

RESEARCH

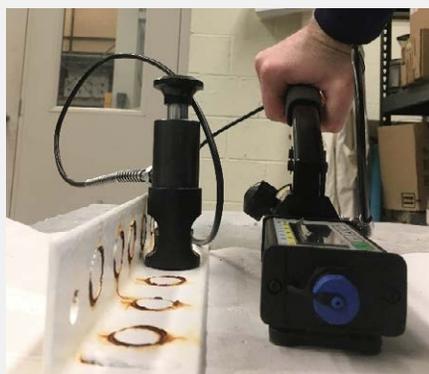
Makes the Difference 2019

Award-Winning Innovations from State DOTs

SMART MAINTENANCE AND PRESERVATION

NEW JERSEY PROTOCOL ENHANCES DURABILITY TESTING OF STRUCTURAL STEEL OVERCOATS

Applying a paint overcoat to steel structures like bridges can extend their service life. It's a more economical approach than repainting steel, and one that the New Jersey Department of Transportation (NJDOT) often uses. But in 2016, NJDOT's original test program for accepting overcoating systems was discontinued, so researchers had to develop a new protocol for testing overcoat durability. The updated method incorporates deep-freezing and circular scribes to significantly **reduce testing time from 1–2 years to 6 months**. It also identifies durable coatings, simulates field performance, and has excellent potential for adoption in accepting all new coatings. Using durable coating systems selected through accurate test methods will not only save money, but also reduce environmental pollution associated with degraded coatings. [Final report](#).



TEXAS STUDIES REPAIR METHODS TO AVOID EMBANKMENT SLOPE FAILURES



The Texas Department of Transportation (TxDOT) spends millions every year to repair recurring embankment slope failures—a costly and sometimes fatal problem that is exacerbated by Texas' extreme weather and soil conditions. In response, the agency initiated a project to determine the advantages and disadvantages of various current slope repair and stabilization methods (mechanical, earthwork, and biotechnical, among others). Using a literature review, surveys, interviews, and case studies, researchers evaluated each method's long-term performance, impacts to traffic during construction, and ease of

implementation. The project also recommended best practices TxDOT should use to avoid future recurring slope failures. By implementing this study's recommendations, TxDOT will **save over \$15 million in annual costs** associated with its slope repair projects. Moreover, the agency anticipates additional public safety, customer satisfaction, and environmental sustainability benefits. [Final report](#).

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 2019 focusing on research innovations in the areas of safety and bridges/structures and hydraulics. All of these publications may be found at research.transportation.org.

AMERICAN ASSOCIATION OF
STATE HIGHWAY AND
TRANSPORTATION OFFICIALS

AASHTO
THE VOICE OF TRANSPORTATION



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.

SMART MAINTENANCE AND PRESERVATION

NEW MEXICO EMBRACES SOLAR ENERGY IN HIGHWAY RIGHTS-OF-WAY

Installing solar power generation systems in highway rights-of-way can reduce a state DOT's carbon footprint and provide added cost benefits. Recognizing its solar energy potential, the New Mexico Department of Transportation (NMDOT) established the Free Energy Solar Highway Program research project. The project identified lessons learned at 11 successful solar highway projects in the United States, focusing on best practices regarding power purchase and land lease agreements as well as ownership and maintenance of photovoltaic systems. Researchers also determined the financial feasibility of generating solar power in different NMDOT districts at the lowest possible cost. In addition to promoting a transition to renewable energy, this research project has identified opportunities for NMDOT to generate revenue through ground-mounted solar systems and **reduce its energy costs by more than \$300,000 over 20 years**. [Final report](#).

KANSAS PROGRAM REDUCES STRESS ON CULVERTS

Often installed at shallow depths, reinforced concrete box culverts must be able to sustain the weight of the heavy backfill materials and vehicles above them. Existing AASHTO standards had not considered how these stressors affect an aging culvert's capacity to handle repeated truck loading, so the Kansas Department of Transportation (KDOT) sponsored a Kansas Transportation Research and New-Developments study to fill this gap. After conducting field tests, researchers developed an improved load testing program—and corresponding user manual—with numerical models that KDOT engineers can input into existing AASHTO software. The software allows users to compute the impacts that various trucks; backfill materials; and pavement types, thicknesses, and elasticity moduli have on the load and stress distribution of buried culverts. By considering this load distribution factor, KDOT will experience safer designs, cost savings, and increased life cycles for these structures. [Research brief](#).

