

RESEARCH

Makes the Difference 2017

AWARD-WINNING INNOVATIONS FROM STATE DOTs

SMART INFRASTRUCTURE ASSESSMENT AND REPAIR

MINNESOTA GOES SMALL TO INSPECT CULVERTS AT LOW COST

To inspect culverts too small for human access, Minnesota DOT had used a fiber-optic inspection system with extensive cabling and a support van, all running upward of \$100,000. With the help of hobbyists,



Source: Minnesota DOT

The Hydraulic Inspection Vehicle Explorer showed a culvert segment needed only \$1,000 in minor repairs, saving \$44,000 in replacement costs.

agency staff developed a low-cost alternative: the Hydraulic Inspection Vehicle Explorer (HIVE). With a total price tag of just \$2,000, the remote-control, waterproof HIVE was fitted with a camera and lights, and designed for operation by a single specialist. In tests of the first unit, video collected helped identify hidden areas of rebar exposure, deformation, and water infiltration far into a culvert. In another test, the HIVE showed that a culvert was in generally good condition despite deterioration at the ends, saving \$44,000 in unnecessary repairs. Based on initial success, Minnesota DOT is building and deploying more HIVEs throughout the state. [Article](#).

MAINE REPLACES UNKNOWNs WITH DATA FOR RIVET TESTING

Without hard data on the strength of bridge rivets, conservatively low default values have led to low rating factors for some truss bridges in Maine. This limited heavy truck loads (causing long and costly detours) or meant the prospect of unnecessary repairs. In partnership with Maine DOT's Advanced Bridge Safety Initiative Program, researchers removed in-service rivets from an existing bridge and tested their strength properties. They found the mean ultimate strength of the rivets to be 69.9 kilopounds per square inch, nearly 40 percent higher than the AASHTO standard for a rivet of unknown type and origin. In a case study, one Maine bridge was reanalyzed using the new rivet strength properties, and the new load ratings allowed for safe passage by heavy trucks. [Final report](#).

For one bridge, the improved load rating eliminated the need for a \$130,000 repair to the rivet connections.

PENNSYLVANIA DEVELOPS BEST PRACTICES TO PREVENT DECK CRACKING

Early age cracking in concrete bridges exposes the interior to water and chlorides, two culprits in the corrosion and freeze-thaw cycles that speed deterioration. Pennsylvania DOT tackled this issue with a research project that examined the causes of bridge deck cracking, assessed the effects of cracking on long-term performance, and, most importantly, provided recommendations for prevention and remediation. The resulting practical guidance addresses a host of approaches to fight deck cracking, encompassing best practices for materials,



Source: Pennsylvania DOT

The "Sweet Sixteen" state research projects

highlighted on these pages were selected by the Research Advisory Committee of the American Association of State Highway and Transportation Officials (AASHTO). They comprise four high-value research projects from each of the four AASHTO regions, funded primarily through the State Planning and Research (SPR) Program.

As the nation's cornerstone state research program, SPR provides Federal Highway Administration funding to the states to address top concerns and identify solutions at the state level. States further address areas of common concern through the Transportation Pooled Fund Program.

Complementing this publication are two companion pieces for 2017 focusing on research innovations in the areas of safety and maintenance. All of these publications may be found at research.transportation.org.

design, construction, and specifications. Researchers also developed a deck performance database for Pennsylvania, a model of deterioration mechanics, and a cost analysis of the recommended practices to help engineers make the most cost-effective decisions. [Final report](#).

A GREENER TRANSPORTATION SYSTEM

SMART SIGNALING IN TEXAS CUTS ENVIRONMENTAL IMPACT OF CONGESTION

The rapid growth of passenger vehicle and freight volume in Texas has meant an increase in urban congestion, greenhouse gas emissions, and fuel consumption. Through a Texas DOT research project, investigators developed a proactive traffic signal control system that integrated data from traffic signals, loop detectors, and connected vehicles. The resulting signal phasing and timing plans reduced congestion on arterial roads and maximized the performance of intersections. Queue lengths dropped by 60 percent, and wait times were cut by as much as 50 percent. The researchers also developed a framework for evaluating the advances of communication technologies in signal design. Texas DOT is building on its success by implementing the new control system at several intersections in the Houston area. [Research web page.](#)

Smart signaling reduced both greenhouse gas emissions and fuel consumption by about 25 percent.

