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Alabama (1)

Project Information

High Value Research Title	Self-Centering Connections for Traffic Sign Structures
Project Number	930-865R
Project Cost	$106,000
Project Duration	12 months
Web link	

Submitter

Submitter Agency	Alabama Department of Transportation
Submitter (Name, Address, Phone, Email)	Ron Johnson, ALDOT johnsonrl@dot.state.al.us

Research Program

No data entered for this section

Research and Results

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Project Description SELF-CENTERING CONNECTIONS FOR TRAFFIC SIGN STRUCTURES By Ying-Cheng Lin (Assistant Professor of Structural Engineering at UAH) RESEARCH NEED: Steel structures for supporting traffic signs, luminaries, and signals are designed as intended to dissipate energy by developing inelastic deformation during severe wind loading (ex. hurricanes or tornadoes, etc.). Inelastic deformations result in permanent damage and out-of-plumb appearance to structures (Fig. 1). Repairing or replacing damaged members have caused enormously direct and indirect costs. I\JEW APPROACH: Self-centering traffic poles have the potential for the following features : (a) energy dissipation is provided by cost-effective devices, not by member permanent deformations; (b) elastic stiffness and strength are similar to conventional traffic sign structures; (c) gap opening at connections enables relative rotations without damage to members; (d) forces in tensioned bolts close connection gap opening and bring the structure back to its plumb position (i.e., self-centering).

	SELF-CENTEIRNG CONNECTION CONCEPTUAL BEHAVIOR: The features described above are due to the self-centering behavior of bolted connections. As shown in Fig. 2 as one example of applications to traffic sign structures, the traffic pole base plate-support connection is pre-compressed by tensioned bolts. The connection conceptual behavior is presented by the bending moment-relative rotation (M-8r) response as shown in Fig. 3. When connection bending moment reaches the imminent gap opening bending moment (MGoL the softening behavior at point A occurs, and a gap opens at the base plate-support interface (see Fig. 4) which initiates a connection relative rotation. Note that this rotation is not a result of permanent deformations. Therefore, there is no damage to the members. When the connection bending moment in Fig. 3 reaches the yield bending moment of the tensioned bolts (MBTYL the second softening behavior occurs at point B. Upon unloading at point C in Fig. 3, energy is dissipated by the energy dissipation (ED) devices shown in Fig. 2. Eventually, at point D in Fig. 3, the force in the tensioned bolts closes the gap shown in Fig. 4, bringing the traffic pole structure back to plumb position (i.e., self-centering behavior). 1 KEY DESIGN CONSIDERATIONS: • Self-Centering traffic pole systems use similar components (ex. bolts, base plate, etc.) for existing traffic pole systems. The differences are: (1) the initial tension force in the bolts is controlled and (2) cost-effective ED devices are added. Torque wrenches can be used on site to control the bolt initial tension force during construction. ED devices could be sealed piston dampers or friction ED devices that made of sandwiched metal plates to meet the costeffective consideration. • If MGO is selected to be smaller than the bending moment yield capacity (My) of the pole as shown in Fig. 5, the connection can open a gap and rotate without damage to the pole. • Gap opening does not occur under frequently occurring wind, but only occurs when severe wind strikes. Therefore, self-centering traffic sign structures act like conventional structures under frequently occurring wind; under severe wind loads, they do not damage.

Florida (3)

Project Information	
High Value Research Title	ITS Data Capture and Performance Management (ITSDCAP) Tool to Optimize TSM&O Efforts
Project Number	BDV29 977-09
Project Cost	$210,290

Project Duration	26 months
Web link	http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT-BDV29-977-09-rpt.pdf
Submitter	
Submitter Agency	Florida Department of Transportation
Submitter (Name, Address, Phone, Email)	Steve Bolyard Research Performance Coordinator FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4613 steve.bolyard@dot.state.fl.us
Research Program	
Sponsoring Agency Name	Florida Department of Transportation; Research Center
Sponsoring Agency Contact (Name, Address, Phone, Email)	FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4615 research.center@dot.state.fl.us
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	This project produced a data analysis dashboard that supports the objectives and activities of FDOT's Transportation Systems Management & Operations (TSM&O) program. In this project, two previously developed tools, the ITS Data Capture and Performance Management module (ITSDCAP) and the Integrated Regional Information Sharing and Decision Support System (IRISDS), have been integrated into a single Web-based environment. The new ITSDCAP tool is able to model and analyze different scenarios and influencing factors using data specific to that arterial or system, helping TMCs to move from a purely reactive to a more predictive method of managing system performance. Using actual system data allows TMC staff to more accurately perform a benefit/cost analysis for evaluation of arterial incident management, estimate the impacts of construction and maintenance activities on system performance, predict breakdown conditions on arterial streets based on system performance and develop tools for automatic identification of arterial performance problems. ITSDCAP consists of two components: one online and one offline. The online component would allow TMCs to manage the system in near real-time. However, few locations have both the necessary ITS data and bandwidth to fully utilize the online component. The offline component of ITSDCAP has been fully implemented at the Broward County, FL Traffic Management Center (TMC). Currently, the TMC staff use the offline component of ITSDCAP each month to analyze potential areas of concern with regards to travel time delay and incident mitigation. The

	TMC typically uses the data and tools from ITSDCAP to focus on certain traffic control signals that may need to be retimed with regards to their contribution to traffic congestion. Using ITSDCAP, TMC staff can easily analyze different retiming scenarios, select the most appropriate scenario with the highest cost/benefit ratio, and can then work with county officials to implement the retiming plan. The best alternative is determined using the ITSDCAP built-in benefit/cost module: the Tool for Operations Benefit Cost Analysis, or TOPS-BC. TOPS-BC allows TMC staff to recommend signal retiming based on a quantified rubric that determines the overall benefit and cost in the system being analyzed. TOPS-BC also takes into account numerous TSM&O strategies such as HAR, DMS, Ramp Metering, Incident Management, Signal Control, Signal Pre-emption, TDM, weather, work zones and more. The benefits are determined and analyzed primarily by improvement in travel time reliability and crash reduction; secondary options include fuel savings, speed harmonization, and secondary crash reductions. As an example, TOPS-BC has estimated that retiming signals at six locations within the central Broward County corridor will result in a 7% reduction in travel time delay during the Peak AM (7 to 9) hours and Peak PM (4 to 6) hours. This reduction equates to approximately $330,000 savings for January 2016 alone. FDOT District 4 is currently partnering with Broward County to implement this retiming plan on a monthly basis. This tool suite is currently being implemented at several other TMCs within the state of Florida. AzDOT has also contacted FDOT and the researchers to explore an adaptation of the ITSDCAP dashboard for use in Arizona.

Project Information

High Value Research Title	FDOT Research Concerning the Detection, Mitigation and Prevention of Wrong Way Crashes
Project Number	BDV30 977-10
Project Cost	$220,838
Project Duration	20 months
Web link	http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT-BDV30-977-10-rpt.pdf
Submitter	
Submitter Agency	Florida Department of Transportation

Submitter (Name, Address, Phone, Email)	Steve Bolyard Research Performance Coordinator FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4613 steve.bolyard@dot.state.fl.us
Research Program	
Sponsoring Agency Name	Florida Department of Transportation; Research Center
Sponsoring Agency Contact (Name, Address, Phone, Email)	FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4615 research.center@dot.state.fl.us
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Between 2002 and 2013, there were 1,173 wrong way crashes in the state of Florida, resulting in 164 fatalities, and 1,322 injuries. The supermajority of these drivers are young and impaired by alcohol, drugs, or both. FDOT has recently concluded four projects related to mitigating wrong-way crashes (WWCs): Turnpike Pilot Project to Install LED Bordered Wrong Way Signs, Statewide Wrong Way Crash Study, Evaluation of the Red Rectangular Rapid Flashing Beacon (RRFB) Implementation, and Driving Simulator Studies of the Effectiveness of Countermeasures to Prevent Wrong Way Crashes. In a pilot project, Turnpike Pilot Project to Install LED Bordered Wrong Way Signs, LED bordered wrong way signs were installed on 17 exit locations along the Florida Turnpike and the Sawgrass Expressway in South Florida. This pilot project uses a TAPCO Blinker sign, a wrong-way sign bordered with LED lights that flash red when a wrong-way vehicle is detected. The system also uses a BlinkLight Alert CCTV system to snap a picture whenever the system is activated. The second project, Statewide Wrong Way Crash Study, quantified the location, time of day, manner, severity, and extent of the WWC problem within the state of Florida and recommended a system of countermeasures to combat this problem. This project was a comprehensive analysis of all of the WWC within the state, and helped FDOT better understand the factors which may contribute to a WWC as well as identify trends and patterns. The third project, Evaluation of the Red Rectangular Rapid Flashing Beacon (RRFB), evaluated a specific WWC countermeasure for effectiveness. In this project, researchers surveyed citizens to determine their reactions to, and understanding of, the Red Rectangular Rapid Flashing Beacon (RRFB) with regards to freeway entrance and exit ramps and their effect on adjacent roadways. The results determined that the placement of these devices have no deleterious effect upon adjacent roadways. After this research concluded, beacons were placed at 6

