Transportation Excellence Through Research

Research Impacts

Better—Faster—Cheaper

2014

Sweet 16 project titles are noted in red text and are featured in the list immediately following the Introduction.

Introduction

This document is the 2014 collection of High Value Research highlights from across the Nation. These highlights, which were compiled for the American Association of State Highway and Transportation Officials (AASHTO) Research Advisory Committee summer meeting, showcase projects that are providing "Transportation Excellence Through Research." The highlights encompass a variety of research with topics ranging from pavements and bridge construction, to wildlife management, and to freight management systems.

States that submitted projects include Alabama, Arkansas, California, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, New Hampshire, New Jersey, Mew Mexico, New York, North Carolina, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virgina, Wisconsin, and Wyoming.

List of Sweet Sixteen High Value Research Projects

From all of the High Value Research highlights submitted for this document, each of the four RAC regions selects its top four projects to form the "AASHTO Research Sweet Sixteen."

Region 1

MD Automated Low Cost and Real-Time Truck Parking Information System
NH Performance of W-Beam Guardrail after Height Adjustment
NY Field Methods for Determining Lead Content in Bridge Paint Removal Waste
PA Improving Mature Driver Safety Efforts

Region 2

LA Safety Improvement from Edge Lines on Rural Two-Lane Highways: A Comprehensive Study on Pavement Edge Line Implementation
MS Performance Evaluation of Roundabouts for Traffic Delay and Crash Reductions in Oxford, MS
SC Rate of Deterioration of Bridges and Pavements as Affected by Trucks
WV Landslide and Slope Stabilization Using Piles and Micro-Piles Based on the LRFD

Region 3

IN Costs And Revenues Associated With Overweight Trucks In Indiana
IA Western Iowa Missouri River Flooding - Geo-Infrastructure Damage Assessment, Repair, and Mitigation Strategies
KS Evaluation of Innovative Traffic Safety Devices at Short-Term Work Zones
MO Live Load Effect in Reinforced Concrete Box Culverts Under Soil Fill

Region 4

MT Testing & Evaluation of Recovered Traction Sanding Material
SD Effects of Wide Base Super-Single Tires on Pavements
WA Evaluation of Recycled Concrete as Aggregate in New Concrete Pavements
WY Managing Risks in the Project Pipeline

Alabama Department of Transportation

PROJECT INFORMATION	
Project Title	***Effectiveness of Silane in Mitigating Alkali-Silica Reaction in the Bibb Graves Bridge***
ID	930-802
Project Cost	$105,446
Duration	34 months
SUBMITTER	
Submitter Agency	Alabama Department of Transportation
Submitter Contact	Jeffrey W. Brown 1409 Coliseum Boulevard (334) 353-6940, brownje@dot.state.al.us
RESEARCH PROGRAM	
Sponsor Contact	Alabama Department of Transportation 1409 Coliseum Boulevard Montgomery, AL 36130-3050 http://www.dot.state.al.us/
RESEARCH AND RESULTS	
Brief Summary of Research Project  The Bibb Graves Bridge in Wetumpka, Alabama built in 1931  Surface deposits and ASR-induced cracking on 3/11/08	Alkali-silica reaction (ASR) is a detrimental reaction in concrete that can cause severe expansion and cracking in structures. The Bibb Graves Bridge is a reinforced concrete bridge that was constructed in 1931, and is located in Wetumpka, Alabama. Both arches of span 5 have severe cracking and surface deposits caused by ASR. A silane-based, ASR mitigation was applied to spans 4 and 5 of the Bibb Graves Bridge during October and November of 2010. The goal of this mitigation procedure was to lower the internal relative humidity of the ASR-affected concrete to below 80 percent so that continued ASR-related expansions do not occur. After the application of the mitigation procedure, monitoring of the internal relative humidity, concrete expansion, and new crack development in the bridge was performed for 35 months to evaluate the effectiveness of the mitigation procedure. Analysis of the 35 months of data revealed that there were few signs of decreasing relative humidity or slowed expansion rates in the ASR-affected concrete. Analysis of the in-situ concrete strain data indicates that the ASR expansion in span 5 is continuing at the same pace as it was before mitigation. This was shown by the onset of new cracking and strong, linear trends with high expansion rates in a majority of the span. Some of the highest expansion rates in the two arches of span 5 range from 344 to 546 microstrains per year. It is concluded that the silane sealer was ineffective, and alternative mitigation options should be considered. It is recommended to continue in-situ monitoring to quantify the effects of ASR in this bridge.
Web Links (if available)	

California Department of Transportation

PROJECT INFORMATION	
Project Title	***Development and Testing of a Low-Profile Barrier***
ID	Task Number 0645
Project Cost	$60,000
Duration	97 months
SUBMITTER	
Submitter Agency	California Department of Transportation
Submitter Contact	Vue Her 1227 O Street Sacramento, CA 95814 (916) 227-5828, vue.her@dot.ca.gov
RESEARCH PROGRAM	
Sponsor Contact	California Department of Transportation 1227 O Street Sacramento, Ca 95814
RESEARCH AND RESULTS	
Brief Summary of Research Project	The physical crash testing in this project validated that the low-profile barrier successfully redirected a 2000-kg pickup truck impacting at 70 km/h and 25° and an 820-kg small car impacting at 70 km/h and 20°. Damage to the low-profile barrier was cosmetic and would not have required immediate repair, if any. The California low-profile barrier meets the critieria set in the National Cooperative Highway Research Program's Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Safety Features" as a Test Level 2 longitudinal barrier.
Web Links (if available)	http://www.dot.ca.gov/research/operations/roadsidesafety/low_profile_barrier/index.htm