WISCONSIN-LED POOLED FUND MAKES THE CASE FOR RECYCLED MATERIALS



Source: Recycled Materials Resource Center

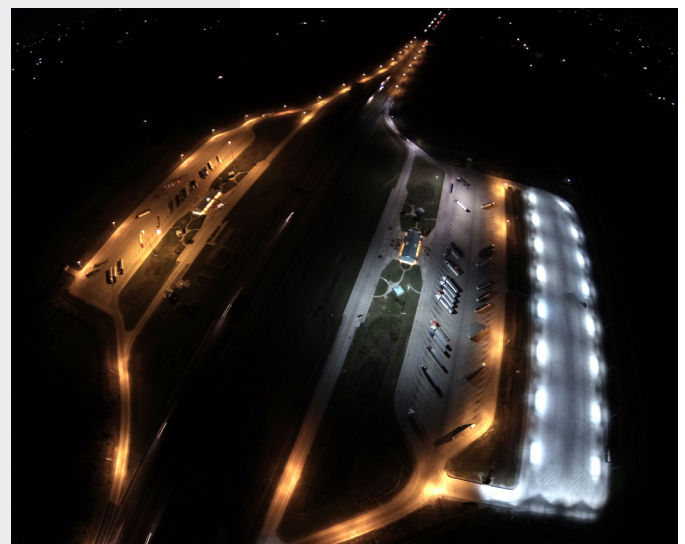
While recycled construction materials promote sustainability by cutting greenhouse gas emissions, energy use, and consumption of virgin resources, many such materials remain underutilized due to technical and institutional barriers. The Recycled Materials Resource Center (RMRC) is a multistate pooled fund effort led by Wisconsin DOT that helps state and federal agencies break through these barriers. Recent research by the RMRC found that states using recycled industrial byproducts—such as fly ash, recycled concrete aggregate, and recycled asphalt pavement—reduced gas emissions, energy and water consumption, and waste generation by 70 to 99 percent. In another project, researchers developed a geographic information system web application to connect producers and consumers of recyclable material to help transportation engineers and contractors make the best use of recycled materials. [Research web page.](#)

LED ROADWAY LIGHTING SAVES ENERGY FOR NEW YORK STATE

Replacing the 1.4 million municipal streetlights in the state of New York with LEDs would cut annual energy use by 524 gigawatt-hours.

LED technology has led a revolution in energy-efficient lighting for home, commercial, and industrial applications. New York State DOT saw that LED lights might be a viable replacement for the agency's high-pressure sodium highway lighting systems. Researchers analyzed a variety of LED systems for parkways and

arterial roadways, and identified several that provided suitable lighting levels while yielding significant energy savings. Expected energy cost savings ranged from 7 to 48 percent, with a savings payback period of 4 to 41 years. A follow-up collaboration project between New York State DOT and New York State Energy Research and Development Authority is taking the research results to the streets, with an installation in Colonie, New York, scheduled for completion in 2018. [Final report.](#)



Source: Indiana DOT

SAFER HIGHWAYS AND WORK ZONES

INDIANA ASSESSES SAFETY AND COST PERFORMANCE OF INTERSECTION LIGHTING

Because nighttime crashes have been an issue at unlit or poorly lit critical roadway safety spots such as interchanges, intersections, and railroad and highway crossings, Indiana DOT investigated the effects of lighting on crashes at intersections. Researchers first conducted lighting field tests to verify in-service light performance at selected intersection sites. To quantify safety effects of lighting at intersections, they developed crash modification factors for major types of intersections. These indicated an expected crash reduction of 10 to 16 percent compared with unlit intersections. Through life-cycle cost analysis, researchers also identified a significant drop in life-cycle costs for using new lighting technologies (LED, plasma, and ceramic metal halide) compared with traditional high-pressure sodium lights. Software and methods developed during the project will further help Indiana conduct more effective evaluations of intersection lighting and safety. [Final report.](#)

Installation of nighttime lighting at intersections can reduce intersection crashes by 10 to 16 percent.

