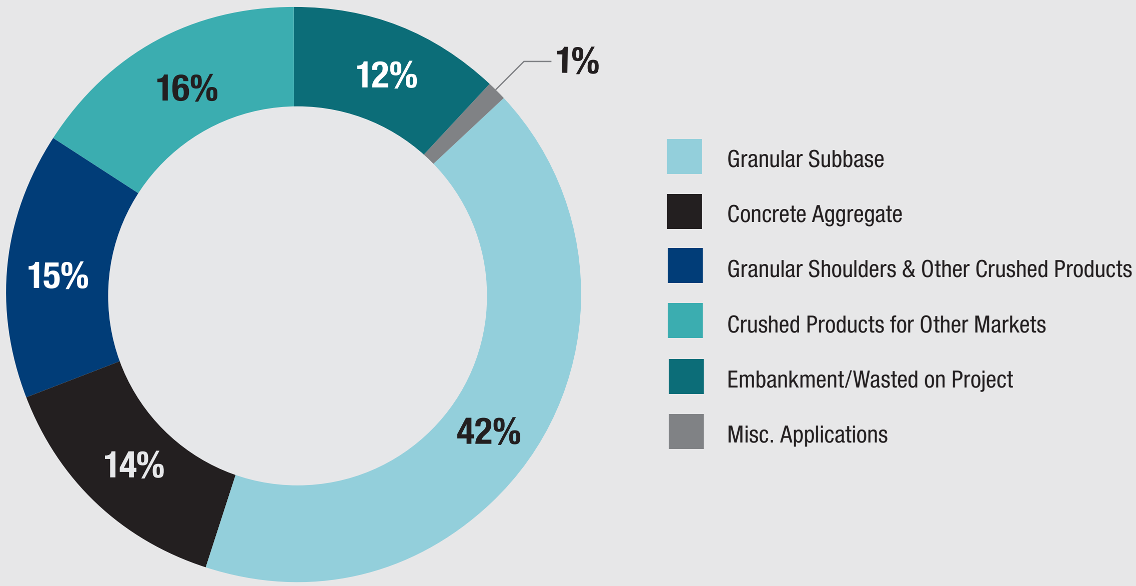
"We are working to provide highway agencies with information to overcome some of the barriers to the use of recycled concrete aggregate," says Tom Cackler, project manager at the CP Tech Center. "RCA is a valuable construction product that when properly designed can be used in a range of highway applications."

To help in this effort, FHWA's technical advisory committee has prepared a series of resources including webinars and technical summaries on various aspects of concrete pavement recycling. To date, the series of recycling webinars—featuring topics on recycling concepts, environmental considerations, construction guidelines, and case study highlights—have reached nearly 300 participants. In addition, a practitioner's guide on using RCA and a series of technical briefs are in development for fall 2017. The goal is to provide agencies and engineers the information they need to take advantage of all the economic and environmental benefits RCA offers.

For more information, visit www.cptechcenter.org/concrete-recycling.

A recent survey reveals the common uses of RCA. As shown, more than 75 percent is repurposed for highway applications.

Source: Tom Cackler, CP Tech Center.



Appendix

Related Pavement Technology Development and Deployment Activities Supporting the AIDPT Program

Following are additional aspects of the multifaceted Technology and Innovation Deployment Program approach providing funding and other resources to offset the risk of innovation.

Every Day Counts (EDC) Innovation Deployment Program

EDC Cycle	Innovation
EDC-4 (2017–2018)	Pavement Preservation (WHEN&WHERE)
EDC-4 (2017–2018)	Pavement Preservation (HOW)
EDC-4 (2017–2018)	Education Connection (ALL)
EDC-4 (2017–2018)	Marketing and Communication
EDC-4 (2017–2018)	Automated Traffic Signal Performance Measures (ATSPMs)
EDC-4 (2017–2018)	Road Weather Management – Weather Savvy Roads
EDC-4 (2017–2018)	EDC Regional Summits
EDC-4 (2017–2018)	Accelerating Traffic Incident Management (TIM) Data Collection
EDC-4 (2017–2018)	Data-Driven Safety Analysis (DDSA)
EDC-4 (2017–2018)	STEP: Safe Transportation for Every Pedestrian
EDC-4 (2017–2018)	CHANGE: Collaborative Hydraulics: Advancing to the Next Generation of Engineering
EDC-4 (2017–2018)	e-Construction and Partnering: A Vision for the Future
EDC-4 (2017–2018)	Ultra-High Performance Concrete Connections for PBES
EDC-4 (2017–2018)	Community Connections
EDC-4 (2017–2018)	Integrating NEPA and Permitting