PROJECT INFORMATION	
Project Title	***Trip-Generation Rates for "Smart Growth" Land Use Projects in California***
ID	Task Number 1940
Project Cost	$485,000
Duration	54 months
SUBMITTER	
Submitter Agency	California Department of Transportation
Submitter Contact	Scott Williams 1227 O Street Sacramento, CA 95814 scott.williams@dot.ca.gov
RESEARCH PROGRAM	
Sponsor Contact	California Department of Transportation 1227 O Street Sacramento, Ca 95814

PROJECT INFORMATION (CONT.)	
RESEARCH AND RESULTS	
Brief Summary of Research Project	University of California, Davis researchers collected trip-generation data at 30 smart growth land uses in California. They then used this information, along with trip-rates data from other studies, to develop a method embedded in a spreadsheet tool that can be used to adjust available trip-generation rates for smart growth land use projects proposed in California.
Web Links (if available)	http://ultrans.its.ucdavis.edu/projects/smart-growth-trip-generation

PROJECT INFORMATION	
Project Title	***Evaluation of an Animal Warning System Effectiveness***
ID	Task Number 2090
Project Cost	$349,960
Duration	27 months
SUBMITTER	
Submitter Agency	California Department of Transportation
Submitter Contact	Nathan Loebs 1227 O Street Sacramento, Ca 95814 (916) 657-4722, nathan.loebs@dot.ca.gov
RESEARCH PROGRAM	
Sponsor Contact	California Department of Transportation 1227 O Street Sacramento, Ca 95814
RESEARCH AND RESULTS	
Brief Summary of Research Project	The results showed that there was a reduction in the average speeds of the drivers when the dynamic animal warning signs were illuminated, and those speed reductions were greater during the evening, overnight, and early morning hours, when deer and other wildlife tend to be more active. There was evidence that the deceleration rates required when drivers spotted animals on the roadway were also reduced, improving safety by mitigating the need for "panic stops." Finally, it was also concluded that there was no evidence of driver adaptation over time to the warnings provided by the PAWS system. The reductions in mean speed continued throughout the entire time of the study after the dynamic animal warning signs were uncovered. The results of the survey among drivers of the road section indicated that most respondents wanted the system removed. The most common concerns expressed related to the cost of the system, the perception that the system is in the wrong location, the brightness of the warning signs at night, and the perception that the system is not reliable. Many respondents complained about perceived unreliability of the system, citing a high number of "false positives." However, the vast majority (93%) of all false animal detections for which the cause could be identified were related to vehicles turn

PROJECT INFORMATION (CONT.)	
	ing on and off the road, which is a limitation that must be overcome to gain public acceptance. Limited data on the effectiveness of animal detection systems suggest that they can reduce wildlife-vehicle collisions with a similar percentage as wildlife fences in combination with wildlife underpasses and overpasses. However, animal detection systems must still be considered experimental, as there are often challenges with the reliability of systems that need to be addressed. The system along SR 3 may well have become more reliable, perhaps "sufficiently reliable," if certain modifications were made to it. Since it is rare to have a reliable system with associated research equipment in place, the researchers suggest continuing the research into the reliability and effectiveness of the system after potential system modifications have been implemented. Only then can it be determined whether or not the implementation of these systems should be considered as an alternative to wildlife fencing in combination with wildlife underpasses and overpasses.
Web Links (if available)	http://www.path.berkeley.edu/PATH/Publications/PDF/PRR/2010/PRR-2010-22.pdf

PROJECT INFORMATION	
Project Title	***Strategies for Reducing Pedestrian and Bicyclist Injury at the Corridor Level***
ID	Task Number 2207
Project Cost	$228,800
Duration	23 months
SUBMITTER	
Submitter Agency	California Department of Transportation
Submitter Contact	Jerry Kwong 1227 O Street Sacramento, Ca 95814 jerry.kwong@dot.ca.gov
RESEARCH PROGRAM	
Sponsor Contact	California Department of Transportation 1227 O Street Sacramento, Ca 95814
RESEARCH AND RESULTS	
Brief Summary of Research Project	A database including all Vulnerable Road User (VRU) collisions was constructed using Statewide Integrated Traffic Records System (SWITRS) data maintained by the California Highway Patrol (CHP). The database includes all pedestrian and bicycle collisions from 1998 to 2007. Each collision was geocoded and matched to the closest intersection. A stratification system was recommended. Different traffic modes collisions can be stratified according to their spatial related features and outcome related features, or by their environmental features such as light and weather conditions.