ANTI-ICING REDUCES WINTER CRASHES IN CONNECTICUT

Starting with the 2006–2007 winter season, Connecticut DOT changed its winter maintenance practice on state-maintained highways, moving from traditional

Since switching to an anti-icing program, Connecticut has seen a 19 percent reduction in nonfatal crashes.

sand-salt deicing to an anti-icing program that included pretreating roads with salt brine, prewetting solid salt during spreading, and eliminating sand. After seven winter seasons, researchers analyzed the safety impact of these changes and found a 19 percent reduction in all crashes with nonfatal injuries and a 33 percent reduction in crashes with nonfatal injuries involving a road surface with snow, slush, or ice. While these results may be partially attributable to improvements in the safety technologies of modern vehicles, analysis suggests that anti-icing leads to a significant reduction in serious crashes by reducing the amount of time that roads are slippery. Connecticut DOT expects that the continued use of anti-icing will lead to increased traveler safety, easier winter weather maintenance, and fewer negative economic impacts of crashes. [Research paper.](#)

WASHINGTON STATE USES INNOVATIVE MATERIALS TO BUILD AN EARTHQUAKE-RESISTANT BRIDGE

Washington State DOT has incorporated bars of nickel-titanium shape memory alloy (SMA) and engineered cementitious composites (ECC) into the columns of a Seattle bridge, the first bridge application in the world to integrate these materials. Replacing conventional steel reinforcements and concrete, these innovative materials help create a structure that is more resilient to earthquakes. To validate these benefits, researchers evaluated the performance of SMA and ECC materials in scaled bridge column models of piers for an off-ramp bridge constructed at the south end of the SR 99 Alaskan Way Viaduct replacement project. The models were subjected to cyclic loading strong enough to lead to displacements similar to those in an actual earthquake. Test results showed that these materials minimized the damage in columns by allowing more energy to dissipate via higher displacements. Washington State anticipates that using SMA and ECC will eliminate the need for extensive repairs to damaged bridge components or replacement of entire bridges, resulting in savings that easily add up to the millions. [Research summary.](#)



Source: Washington State DOT

STRATEGIC PLANNING AND ADVANCED OPERATIONS

IDAHO WEIGHS NEW TECHNOLOGIES AND BEST PRACTICES FOR PORTS OF ENTRY

Idaho Transportation Department undertook a study to review best practices for state ports of entry (POE) programs, examine new and emerging technologies for commercial vehicle enforcement, and develop recommendations for future operations of Idaho's program. Researchers studied Idaho's POE program, which includes 17 fixed sites and approximately 200 rover sites.

Drawing also from a survey of customer needs and new POE technologies, investigators developed new concepts of operation for fixed and rover sites. Recommendations included weigh-in-motion and automatic vehicle identification technologies, online permitting, integrated data warehousing, and even relocation of a POE site. Idaho is moving forward with many of these recommendations and anticipates enhanced program efficiency and effectiveness, as well as better mobility for commercial trucks in the state. [Final report.](#)



Source: Idaho Transportation Department

GEORGIA AUTOMATES SIGN INVENTORY AND PAVEMENT CONDITION EVALUATION

Establishing comprehensive asset inventories is an extraordinary challenge, but this information is vital to making informed operations and management decisions. Georgia DOT turned to research to develop and use automatic collection methods based on mobile 3-D lidar, digital imaging, and 3-D line laser imaging for pavements. Now for the first time, Georgia DOT has inventoried a complete data set of 22,344 signs on its Interstate highways, including conditions and federal classifications. Beyond that, the agency also has a complete 1,513-mile survey of asphalt pavement condition data. Georgia's research showed that the collection methods are consistent, reliable, and cost-effective. As an added benefit, the automated methods enhance safety by eliminating workers' exposure to roadway hazards. [Final report.](#)

MISSOURI REACHES THE PUBLIC WITH ONLINE SURVEYS PROMOTED ON FACEBOOK

In line with its innovative approach to transportation, Missouri DOT piloted an online survey tool to gauge customer opinion about recent projects. Built on the SurveyMonkey platform and promoted through Facebook advertising, the surveys sought opinions on an urban bridge project and an Americans with Disabilities Act project in a rural community. Together with a communications and marketing campaign in each locality that complemented the Facebook ads, the survey efforts were a success. For the St. Louis bridge project, 314 of 612 responses came from