Accelerated Innovation Deployment Grant Program

Agency	Project	Innovation
Alabama Department of Transportation	Ross Clark Circle Bridge Over Beaver Creek	Slide-in Bridge Construction
Alabama Department of Transportation and the City of Auburn, AL	Moore's Mill Road Bridge	Prefabricated Bridge Elements and Systems
Arizona Department of Transportation	Light-Emitting Diode Lighting System in the Queen Creek Tunnel	Light-Emitting Diode Lighting System
Arizona Department of Transportation	Virgin River Bridges	Structural Health Monitoring
Arizona Department of Transportation and Mohave County	Oatman Highway (Historic Route 66) Crossing at Sacramento Wash in Topock, AZ	Prefabricated Bridge Elements and Systems
Arkansas State Highway and Transportation Department and City of Jonesboro, AR	West College Avenue Bridge Replacement	Geosynthetic Reinforced Soil–Integrated Bridge System
Assiniboine Sioux Tribes	Rocky Mountain Tribal CORS Project	Geospatial Data Collaboration
California Department of Transportation	Geo-Reference and Visualization of Right-of-Way (ROW) Maps	Geospatial Data Collaboration
Colorado Department of Transportation	Managed Motorway on I–25	Intelligent Systems Technology
Confederated Salish and Kootenai Tribes	North Valley Creek Bridge	Accelerated Bridge Construction
Delaware Department of Transportation	Diverging Diamond Interchange (DDI) at SR–1 and SR–72	Diverging Diamond Interchange
Florida Department of Transportation	Commercial Vehicle Parking System on I–95 and I–4 Corridors	Commercial Vehicle Parking System
Florida Department of Transportation and Manatee County	Adaptive Signal Control Technology on SR–70	Adaptive Signal Control
Gwichyaa Zhee Gwich'in Tribe	Ivar's Bridge Replacement Project	Geosynthetic Reinforced Soil–Integrated Bridge System
Indiana Department of Transportation	Accelerated Bridge Construction Alternate Design Project	Slide-in Bridge Construction and Self-Propelled Mobile Transport
Iowa Department of Transportation	Iowa 92 Bridge Over Little Silver Creek	Prefabricated Bridge Elements and Systems and High-Performance Materials

Agency	Project	Innovation
Kansas Department of Transportation	Innovative Approach to Road Centerline Geospatial Data Collaboration	Geospatial Data Collaboration
Kansas Department of Transportation	Construction Management System	e-Construction
Kentucky Transportation Cabinet	Intelligent Compaction Project	Intelligent Compaction
Kentucky Transportation Cabinet	Roundabout Installation in London, KY	Roundabout
Maine Department of Transportation	Sarah Mildred Long Bridge Replacement Project	Construction Manager/ General Contractor
Michigan Department of Transportation	Diverging Diamond Interchange (DDI) at I–96 and Cascade Road	Diverging Diamond Interchange
Michigan Department of Transportation	M–86 Over the Prairie River Bridge in St. Joseph County	Carbon Fiber Reinforced Polymer (CFRP)
Michigan Department of Transportation	U.S. 131 Over 3 Mile Road Bridge Replacement	Slide-in Bridge Construction
Michigan Department of Transportation and the Dickinson County Road Commission	Pine Mountain Road/Westwood Avenue Pavement Rehabilitation	Hot In-Place Recycling and Warm Mix Asphalt
Minnesota Department of Transportation	Paving Projects Using Intelligent Compaction (IC) and Infrared (IR)	Intelligent Compaction and Infrared
Minnesota Department of Transportation and the City of St. James	Interconnected Mini-Roundabouts on Minnesota State Highway 4	Mini-Roundabout
Missouri Department of Transportation	High Friction Surface Treatments in Missouri	High Friction Surface Treatments
Missouri Department of Transportation	Paving Projects	Intelligent Compaction and Infrared (IR) Scanning
Montana Department of Transportation	Systems Engineering Analysis for a Statewide Traffic Signal System Evaluation	Traffic Signal System Evaluation
National Park Service	Safety Analysis Project	Safety Management System
New Hampshire Department of Transportation	I–93 Pavement Preservation Project	Asphalt Rubber Bonded Wearing Course