PROJECT INFORMATION (CONT.)	
	A systemic approach was developed for pedestrian safety along urban arterials. Applying this method, users can identify systemic hotspots which share the same high risk characteristics and specific crash types. Then the systemic countermeasures can be selected and implemented throughout all similar types of locations.
Web Links (if available)	http://www.dot.ca.gov/research/researchreports/reports/2013/final_report_65A0407.pdf

PROJECT INFORMATION	
Project Title	***Required Embedment Length of Column Rebar into Type II Shafts***
ID	Task Number 2240
Project Cost	$1,087,397
Duration	71 months
SUBMITTER	
Submitter Agency	California Department of Transportation
Submitter Contact	Charles Sikorsky 1227 O Street Sacramento, CA 95814 (916) 227-8759 charles.sikorsky@dot.ca.gov
RESEARCH PROGRAM	
Sponsor Contact	California Department of Transportation 1227 O Street Sacramento, Ca 95814
RESEARCH AND RESULTS	
Brief Summary of Research Project	Enlarged (Type II) pile shafts are used frequently as foundations of reinforced concrete bridge columns because of the convenience in construction and post-earthquake damage inspection and repair. According to the specifications of the California Department of Transportation (Caltrans), the diameter of a Type II shaft shall be at least 610 mm (2 ft) larger than the cross-section dimension of the column. Hence, the column reinforcement extended into a pile shaft forms a non-contact splice with the shaft reinforcement. Because of the lack of information on the performance of these splices, the seismic design specifications of Caltrans on the embedment length of column reinforcement terminating in a Type II shaft are very conservative, especially for large diameter columns, which could complicate the construction work and entail high construction costs.

PROJECT INFORMATION (CONT.)	
	This report presents an experimental and analytical investigation to determine the minimum embedment length required for column longitudinal reinforcement extended into a Type II shaft and the transverse reinforcement required in the bar anchorage regions of these shafts. Experiments were carried out to investigate the bond strength and cyclic bond deterioration of large-diameter bars (No. 11, 14, and 18 bars), which are frequently used in large-diameter bridge columns and piles, and to evaluate the adequacy of the development length requirements in the AASHTO LRFD Bridge Design Specifications for these bars when they are subjected to severe cyclic tensile and compressive loads. Such data were not available in the literature and are crucial to gaining a good understanding of the anchorage performance of large-diameter bridge columns in a severe earthquake event. The experimental results have been used to develop, calibrate, and validate a semi-empirical bond-slip model for bars embedded in well-confined concrete. The model can successfully reproduce bond deterioration caused by cyclic bar-slip reversals and the tensile yielding of the bar. It has been implemented in an interface element in a finite element program. While the development length tests have indicated that the AASHTO requirements are adequate to develop the tensile strength of a large-diameter bar, further numerical studies using finite element models and Monte Carlo simulations have indicated that they do not have sufficient reliability to develop the full-tensile capacity of a bar when uncertainties in material properties and construction quality are considered. In addition, large-scale tests were conducted on four column-pile shaft assemblies. Based on these tests, additional finite element analyses, and the aforementioned reliability analysis, new design recommendations on the minimum embedment length for column reinforcement extended into enlarge shafts have been proposed. Recommendations on the transverse reinforcement required in the bar anchorage region of a shaft are also provided. While the amount of transverse reinforcement recommended is higher than that required by the current design specifications of Caltrans and AASHTO, the required embedment length is reduced by 40 to 50%. It has also been shown that the additional transverse reinforcement can be provided by an engineered steel casing, which can effectively control tensile splitting cracks induced by bar slip in a pile shaft and thus minimize post-earthquake damage repair on pile shafts.
Web Links (if available)	http://www.dot.ca.gov/hq/esc/earthquake_engineering/research_reports_site/

PROJECT INFORMATION	
Project Title	***Evaluation of the Effectivness of using CHP to Manage Traffic in Highway Work Zones***
ID	Task Number 2249
Project Cost	$300,366
Duration	26 months
SUBMITTER	
Submitter Agency	California Department of Transportation
Submitter Contact	Hassan Ghotb 1227 O Street Sacramento, Ca 95814 hassan.ghotb@dot.ca.gov
RESEARCH PROGRAM	
Sponsors	California Department of Transportation 1227 O Street Sacramento, Ca 95814
RESEARCH AND RESULTS	
Brief Summary of Research Project	The presence of CHP in the work zone slows traffic on the average of 5–7mph. However, if a CHP unit is located only before the workers, drivers often speed up after passing them. When multiple CHP units are used, drivers generally maintain the slower speed until passing the last unit. The effectiveness of using CHP is highly dependent on the geometry of the work zone: If drivers can see all CHP units in the work zone, they maintain the slower speed throughout the work zone. Simulations show that if speeds are reduced 5–7 mph at a work zone, injury severity could be reduced 28%–40%, and 3%–28% of all collisions would be prevented altogether.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Load Testing of Bridge Expansion Joints***
ID	Task Number 2384
Project Cost	$55,000
Duration	19 months
SUBMITTER	
Submitter Agency	California Department of Transportation
Submitter Contact	Joe Holland Sacramento, Ca 95814 (916) 227-5825 joe.holland@dot.ca.gov
RESEARCH PROGRAM	
Sponsors	California Department of Transportation 1227 O Street Sacramento, Ca 95814