SAFER HIGHWAYS AND WORK ZONES

FLORIDA COUNTERMEASURES ELIMINATE WRONG-WAY DRIVING COLLISIONS



After ranking third in the United States for wrong-way driving (WWD) crashes, Florida has become a pioneer in developing countermeasures to avoid these rare but often fatal incidents. One Florida Department of Transportation (FDOT) project is specifically targeting the state's 1,447 highway off-ramps. Researchers used demographics data from past WWD crashes to identify the preconditions and predominant factors (impaired drivers, drivers aged 65 or older, or tourists) contributing to accidents at each off-ramp. The research results provided FDOT

with recommended countermeasures specific to each factor—such as placing LED lights around wrong-way signs for older drivers or installing red rectangular rapid flashing beacons for impaired drivers. FDOT also now has a prioritized list of off-ramps, indicating where it should deploy WWD countermeasures first. The agency estimates that full implementation of countermeasures at top-ranked locations **could eliminate nearly 100 percent of WWD crashes at Florida off-ramps**. [Final report](#).

CONNECTICUT DEVELOPS STRATEGIES TO SAVE PEDESTRIAN LIVES

In 2016, Connecticut ranked 20th in the nation for pedestrian fatality rates. To work toward a goal of zero traffic-related deaths, the Connecticut Department of Transportation (CTDOT) conducted a 2017–2018 observational study of pedestrians. Researchers analyzed video footage and data from six “hotspot” intersections across the state—selected based on a combination of crash volume and severity—to understand pedestrian risk-taking behaviors, such as not waiting for a crossing signal, not checking for oncoming traffic, or texting while crossing. They used the study results to develop a pedestrian safety guide with countermeasures to combat these behaviors. Recommendations include conducting educational campaigns and outreach; building public support for targeted police enforcement of pedestrian safety laws; and upgrading crosswalk areas, signals, and other pedestrian infrastructure. In collaboration with the University of Connecticut, CTDOT also purchased a full-scale, state-of-the-art driving simulator to continue studying pedestrian safety. [Final report](#).

ARKANSAS IDENTIFIES SUBSURFACE HAZARDS WITH GEOPHYSICAL METHODS

Understanding subsurface conditions—and whether any hazardous slope or bedrock issues exist—leads to safer roads and helps avoid unexpected expenses related to slope remediation and bedrock removal. The Arkansas Department of Transportation (ARDOT) is exploring geophysical methods, which create two- and three-dimensional subsurface maps, as a way to locate such hazards along its highways. Researchers field tested these methods at four sites that have shallow bedrock and weak slope stability, analyzing the advantages, benefits, costs, limitations, and accuracy of each. The project provided ARDOT with best practices, equipment recommendations, and training materials for select geophysical



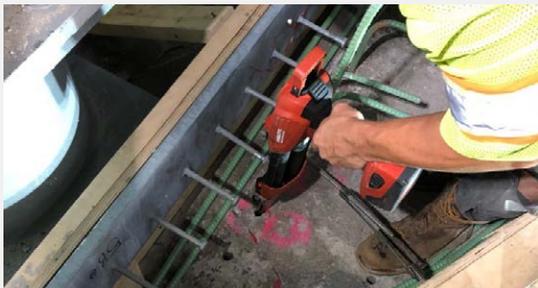
methods, as well as slope stability data sets and analyses. Geophysical methods have already proven to be cost-effective, **saving ARDOT \$750,000 on three construction projects**. Once fully implemented, the project could **save ARDOT over \$3 million** in its first year. [Research presentation](#).

SMART MAINTENANCE AND PRESERVATION

MASSACHUSETTS ENSURES ANCHORING MATERIALS CAN PERFORM UNDER PRESSURE

Adhesive and cementitious anchoring materials are easy to attach to existing structures and can be used to efficiently repair bridges, tunnels, and other infrastructure. But they're also vulnerable to environmental conditions and can fail over time due to long-term tension load, potentially leading to catastrophic accidents like the 2006 I-90 tunnel ceiling collapse in Boston.