Agency	Project	Innovation
New Hampshire Department of Transportation	Bridge Monitoring Technology at Portsmouth's Memorial Bridge	Structural Health Monitoring
New York State Department of Transportation	Kew Garden Interchange Reconstruction Project	3D Engineered Models Incorporating Civil Integrated Management (CIM) Modeling
North Carolina Department of Transportation	Anson County Bridge Replacement Project	Geosynthetic Reinforced Soil–Integrated Bridge System
Ohio Department of Transportation	e-Construction on Two ODOT Projects	e-Construction
Ohio Department of Transportation and Muskingum County	Fabricated Steel Bridge Replacement System Project	Fabricated Steel Bridge System
Ohio Department of Transportation and Northeast Ohio Areawide Coordinating Agency	Development of Comprehensive Transportation Asset Management Program	Transportation Asset Management Program
Ohkay Owingeh Tribe	White Swan Bridge	Geosynthetic Reinforced Soil–Integrated Bridge System
Oklahoma Department of Transportation	Safety Project Utilizing High Friction Surface Treatment at Spot Locations	High Friction Surface Treatments
Oregon Department of Transportation	Expediting On-Scene Investigation/ Reconstruction Mapping Activities Along I–5 Corridor	Robotic Total Measuring Stations for Traffic Incident Management (TIM)
Pennsylvania Department of Transportation	Adaptive Traffic Signal Control for McKnight Road Corridor Project	Adaptive Signal Control
Pueblo of Acoma	Construction Manager/General Contractor (CM/GC) Project	Construction Manager/ General Contractor
Rhode Island Department of Transportation	Innovative Arch Construction Project	Innovative Arch Construction
Rhode Island Department of Transportation	Design and Replacement of the Park Avenue Bridge in Cranston	Construction Manager/ General Contractor (CMGC) and Early Contractor Involvement (ECI)
Rhode Island Department of Transportation	Highway Improvement on RI Route 102 Within the Towns of Coventry and Foster	WMA Additive and IC

Agency	Project	Innovation
Rhode Island Department of Transportation and Rhode Island Airport Corporation	Airport Road in the City of Warwick, RI	Adaptive Signal Control
South Carolina Department of Transportation	Structural Health Monitoring (SHM) Technology Project	Structural Health Monitoring
South Dakota Department of Transportation	Safety Project Utilizing High Friction Surface Treatment at Spot Locations	High Friction Surface Treatments
Tennessee Department of Transportation	Accelerated Steel Bridge Girder Fabrication	3D Modeling
U.S. Fish and Wildlife Service	Improving Road Safety for Bicyclists and Drivers	Dynamic Warning System
USDA Forest Service	Layout Creek Bridge	Geosynthetic Reinforced Soil–Integrated Bridge System
Utah Department of Transportation	Variable Speed Reduction in Active Work Zones	Work Zone Safety
Utah Department of Transportation	e-Construction to Improve Business Practices	e-Construction
Vermont Agency of Transportation	Tri-State Advanced Transportation Management System and Traveler Information System	Advanced Transportation Management System and Traveler Information System
Vermont Agency of Transportation	Right-of-Way (ROW) Acquisition Process on Roadway Project in the Towns of Pittsford and Brandon	Business Process Management (BPM) systems
Vermont Agency of Transportation and Chittenden County Regional Planning Commission	Advanced Traffic Monitoring Project	Corridor Level Advanced Traffic Monitoring
Virginia Department of Transportation and Town of Vienna	Park and Locust Streets SE Intersection Project	Mini-Roundabout
Washington State Department of Transportation	Practical Solutions Project	Practical Solutions with Lean Techniques and Knowledge Management
Washington State Department of Transportation	Light-Emitting Diode (LED) Adaptive Roadway Lighting on I–5	LED Adaptive Roadway Lighting System
Wisconsin Department of Transportation	Traffic Queue Warning Systems (QWS) in Work Zones on Two Bridge Construction Projects	Smarter Work Zones