PROJECT INFORMATION (CONT.)	
RESEARCH AND RESULTS	
Brief Summary of Research Project	A novel use of the Heavy Vehicle Simulator, which is used to evaluate pavement performance to vehiclular loading, for bridge axpansion joints. The particular bridge joint in this study is relatively new to Caltrans because it is designed as a lane joint, which will allow for maintenance on a single joint at a time while allowing traffic on the other lanes. To assure that it and all of its components would withstand car and heavy truck traffic, a full-sized model was constructed near the Bay Bridge site and tested with the Heavy Vehicle Simulator. Testing was done over 3 months with the loads increasing to 150 kN halfaxle load in the last phase of the test. The excessive loading caused some damage to the Trelleborg unit of the joint and it was recommended that the unit be evaluated on a regular basis for normal wear. No seismic studies were done for this study.
Web Links (if available)	http://www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2011-06.pdf

District of Columbia Department of Transportation

PROJECT INFORMATION	
Project Title	***Increasing the Cost Efficiency of Pavement Condition Assessment: Predicting Pavement Condition Index Values from International Roughness Index Values in Washington, DC***
ID	DDOT-RDT-13-7
Project Cost	$43,604
Duration	5 months
SUBMITTER	
Submitter Agency	District of Columbia Department of Transportation
Submitter Contact	Stephanie Dock Research Program Specialist 55 M Street, SE, 5th Floor Washington, DC 20003 202.671.1371 stephanie.dock@dc.gov
RESEARCH PROGRAM	
Sponsor Contact	District Department of Transportation 55 M Street, SE, 5th Floor Washington, DC 20003

PROJECT INFORMATION (CONT.)	
RESEARCH AND RESULTS	
Brief Summary of Research Project	Highway agencies use pavement condition data for developing programs for the maintenance, repair and rehabilitation of roadways. The International Roughness Index (IRI) and Pavement Condition Index (PCI) are two important datasets complied for pavement management purposes. The IRI is typically determined using specialized field equipment for measuring surface variations, which serves as input to established computer algorithms. The PCI is based on subjective rating of observed pavement distress. The process for determining the subjective PCI values is laborious and time-consuming since engineers and technicians usually review several photographs over a long period of time in order to obtain an estimated PCI value. The literature suggests that these pavement indices are related and, as a result, several jurisdictions have developed models to predict one index from the other to reduce cost and subjectivity. This study used three years of IRI and PCI data from the District Department of Transportation to develop models to predict PCI from IRI by functional roadway classification and by pavement type in the District of Columbia. Regression models of the relationship between IRI and PCI, using natural logarithmic transformations, had very good fit based on statistical analysis. The models created in this project were coded into an Excel-based template that can be used to compute PCI values based on the IRI, functional classification, and pavement type. Once adopted, this tool will allow DDOT to reduce the frequency with which it collects PCI data. The report's recommendation is that new PCI data be collected and the models be re-validated every 4-5 years. It is expected that at least one more year of data will be used to finish validation of the current model; then, the tool can be adopted and PCI data collection can be put on its new 4-year cycle. Cost Savings: Currently, DDOT collects both IRI and PCI every year for federal-aid roads and every other year citywide. Using the model developed by this research instead, and assuming a 4-year cycle for revalidation, for the first three years of the cycle, only IRI will need to be collected; in the fourth year, both IRI and PCI data will be collected and analyzed. By reducing the required data collection and the labor hours for obtaining the PCI values to once every 4 years, this research project will save DDOT an estimated $750,000 over a 4-year cycle (in 2014 dollars, assuming no cost escalation). This is a savings of almost 30 percent over the current collection schedule.
Web Links (if available)	

Florida Department of Transportation

PROJECT INFORMATION	
Project Title	***Aging Road User, Bicyclist and Pedestrian Safety Phase 3: Effective Bicycling Signs and Minimizing Left-Turn Crashes***
ID	BDK83 977-15
Project Cost	$246,957
Duration	28 months
SUBMITTER	
Submitter Agency	Florida Department of Transportation
Submitter Contact	Steven Bolyard FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4613 steve.bolyard@dot.state.fl.us
RESEARCH PROGRAM	
Sponsor Contact	Florida Department of Transportation 605 Suwannee Street Tallahassee, FL USA 32399-0450
RESEARCH AND RESULTS	
Brief Summary of Research Project	This study was a follow-on to the human factors research performed by Florida State University (FSU). The objectives of the study were to develop and complete lab studies to help understand sign message perception; to help determine appropriate standards and guidelines for the bicycle warning sign; and to study driver comprehension of the differences between a shared lane marking in contrast to a marked bike lane. Task 1 assessed younger, middle-aged, and older drivers' knowledge of various bicyclist-related signs and lane markings, finding: 1. In general, knowledge was high, 2. Some lane markings and signs were frequently misunderstood even among bicyclists (i.e., Sharrow, Bicyclist Detector markings and Bicyclist Slippery when Wet sign), 3. Share the Road and 3-Foot Minimum signs were generally more quickly understood and recognized in versions of the sign depicting a sideways view of a bicycle rather than a rear view of a bicyclist/bicycle, and 4. Low-pass filtering of these signs also suggested a legibility advantage for versions of the sign depicting a sideways view of a bicycle. In Task 2, researchers explored whether these differences in comprehension/recognition/legibility had an impact on driver behavior in a simulator study. Younger, middle-aged, and older drivers navigated a simulated route in which they passed single and groups of bicyclists. Sometimes bicyclists were located within a bicycle lane and sometimes a bicyclist lane was not present.