	intersection (2 sets per intersection) along interstates in the Tampa Bay area. The RRFBs alert the wrong-way driver of their error via a radar-activated flashing beacon. The sign then takes a picture of the vehicle which is sent to local law enforcement and also sends a signal to the local TMC so that dynamic message signs in the area can be updated to warn drivers of this potentially lethal wrong way driver. The fourth project, Driving Simulator Studies of the Effectiveness of Countermeasures to Prevent Wrong Way Crashes, used laboratory tasks and driving simulator scenarios to understand and evaluate countermeasures for effectiveness at preventing wrong-way entries. Drivers were separated into younger and older groups and tested in conditions most likely to predicate a WWC: younger drivers at night, older drivers during the day. A subset of younger participants was asked to drive scenarios while under conditions of simulated impairment, with visual distortion and under cognitive load. In the simulator task, drivers were instructed to enter a highway and exit ramps were marked with the minimum number of countermeasures recommended by the Manual for Uniform Traffic Control Devices and then again with a greater number of countermeasures and enhancements recommended by the Statewide Wrong Way Crash Study. Researchers found that, in general, a greater number of different types of countermeasures installed increased the accuracy rate of rejection of exit ramps. Both younger and older adults benefited from an increase in diversity of countermeasures. In addition to a greater variety of countermeasures, the presence of redundant signs improved the identification of exit ramps though more so for younger adults as compared to older adults. The visibility of wrong way signs was also found to be one of the best predictors of drivers correctly rejecting an exit ramp. The presence of other vehicles was also a strong predictor of accuracy, consistent with the fact that many WWCs occur at night with few other vehicles on the road. Since the TAPCO Blinker signs were installed in October 2014 on Florida's Turnpike and Sawgrass Expressway, 23 people have attempted go the wrong way at just the 17 exits in South Florida being monitored; all but one driver turned around (~96% success rate). Quantified numbers with regards to the 6 locations of the RRFB in Tampa Bay will be available soon (as this was a more recent installation.) FDOT is also moving forward with adding WWC countermeasures such as the RRFB to additional intersection locations throughout the state of Florida. The countermeasure type, quantity and placement will continue to be evaluated and refined. Future ongoing and planned research will allow FDOT to better understand the impact of various countermeasures on WWC mitigation.

Project Information

High Value Research Title	Soil Mixing Design Methods and Construction Techniques for the use in High Organic Soils, Phase 2
Project Number	BDV25 977-14
Project Cost	$271,823
Project Duration	39 months
Web link	http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SMO/FDOT-BDV25-977-14-rpt.pdf

Submitter

Submitter Agency	Florida Department of Transportation
Submitter (Name, Address, Phone, Email)	Steve Bolyard Research Performance Coordinator FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4613 steve.bolyard@dot.state.fl.us

Research Program

Sponsoring Agency Name	Florida Department of Transportation; Research Center
Sponsoring Agency Contact (Name, Address, Phone, Email)	FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4615 research.center@dot.state.fl.us

Research and Results

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Stabilizing soils to increase their load capacity is necessary in construction projects. However, the composition of the soil, namely the presence of high amounts of organic materials, can drastically affect the success of soil mixing stabilization methods. Current soil mixing guidelines developed by an FHWA pooled fund study, provide adequate guidance for inorganic clay soils. However, high organic soils were not studied. In this project, researchers sought to fill this gap in the knowledge. They identified the mechanisms which produce excessive settlement of organic soil, explored and evaluated various soil mixing options that can be used to effectively stabilize organic deposits for roadway applications, and identified ground modification techniques that could potentially be cheaper and faster than other alternatives such as soil replacement, surcharge, and/or columns. Soil mixing stabilization was tested in the laboratory to assess the effect of cementitious binder type, binder content, mixing method, organic content, and curing time on strength gain. Over 700 tests were conducted and, in every case where organic content was higher than approximately 10% of the total volume, much more cement was required to achieve the same strength gain than

	was needed for inorganic or low organic content samples. Following the bench-scale tests, a tenth-scale test bed was built in which soil containing approximately 60% organics was placed and conditioned with rain water. The bed was divided into three equal testing regions: dry soil mixing (binder + soil), wet soil mixing (binder + water + soil), and no treatment (soil only). A simulated roadway was placed on each section of the test bed, left in place for several weeks, and monitored for movement. Results showed marked improvement for the soil mixed sections relative to untreated; dry or wet methods, using identical amounts of cement per volume, showed nearly identical results. FDOT staff will be discussing with FHWA about the potential to update the national design manual with the new guidance developed as part of this research project. FDOT has currently adopted the recommendations from this project on an interim basis, and the FDOT Soils and Foundations Handbook has been updated and will be released in print in January 2017. Typically between 6 and 12 projects across the state will benefit from this guidance every year.

Georgia (7)

Project Information	
High Value Research Title	Implementing Communities of Practice in the Georgia Department of Transportation
Project Number	RP 11-37
Project Cost	$391,433
Project Duration	32 months
Web link	http://g92018.eos-intl.net/G92018/OPAC/Index.aspx
Submitter	
Submitter Agency	Georgia Department of Transportation
Submitter (Name, Address, Phone, Email)	Jeff Conrad, 3993 Aviation Circle, Atlanta, GA 30336, 404-507-3404, jconrad@dot.ga.gov Andrew Heath, 935 E. Confederate Ave., Atlanta, GA 30316, 404-635-2828, aheath@dot.ga.gov
Research Program	
Sponsoring Agency Name	Georgia Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Supriya Kamatkar, 15 Kennedy Dr., Forest Park, GA 30297, 404-608-4797, skamatkar@dot.ga.gov

Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Communities of Practice (COPs) are groups of professionals within an organization who develop on-going, informal knowledge exchanges to learn and performing key job-related processes and skills. This research, through experimental group studies, investigated strategies by which GDOT can develop COPs to facilitate critical exchanges of knowledge, support organizational learning, and ultimately improve performance outcomes. The research also explored knowledge retention agency-wide. Researchers interviewed managers nearing retirement who were also associated with the various COPs observed in this project. The research identified practices and functions of four COPs within GDOT: Environmental Services, Geographic Information Systems, Practical Design Training (PDT), and Roundabout and Alternative Intersection Design (RAID). The first two were non-treatment groups in place before the research project and the other two were treatment groups. SharePoint sites were created for the PDT and RAID COPs. The following findings were observed between the treatment groups and non-treatment groups: • All community members (whether in a treated or untreated group) reported an increase in the number of knowledge sources used. • Members of treatment groups demonstrated improvements over non-treatment groups in accurately identifying sources of knowledge. This was true whether the knowledge was documented or tacit. • Treatment groups also reported greater reductions in problem-solving time and hence greater job effectiveness. These gains were highest among younger managers. • The treatment group with members and their offices distributed throughout GDOT saw some of the biggest gains from the workshops and the development of the COP website. All four groups continued to be active after the research project ended. The COP websites were still active resources for the PDT and RAID groups. The RAID group had also dedicated a portion of a staff member's time to update and maintain their website.

Project Information

High Value Research Title	Corrosion-Free Precast Prestressed Concrete Piles Made with Stainless Steel Reinforcement: Construction, Test, and Evaluation

Project Number	RP 11-34
Project Cost	$499,239
Project Duration	36 months
Web link	http://g92018.eos-intl.net/G92018/OPAC/Index.aspx
Submitter	
Submitter Agency	Georgia Department of Transportation
Submitter (Name, Address, Phone, Email)	Bill DuVall, 600 W. Peachtree St. NW, Atlanta, GA 30308, 404-631-1883, bduvall@dot.ga.gov
Research Program	
Sponsoring Agency Name	Georgia Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Supriya Kamatkar, 15 Kennedy Dr., Forest Park, GA 30297, 404-608-4797, skamatkar@dot.ga.gov
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	The use of duplex high-strength stainless steel (HSSS) grade 2205 prestressing strand and austenitic stainless steel (SS) grade 304 spiral wire reinforcement was proposed as a replacement of conventional prestressing steel. This replacement is to provide a 100+ year service life for prestressed concrete piles located in coastal Georgia. Researchers investigated 16-in. square, 70-ft. long piles constructed using duplex HSSS 2205 strands and SS 304 spiral wire reinforcement and compared their behavior with identical piles which were built using conventional strands and spirals. The piles were successfully driven to refusal without visible damage, extracted, and tested in flexure and shear. Transfer and development length of piles using duplex HSSS 2205 strands were 57% and 55%, respectively, of values predicted by AASHTO LRFD (2013). Transfer length of duplex HSSS 2205 strands was not affected by pile driving and extraction. Flexural and shear strength of piles using duplex HSSS 2205 strands were greater than predicted by ACI 318-11 and AASHTO LRFD (2013) specifications. Experimental prestress losses at 335 days for piles using duplex HSSS 2205 strands were 82% of the predicted losses by AASHTO LRFD refined method. Prestress losses were not affected by pile driving and extraction. It was concluded that duplex HSSS 2205 can be used for prestressing strands, in combination with austenitic SS 304, for the transverse confinement and shear reinforcement for prestressed concrete piles, using the same design requirements and construction procedures for

	conventional prestressing strand and wire reinforcement. GDOT used stainless steel reinforced piles on a bridge to be constructed in Liberty County as a result of this research. This research also encouraged Virginia DOT and Florida DOT to construct and test similar piles made with the same high strength stainless steel (2205 strands) that GDOT studied. In short, GDOT innovation has encouraged other states to initiate their own applied research for development of corrosion-free piles.