Agency	Project	Innovation
Wisconsin Department of Transportation & Dodge County	Replacing Two County Bridges Using Accelerated Bridge Construction (ABC)	Geosynthetic Reinforced Soil-Integrated Bridge System
Illinois Department of Transportation	Located on Campground Road Over I–57 in Jefferson County, IL.	Incorporation of prefabricated deck panels with Ultra-High Performance Concrete (UHPC) connections in the replacement of the bridge.
Delaware Department of Transportation	Bridge 1–438 on Route N–463 Blackbird Station Road over Blackbird Creek.	Incorporation of UHPC in the replacement of structurally deficient.
City of Mexico, MO (sub recipient from Missouri Department of Transportation)	The proposed project will replace the roadway with an identical width street constructed of compacted concrete pavement.	Use of compacted concrete pavement in reconstructing a portion of Holt Street, a two-lane concrete roadway.
Alabama Department of Transportation	Deployment of e-Construction for the inspection of a multimillion-dollar construction project in Pickens County.	e-Construction is an innovation highlighted as part of the EDC initiative.
Colorado Department of Transportation	Deployment of e-Construction as a project inspection and electronic plan set solution on one design-bid-build project and one design-build project.	e-Construction is an innovation highlighted as part of the EDC initiative.
Maine Department of Transportation	On I–95 in Bangor, ME. The use of DDI, an EDC initiative, will provide a long-term solution to mitigate the mobility, safety, and access issues along the busiest diamond interchange in the State.	Design activities for a Diverging Diamond Interchange (DDI) that will be constructed.
Missouri Department of Transportation	For structure number 713, Big Bend Boulevard Bridge over I–270 in east central St. Louis County.	Use of a passive corrosion protection system to recoat the structural steel as part of a bridge rehabilitation project.

State Transportation Innovation Councils (STIC) Incentive

Fiscal Year	State	STIC Incentive Projects
2016	AK	Develop training courses and associated materials to implement quality environmental documentation and NEPA assignment as standard practices for the State of Alaska
2016	AL	Development of standards and specifications for utilization of 3D models/data for construction, including survey, design, and construction procedures
2016	AR	Implementation of e-Construction through the use of mobile devices for field personnel
2016	AZ	1. Advanced Hydraulic Modeling Tools ($80,000)
2016	AZ	2. Traffic Incident Management (TIM) Challenge Program ($7,000)
2016	AZ	3. Arizona Road Diets Peer Exchange ($3,000)
2016	AZ	4. Technology and Transportation Summit ($10,000)
2016	CA	1. Conduct Accelerated Bridge Construction Outreach ($45,000)
2016	CA	2. First/Last Mile Innovation Training ($40,000)
2016	CA	3. Roadway Departure Workshops ($15,000)
2016	CO	1. e-Construction – Advancing the Use of Mobile Devices With a Mobile Field Inspection Application ($49,088)
2016	CO	2. Monitoring Traffic in Work Zones Using Intelligent Traffic Control Devices ($46,400)
2016	CT	Advancing the use of mobile devices for e-Construction in field inspection applications
2016	DC	Enhance the functionality of the Work Zone Project Management System
2016	DE	1. Procurement of an Automated Cylinder End Grinder for the purpose of testing UHPC ($16,000)
2016	DE	2. Procure and implement a Document Management System (DMS) that can store engineering content at Delaware Department of Transportation ($63,854.40)
2016	FL	Purchase mobile devices for construction field inspection to fully implement e-Construction as a standard practice