For one project survey, the Facebook ad was responsible for more than 50 percent of public responses.

the Facebook ad (and they were overwhelmingly positive with 95 percent of respondents indicating that the project was the "right transportation solution"). Compared with traditional mail surveys, the online tool improved response rate, cost less, and allowed for invaluable real-time results and customer dialogue. [Research summary.](#)

BUILDING BETTER ROADS AND BRIDGES

VIRGINIA DOT TO SAVE MILLIONS WITH COLD CENTRAL-PLANT RECYCLING

Virginia DOT partnered with the National Center for Asphalt Technology to perform one of the first full-scale accelerated loading studies of instrumented pavement sections using cold central-plant recycling (CCPR), an effective method for processing recycled asphalt for reuse in the field. Pavements using CCPR showed excellent performance, and results were even better when CCPR was used above a cement-stabilized base designed

Virginia expects to save \$10 million using cold central-plant recycling on a 7-mile-long Interstate project.

to simulate a full-depth reclamation (FDR) layer. Based on the results of this study, Virginia is now using these techniques on a 7-mile-long project along Interstate 64 to reconstruct two existing lanes with both CCPR and FDR, and add a third lane using CCPR in both directions. In addition to the environmental benefits of using recycled materials, the agency expects to save \$10 million on this project by using a recycled design in place of a traditional pavement structure. [Final report.](#)

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ARKANSAS INCREASES PRODUCTIVITY WITH GROUND PENETRATING RADAR

Ground penetrating radar (GPR) has long given Arkansas State Highway and Transportation Department a nondestructive way to determine pavement thickness. GPR can also be used during design and construction to detect and locate underground utilities, unmarked graves, and soil anomalies, as well as to inspect highway infrastructure projects such as bridges, bridge decks, and tunnels. Arkansas recently tested the accuracy of lower frequency GPR systems that might be more effective for these purposes than its current 2-gigahertz systems. Based on test results, the agency acquired new GPR equipment of various frequencies, along with a GPR software package, and conducted a training workshop on GPR methodology at agency headquarters. The new equipment and training have increased the productivity of design work for the agency, with the potential to save Arkansas millions of dollars. [Project overview.](#)



Source: Arkansas State Highway and Transportation Department



Source: Utah DOT

UTAH IMPROVES ITS COLD IN-PLACE RECYCLING DESIGN

Through a multiphase research effort, Utah DOT improved its construction process and specification for pavement rehabilitation projects that involve cold in-place recycling (CIR) asphaltic base with a solvent-free emulsion overlaid with hot mix asphalt or stone matrix asphalt. Field and lab testing showed that the new CIR mix design performed well, and researchers also found that the engineered emulsion CIR material behaved more like an unbound material during the construction phase. Using the new specification and performance tests from the research, Utah DOT successfully constructed four projects in 2016, for an estimated savings of \$1,870,000 on about 30 centerline miles when compared with typical reconstruction using hot mix asphalt. The agency will continue to monitor these projects for long-term performance, and it is planning at least one additional project for 2017 using the new specification. [Final report.](#)

Compared with hot mix asphalt reconstruction, cold in-place recycling generated savings of \$62,000 per centerline mile.

ROLLER-COMPACTED CONCRETE IN LOUISIANA IMPROVES PERFORMANCE AND REDUCES COSTS

For low-volume roads, thin roller-compacted concrete over a stabilized soil base could save \$133,000 per lane mile.

soil base generally has superior structural performance and load carrying capacity. These results led to the development of a thin RCC thickness design procedure. Louisiana estimates that by using a 5-inch-thick RCC surface instead of a 7-inch-thick asphalt surface, the agency will save about \$2.26 million for a typical two-lane, 10-mile road project. [Journal article.](#)

With an increase in shale gas exploration and agricultural and logging activities, Louisiana Department of Transportation and Development is interested in using thin roller-compacted concrete (RCC) surfaces for low-volume roadways that have frequent heavy and overloaded truck traffic. Researchers showed that a thin RCC layer over a stabilized



Source: Louisiana Department of Transportation and Development

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Access the electronic edition of this document with project links, as well as more high-value state DOT research projects, at AASHTO's research website, research.transportation.org.