Project Information

High Value Research Title	Developing Education and Extension Recommendations on Vegetation Management for the Georgia DOT
Project Number	RP 12-09
Project Cost	$250,034
Project Duration	36 months
Web link	
Submitter	
Submitter Agency	Georgia Department of Transportation
Submitter (Name, Address, Phone, Email)	Ray Dorsey, 600 W. Peachtree St. NW, Atlanta, GA 30308, 404-519-9284, rdorsey@dot.ga.gov
Research Program	
Sponsoring Agency Name	Georgia Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Gretel Sims, 15 Kennedy Dr., Forest Park, GA 30297, 404-608-4802, gsims@dot.ga.gov
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Weed control is the greatest challenge for Georgia DOT (GDOT) in grassy roadside management. Weeds reduce aesthetics, safety, and visibility for drivers on highways, interstates, and other roads. Weed competition with desirable grasses may also result in significant soil erosion that could reduce safety and stability of roadside vegetation. Also, roadsides are mowed infrequently, usually once or twice per year, which may thin grass canopies and reduce competition with weeds. Study of herbicide use for growth regulation of grasses and weed control has reduced annual GDOT mowing costs to approximately $7 million per year.

	The objectives of this research were to (1) improve the ability to produce an intended result of GDOT weed management practices by evaluating herbicide selection and vegetation management practices (application timing and herbicide combinations) on emerging weeds on Georgia roadsides; and (2) develop the smartphone mobile application, "Georgia Roadside Management," to allow agronomists to access real-time recommendations for weed and grass control from the University of Georgia (UGA). During this research, herbicide application timing was observed for roadside vegetation during spring, summer, or fall months. Mowing and herbicide application timing apparently affected the release of certain desirable grasses (such as Bermuda grass) while reducing the effectiveness of grassy weed control. Findings also suggest that GDOT should consider new herbicide combinations. The observed combinations consistently provided greater release of desirable grasses versus single use herbicides and had superior control of certain weeds affecting the desired grasses under observation. The mobile application, "Georgia Roadside Management," was developed and released in October 2014. The application contains (1) pictures and information of important weeds and grasses in vegetation management with recommendations for control; and (2) a pesticide database listed by common and trade names of all products used in GDOT spray programs. The application is routinely updated so agronomists have access to real-time extension recommendations from UGA. This technology provides GDOT agronomists quick access to information for education and enhanced productivity.

Project Information

High Value Research Title	Developing a GDOT Pavement Marking Handbook Using Field Test Deck Evaluation and Long-term Performance Analysis
Project Number	RP 12-31
Project Cost	$253,526
Project Duration	36 months
Web link	
Submitter	
Submitter Agency	Georgia Department of Transportation
Submitter (Name, Address, Phone, Email)	Richard (Rick) Douds, 15 Kennedy Dr., Forest Park, GA 302397, 404-608-4805, rdouds@dot.ga.gov

Research Program	
Sponsoring Agency Name	Georgia Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Binh Bui, 15 Kennedy Dr., Forest Park, GA 30297, 404-608-4798, bbui@dot.ga.gov
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	The two primary goals of this research project were (1) review of best practices on selecting, installing, and inspecting pavement marking materials (PMM); and (2) evaluation of PMM performance and retroreflectivity data from test sites compared with data from the National Transportation Product Evaluation Program. A methodology was developed to enhance the reliability of PMM retroreflectivity data analysis by systematic removal of any data variability due to construction issues. Statistical models were further developed to predict the retroreflectivity and expected service life of the PMM studied. Life cycle cost analysis was also conducted for each material type. Results from this research were compiled in a GDOT Pavement Marking Manual. An interactive tutorial was also developed to simplify the manual content through interactive means (graphic user interfaces) such as images, videos, and user inputs. GDOT developed PMM training to disseminate this research to the GDOT Offices of (1) Materials and Testing; (2) Construction; (3) Traffic Operations; and (4) Maintenance. This is to ensure proper protocol among the offices concerning PMM design, selection, installation, and inspection, so that GDOT uses the most cost effective PMM that improve visibility for motorists. The training will also be provided to local governments through GDOT's Local Technical Assistance Program for their on PMM management needs.

Project Information

High Value Research Title	Innovative Project Delivery Using Alternative Financing Mechanisms: Assessment of Benefits, Costs, and Risks
Project Number	RP 13-01
Project Cost	$206,164
Project Duration	21 months
Web link	http://g92018.eos-intl.net/G92018/OPAC/Index.aspx
Submitter	

Submitter Agency	Georgia Department of Transportation
Submitter (Name, Address, Phone, Email)	Darryl VanMeter, 600 W. Peachtree St. NW, Atlanta, GA 30308, 404-631-1703, dvanmeter@dot.ga.gov
Research Program	
Sponsoring Agency Name	Georgia Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Supriya Kamatkar, 15 Kennedy Dr., Forest Park, GA 30297, 404-608-4797, skamatkar@dot.ga.gov
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	The U.S. Department of Transportation (U.S. DOT) and state DOTs seek private investments to leverage their shrinking financial resources. Involvement of the private sector in financing highway projects is subject to various limitations and challenges that affect state DOTs' project planning and development, and limit the expansion of private financing for highway projects. State DOTs face different kinds of financial, political, legal, management, and organizational issues affecting their ability to attract private investments in highway projects. The purpose of this project was to enhance GDOT understanding of incorporating financing into the innovative project delivery process, particularly by capturing the underpinnings of private financing in highway projects in the following areas: (1) latest developments and trends in utilizing innovative financing mechanisms for highway projects; (2) main objectives and major concerns of state DOTs in decision-making processes; (3) deal-breaker issues and major concerns of private sector participants; and (4) recommended best practices to enhance adoption of private financing for highway projects. A comprehensive literature review was conducted to analyze and document the latest developments and trends in utilizing private financing for highway projects. To document the current state of private financing for highway projects, a survey of state DOTs was conducted from state DOTs. Finally, through conducting interviews with the industry experts in private financing, the research team identified a list of deal-breaker issues and major challenges that hinder private sector involvement in financing highway projects. The findings of this research have helped guide many decisions, including the current design-build finance contract for the I-285/Georgia 400 interchange reconstruction. This construction project is the largest contract in GDOT, and potentially Georgia, history. Key elements of the research have been used to ensure market favorableness to GDOT's approach. The study also facilitated the delivery analysis for other

	potential public-private partnerships in the program. Because the design-build finance model is relatively new in the U.S. and cuts across traditional delivery approaches by introducing a private finance component that can be considered as non-debt to a state, the research helps characterize the risks and rewards with careful consideration of market perceptions.

Project Information

High Value Research Title	STEM and Our Future Transportation Leaders
Project Number	RP 14-08
Project Cost	$90,000
Project Duration	21 months
Web link	
Submitter	
Submitter Agency	Georgia Department of Transportation
Submitter (Name, Address, Phone, Email)	Genetha Rice-Singleton, 600 W. Peachtree St. NW, Atlanta, GA 30308, 404-631-1860, grice-singleton@dot.ga.gov
Research Program	
Sponsoring Agency Name	Georgia Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Yusuf Ahmed, 15 Kennedy Dr., Forest Park, GA 30297, 404-608-4803, yahmed@dot.ga.gov
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Between 2012 to 2022, 40 to 50 percent of the transportation workforce is expected to retire taking valuable knowledge with them. State Departments of Transportation (DOTs) are expected to play a significant role in replenishing the workforce pipeline. STEM (i.e., science, technology, engineering and mathematics) development is considered a critical priority in Georgia and the U.S. to preserve science and technology efficacy and promote economic competitiveness. This study reviewed state DOT involvement in transportation-related STEM outreach programs and identifies opportunities to engage kindergarten through high school (K-12) students in STEM programs to enhance their interest in the transportation field. STEM theory and empirical evidence both show that STEM has academic and behavioral benefits, and that students exposed to STEM are more likely to choose a

	career in STEM. The study showed that over 40% of state DOTs are involved in K-12 STEM outreach programs: most commonly residential or non-residential summer programs, teacher training and curriculum development programs, internship and shadow opportunities, one-day STEM awareness events, and periodic employee visits to schools to present on transportation-STEM. A business case analysis conducted shows that agencies will benefit from including both longer-term and shorter-term alternatives in their STEM programming to cultivate STEM efficacy while building long-term relationships with a smaller percentage of students and increasing STEM awareness broadly among K-12 students. Such strategic programming will contribute to developing a pool of students for recruitment to replenish the transportation workforce and enhancing STEM culture within the agency. Strategic STEM program implementation by GDOT, in conjunction with Georgia's STEM stakeholders, has the potential to increase Georgia's college graduates with transportation-related STEM efficacy and an interest in the transportation field. This will improve the transportation workforce pipeline while advancing Georgia's science and technology effectiveness and economic competitiveness.