PROJECT INFORMATION (CONT.)

The main findings were:

1. Drivers generally passed bicyclists with care, allowing a clearance much greater than 3 feet,
2. Groups of bicyclists were given more clearance compared to single bicyclists,
3. Passing distances were smaller in the presence of oncoming traffic,
4. Passing distances were smaller when a bicycle lane was present,
5. The type of sign and the presence of a sign with the message to give bicyclists at least 3 feet of clearance did not impact passing distances, and
6. Age did not have a significant impact on passing distances.

Finally, Task 3 examined whether decreased negative offset (minimal offset) left-turn lanes provide a safety advantage to drivers of all ages. Drivers first completed a gap judgment task in the driving simulator. Also, participants drove a simulated route and were asked to make turns at intersections featuring a minimal or large negative offset.

Findings were as follows:

1. No differences between minimal and negative offsets were observed in the gap judgment task,
2. Younger adults tolerated smaller gaps in traffic compared to older adults,
3. The minimal offset resulted in a benefit in the turn execution task; turns were executed in such a way that the distance between the drivers' car and oncoming traffic was larger compared to the negative offset condition.

Researchers concluded that (1) educational campaigns focused on the meaning of certain bicyclist-related road markings and signs may be beneficial; (2) although passing distance was not influenced, Share the Road signs; and (3) Foot Minimum signs should feature a side profile of a bicycle to facilitate comprehension, 3) decreasing negative offset of left-turn lanes is an effective means to encourage safer left turns for drivers of all ages.

Presentations to the Pedestrian and Cyclist Safety Coalition have been scheduled; the project manager will need to discuss the results of the study with the FDOT Design, Safety, and Operations offices, as well as the Florida Department of Highway Safety and Motor Vehicles. These discussions should lead to changes in the FY2015-16 State of Florida Drivers Handbook, the FDOT Traffic Engineering Manual (TEM) and, hopefully, the Manual on Uniform Traffic Control Devices (MUTCD). FDOT is moving forward with implementing the project's recommendations but will need to check with FHWA first to see if there is a requirement to conduct experiments first. If not, FDOT will update FDOT's Traffic Engineering Manual (TEM) first (Section 2.11), if experiments are required, then request a pilot/demonstration project for these

PROJECT INFORMATION (CONT.)	
	recommendations. Then, the Florida Driver's Handbook will be updated to reflect the newly approved signs, and lastly, FDOT will recommend national changes to the MUTCD through AASHTO. These changes will ultimately increase safety for cyclists and drivers, lowering the amount of accidents on Florida's and the nation's roadways. The off-set left turn lanes will increase safety for drivers by allowing them to have a better view of oncoming traffic and to make better turning gap judgments.
Web Links (if available)	http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT-BDK83-977-15-rpt.pdf

PROJECT INFORMATION	
Project Title	***Landscaping of Highway Medians at Intersections***
ID	BDK84 977-19
Project Cost	$183,369
Duration	29 months
SUBMITTER	
Submitter Agency	Florida Department of Transportation
Submitter Contact	Steven Bolyard FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850)414-4613 steve.bolyard@dot.state.fl.us
RESEARCH PROGRAM	
Sponsor Contact	Florida Department of Transportation 605 Suwannee Street Tallahassee, FL USA 32399-0450
RESEARCH AND RESULTS	
Brief Summary of Research Project	AASHTO provides general guidance on landscaping that requires unobstructed views for drivers. In Florida, detailed highway landscaping practice is governed by FDOT's Standard Index 546 (SI-546), which serves as FDOT's interpretation of AASHTO policy. In this project, researchers focused on current landscaping criteria, performing an empirical study of the safety performance of SI-546, and developing a computational procedure to analyze landscaping configurations. A literature review of 29 states determined that SI-546 was considered the leading critical standard for tree setbacks and detailed spacing requirements on highway medians near intersections, several other states even cited SI-546 in their own standards. To validate SI-546, researchers collected landscaping field data at 72 Florida intersections and combined with historical crash data to evaluate the safety performance of and compliance with SI-546. Researchers analyzed the latest two years of crashes within 300 ft. from the centerline of the intersections, excluding right-turn crashes. Researcher's developed a visibility simulation

PROJECT INFORMATION (CONT.)	
	tool to evaluate different landscaping configurations. Using parameters like observer location, vehicle profile, vehicle trajectory and speed, tree position and spacing, and threshold distance, the simulation yielded several performance measures, including average visibility, total time of unobstructed visibility, and maximum time of unobstructed visibility. The simulator can be adapted to produce other measures of interest. The researchers concluded that intersections that properly followed the SI-546 did not see a reduction in overall safety due to highway median landscaping. Several updates to SI-546 were proposed by the researchers and are being discussed for adoption by FDOT. The full implementation of this research will be realized once FDOT updates its SI-546 with the researcher's recommendations, a GUI is added to the planning tool developed under the project, and SI-546 planning tool is updated for 3-D applications. Uniform standards could allow roadway designers and planners to develop highway median landscaping designs that are both visually appealing and functional. The planning tool will allow these designers and planners to create a multitude of diverse landscaping designs, and then test these new designs for any potential safety deficiencies. Adoption of the revised SI-546 standards are expected before the end of the current fiscal year.
Web Links (if available)	http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_RD/FDOT-BDK84-977-19-rpt.pdf

