

# RESEARCH

## Makes the Difference 2016

INNOVATIVE STATE DOTs ADVANCE TRANSPORTATION

### BUILDING BETTER ROADS AND BRIDGES

#### GEORGIA EXTENDS MARINE BRIDGE LIFE USING STAINLESS STEEL REINFORCEMENT



Marine environments can be highly challenging for concrete bridges with the salt from ocean water corroding steel reinforcements in their foundations. After 11 bridges in coastal Georgia were found to have remaining service lives of only 24 to 58 years, Georgia DOT investigated replacing conventional steel in prestressed concrete piles with stainless steel alloys.

**S**tainless steel pile elements extend marine bridge life beyond 100 years.

Results showed that these alloys can be used with the same design requirements and construction procedures as conventional prestressing strand and wire reinforcement, but with an expected service life of more than 100 years. Based on this research, Georgia DOT used piles reinforced with stainless steel on a bridge completed in 2016 in Liberty County, and nearby states are constructing and testing bridges with similar reinforcing.

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. 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 aid 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.

#### ILLINOIS’ PROTOCOLS ENSURE THE PERFORMANCE OF ASPHALT MADE WITH RECYCLED MATERIALS

While there are significant economic and environmental benefits to using reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) in hot-mix asphalt (HMA), the mixes must be carefully designed and tested to minimize fatigue cracking, low-temperature cracking, and other deterioration related to long-term aging. Illinois DOT has developed an innovative and practical new test method for evaluating the performance of HMA mixtures with high amounts of RAP and RAS. Known as I-FIT, this method modifies the semicircular bend test and adds a flexibility index that allows the quantification of an HMA mixture’s cracking resistance in a consistent way. Illinois DOT has implemented a special provision specification that includes the use of I-FIT currently on 11 related pilot projects. With its reliable, repeatable test results, I-FIT will help provide durable asphalt pavements while achieving lower life-cycle costs.

#### QUALITY CONTROL FOR EMULSIONS IMPROVES NORTH CAROLINA PAVEMENTS

Asphalt emulsions are used as tack coats to bond asphalt concrete layers and as a bonding agent for aggregates in chip seals. Emulsion application rates (EARs) are critical to the performance of these surface treatments, but can be highly variable due to absorption by the existing paving surface and variability in distributor nozzle output, fan patterns, speed, and flow rates. North Carolina DOT developed a quality control method for emulsions that includes a new test for adjusting EARs based on pavement absorption rates as well as tests for controlling EAR variability. Improved quality control of EARs will lead to longer pavement service life, decreased life-cycle costs, and safer pavement surfaces.



# A GREENER TRANSPORTATION SYSTEM

## MARYLAND IMPROVES MEDIAN LANDSCAPE AND DRAINAGE

Maryland State Highway Administration explored new practices to loosen compacted soil in medians and other roadside areas to support healthy vegetation, stormwater infiltration, and tree growth. Researchers evaluated test plots using a technique called suburban subsoiling, which combines deep soil ripping and the addition of compost. A before-and-after study of vegetation and soil characteristics showed this to be an effective treatment.

After rehabilitation, soil density decreased nearly 30 percent, the mass of organic matter almost doubled, and the soil structure went from being effectively impermeable to having an infiltration rate of 8.4 inches of water

per hour. Forage radishes planted as a means of “bio-drilling” were also effective in further loosening the compacted soil. Maryland aims to use this land development technique to reduce costs for maintaining medians and roadsides and to foster long-term landscape sustainability.

**R**ehabilitation of compacted median soil doubles vegetation growth and transforms soil from being impermeable to passing 8.4 inches of rain per hour.

## SPECIES-TARGETED HIGHWAY CROSSINGS REDUCE COLLISIONS IN WYOMING



Wyoming research keyed in on employing the right highway crossing solutions for the right species. Wyoming DOT installed six underpasses and two overpasses along a state highway and undertook a three-year study to track movement of two large species with different movement patterns: mule deer and pronghorns. Researchers found 79 percent of mule deer moving from one side of the highway to the other used the underpass, and 93 percent of pronghorns used the overpass.