Project Information

High Value Research Title	Streamlining Project Delivery through Risk Analysis
Project Number	RP 13-05
Project Cost	$499,994
Project Duration	28 months
Web link	http://g92018.eos-intl.net/G92018/OPAC/Index.aspx
Submitter	
Submitter Agency	Georgia Department of Transportation
Submitter (Name, Address, Phone, Email)	Genetha Rice-Singleton, 600 W. Peachtree St. NW, Atlanta, GA 30308, 404-631-1860, grice-singleton@dot.ga.gov
Research Program	
Sponsoring Agency Name	Georgia Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Supriya Kamatkar, 15 Kennedy Dr., Forest Park, GA 30297, 404-608-4797, skamatkar@dot.ga.gov

Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Project delivery is subject to several risk factors throughout GDOT's Plan Development Process. These risk factors are attributed to major areas of project development. Occurrence of the risk event negatively impacts the project outcomes as experienced as cost overrun and schedule delay by GDOT. Risk management is a systematic process of identifying, analyzing, and responding to the project risks. Two main benefits of risk management are: (a) identification of potential problems long before they occur; and (b) development of strategies to increase the likelihood of favorable outcomes. The objective of this research was to develop a comprehensive guidebook that advances the adoption of risk analysis tools in GDOT to expedite project delivery. Various project risk management processes developed by different organizations were reviewed. Furthermore, current practice of risk management in different state DOTs was studied. A semi-structured interview was conducted with subject matter experts at GDOT to explore key factors that influence risk management practices within GDOT. The results were analyzed and a model explaining the current risk management practice and future needs was developed. The most important risks to GDOT were identified, and a short list of major potential risks was developed for each office at GDOT. Finally, a risk analysis software tool, Comprehensive Risk Management For Transportation (CRAFT©), was specifically developed to assist GDOT in identification and qualitative assessment of highway project risks during the pre-construction phase of the project. GDOT has decided to implement the results of this study and use the developed software in all projects. Several software training workshops were held at GDOT for more than 80 staff. The CRAFT® software has been well received by the users. The developed risk management guidebook and software tool will help project managers engage all stakeholders from different offices in identifying and analyzing the project issues in early steps of the project development process.

Kentucky (1)

Project Information	
High Value Research Title	IBRC / FRT 126 - Repair of I-65 Bridge using CFRP Composites (Phase I, IV)
Project Number	FRT 126 (I, IV)

Project Cost	$130,000
Project Duration	115 months
Web link	http://www.ktc.uky.edu/files/2013/10/KTC_13_16_FRT126_03_1F.pdf

Submitter

Submitter Agency	Kentucky Transportation Cabinet
Submitter (Name, Address, Phone, Email)	Jason J. Siwula, PE Innovation Engineer Kentucky Transportation Cabinet - State Highway Engineer's Office 200 Mero Street Frankfort, KY 40601

Research Program

No data entered for this section

Research and Results

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	The two phases of the project dealt with the retrofit of ninety five crack locations on prestressed concrete girders of the I-65 expressway in Louisville, KY. The study objective was achieved through the following tasks: (1) Instrumentation and remote monitoring of select locations to evaluate degree of crack movement. (2) Evaluate the data collected over a year and identify that the cracks were not growing rapidly. (3) Design of an economical and effective retrofit using CFRP fabric. (4) Repair cracks by high strength epoxy injection and strengthen crack locations using CFRP fabric. (4) Remote monitoring of previous crack locations to evaluate the effectiveness of the retrofit. The alternative to the performed retrofit was the construction of new piers or the extension of existing pier caps or replace the damaged section of the I-65 expressway, any one of which would have cost more than $1 million considering the number of crack locations. This resulted in a direct savings of no less than $850,000 while also extending the service life of the structure. The combined use of remote monitoring and lightweight CFRP fabric as the method of strengthening provided the most cost effective and efficient retrofit for the cracked girders. By the end of calendar year 2015 these types of repairs have been made on at least 28 locations throughout Kentucky resulting in millions of dollars in cumulative savings. Following the retrofit (Phase I in 2005 and Phase IV in 2009), the crack locations are still being continuously monitored for the minimal cost of a monthly mobile data usage charge required for data transmission. The repair caused no traffic disruptions and utilized no heavy equipment. The

	CFRP fabric retrofit extended the service life of the structure. The success of this project lead to the adoption of active and/or passive monitoring coupled with retrofit on other projects in the state.

Louisiana (2)

Project Information	
High Value Research Title	Development of DARWin-ME Design Guideline for Louisiana Pavement Design
Project Number	12-4P
Project Cost	$267,960
Project Duration	37 months
Web link	http://www.ltrc.lsu.edu/pdf/2016/FR_551.pdf
Submitter	
Submitter Agency	Louisiana Department of Transportation and Development
Submitter (Name, Address, Phone, Email)	Tyson Rupnow 4101 Gourrier Avenue Baton Rouge, LA 70808 225-767-9124 tyson.rupnow@la.gov
Research Program	
No data entered for this section	
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	ince the release of the first research version of mechanistic empirical pavement design guide (MEPDG) software, Louisiana has conducted a series of studies in preparation to adopt this new mechanistic-empirical based pavement design method. The objective of this study was to develop an implementation guideline for the full implementation of AASHTOWare Pavement ME in Louisiana. For this purpose, a Louisiana default input strategy that reflects state local condition and practice was first developed. Design reliability and performance criteria were established based on a consensus survey and pavement management system (PMS) distress triggers. A total of 162 projects were selected from the existing Louisiana highway network, including flexible pavements with five types of base, rigid pavements with three types of base, and rehabilitation with asphalt overlays. Performance data was retrieved from the PMS database and validated through additional field performance survey. Through comparing the predicted performance from Pavement ME and the measured performance from PMS, distress models were evaluated and calibrated

	according to Louisiana local conditions. Subsequently, a Louisiana Pavement ME Design Guideline that contains all necessary design inputs information and calibration coefficients was developed. A comparison of thicknesses designed from the current AASHTO 1993 design and the local-calibrated Pavement ME generally indicated that the two design methods were comparable and the Pavement ME design tended to require on average 0.5-in. thinner thickness than the AASHTO 1993 design for Louisiana pavements. Finally, the practical and economic benefits of the full implementation of Pavement ME for Louisiana pavement design were demonstrated by a direct comparison to the current 1993 AASHTO design method through a group of thickness design examples and life cycle cost analyses (LCCA). On average, the LCCA results indicated that, if full implementation of Pavement ME occurs, each lane mile could save $11,065 in present worth value and 7.4% in life cycle costs over a pavement design life time.

Project Information

High Value Research Title	Evaluation of LADOTD Aggregate Friction Rating Table by Field Measurements
Project Number	12-5P
Project Cost	$217,957
Project Duration	36 months
Web link	http://www.ltrc.lsu.edu/pdf/2016/FR_554.pdf

Submitter

Submitter Agency	Louisiana Department of Transportation and Development
Submitter (Name, Address, Phone, Email)	Tyson Rupnow 4101 Gourrier Avenue Baton Rouge, LA 70808 225-767-9124 tyson.rupnow@la.gov

Research Program

No data entered for this section

Research and Results

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Research shows that by improving pavement surface friction resistance the wet pavement crashes can be reduced or prevented. However, the current LADOTD asphalt mixture design procedure does not directly consider friction as a design requirement. The main objective of this study was to evaluate the current coarse aggregate friction rating table

	and develop a procedure to predict the pavement field skid resistance based on the design traffic, aggregate polishing and mixture properties commonly available during a mix design. Field tests were carried out to collect the pavement surface friction and texture data, which included the measurements from a locked-wheel skid trailer at different sliding speeds (30-, 40- and 50- mph) using both ribbed and smooth tires, laser profiler, Dynamic Friction Tester (DFT), and Circular Track Meter (CTM) tests at the beginning-, mid-, and end-point on each 1000-ft. long test section selected. In addition, multiyear field skid number measurements were also retrieved from the DOTD PMS database and included in the analysis. Statistical correlation models were developed among different measurement devices as well as various surface texture and frictional properties. Consequently, the analysis results led to the development of a procedure for predicting pavement end-of-life skid resistance based on the design traffic, aggregate blend polish stone value and gradation parameters from a mix design. The developed friction prediction procedure can be used to update the current DOTD coarse aggregate friction table by specifying the pavement friction requirements under different traffic levels through selection of different mixture and aggregate types. The new procedure will allow engineers to check whether a mix design with a selected blend of aggregates would meet field friction requirements during the mix design stage. The procedure can also assist in the use of lower skid-resistant, locally available aggregates in a wearing course mix design, and thus help produce both cost-effective and skid-resistant surface mixtures.

Mississippi (1)

Project Information	
High Value Research Title	Evaluation of MSDOT's Distress Thresholds for Maintained Pavement (Warranty) Projects
Project Number	221-MS
Project Cost	$120,421
Project Duration	27 months
Web link	Link to report
Submitter	
Submitter Agency	Mississippi Department of Transportation
Submitter (Name, Address, Phone, Email)	William F. Barstis, P.E. Mississippi DOT Research Division 86-01 PO Box 1850 Jackson, MS 39215-1850 601-359-7649

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Research Program	
Sponsoring Agency Name	Mississippi Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	P.O. Box 1850, 500 North West Street Jackson MS USA 39215-1850
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	This project evaluated the effectiveness of MDOT's warranty thresholds for pavement performance. The analytical results show that the performance of the warranty pavements is significantly better than that of the non-warranty pavements at the same service time level, and warranty pavements can maintain at high service levels for a longer time than non-warranty pavements. The pavement warranty program adopted by MDOT has improved pavement performance, and is effective in practice.