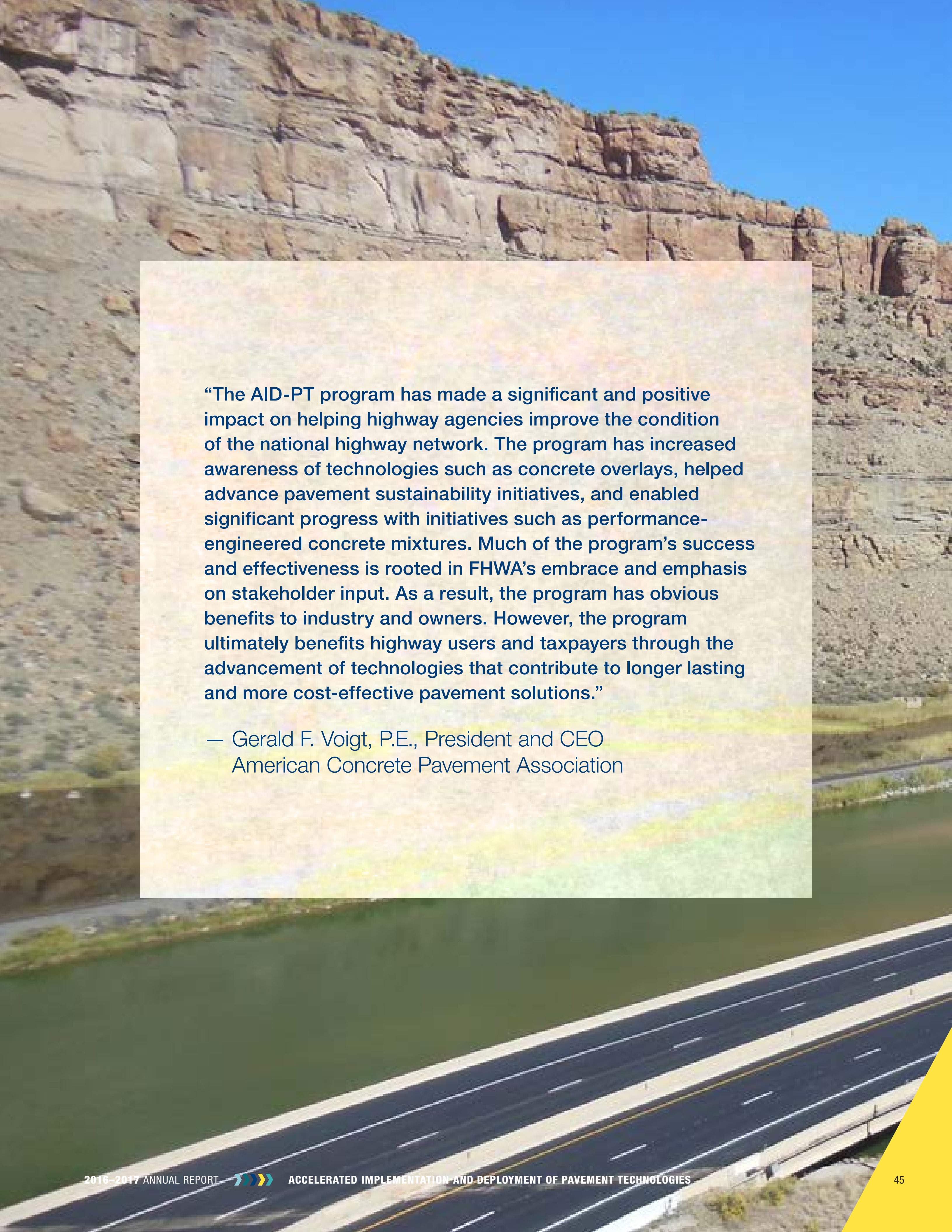
Fiscal Year	State	STIC Incentive Projects
2016	GA	Advancing the use of mobile devices for e-Construction in field inspection applications
2016	HI	Host workshops, develop strategies, and analyze data to integrate accessibility and design into Hawaii transportation decision-making
2016	IA	1. Expand the use of mobile devices for e-Construction in field inspection applications ($36,000)
2016	IA	2. Support for the “Innovations in Transportation Conference” ($8,000)
2016	IA	3. Deployment of Iowa Department of Transportation Traffic Operations Open Data Service ($56,000)
2016	ID	Hosting a 2-day workshop to advance 3D Modeling and Automated Machine Guidance
2016	IL	Procure equipment, develop training, and provide training to facilitate the implementation of 3D modeling statewide
2016	IN	Implementation of LiDAR-Based Mobile Mapping System for Lane Width Evaluation and Reporting in Work Zones for Indiana Department of Transportation Traffic Management
2016	KS	1. Low Distortion Projection (LDP) ($40,000)
2016	KS	2. Statewide Traffic Incident Management (TIM) Initiative ($60,000)
2016	KY	Implement an electronic Engineering Policy Guide at the Kentucky Transportation Cabinet, including development, technology delivery, and training
2016	LA	1. Advancing 3D modeling by updating Louisiana Department of Transportation & Development’s current InRoads design software standards to meet the requirements of the new OpenRoads software ($38,080)
2016	LA	2. Improve and integrate Traffic Data for Data Driven Safety Analysis ($28,514)
2016	LA	3. Improve the partnerships with Local Public Agencies (LPA) through focus group sessions, partnership meetings, charter development, and recommendations for streamlining ($36,120)
2016	MA	Develop and implement a statewide Construction Project Documentation (CPD) SharePoint System
2016	ME	1. Establishing Planning and Environment Linkages by incorporating environmental and NEPA-related risks assessments into candidate project screening ($38,400)
2016	ME	2. Expansion of Maine Department of Transportation’s use of mobile devices for e-Construction in field inspection applications ($61,600)