In this study, the combination of overpass and underpass construction, together with continuous fencing, reduced wildlife-vehicle collisions of all species by approximately 81 percent and completely eliminated collisions with pronghorns. The findings highlight that species-specific preferences are an important consideration for highway crossing structures both to reduce wildlife collisions and mitigate the fragmentation of animal habitats.

# STRATEGIC PLANNING AND ADVANCED OPERATIONS

## NEW MEXICO MAKES THE BUSINESS CASE FOR ASPHALT MODIFIERS

Adding modifiers to liquid asphalt has well-documented benefits for pavement life and performance, but the economic case for this practice has been less clear. A New Mexico DOT research study found that traditional cost assumptions are outdated. With updated costs, an economic analysis showed that for the state's annual \$100 million asphalt expenditures, using elastic polymers would cost less than an additional 5 percent, but would extend the pavement life by more than 20 percent. This would net an annual savings of over \$4.5 million using typical prescribed formulations. The study also revealed that optimization using up-to-date knowledge about prices, modified asphalt behavior, and test procedures will further decrease life-cycle costs. These factors will be integrated in a subsequent phase.



**F**or annual state asphalt pavement expenditures of \$100 million, asphalt modifiers could net over \$4.5 million per year in savings.

## CALIFORNIA REDUCES COSTS WITH SCALABLE TRAFFIC MANAGEMENT

Caltrans successfully deployed the Intelligent Roadway Information System (IRIS), an advanced traffic management system (ATMS), in four districts and found that it offers rural areas a robust and unified traffic management program that is expandable, scalable, and reliable. Traffic management operators can centrally manage traffic devices and applications from a single integrated interface. IRIS employs an open-source methodology that reduced the life-cycle costs by approximately 72 percent compared with the full ATMS software package used in urban areas. Caltrans developed the following new features to enhance the original IRIS application created by Minnesota DOT: automated warning, performance measurement system, closed-circuit television, changeable message signs, and integrated mapping.

## IOWA'S SELF-CLEANING CULVERTS ARE A LOW-MAINTENANCE SOLUTION

Iowa DOT knows that proper water control is vital to highway operations, and its culverts are designed to handle 10- to 50-year water flow events. However, the potential for blockages due to sediment and debris prompted Iowa DOT to investigate novel designs to assure capacity. A multipart research project led to the development of a self-cleaning culvert design requiring little maintenance. Installation and testing of the wedge-shaped hydraulic flume design have shown that it is effective in streamlining water flow and increasing turbulence, which reduces sedimentation and vegetation growth. The wedges are easy to install and retrofit on existing culverts, giving Iowa an effective, low-maintenance method to ensure the critical functioning of culverts.



# SMART INFRASTRUCTURE ASSESSMENT AND REPAIR

## DRONES MEAN FASTER, SAFER BRIDGE INSPECTION IN MINNESOTA

Unmanned aircraft systems (UAS, or “drones”) are up to the serious business of bridge safety inspection in Minnesota, with research demonstrating that UAS lower safety risks to bridge inspectors, improve access to structures, and reduce inconvenience to the public. At the same time, UAS provide high-quality data to inspectors with the

**Unmanned aircraft systems trim bridge inspection time from eight days to five and save 66 percent in costs.**

successful integration of high-definition still, video, and infrared imaging with 3-D software. Minnesota also tested GPS-independent UAS specifically designed for inspecting bridges and confined spaces. For the structures studied, UAS trimmed inspection time from eight days to five, increased data quality, and yielded savings of 66 percent compared with traditional bridge inspection. The research results are timely, offering an economical alternative to meet new inspection requirements for some 2,700 Minnesota bridges.