PROJECT INFORMATION	
Project Title	***Evaluation of Driver Behavior to Hydroplaning in the State of Florida Using Driving Simulation***
ID	BDQ22 977-01
Project Cost	$61,654
Duration	13 months
SUBMITTER	
Submitter Agency	Florida Department of Transportation
Submitter Contact	Steven Bolyard FDOT Research Center 605 Suwannee St. MS 30 Tallahassee, FL 32399 (850) 414-4613, steve.bolyard@dot.state.fl.us
RESEARCH PROGRAM	
Sponsor Contact	Florida Department of Transportation 605 Suwannee Street Tallahassee, FL USA 32399-0450
RESEARCH AND RESULTS	
Brief Summary of Research Project	The goal of this study was to evaluate drivers' behaviors, especially speed control, on conditions that simulate hydroplaning potential. The specific objectives were to: (1) collect and review all the pertinent literature and other information related to driving applications on roadways, (2) design and conduct a driving simulation along with an experimental design to determine drivers' response during rainfall events, (3) conduct surveys to determine the perspective of the subjects used on this study while driving in rainfall events, and (4) provide recommendations that can be used on designing roadway sections to accommodate for hydroplaning. This project used a driving simulator to investigate patterns of drivers' behavior during rainfall events using different geometries. The data was broken into two major categories: light rain for rainfall intensity ranging from 0.01 to 0.24 inches/hour and heavy rain for rainfall intensity of greater than 0.25 inches/hour. The driving simulator at the University of Central Florida simulated the parameters such as speed and rainfall intensity observed in the field. Based on our analysis, researchers found that drivers are not affected by light rainfall events. However, heavy rainfall has a significant impact on their speed. On average, drivers reduced their speed by 6- to 12-mph. Also, there is no interaction between rainfall intensity and either gender or age group. The female participants appeared to drive faster as compared to their male counterparts and the age group ranging from 16- to 21-year-olds appears to be the most aggressive driver age group. Eighty percent of the participants reported on the survey that they have experienced some level of hydroplaning while driving on the road.

PROJECT INFORMATION (CONT.)	
	The simulator appears to provide identical results to the field data analysis, lending credence to the validity of using a driving simulator to investigate the pattern of drivers' behavior during rainfall events. The researchers recommended further validation and refinement of this study. Continuation of this project may also help FDOT and other agencies with future decision making, such as variable message signs, determining appropriate corrective measures on existing roadway sections, and/or designing future roadway sections to reduce hydroplaning. Both field and simulator studies demonstrated that drivers tend to reduce speed during rainfall events. Field data showed that traffic volume did not affect free-flow speed during rainfall, but drivers reduced speed by 2- to 8-mph, with greater decreases during night and weekday peak hours. Importantly, simulator studies agreed closely with field studies, but they gave a more refined view. Simulation drivers did not slow for light rainfall but slowed significantly at higher rain intensity, on average decreasing speed by 6- to 12-mph. There was no interaction between rainfall intensity and age group or gender. A better understanding of driver behavior under conditions conducive to hydroplaning can be an important aid in preventing loss-of-control incidents and collisions. With informed educational efforts and public information campaigns, drivers can be better equipped to respond appropriately to hydroplaning conditions. Also, better on-road warning systems, including variable message signs, can be devised to aid drivers in making real-time judgments. The full implementation of FDOT's hydroplaning research will not occur until new roadway sections are constructed using this research. Before a roadway section is built, however, FDOT must update its Plans Preparation Manual (PPM) to allow for greater than three thru lanes to be sloped in one direction. A software design tool will also be part of the implementation. The newly completed I-4 "Ultimate" roadway design utilizes elements of this research and will be the first roadway in the Florida designed with more than three thru lanes sloped in one direction. Other roadway projects are currently being studied for implementation of this research in South Florida and along the Florida Turnpike. The potential impacts of FDOT's hydroplaning research is aimed at enhancing safety on both new and existing roadway segments. Additional FDOT hydroplaning research indicates that allowing all of the roadway lanes to be sloped in one direction (preferably to the outside shoulder) will ultimately save money through reductions in constructing drainage pipes, drainage inlets, and the maintenance required for these structures/systems. For existing roadway segments, variable message and speed limit signs could allow drivers to better determine a safer speed during instances of potentially significant rainfall.
Web Links (if available)	http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_RD/FDOT-BDQ22-977-01-rpt.pdf