To avoid future accidents, the Massachusetts Department of Transportation (MassDOT) developed a new process to evaluate the strength of anchor materials before they are placed on its Qualified Construction Materials List (QCML). Researchers studied adhesive anchors from various manufacturers—analyzing parameters such as installation time, bonding material strength, and performance under extreme temperatures—to create new implementation criteria and procedures for qualifying anchor construction materials. Under the new criteria's submission requirements, the agency will accept higher-quality products and expects to see increased anchor lifespans and cost savings. MassDOT has already updated its QCML and is using one new anchor product on a bridge replacement project. [Final report.](#)



NEW CONCRETE MIX SAVES MONEY FOR IDAHO'S ACCELERATED BRIDGE CONSTRUCTION PROJECTS

For several years, the Idaho Transportation Department (ITD) has been using ultra-high performance concrete (UHPC) to connect precast deck bulb-tee girders during accelerated bridge construction projects. Although UHPC is durable and strong, this proprietary material is labor-intensive to place and expensive—costing \$10,000 to \$15,000 per cubic yard. Needing an affordable alternative, ITD and researchers at Idaho State University developed a new girder connection using a high early strength (HES) concrete mix with polypropylene fibers. Researchers analyzed the connection in the lab and used a computer model to confirm its performance under AASHTO strength and fatigue limit states. Full-scale field testing under truck loading further verified the connection's performance. HES concrete can be placed similarly to conventional concrete and **costs only \$800 per cubic yard**. ITD has already developed several bridge designs with the new connections, and the combined anticipated **cost savings for those bridges is \$800,000**. [Final report.](#)

BETTER ROADS AND BRIDGES

COST-EFFECTIVE METHOD RESTORES MINNESOTA'S CONCRETE BEAMS TO ORIGINAL STRENGTH

After encountering concrete girder ends with significant deterioration on a bridge that was nearing the age of replacement, the Minnesota Department of Transportation (MnDOT) developed an innovative solution based on a smaller-scale repair technique researched in Michigan. MnDOT repaired the beams using reinforcement cages and shotcrete—a method



that can **save \$290,000 per project** and doesn't require traffic closures, beam fabrication, or deck removal. When MnDOT replaced the bridge several years later, researchers tested the salvaged beams in a laboratory and determined they could withstand more load than their original counterparts. MnDOT and the City of Saint Paul have since used the technique on three projects, including an I-94 bridge repair in downtown Minneapolis. Other state DOTs have plans to follow MnDOT's lead on their own bridge concrete beam repair projects. [Project web page.](#)

ILLINOIS ULTRASONIC IMAGING DEVICE IDENTIFIES CONCRETE DEFECTS

Bridge and pavement testing is vital for detecting defects in aging concrete infrastructure, which deteriorates and cracks over time. The Illinois Department of Transportation (IDOT) initiated a project to identify a non-destructive technology to meet this testing need, ultimately settling on an ultrasonic shear wave imaging device known as MIRA. In addition to investigating MIRA's ability to complete field tasks, such as identifying bridge deck delamination, concrete thickness, and internal steel bars and dowels, researchers developed a MIRA user manual, video, and hands-on training to introduce IDOT staff to the device's functions and operations. Not only is MIRA portable—meaning it can be quickly deployed to different field locations—but it also generates two- and three-dimensional images that a technician can easily read to identify defect locations in need of repair. IDOT will deploy MIRA for targeted spot inspections, and District 6 and USACE have already used the device to locate rebar on the new Meredosia Bridge for river gauge installation. [Final report.](#)



STRATEGIC PLANNING AND ADVANCED OPERATIONS

FUNDING FOR PUBLIC PORTS BOOSTS MISSOURI'S ECONOMY

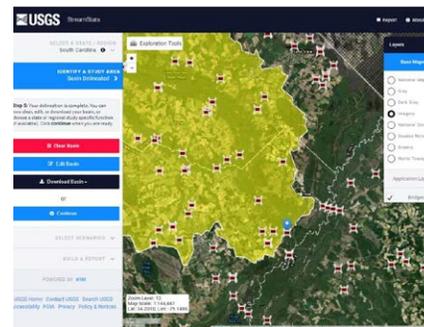
Missouri's 12 public ports and 1,050 miles of inland waterways connect the state's shippers to ports along the entire Mississippi River and to markets worldwide. The Missouri Department of Transportation (MoDOT) therefore made it a priority to secure state and private funding for capital improvements to these vital resources. The agency worked with public port authorities on an 18-month project that showed stakeholders how ports enhance the state and local economy. Through port/shipper interviews, site visits, a commodity flow data analysis, and economic modeling, the research team found that Missouri's public ports bolster employment in almost every county—supporting nearly 290,000 jobs, \$15.7 billion in labor income, and \$100.6 billion in economic activity annually. Thanks to the study, state funding for ports rose from \$1.5 million in fiscal year 2018 to \$7.8 million in 2019, and MoDOT has seen increased interest in port investments and fewer port program reductions. Overall, the ports help **create \$2.4 billion in annual state and local tax revenue**. [Project web page](#).