## RHODE ISLAND REFINES NONDESTRUCTIVE BRIDGE DECK EVALUATION

Nondestructive testing is an important way to detect invisible damage to infrastructure assets. Rhode Island DOT sought to increase the value of two existing techniques—ground penetrating radar and infrared thermography—by using them in concert. A research study of both methods indicated that they revealed comparable overall damage on a Rhode Island bridge deck, and a point-by-point evaluation of “healthy” versus “damaged” across the bridge deck showed 93 percent agreement between the methods. The data collection and evaluation guide resulting from this research study will allow bridge inspectors and engineers to have a higher level of confidence in the detected hidden damage indicated in structures. This in turn will help engineers plan for bridge deck repair and rehabilitation in the most targeted and cost-effective manner possible.

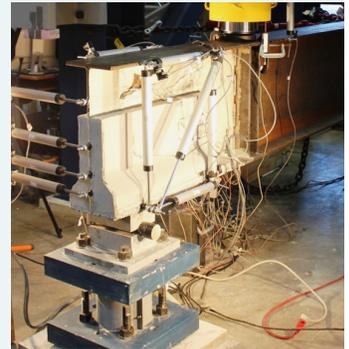


## ULTRA-HIGH PERFORMANCE CONCRETE IMPROVES REPAIRS FOR CONNECTICUT BRIDGE BEAMS

Connecticut DOT investigated a novel approach for the rehabilitation of corroded bridge beams using ultra-high performance concrete (UHPC), a fiber-reinforced composite with high compressive strength and excellent durability. Large-scale laboratory

investigation showed that a severely corroded beam had only a quarter of the bearing capacity of an undamaged beam. However, a corroded beam repaired by encasement in UHPC

outperformed the undamaged beam, exhibiting a 27 percent higher bearing capacity. The beam repaired by UHPC ultimately failed due to bending as opposed to buckling. The results of these experimental tests, along with additional benefits of the UHPC repair, show the promise of using UHPC to extend bridge life. These benefits include ease of preparation, reduced cost, and minimal disruption of traffic.



## CAMERAS WORK AS STRAIN GAUGES IN NEW HAMPSHIRE

Engineers commonly use strain gauges to gather critical data on how bridges respond to loading. However, these sensors must be affixed directly to a bridge’s metal structure, which requires the removal of the paint that protects against corrosion. New Hampshire

DOT investigated a less invasive alternative: commercially available digital cameras that can be temporarily clamped to a painted bridge. The cameras record visual deflections in removable chalk marks on the bridge, and the visual recording data can be used to calculate strain. A side-by-side study on a New Hampshire bridge revealed a close correlation between traditional strain gauge testing and the digital camera methodology. This gives New Hampshire the ability to collect highly accurate bridge loading data while minimizing maintenance impacts.



**A corroded bridge beam repaired with ultra-high performance concrete had a 27 percent higher bearing capacity compared to an undamaged beam.**

# SAFER HIGHWAYS AND WORK ZONES

## NEW COUNTERMEASURES REDUCE WRONG-WAY DRIVING CRASHES IN FLORIDA AND TEXAS

Wrong-way crashes are a major challenge for transportation agencies and are usually caused by drug- or alcohol-impaired drivers mistakenly entering the highway via exit ramps. Two agencies recently conducted research to evaluate the causes of wrong-way crashes and test the effectiveness of countermeasures for preventing them.



Florida DOT research recommended and validated an enhanced system of wrong-way driving countermeasures. Driving simulators showed a reduction of wrong-way movements among study participants—from 3.3 percent with standard countermeasures down to 0 percent with enhanced countermeasures. Florida also field-piloted wrong-way signs bordered with red flashing LED lights triggered by a wrong-way vehicle; these had a 96 percent success rate at 17 exit ramps in southern Florida. In a related project, Florida installed a system that detects a wrong-way driver, activates red rectangular flashing beacons, and notifies the Traffic Management Center to take action.