Georgia Department of Transportation

PROJECT INFORMATION	
Project Title	***Estimating Foundation Scour for Extreme Hydrologic Events at Scour-Critical Bridges***
ID	RP 09-08
Project Cost	$233,056
Duration	34 months
SUBMITTER	
Submitter Agency	Georgia Department of Transportation
Submitter Contact	David Jared, P.E. 15 Kennedy Dr. Forest Park, GA 30297 404-608-4799 djared@dot.ga.gov
RESEARCH PROGRAM	
Sponsor Contact	Georgia DOT 15 Kennedy Drive Forest Park, GA 30297
RESEARCH AND RESULTS	
Brief Summary of Research Project	During large floods, bridge foundations are subject to severe scour at the sediment bed, which can cause bridge failure, especially in the case of overtopping of the embankment. In September 2009, several bridges in the Atlanta metro area were subject to overtopping and had to be closed due to erosion of the abutment end-roll and collapse of some bridge deck spans. Total flood damage in the metro Atlanta area was estimated at $500 million. In the face of such extreme events, a number of bridges in Georgia have been classified as scour-critical based on empirical scour formulas that are unreliable and over-conservative in some cases. Consequently, research was conducted to refine bridge scour estimates considering the (1) complex turbulent flow field responsible for scour; and (2) scour resistance of the local soils at the bridge sites. The aim of this research to improve scour prediction methods by quantifying these critical factors for the specific conditions of simultaneous contraction, abutment, and pier scour during overtopping hydrologic events when scour-critical conditions are most likely to occur. Project work consisted of (1) flume tests to determine the scour resistance of local soils at bridge sites; (2) physical river models to study various types of scour occurring simultaneously with (or without) overtopping; (3) application of computational fluid dynamics to determine scour near the abutments before and during bridge overtopping; and (4) recommendations for improved prediction of scour potential for scour-critical bridges.

PROJECT INFORMATION (CONT.)	
	Based on the findings of this research, implementation is underway via a follow-up research project to (1) synthesize and consolidate the current research results and (2) provide a manual for applying them, a webinar designed for GDOT and its consultants, and short courses including course notes. This research will provide the procedure and training materials necessary to implement an improved design and evaluation process for bridge foundations subject to scour failure during extreme floods under conditions of pressure flow and/or overtopping. When combined with estimates of economic losses associated with bridge repair/replacement and economic losses due to inaccessibility of critical transportation routes for industry in the south, economic competitiveness in Georgia will be enhanced through realistic bridge foundation designs informed by risk assessment, i.e., ranking bridges according to relative susceptibility to damage and failure, and provide greater safety for drivers by prioritizing vulnerable bridges in the bridge closure plan during extreme events.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Sustainable Streets and Highways: An Analysis of Green Roads Rating Systems***
ID	RP 10-13
Project Cost	$80,000
Duration	24 months
SUBMITTER	
Submitter Agency	Georgia Department of Transportation
Submitter Contact	Binh Bui 15 Kennedy Dr. Forest Park, GA 30297 404-608-4798 bbui@dot.ga.gov
RESEARCH PROGRAM	
Sponsor Contact	Georgia DOT 15 Kennedy Drive Forest Park, GA 30297
RESEARCH AND RESULTS	
Brief Summary of Research Project	With increasing concerns about the sustainability of transportation systems, state transportation agencies are looking to adopt initiatives that will both educate their employees and the communities they serve on how transportation systems and system operations can be viewed within a sustainability context. One of the strategies some of these agencies have adopted for providing a more sustainable approach to highway design is a "green streets and highways rating system." Adoption of a strategy like the one developed in this project for the Georgia Department of Transportation (GDOT) enables

PROJECT INFORMATION (CONT.)	
	an agency to compare projects based on sustainability goals and outcomes. This rating system can provide several benefits to a state DOT. As a public relations tool, publishing the sustainability rating results of completed projects can promote an "environmentally friendly" image of the agency. In some cases, this could be used to garner increased support for an agency's program. Comparing the ratings of proposed projects during the early programming process may also help in selection of more sustainably effective and efficient projects. Additionally, a project in the project planning phase could use the green rating criteria to identify those areas where changes in design could result in more environmentally sensitive designs. Overall, a green streets and highways rating tool is an important means of fostering an environmental ethic in a transportation agency, one that could become more important in years to come. The two objectives of this project were to: (1) evaluate emerging transportation sustainability rating systems to determine best practices and methods that might be applied within GDOT and (2) propose a Georgia-specific rating system that would enable uniform consideration of sustainability characteristics for state DOT projects. This project proposes a rating system that is specific to GDOT, but bears some semblance to operational systems that have been used in other states. In addition to the expected intra-agency benefits described above, GDOT may make this rating tool available for use outside GDOT. The tool could be available solely as a self-evaluation tool, meant to provide information only. Alternatively, GDOT could sponsor a program that would review both in-house and projects outside of GDOT and award outstanding leadership in environmental stewardship. The program would be evaluated after a year to determine how effective the rating system has been with respect to the benefits associated with rating projects, and the areas in which GDOT has both exceeded expectations, as well as the areas that are lacking and could use improvement. Thereafter, if the program is considered successful and worth pursuing in future years, it is likely that it would need to be reviewed on a regular basis to ensure that it is keeping current with sustainable practices. It is expected that the use of a sustainability rating system as part of project planning may help achieve some degree of improved sustainability in support of state and regional transportation plans.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Development of a Risk-Based Scorecard to Assess Scour Vulnerability of Georgia's Bridges***
ID	RP 11-27
Project Cost	$75,000
Duration	18 months
SUBMITTER	
Submitter Agency	Georgia Department of Transportation
Submitter Contact	Gretel Sims 15 Kennedy Dr. Forest Park, GA 30297 404-608-4802 gsims@dot.ga.gov
RESEARCH PROGRAM	
Sponsor Contact	Georgia DOT 15 Kennedy Drive Forest Park, GA 30297
RESEARCH AND RESULTS	
Brief Summary of Research Project	The majority of bridge failures in the U.S. are the result of scour. Determining which bridges are most vulnerable to scour is challenging, particularly in Georgia where more than 5,000 bridges have unknown foundations. To help determine which bridges are most vulnerable to scour, FHWA developed a risk assessment tool called HYRISK. HYRISK can be used to calculate the probability of bridge failures due to scour, including those with unknown foundations. The HYRISK model can also be used to develop a "scorecard" of bridge vulnerabilities and help GDOT prioritize monitoring efforts of its 5,000 bridges with unknown foundations. The current HYRISK model determines vulnerability using National Bridge Inventory (NBI) fields that are reported to the federal government. HYRISK can be used to prioritize bridges based on both the probability of failure as well as the economic consequences of failure [e.g., a bridge that has a high probability of failure but has a low annual daily traffic (ADT) could be ranked lower than a bridge with a lower probability of failure that has a high ADT]. To date, few states have applied the HYRISK model to assess bridge failure risks due to scour or customized the HYRISK model to include NBI items not reported to the federal government (e.g., soil type information).