Fiscal Year	State	STIC Incentive Projects
2016	MI	1. Develop Data-Driven Safety Analysis (DDSA) guidance ($28,000)
2016	MI	2. Adopt the use of the Super Air Meter for field testing of fresh portland cement concrete, including purchasing equipment, training, specification development, and outreach ($72,000)
2016	MO	1. Accelerating Traffic Incident Management (TIM) Data Collection by integrating data feeds with Regional Integrated Transportation Information Systems ($60,000)
2016	MO	2. Automated Traffic Signal Performance Measures (ATSPM) Peer Exchange ($2,490)
2016	MO	3. Host a Traffic Incident Management (TIM) Summit ($37,370)
2016	MS	e-Construction State's Construction Manual
2016	MT	Implement a statewide data innovation to incorporate resource leveling control practices into the Preconstruction Project Management scheduling application
2016	NC	Develop standards and specifications for preventive maintenance and repair of the North Carolina Department of Transportation's Ferry System in order to implement the principles of asset management
2016	ND	Continued Support for the North Dakota Department of Transportation's Transportation Innovations Program (TRIP)
2016	NE	Implement Safety and Asset Management (SAM) by providing the hardware, software, training, and technical support necessary for the initial development of TAM systems
2016	NH	1. Strategic Highway Research Program (SHRP2) Traffic Incident Management (TIM) Training ($16,000)
2016	NH	2. Implement e-Document Storage Solutions, including research, integration, preparing standard operating procedures, developing mobile applications, and training ($84,000)
2016	NM	Develop and implement a user's manual to convert LiDAR cloud data to point data in order for AutoCAD to read as a digital terrain model
2016	NV	Develop and pilot a "Smarter Work Zone System" for the Nevada Department of Transportation
2016	NY	1. New York STIC Innovation Workshop ($38,000)
2016	NY	2. Mobile LiDAR Scanning, Data Extraction, Digital Mapping, and Modeling of Pedestrian Sidewalk Ramp Locations along a 60-mile segment of Route 25, Long Island, NY ($62,000)

Fiscal Year	State	STIC Incentive Projects
2016	OH	1. Hold 12 LPA Days to advance e-Construction, Road Diets, and Data-Driven Safety Analysis with Ohio's Local Community ($60,000)
2016	OH	2. Development of a software application utilizing portable devices (smartphone/tablet) for construction contractors to perform required NPDES erosion and sediment control inspections ($40,000)
2016	OK	Develop standard drawings for Precast Concrete Drainage Structures per the AASHTO and ASTM Specifications
2016	OR	Implementation of the results from a research project to improve the Oregon Department of Transportation's Chip Seal Program, including implementation workshops, specification updates, and field demonstrations
2016	PA	Local Government Safety Seminar
2016	PR	Implementation of a Traffic Management Center, including the acquisition of new and the improvement of existing networking infrastructure
2016	RI	Implement the Rhode Island Department of Transportation e-Construction program, including workshops, training, software purchase and configuration, and purchasing electronic devices
2016	SC	Purchase GPS surveying equipment and deliver 3D modeling training
2016	SD	Host an innovation exchange with other States
2016	TN	Development of Predictive Analytics for HELP Truck Development
2016	UT	Advance the Design-Build program to include the use of Progressive Design-Build as an alternative contracting method
2016	VA	1. Development of standard specification and drawings for Carbon Fiber Prestressed piles ($30,000)
2016	VA	2. Installation of wildlife fencing and jump outs designed to guide wildlife into the underpass, including game cameras to verify the effectiveness of the installation ($70,000)
2016	VT	Development of a mapping framework for data integration
2016	WA	Develop a program to bundle bridge repair and replacement projects
2017	AZ	1. Purchase and evaluate 3D GPS-equipped tablets for use in field verification ($19,200)
2017	AZ	2. Purchase and evaluate Unmanned Aircraft System (UAS) for use in Arizona Department of Transportation Bridge Inspection ($18,100)