North Carolina (4)

Project Information	
High Value Research Title	Ecology of Corynorhinus townsendii virginianus in North Carolina
Project Number	FHWA/NC/2013-35
Project Cost	$307,278
Project Duration	30 months
Web link	
Submitter	
Submitter Agency	North Carolina Department of Transportation
Submitter (Name, Address, Phone, Email)	John Kirby NCDOT 104 Fayetteville St Raleigh, NC 27601 jkirby@ncdot.gov 919-508-1816
Research Program	
Sponsoring Agency Name	North Carolina Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Neil Mastin, P.E. Research and Development 1549 Mail Service Center Raleigh NC USA 27699-1549 http://www.ncdot.org/doh/preconstruct/tpb/research/ nmastin@ncdot.gov 919-508-1865

Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Background: The North Carolina Department of Transportation (NCDOT) has several State Transportation Improvement Projects (STIP) scheduled in Avery, Caldwell and Watauga counties. At the intersection of these three counties is the primary winter roost site of an endangered bat species, the Virginia big-eared bat (VABEB), Corynorhinus townsendii virginianus. The species has a very limited range in the eastern U.S., and very little was known about it. Only 12,000 to 20,000 Virginia big-eared bats remain in N.C., T.N., W.V., V.A. and K.Y. These docile animals provide a valuable service by eating many harmful insects on their nightly excursions. The major causes of the species' decline are loss of habitat, vandalism, and increased human visitation to maternity roosts and hibernacula. Virginia big-eared bats are extremely sensitive to human disturbance. Even slight disturbances can cause adults to abandon caves, abandon young, and force bats to use valuable energy reserves needed to survive hibernation. As a result, anticipating whether the effects of NCDOT highway and bridge projects by the presence of this species was not understood by NCDOT biologists or any other state or federal agency. STIP projects are proposed in the three counties within ten miles of known VABEB occurrences, a distance that bats can easily fly in one night. The most notable of the STIP projects occurring near the VABEB roost is STIP R-2566, the proposed widening of N.C. 105 in Watauga county. Specific Research Objective: Virginia big-eared bats are extremely difficult to capture with nets. Although the bats were known to be in the vicinity of STIP R-2566, two summers of mist-netting survey work by NCDOT staff had not produced any data about the species. U.S. Fish and Wildlife Service staff concluded that more information must be collected on the VABEB before formal consultation under the Endangered Species Act could occur. The project(s) could not proceed until more information was obtained. NCDOT contracted with researchers at Indiana State University's Center for Bat Outreach, Research and Conservation. Graduate student Joey Weber and other researchers used advanced radio telemetry techniques to discover more about the migration routes and foraging areas used by these bats. Cave entrances were monitored with acoustics and night time emergence counts were recorded. Contact was established with approximately 20 private property owners to gain property access to bat roosts and foraging telemetry stations. Telemetry towers with data loggers were installed near North Carolina's Grandfather Mountain, including 5 points along N.C. 105. Tiny radio transmitters were attached to the backs of captured bats. Weber captured 42 bats in caves on Grandfather Mountain and other springtime roosts, attaching tiny radio

	transmitters to their backs. Researchers tracked the bats to caves at the base of Beech Mountain, North Carolina, eight miles away and to 31 additional roosts. This is the first time maternity roosts have been found in North Carolina. One transmitter was found in scat after the bat ran afoul of an owl and another was tracked to the basement of an unfinished house in a nearby golf course community. In addition, the researchers developed conservation outreach materials for the general public and private land owners affected by the VABEB. The research provided NCDOT with essential data for writing Biological Assessments as mandated under the Endangered Species Act to determine the effects on STIP R-2566 and other STIP projects, and developed potential conservation measures for VABEBs. In addition, it provided the US Fish and Wildlife Service with the necessary data to produce Biological Opinions necessary to allow STIP projects to proceed.

Project Information

High Value Research Title	In-Situ Determination of Emulsion Application Rate for Tack Coats and Surface Treatments
Project Number	2014-03
Project Cost	$197,000
Project Duration	28 months
Web link	https://connect.ncdot.gov/projects/planning/Pages/ProjDetails.aspx?ProjectID=2014-03
Submitter	
Submitter Agency	North Carolina Department of Transportation
Submitter (Name, Address, Phone, Email)	Mustan Kadibhai, P.E.; Research Engineer, NCDOT Research and Development 1549 MSC, Raleigh, NC 27699-1549 919 508 1819 mkadibhai@ncdot.gov
Research Program	
Sponsoring Agency Name	North Carolina Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	Neil Mastin, P.E.; Research Manager, NCDOT Research and Development 1549 MSC, Raleigh, NC 27699-1549 919 508 1865 jmastin@ncdot.gov

Research and Results

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Background: Emulsions are used as tack coats to bond asphalt concrete layers and as a bonding agent for aggregates in chip seals. The rate of emulsion application is critical to the performance of both tack coats and chip seals. It has been demonstrated that field emulsion application rates (EARs) can be highly variable. Emulsion application can vary transversely across a pavement due to variability in emulsion output and fan patterns among distributor nozzles. Emulsion application can also vary longitudinally along the length of paving as a result of fluctuations in distributor speed and flow rates. In addition, the existing paving surface will absorb a fraction of emulsion applied which will be unavailable to act as a bonding agent for aggregate or asphalt concrete placed on top of the emulsion. Thus, it is important to differentiate between total EAR and "effective" EAR available for bonding. The importance of surface absorption is considered in many tack coat and chip seal design methods. However, specified adjustments to EARs to account for surface absorption lack experimental or theoretical basis. Existing methods for quality control (QC) of EAR are very limited. The only standardized test procedure is ASTM D 2995, which targets calibration rather than in-situ measurements and does not allow for capture of the effective EAR. Specific Research Objective: 1. To identify issues in determining EARs in the field. 2. To develop a recommended field test for determination of EARs at specific locations along a roadway for QC purposes What research work was done? A literature review was conducted to identify existing test methods for QC of EARs, sources of variability in the EAR, and issues in determining EARs in the field. The Tack Lifter was developed as a simple and efficient means for in-situ measurements of applied EAR and effective EAR, neglecting emulsion absorbed by the paving surface to improve QC measures. The Tack Lifter consists of a weight device, frame, and absorbent sheet. Following emulsion application by a distributor, the frame is applied to the surface of interest to seal the test area. The absorbent sheet is inserted into the frame and the weighted device is applied. Emulsion is absorbed into the sheet. The weight of emulsion combined with the sheet area is used to obtain a spot check of EAR. Tests can be applied directly to the paving surface to provide a measure of effective EAR. Alternatively, tests can be applied to pans placed on the paving surface prior to emulsion application to provide a measure of the applied EAR. The difference between applied and effective EARs measured by the Tack Lifter allows for quantifying the rate by which a pavement absorbs applied emulsion. Comprehensive laboratory and field experiments were conducted to develop and evaluate the use of the Tack Lifter for QC of EAR. In addition, ASTM D 2995 was evaluated.

	Impact, or Potential Impact, of Implementing Research Results A proposed practice for QC of EARs was developed. The practice includes three test procedures: 1. ASTM D 2995 Test Method B for QC of transverse variability in the applied EAR. 2. Tack Lifter tests applied in the wheel path to flat, steel pans and the paving surface on a test pavement section to quantify the rate by which the pavement absorbs emulsion and correspondingly, guide adjustment of the target EAR, 3. Tack Lifter tests conducted on elevated plates following removal from the roadway for QC of longitudinal variability in the applied EAR.

Project Information

High Value Research Title	CFRP Strands in Prestressed Cored Slab Units
Project Number	FHWA/NC/2014-09
Project Cost	$217,758
Project Duration	20 months
Web link	https://connect.ncdot.gov/projects/planning/Pages/ProjDetails.aspx?ProjectID=2014-09

Submitter

Submitter Agency	North Carolina Department of Transportation
Submitter (Name, Address, Phone, Email)	F. Rasay Abadilla, Jr., P.E. Research Staff Engineer, NCDOT Research and Development 1549 MSC, Raleigh, NC 27699-1549 919 508 1832 rabadilla@ncdot.gov

Research Program

Sponsoring Agency Name	North Carolina Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	J. Neil Mastin, P.E. Research Manager, NCDOT Research and Development 1549 MSC, Raleigh, NC 27699-1549 919 508 1865 jmastin@ncdot.gov

Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Steel-cable, prestressed concrete cored slab superstructures are commonly used for bridges in coastal North Carolina (NC). This type of bridge is subjected to an aggressive marine environment, so corrosion of the internal reinforcement is of significant concern. Several of these bridges in NC are in need of repair or replacement after having been in service for little more than 40 years. To prevent corrosion in future cored slab superstructures, the North Carolina Department of Transportation (NCDOT) chose to evaluate the performance of cored slabs reinforced with non-corroding Fiber Reinforced Polymer (FRP) instead of traditional steel. The objective of the study was to investigate the performance of cored slabs prestressed with carbon FRP (CFRP) strands and reinforced with glass FRP (GFRP) stirrups. The structural performance of these experimental cored slabs was compared to that of steel control specimens to evaluate their suitability with respect to the current standard design. The general objective was accomplished through the following specific tasks: • Previous research in the field of FRP reinforcement was reviewed, with an emphasis on FRP prestressing. • FRP material tests were performed to confirm manufacturers' design values. • The bond properties of the CFRP prestressing strands were comparatively measured using tests on beam-end specimens • The current standard NCDOT cored slab design was reviewed and an all-FRP substitute reinforcing scheme for cored slabs was designed. • Three full-scale, 45 ft. long cored slabs were cast and tested to failure in flexure. Two of the specimens were reinforced with FRP and a third served as a steel-reinforced control specimen. • Three full-scale, 15 ft. long cored slabs were cast and tested to failure in shear. Two of the specimens were reinforced with FRP and the third served as a steel-reinforced control specimen. • The tests of the steel and FRP reinforced specimens were compared to each other and to their calculated design strengths. This report presents the findings from the literature review, testing, and analysis of the test data. Specific findings include the following: • A large body of research exists on the topic of FRP prestressing. Test results have shown that the capacity of FRP prestressed concrete members can equal or exceed that of equivalent steel prestressed members. • A growing number of FRP prestressed bridge decks and piles are being implemented by Departments of Transportation across the country and abroad. • The manufacturers' reported values for the mechanical properties of the CFRP strand and GFRP rebar used in this project are accurate. • The voids in a hollow cored slab can float during casting, which has been observed by others, and dramatically weakens the cored slab section. Care must be taken to prevent this phenomenon during construction when using either steel or FRP reinforcement. • The experimental flexural capacity of the properly manufactured FRP reinforced cored slab was 9% greater than the capacity of the steel reinforced control cored slab, however, this capacity was 10% lower than the unfactored ACI 440.4R (2004)

	capacity. • The presence of closely spaced, large diameter GFRP stirrups in the compression zone of the FRP reinforced cored slabs appears to have triggered premature compression zone failure in one of the specimens. • Even with the postulated effect from the GFRP stirrups, ACI 440.4R (2004) predicts a safe flexural design strength that is 8% lower than the experimental flexural capacity. • The GFRP stirrups remained intact after all full-scale tests. • ACI 440.4R (2004) provided conservative predictions for shear strength. • Due to the nature of the prestressed cored slab section studied, shear failure is unlikely to be a design concern, as the flexural failure mode dominates the behavior for this section. Based on these findings, the all-FRP reinforcement scheme for cored slabs should be a suitable structural replacement for the current design using steel reinforcement. However, the GFRP stirrups may have had a deleterious effect on the strength of the cored slabs. This effect should be explored further so that it may be quantified, and perhaps mitigated. An alternative arrangement of corrosion resistant shear reinforcement would likely address this situation. Impact, or Potential Impact, of Implementing Research Results: 1) Revise Documents - CFRP strands could be added to the ASTM Specifications and the Bridge Design Specifications. 2) Application to Processes - Design tool for highly corrosive sites. 3) Application to Projects - Possible application of CFRP in highly corrosive sites where the bridge is close to the saltwater environment. A life cycle assessment to evaluate the true economic benefit of replacing corrosive steel-reinforced structural systems in aggressive environments with more durable FRP alternatives is recommended.

Project Information

High Value Research Title	Planning-Level Extensions to NCDOT Freeway Analysis Tools
Project Number	2015-09
Project Cost	
Project Duration	19 months
Web link	
Submitter	
Submitter Agency	North Carolina Department of Transportation
Submitter (Name, Address, Phone, Email)	Ernest Morrison, P.E.; Research Staff Engineer, NCDOT Research and Development 1549 MSC, Raleigh, NC 27699-1549 919 508 1874

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Research Program	
Sponsoring Agency Name	North Carolina Department of Transportation Research and Development Unit
Sponsoring Agency Contact (Name, Address, Phone, Email)	Neil Mastin, P.E.; Research Manager, NCDOT Research and Development 1549 MSC, Raleigh, NC 27699-1549 919 508 1865 jmastin@ncdot.gov
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Background: Conducting a full operational analysis of freeway facilities is a challenging undertaking, as most available methods either lack the necessary detail for specific geometry and demand patterns, or are very data and cost-intensive to implement. For the past few years, NCDOT has been using a customized software application for conducting in-house analyses of freeway facilities, with a special emphasis on work zones. The analysis methodology and associated software tool, FREEVAL-WZ, were deliverables from a prior NCDOT research effort (2010-08). The methodology is founded on the analytical method for evaluating freeway facilities in the most recent Highway Capacity Manual, but has been enhanced to incorporate work-zone analysis details, as well as some state-specific defaults for its application in North Carolina. The particular focus of this project is on implementing a series of planning-level analysis extensions to the methodology. Planning-level freeway (work zone) analyses are oftentimes performed in a “data poor” analysis context, where the available data is limited to basic freeway geometry characteristics and daily traffic demand patterns. Detailed peak-hour volume estimates are oftentimes not available at the early stages in a project. Further, in a planning-level application for work zones, a key decision of interest is when to close lanes and for how long, which ultimately calls for a full-day analysis context. Finally, customized output reports are needed to present key performance metrics in a standardized and readily usable format. Specific Research Objective: The objectives of this project was to : 1. Develop traffic volume distributions by freeway facility type and time of day for North Carolina freeways; 2. Enhance the FREEVAL-WZ tool through additional planning-level enhancements, including customized output features such as PDF reports; and 3. Improve the user-friendliness, reliability and computational

	performance of the FREEVAL-WZ tool. What research work was done? The research team collected and investigated the hourly volume data from permanent and temporary traffic count stations across North Carolina. By investigating the traffic volumes, the research team has developed a set of default hourly traffic distributions that can be used to analyze freeway facilities based on HCM context with only AADT. Also, the research team has used new work zone analysis methodology based on NCHRP 03-107 in the FREEVAL-WZ tool.

South Carolina (2)

Project Information	
High Value Research Title	Seismic Site Coefficients and Acceleration Design Response Spectra (ADRS) based on Conditions in South Carolina
Project Number	FHWA–SC–14–02
Project Cost	$401,964
Project Duration	35 months
Web link	http://www.clemson.edu/t3s/scdot/pdf/projects/SPR686-report.pdf
Submitter	
Submitter Agency	South Carolina Department of Transportation
Submitter (Name, Address, Phone, Email)	Terry Swygert 1406 Shop Road Columbia, SC 29201 803-737-6691 swygerttl@scdot.org
Research Program	
Sponsoring Agency Name	South Carolina Department of Transportation
Sponsoring Agency Contact (Name, Address, Phone, Email)	P.O. Box 191 Columbia SC USA 29202 http://www.dot.state.sc.us/
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	As part of the continuing efforts to improve seismic design of structures built for SCDOT, the Department recognized the differences between the 3-Point Method of developing Acceleration Design Response Spectra (ADRS) curves and curves that were being developed from Site-Specific Seismic Response Analyses. Prior to conducting this research, SCDOT had begun using Vs100 (shear wave velocities in the upper 100 feet of

	the soil profile) to determine Site Class. Site Class is used to determine the multiplier (Site Coefficients) used to model the effect a specific site will have on the design response spectrum at that site. The Site Coefficients (F) are based on California type soils and seismic events neither of which adequately represent South Carolina foundations. Therefore, SCDOT engaged Clemson University to develop Site Coefficients specific to South Carolina, with the desired outcome of reducing the ground motions when compared to using the Site Coefficients contained in AASHTO. Over 25,000 linear and non-linear site response analyses were performed to develop the Site Coefficients specific to South Carolina. Instead of a single set of Site Factors for the entire state, the new Site Coefficients were varied with geologic province (Coastal Plain versus Piedmont) and with Vs100. SCDOT continues to implement recommendations from this research. Based on the projects where the new procedure has been used, a reduction in the ADRS curve has been noted when compared to the ADRS curve developing using the former model of California-type soil Site Coefficients. A reduction in the ADRS curve is corollary to a reduction for loadings on all structural components (i.e., bridge, embankment, etc.). Lower loadings tend to reduce costs as fewer materials are required for the structure and ground improvement is either not required or significantly reduced.

Project Information

High Value Research Title	Support for the Development and Implementation of an Access Management Program through Research and Analysis of Collision Data
Project Number	FHWA-SC-15-02
Project Cost	$272,887
Project Duration	21 months
Web link	http://www.scdot.scltap.org/wp-content/uploads/2016/01/SPR-706-Final-Report-12-28-151.pdf
Submitter	
Submitter Agency	South Carolina Department of Transportation
Submitter (Name, Address, Phone, Email)	Terry Swygert 1406 Shop Road Columbia, SC 29201 803-737-6691 swygerttl@scdot.org
Research Program	
Sponsoring Agency Name	South Carolina Department of Transportation
Sponsoring Agency Contact	

(Name, Address, Phone, Email)	
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Overview The South Carolina Access and Roadside Management Standards (ARMS) provides standards and guidelines for permitting access encroachments onto SCDOT right-of-way. In April, 2013, SCDOT initiated research that would be used to update this manual with the intent that recommended changes could result in a reduction in crashes, injuries, and fatalities on South Carolina roadways. The research examined current and historical practices used by other transportation agencies with regard to access management. Using empirical data collected along several corridors that ranked highest in driveway related crashes, the researchers statistically analyzed and identified the correlation of access issues with crash data. Crash data were associated with driveways using complex Geographic Information System (GIS) modeling tools. Key Findings The statistical analysis identified several significant independent variables that influence crash rates. The results indicate that increasing the distance between driveways, increasing the number of entry lanes, and having a raised median will decrease driveway related crashes. Conversely, increasing driveway width, corridor volume and corridor speed limit will increase crashes. Similarly, a driveway with high turnover land use, a driveway with full access (as opposed to right-in/right-out), and the presence of nearby signalized intersections will increase crashes. A summary of key findings: • Converting a full access driveway to a right-in/right-out will reduce driveway crashes by 55%. • Driveways within 150’ of an intersection have nearly twice the crash frequency of driveways 150’ to 300’ from an intersection. • Better access policies result in lower crash severity, not just frequency. • Higher turnover land uses such as fast-food restaurants and gas stations have over twice the crash frequency of other land uses such as a small business or an apartment complex. Other Results A micro-simulation analysis was used to investigate the operational performance of different driveway spacing policies adopted by various DOTs in the US. Experimental results indicate that driveway spacing has direct influence on the average travel speed of a corridor. Since reduced driveway spacing negatively impacts corridor travel speed, selection of a minimum spacing should consider its effect on the operational

	performance of the corridor. Benefit-cost analyses of two different access modification strategies suggest that it is beneficial to convert a TWLTL to a raised median. Similarly, it is beneficial to reduce the driveway density on a corridor. The research also reviewed SCDOT access waiver procedures. While the current process suffices based on our literature review it is evident that this process could be significantly streamlined and enhanced with a paperless system. Conclusion Based on findings from the research a series of proposed changes and modifications are identified for the SCDOT Access and Roadside Management Standards (ARMS). Most of the standards identified in the current ARMS are still valid. Safety problems are most prevalent at driveways that deviate from adopted design standards. It is anticipated that implementation of the findings of this research will result in long-term economic benefits, and improved traffic flow and safety.