to other state DOTs. Researchers analyzed turnover data from fiscal year 2016 and conducted focus groups to gauge why staff—especially younger, early-career employees—choose to stay or leave VTrans. They also distributed a knowledge assessment litmus test among VTrans managers and an in-depth survey across three agency units to identify barriers to sharing knowledge. This effort provided VTrans with a comprehensive exit questionnaire to gather data from departing employees, recommendations to improve employee retention, and tools to capture and store tacit knowledge and expertise. The project has received high-level support from VTrans leadership, and parts of the project have been adapted into agency practice. [Final report](#).

STREAMFLOW APP HELPS SOUTH CAROLINA PREPARE FOR FLOODING

The South Carolina Department of Transportation (SCDOT) worked with the U.S. Geological Survey to develop an innovative tool that standardizes drainage



area delineations, streamlines the computation of basin characteristics, and helps engineers locate bridges and roadways susceptible to flooding. Using LIDAR-derived elevation and stream data, the StreamStats web app delineates South Carolina watersheds and generates state-specific streamflow statistics and map layers. Users can compare historic bridge scour data and indirect flow calculations at particular sites. StreamStats has streamlined the time it takes for SCDOT engineers to obtain the information they need to scope and design discharge areas. What would previously take hours or even days for each watershed has been reduced to five minutes or less. SCDOT estimates that the app could help the agency **save more than \$20 million** in engineering costs over the next 10 years. [Final report](#).

IMPROVED METHODOLOGY HELPS UTAH PREDICT EARTHQUAKE LIQUEFACTION

With support from other states, the Utah Department of Transportation (UDOT) developed a probabilistic, performance-based design method that incorporates uncertainties (ground motions, triggering, and other effects) in predictions of earthquake-induced soil liquefaction. This probabilistic analysis is simpler than a full performance-based analysis, and it produces more consistent seismic hazard estimates that UDOT's geotechnical engineers can use when designing transportation projects and infrastructure to withstand earthquakes. UDOT incorporated the methodology into SPLiq (Simplified Performance-based Liquefaction

Analysis Tool), a new spreadsheet tool that enables users to quickly estimate site-specific parameters such as liquefaction triggering, post-liquefaction settlement, lateral spread displacement, and seismic slope displacement. Several projects have already used SPLiq, and the tool has reduced liquefaction hazard estimates for bridge and retaining wall projects—resulting in lower design, construction, and mitigation costs for UDOT. [Project web page](#).



VERMONT IMPROVES EMPLOYEE RETENTION AND KNOWLEDGE SHARING PRACTICES

Recognizing high employee turnover can result in a corresponding loss of operational knowledge, the Vermont Agency of Transportation (VTrans) commissioned a study to assess its current employee retention and knowledge management practices and determine how these compared

NEW DATA TOOL IMPROVES GEORGIA'S WORKFORCE

Without a tool to analyze existing data on its nearly 4,000 employees, the Georgia Department of Transportation (GDOT) lacked important insights for its workforce planning and knowledge management efforts. To fill this gap, GDOT created an integrated, modular software platform known as the HR Data Tool, as well as an accompanying user's manual and training module. Developers used data mining and analysis techniques to program the tool, which evaluates parameters such as job shadowing, workforce planning, and training and development, among several others. GDOT leadership can now easily identify key persons, positions, competencies, and vacancies and design training activities that better prepare its workforce to fill these critical roles. Beyond supporting internal decision-making and planning, the HR Data Tool also allows GDOT to focus on recruiting qualified outside candidates for any skillsets that may be missing in-house. [Final report](#).

Photos courtesy of: NJDOT, TxDOT, NMDOT, KDOT, FDOT, CTDOT, ARDOT, MassDOT, MnDOT, IDOT, ITD, MoDOT, UDOT, VTrans, SCDOT, GDOT