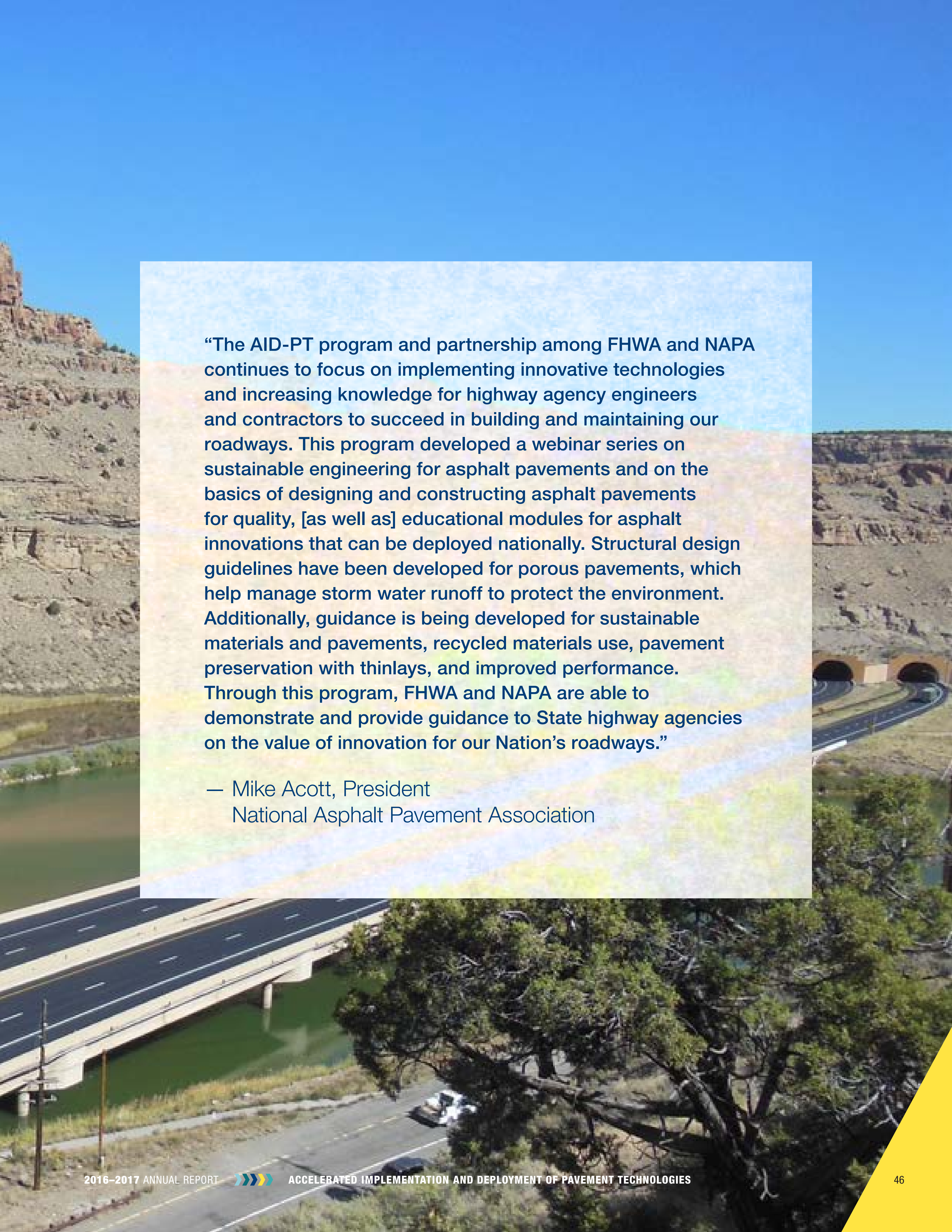
Fiscal Year	State	STIC Incentive Projects
2017	AZ	3. Pima Association of Government's Technology and Transportation Summit ($10,000)
2017	AZ	4. Purchase and use Unmanned Aircraft System (UAS) for showcasing Arizona Department of Transportation innovations in communication and outreach efforts ($2,700)
2017	AZ	5. Hold a Visioning Workshop for the AZTech Regional Partnership ($10,000)
2017	AZ	6. Hold a 2017 Arizona Council on Transportation Innovation (ACTI) Innovation Day ($24,000)
2017	AZ	7. Provide outreach, communication, facilitation, and coordination for the Arizona Council on Transportation Innovation (ACTI) ($16,000)
2017	IA	In situ modulus measurement using automated plate load testing (APLT) to support the implementation of pavement mechanistic-empirical (ME) design
2017	KS	Develop revised processes and training needed to continue with the implementation of 3D subsurface modeling
2017	ME	1. Provide Automated Traffic Signal Performance Measures (ATSPMs) education to signal designers and operators ($64,000)
2017	ME	2. Provide Strategic Highway Research Program (SHRP2) Traffic Incident Management (TIM) Training ($16,000)
2017	ND	Advance the e-Construction initiative, including combining two required diaries into one "General Project Diary" and adding a general file upload feature to upload, organize, and search documents
2017	NJ	Purchase, use, and evaluate Unmanned Aerial Systems (UAS) with the goal of developing guidance and specifications for bridge inspection and traffic incident monitoring
2017	NM	1. Purchase tablets for construction field inspection to pilot e-Construction on several projects ($40,000)
2017	NM	2. Coordinate and sponsor an NHI training session for 2D Hydraulic Modeling ($15,000)
2017	NM	3. Develop a mix design for bridge deck overlay utilizing local materials for UHPC ($45,000)
2017	OH	1. e-Construction – to purchase and evaluate software for use on mobile devices in order to execute work orders and conduct condition inspections ($28,000)
2017	OH	2. Community Connections – to create of a decision matrix that allows for input and output of multiple variables as well as scenario planning ($100,000)
2017	OH	3. e-Construction and asset management – to develop a sign condition inventory that can be integrated with GIS ($39,427.33)