A Texas DOT project used data on crashes and countermeasures to evaluate the causes of wrong-way driving and develop wrong-way warning messages for dynamic message signs. Researchers also installed radar and illuminated wrong-way warning signs on the US 281 corridor and in construction zones. As a result, San Antonio has seen a 30 percent reduction in wrong-way driving incidents, and the number of wrong-way driving 911 calls decreased from 330 to 280 over three years. Texas DOT personnel estimate that 40 lives have been saved due to monitoring high-incidence corridors and implementing wrong-way warning devices.

**In San Antonio, annual wrong-way driving 911 calls decreased from 330 to 280 over three years.**

## VIRGINIA IMPROVES CRASH RATE PREDICTIONS WITH CONTINUOUS FRICTION DATA

A recent pilot study by Virginia DOT collected continuous pavement friction data for a single district of 650,000 residents to see whether it could help improve roadway crash rate predictions. By analyzing friction data in combination with crash records, Virginia DOT significantly improved the predictive power of its safety performance models. The improved models predict that using a conventional plant-mix overlay to improve

**Pavement modeling points the way to 761 fewer crashes in a region of 650,000 residents, saving more than \$100 million every three years.**

friction would lead to 761 fewer crashes in this district, with more than \$100 million in savings every three years. Research results improve the ability of engineers to match user demands for pavement friction with the capabilities of common surface treatments. Virginia DOT plans to collect continuous friction data on thousands of centerline miles in Virginia as well as data on texture, cross-slope, and grade.

## ENGINEERING FOR OLDER DRIVERS REDUCES CRASHES AND COSTS IN MICHIGAN

Faced with an increasing number of older Michigan drivers involved in traffic collisions, Michigan DOT has been implementing countermeasures to address their needs for more than a decade. A recent project quantified the safety impacts and cost-effectiveness of these improvements by analyzing historical crash data before and after implementation. The combination of a Clearview font on guide signs and fluorescent yellow sheeting for warning signs reduced crashes by 24 to 33 percent, with a benefit ranging from \$1,090 to \$7,456 for every dollar spent. Arrow-per-lane signing was shown to reduce crashes among drivers 65 and older by 68 percent, producing \$1,440 in benefits for every dollar invested. Other improvements to aid older drivers also led to cost-effective reductions in crash rates, and researchers recommended continuing to install them at appropriate locations.



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**DISCLAIMER** The opinions and conclusions expressed or implied in reports are those of the research agencies. They are not necessarily those of the Transportation Research Board, the Academies, or the program sponsors.

Project links are available in the online version of this document at [research.transportation.org](https://research.transportation.org):

GEORGIA'S STAINLESS STEEL BRIDGE ELEMENTS

**Final report**

ILLINOIS' ASPHALT MIX TESTING

**Final report**

NORTH CAROLINA'S QUALITY CONTROL FOR TACK

**Research project web page**

MARYLAND'S MEDIAN SOIL IMPROVEMENT

**Project overview**

WYOMING'S ANIMAL HIGHWAY CROSSINGS

**Final report**

NEW MEXICO'S EVALUATION OF ASPHALT MODIFIERS

**Final report**

CALIFORNIA'S ADVANCED TRAFFIC MANAGEMENT SYSTEMS

**Final report**

IOWA'S SELF-CLEANING CULVERTS

**Final report**

MINNESOTA'S BRIDGE INSPECTION DRONES

**Project web page with final report**

RHODE ISLAND'S NONDESTRUCTIVE BRIDGE DECK EVALUATION

**Research program web page**

NEW HAMPSHIRE'S DIGITAL CAMERAS FOR BRIDGE LOADING

**Final report**

CONNECTICUT'S BRIDGE BEAM REPAIR

**Final report**

FLORIDA'S WRONG-WAY DRIVING RESEARCH

**Statewide crash study report and simulator study report**

TEXAS' WRONG-WAY DRIVING COUNTERMEASURES

**Final report**

VIRGINIA'S CRASH PREDICTION METHODOLOGY

**Final report**

MICHIGAN'S OLDER DRIVER CRASH COUNTERMEASURES

**Final report**

See AASHTO's research website, [research.transportation.org](https://research.transportation.org), for additional high-value state DOT research projects.