Virginia (5)

Project Information	
High Value Research Title	Evaluation of the Virginia Department of Transportation Adaptive Traffic Signal Control Technology Pilot Project
Project Number	1118012-RC00024
Project Cost	$204,010
Project Duration	49 months
Web link	http://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r24.pdf
Submitter	
Submitter Agency	Virginia Department of Transportation
Submitter (Name, Address, Phone, Email)	Michael D. Fontaine, P.E., Ph.D. Virginia Transportation Research Council 530 Edgemont Road Charlottesville, VA 22903 (434) 293-1980 Michael.Fontaine@VDOT.Virginia.Gov
Research Program	
Sponsoring Agency Name	Virginia Transportation Research Council
Sponsoring Agency Contact (Name, Address, Phone, Email)	530 Edgemont Road Charlottesville VA USA 22903 http://www.VTRC.net
Research and Results	

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Currently, most traffic signals operated by the Virginia Department of Transportation (VDOT) use actuated plans that vary by time of day (TOD) and day of the week. These timing plans are typically developed off-line using traffic count informationcollected in the field and then processed using signal optimization software. This method works well as long as traffic volumes remain consistent with the conditions used to develop the timing plan, but timing plans can become suboptimal if traffic demands deviate from those conditions. Traffic growth over time, seasonal changes in traffic, special events, or incidents can all cause TOD plans to perform poorly, resulting in increased delays to drivers. As a result, VDOT must regularly retime signalized intersections to deal with long-term changes in travel patterns, which incurs costs to VDOT. Even so, non-recurring events can still cause TOD plans to perform poorly. Adaptive signal control technology (ASCT) is one tool that has been proposed to handle variable traffic demand better. VDOT's Traffic Engineering Division began a pilot program to install the InSync ASCT developed by Rhythm Engineering on 13 corridors around the state beginning in 2011. The InSync system uses enhanced detection along a corridor to adjust signal timing parameters dynamically to meet observed demand in real time, eliminating the need to develop static timing plans. This allows the ASCT system to adjust signal timing parameters to account for variations in flow attributable to special events, seasonal flows, incidents, or simply the increase of volumes over time. In this case, signal timings are not pre-defined based on historic data, so ASCT systems can potentially reduce delays created by outdated static TOD plans. These pilot deployments were evaluated to determine if ASCT created operational and safety improvements large enough to justify the additional costs to install ASCT. Data on mainline traffic operations, side street delays, and intersection crashes were collected with and without ASCT active. The results showed that mainline traffic operations generally improved if (1) the corridor was not oversaturated; (2) the corridor did not have characteristics that encourage platoon dispersion; and (3) the corridor did not already function well. Side street delays generally increased, although net benefits in overall corridor travel time were usually still observed. Mainline travel speeds typically improved by 3 to 5 mph, and the number of stops decreased by an average of around 30 percent. An Empirical Bayes safety analysis of crashes at the intersections where ASCT was installed also found a 17% decrease in total crashes. Overall, ASCT generally produced a favorable benefit/cost ratio, averaging 8.17:1 for a single year based on safety and travel time improvements. The findings from the pilot tests were used to identify key considerations for future ASCT deployments so that VDOT could better identify future sites that might benefit from ASCT installation. Based on these findings,

	VDOT has continued to expand the usage of ASCT on new corridors around the state.

Project Information	
High Value Research Title	REDUCING CRACKS IN CONCRETE BRIDGE DECKS USING SHRINKAGE REDUCING ADMIXTURE (SRA)
Project Number	103636
Project Cost	$250,268
Project Duration	26 months
Web link	http://vtrc.virginiadot.org/PubDetails.aspx?PubNo=16-R13
Submitter	
Submitter Agency	Virginia Department of Transportation
Submitter (Name, Address, Phone, Email)	Michael M. Sprinkel, Associate Director Virginia Transportation Research Council 530 Edgemont Road, Charlottesville, VA 22903 434-293-1941 Michael.Sprinkel@VDOT.Virginia.gov www.VTRC.net
Research Program	
Sponsoring Agency Name	Virginia Transportation Research Council
Sponsoring Agency Contact (Name, Address, Phone, Email)	Jose P. Gomez, Director 530 Edgemont Road, Charlottesville, VA 22903 434-293-1900 www.VTRC.net
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Restrained shrinkage cracking of concrete bridge decks creates a significant durability problem. Major U.S. admixture suppliers have introduced a new category of chemical admixtures called shrinkage-reducing admixtures (SRAs). SRAs work by reducing the surface tension of pore water and thereby decreasing the capillary stress and shrinkage induced by drying. Several studies report that use of SRAs in concrete mixes is one of the most effective ways of reducing shrinkage cracking. The purpose of this research was to investigate the effectiveness of SRAs in reducing drying shrinkage in Virginia Department of Transportation (VDOT) concrete mixes and thus reducing cracks in bridge decks. Nine bridges located in VDOT's Northern Virginia, Staunton and Fredericksburg districts were selected for study. Three different SRA products were used. With the exception of one mix, maximum cementitious content was limited to 600 lb/yd3. Fresh and hardened concrete properties were tested for each mixture, and field placement

	details were documented. Results showed that low cementitious concrete with SRA was effective in minimizing bridge deck cracking. The study showed that bridges with few and narrower cracks or no cracks can be constructed and that proper construction practices are needed to reduce bridge deck cracking. Further, this project recommends the use of SRA with lower cementitious content in VDOT bridge deck concrete mix. A special provision is developed for future use of SRA in concrete mixtures.

Project Information

High Value Research Title	AN EVALUATION OF ROADSIDE ACTIVITY AND BEHAVIOR OF DEER AND BLACK BEAR TO DETERMINE MITIGATION STRATEGIES FOR ANIMAL-VEHICLE COLLISIONS
Project Number	103647
Project Cost	$106,870
Project Duration	34 months
Web link	

Submitter

Submitter Agency	Virginia Department of Transportation
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Research Program

Sponsoring Agency Name	Virginia Transportation Research Council
Sponsoring Agency Contact (Name, Address, Phone, Email)	530 Edgemont Road Charlottesville VA USA 22903 http://www.VTRC.net

Research and Results

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Virginia is consistently among the top 10 states with the highest number of deer-vehicle collisions (DVCs), with more than 56,000 DVCs per year since 2007. The Virginia Department of Transportation has targeted a section of I-64 on and near Afton Mountain for safety and mobility improvements because of a high number of crashes and traffic stoppages. DVCs are a primary driver safety concern in the area, and vehicle collisions with black bears are also relatively frequent. Mitigation strategies are needed to address this issue.

	The purpose of this study was to evaluate white-tailed deer activity and behavior along (1) an interstate roadside adjacent to unfenced isolated underpasses used by deer and (2) a stream corridor / highway intersection with no viable underpass for deer. Although not a primary focus, black bear and other wildlife activity was also evaluated. Two years of camera data and animal carcass removal data were analyzed to gain a better understanding of deer and black bear activity and behavior relative to the two road and landscape features. Cameras were installed at a large bridge underpass and a box culvert (both used by deer to cross beneath the highway) and along the adjoining 0.5-mile roadside on both sides of the underpasses. Despite frequent use of the underpasses by deer (1,187 per year), there was high deer activity along the adjacent roadside (1,182 per year). A statistically significant relationship was found between roadside deer activity and DVCs (i.e., as deer activity increased, DVCs increased), and this relationship was strongest in October and November. Although highway crossing attempts comprised a low proportion of deer behavioral responses (n = 100 crossing attempts), crossing attempts resulted in 7.5 DVCs per year on the 1-mile highway segments adjacent to each unfenced underpass. Deer along the roadside exhibited relatively low responsiveness (or vigilance) to the interstate; predominant behaviors included walking along the roadside and feeding. At the stream corridor / highway intersection, cameras were installed at the intersection and extended along the adjoining 0.25-mile roadside on both sides of the intersection. Bear were more active along the roadside near the stream corridor than at the underpass sites. The stream corridor and associated topography were found to concentrate deer movement toward a relatively short section of highway; deer activity was statistically higher nearest the stream corridor / highway intersection and decreased farther away from this intersection. DVCs were statistically correlated with roadside deer activity and were significantly higher during October and November than during the other months of the year. Study recommendations include (1) the installation of fencing along the roadside adjacent to existing large underpasses, and (2) an animal advisory message on the dynamic message signs along I-64 in the Afton Mountain area. Messages should be displayed from dusk through dawn from October through November (to correspond with periods of higher deer activity and DVCs). Fencing both sides of just one underpass is expected to result in a savings in costs associated with DVCs of $501,473 over its service life. A planned post-mitigation study may find that these low-cost forms of mitigation could have a substantial impact on drivers and wildlife, particularly if implemented on a larger scale.