Fiscal Year	State	STIC Incentive Projects
2017	OH	4. e-Construction – to purchase and evaluate Web-based software for e-Construction for several local municipalities ($26,400)
2017	OH	5. Local Technical Assistance Program support for EDC and STIC promotional activities and materials ($6,172.67)
2017	PA	1. Business plan development and outreach for a Traffic Incident Management (TIM) training facility ($54,000)
2017	PA	2. Modifications to Geosynthetic Reinforced Soil–Integrated Bridge System (GRS-IBS) specifications to allow for higher volume, longer structures, and heavier stream velocities ($46,000)
2017	UT	Develop a geospatially enabled indexing program in order to provide an easy point access to data from across the department without copying or duplication
2017	VT	Develop an electronic document management system for construction submittals
2017	WA	Evaluate Ground Penetrating Radar (GPR) to determine Asphalt Mixture In-Place Density and share these results statewide
2017	WY	Develop and deploy additional e-Construction features to the Wyoming Department of Transportation's paperless project management system for electronic workflow communications, construction e-Prequalification, submittal review, material e-Certification, equipment rental rate, and reporting



"The AID-PT program has made a significant and positive impact on helping highway agencies improve the condition of the national highway network. The program has increased awareness of technologies such as concrete overlays, helped advance pavement sustainability initiatives, and enabled significant progress with initiatives such as performance-engineered concrete mixtures. Much of the program's success and effectiveness is rooted in FHWA's embrace and emphasis on stakeholder input. As a result, the program has obvious benefits to industry and owners. However, the program ultimately benefits highway users and taxpayers through the advancement of technologies that contribute to longer lasting and more cost-effective pavement solutions."

— Gerald F. Voigt, P.E., President and CEO
American Concrete Pavement Association



"The AID-PT program and partnership among FHWA and NAPA continues to focus on implementing innovative technologies and increasing knowledge for highway agency engineers and contractors to succeed in building and maintaining our roadways. This program developed a webinar series on sustainable engineering for asphalt pavements and on the basics of designing and constructing asphalt pavements for quality, [as well as] educational modules for asphalt innovations that can be deployed nationally. Structural design guidelines have been developed for porous pavements, which help manage storm water runoff to protect the environment. Additionally, guidance is being developed for sustainable materials and pavements, recycled materials use, pavement preservation with thinlays, and improved performance. Through this program, FHWA and NAPA are able to demonstrate and provide guidance to State highway agencies on the value of innovation for our Nation's roadways."

— Mike Acott, President
National Asphalt Pavement Association

CONTACTS FOR MORE INFORMATION

Federal Highway Administration
Office of Asset Management, Pavement, and Construction
www.fhwa.dot.gov/pavement

Gina Ahlstrom
Team Leader
Pavement Design and Analysis Team
202–366–4612
gina.ahlstrom@dot.gov

U.S. Department of Transportation
Federal Highway Administration

FHWA-HIF-17-047