Project Information

High Value Research Title	Continuous Friction Measurement Equipment As a Tool for Improving Crash Rate Prediction: A Pilot Study
Project Number	RC00069
Project Cost	$200,926
Project Duration	20 months
Web link	http://vtrc.virginiadot.org/PubDetails.aspx?PubNo=16-R8

Submitter

Submitter Agency	Virginia Department of Transportation
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Research Program

Sponsoring Agency Name	Virginia Transportation Research Council
Sponsoring Agency Contact (Name, Address, Phone, Email)	Jose P. Gomez 530 Edgemont Road Charlottesville VA USA 22903 434-293-1900 http://www.VTRC.net

Research and Results

Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	The study described in this report developed a pavement friction inventory for a single construction district in Virginia using the Grip Tester, a low-cost CFME. The continuous friction data were then coupled with crash records to develop a strategy for network analysis that could use friction to improve the ability to predict crash rates. The crash rate analysis applied the well-established methodology suggested by the FHWA for the identification of high crash risk areas using safety performance functions (SPFs),which include empirical Bayes rate estimation from observed crashes. The current Virginia Department of Transportation SPF models were modified to include skid resistance and radius of curvature (interstate and primary system only) to improve the predictive power of the models.The added predictive power of friction in the current VDOT SPF model proved significant in estimating crash occurrences. To further illustrate the value of these modified SPF models, a benefit analysis was conducted for all sections of the three highway systems in the Salem District for which the B/C ratio for friction repair was greater than 1.0. Using these improved SPFs, the higher the friction, the fewer the expected crashes. When a conventional plant-mix overlay (OL) is used, the analysis predicts 761 fewer crashes. When an HFS is used, the

	analysis expects to reduce crashes by 1,065. The majority of the comprehensive savings is achieved on the interstate and primary systems, but regardless of the treatment chosen, the net economic benefit (societal savings) for one VDOT district could be in excess of $100 million every 3 years. Total economic savings of this magnitude would easily offset the costs of a comprehensive PFMP, the equipment necessary to administer it, the construction of the treatments on high volume roads, and even significant skid-crash mitigation on those sites for which traffic volumes would ordinarily be too low to meet strict economic criteria (such as low-volume high-risk rural roads, HRRR). This research ultimately improves the ability of the district maintenance and regional traffic engineers to match user demands for pavement friction with the capability of common surface alternatives, both on a local and system-wide basis. An effective PFMP better positions VDOT to respond to its FY15-16 Business Plan, Section 3.2.3., which includes a focus on "lowering the number of deaths and severe crashes through engineered safety improvements." Implementation will next involve collecting continuous data on Virginia's Corridors of Statewide Significance (CSS), a joint activity with VDOT, FHWA, and VTTI. This effort will include about 3,700 centerline miles of highway; 1,100 miles of divided interstate; and approximately 2,600 miles of divided and four-lane undivided primary routes (see Figure 9). In addition to friction and curvature, the analysis of the CSS data will also incorporate texture, cross-slope, and grade. The preliminary cost is estimated to be around $200,000; and the effort is expected to consume about 1 year.

Project Information

High Value Research Title	Asphalt Mixture Performance Characterization Using Small-Scale Cylindrical Specimens
Project Number	RC00081
Project Cost	$38,397
Project Duration	4 months
Web link	http://vtrc.virginiadot.org/PubDetails.aspx?PubNo=15-R26

Submitter

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Research Program	
Sponsoring Agency Name	Virginia Transportation Research Council
Sponsoring Agency Contact (Name, Address, Phone, Email)	Jose P. Gomez, Director 530 Edgemont Road, Charlottesville, VA 22903 434-293-1900 www.VTRC.net
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	The results of dynamic modulus testing have become one of the primarily used performance criteria to evaluate the laboratory properties of asphalt mixtures. This test is commonly conducted to characterize asphalt mixtures mechanistically using an asphalt mixture performance tester as developed in NCHRP Project 9-29. The typical test specimen geometry consists of a cylinder having a 100-mm diameter and a 150-mm height. This geometry is practical for laboratory-prepared specimens produced using a gyratory compactor. However, the specimen scale is problematic when the test specimen is prepared from field cores and the investigator wishes to isolate the testing to a single asphalt mixture material/layer. This is because most asphalt mixture layers, especially surface and intermediate layers, are placed having a thickness less than 150 mm. This study investigated the use of small-scale cylindrical specimens as an alternative means to conduct dynamic modulus testing of asphalt mixtures. To validate the small-scale approach, the dynamic modulus from full-size specimens (100 × 150 mm) using asphalt mixtures having a nominal maximum aggregate size (NMAS) of 9.5, 12.5, 19.0, and 25.0 mm. Small-scale cylindrical specimens having a diameter and height of 38 × 135 mm, 50 × 135 mm, 38 × 110 mm, and 50 × 110 mm were studied. Based on the findings of the study, for 9.5- and 12.5-mm NMAS mixtures, any of the four small-scale geometry dimensions appears to be a suitable alternative to the full-size specimen when the full-size specimen cannot be produced. For 19.0- and 25.0-mm NMAS mixtures, the two small-scale geometries having a diameter of 50 mm appear to be suitable alternatives to the full-size specimen when the full-size specimen cannot be produced.

West Virginia (1)

Project Information	
High Value Research Title	Evaluation of Deer-Vehicle Collision Rates in West Virginia and a Review of Available Mitigation Techniques

Project Number	RP 291
Project Cost	$125,000
Project Duration	19 months
Web link	Link to report
Submitter	
Submitter Agency	West Virginia Department of Transportation
Submitter (Name, Address, Phone, Email)	Michael Pumphrey, P.E., Research Project Manager, West Virginia Department of Transportation, Chestnut Ridge Research Building, Room 705, PO Box 6884, Morgantown, WV 26506, (304) 206-8625, Michael.E.Pumphrey@wv.gov
Research Program	
No data entered for this section	
Research and Results	
Brief Summary of the Research Project and Impact, or Potential Impact, of Implementing Research Results	Over the last few years, West Virginia has been consistently identified by State Farm Insurance Company as the state with the highest rate of deer-vehicle collisions (DVCs). In January 2011, an agency review of the West Virginia Division of Natural Resources (WVDNR), as part of the Departmental Review of the Department of Commerce, was conducted by the Performance Evaluation and Research Division of the West Virginia Legislative Auditor's office. No major wrongdoing with the WVDNR was identified by the audit, however, the legislative auditor recommended that the WVDNR increase efforts to reduce the potential for DVCs in the state. As a partial response to the aforementioned auditor recommendation, WVDNR initiated an evaluation and review of DVCs in cooperation with the West Virginia Department of Transportation-Division of Highways (WVDOT-DOH). This project was jointly funded by State Farm Insurance, WVDNR, Federal Aid in Wildlife Restoration (W-48-R), and the WVDOT-DOH. This project reviewed police crash reports involving deer and carcass data reported by the WVDOT-DOH from 2008-2012. The police crash reports were deemed the most reliable in terms of location reliability and consistency across the state. This data was used for identifying DVC "hotspots" across the state based on 2-mile segment lengths. Segments identified as being "high" ranged from 13-22 reported DVCs over the 5-year period, which is assumed to be lower than the actual number due to underreporting. Modeling completed as part of the project suggested that the DVC frequency was positively related to landscape diversity and urban/urbanized areas and negatively related to presence of roadside slopes exceeding 60 degrees (uphill or downhill). The research provides a summary of DVC mitigation measures and funding mechanisms,

	including specific mitigation recommendations for West Virginia. The research evaluates various transportation metrics for normalizing state-by-state DVC estimates generated by State Farm insurance for national ranking purposes, including the rural and urban components of the metrics. The research showed that the number of DVC fatalities in West Virginia during the 2008 to 2012 study period was very low (0.73%) when compared to other crash types with fatalities, such as vehicle-vehicle collisions (31%), vehicle rollovers (16%), and roadway departures (20%). The research also showed that DVCs were very dispersed across Interstate, US, and WV state routes. The 2-mile segments that ranked as "High" hotspot locations did not have high enough DVC concentrations to warrant using Highway Safety Improvement Program (HSIP) funding for possible mitigation. In addition, the research showed that currently there are no cost-effective measures available that have been shown to significantly reduce DVCs. This research was significant as that it validates that the current level of response to DVC mitigation by the WVDOT-DOH is appropriate. HSIP funds should be appropriated to mitigate the other more prevalent crash types (e.g. road departures crashes, intersection crashes, etc.) before DVCs. The findings from this study have already been referenced in the evaluation of new highway construction projects. (**A final report summary and a technical brief are attached.)