PROJECT INFORMATION (CONT.)	
	The objective of this research was to investigate how HYRISK could be customized to Georgia and how it can be used to develop a scorecard of scour vulnerabilities for bridges with unknown foundations. This scorecard can help GDOT prioritize monitoring and maintenance efforts of its bridges with unknown foundations. The process of developing a scorecard may also enable GDOT to eliminate bridges from the "unknown foundation." In turn, measures of risk could be incorporated into asset management systems to help prioritize bridge maintenance, repair, and replacement schedules (or justify the need for additional funding to support these activities). Project results showed a state-level comparison of large variations in risk (as measured by the percentage of bridges expected to fail) across states, with one of the key drivers of this risk being the percentage of bridges with high scour vulnerability indices. Expected economic losses are only loosely related to the percentage of bridges expected to fail, reflecting underlying trade-offs that need to be made between the time to repair a bridge, traffic volumes, and availability of alternative routes. GDOT is moving forward with the scorecard developed from this project by incorporating the use of the HYRISK model to identify a subset of bridges for which it will perform initial scour screenings and/or detailed scour evaluations. The ranking of bridges will consider both the probability of failure as well as expected economic losses.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Development of Risk Management Strategies for State Dots to Effectively Deal with Volatile Prices of Transportation Construction Materials***
ID	RP 12-20
Project Cost	$92,493
Duration	26 months
SUBMITTER	
Submitter Agency	Georgia Department of Transportation
Submitter Contact	David Jared, P.E. 15 Kennedy Dr. Forest Park, GA 30297 404-608-4802 djared@dot.ga.gov
RESEARCH PROGRAM	
Sponsor Contact	Georgia DOT One Georgia Center 600 West Peachtree Street, NW Atlanta, GA USA 30308
RESEARCH AND RESULTS	
Brief Summary of Research Project	Volatility in price of critical materials used in transportation projects, such as asphalt cement (AC), leads to considerable uncertainty about project cost. This uncertainty may lead to price speculation and inflated bid prices submitted by highway contractors to protect against possible price increases. One of the most common risk-sharing strategies widely used by transportation agencies is price adjustment clauses (PACs) that divide potential upside and downside risk of material prices between contractors and owners. However, it is not clear whether offering PACs reduces risk premium of bids submitted by highway contractors. This research explored whether offering PACs for AC can explain the variation of submitted bid prices for major asphalt line items by highway contractors. Data on 3,749 highway projects bid in Georgia (January 1998 - July 2013) were collected to analyze the impact of the PAC on bid prices. Multivariate regression analysis was conducted to evaluate the effect of several factors, such as project size, number of bidders, AC price, and availability of PACs on unit price bids submitted by highway contractors for major asphalt line items. Results show that a linear combination of several explanatory variables such as quantity of the item, total bid price, and AC price index can explain the variations of the submitted bid prices appropriately. However, offering the PAC for the project is not a statistically significant explanatory variable in most of the models. More specifically, statistical analysis did not produce any significant evidence that offering AC price adjustment clauses decreases contractors' submitted bid prices for major asphalt line items.

PROJECT INFORMATION (CONT.)	
	Although PACs are aimed at eliminating extra risk premiums and therefore reducing contractors' submitted bid prices, offering these clauses freezes the scarce financial resources of state DOTs that otherwise could be used elsewhere. Thus, offering PACs has significant burden on state DOTs' limited budgets. For instance, Georgia DOT paid more than $69 million to highway contractors between 2007 and 2012 as price adjustment clauses for just asphalt cement in its transportation projects. Considering the significant magnitude of PACs for major AC line items, it is imperative to examine the financial implications of offering PACs for AC line items in transportation projects. It is expected that this work contributes to the transportation community by helping capital planners in transportation agencies to systematically evaluate the financial impact of state DOTs' price adjustment clauses on the cost of their highway construction projects. The proposed framework for conducting rigorous statistical analysis can be readily replicated by the other state DOTs across the nation to assess the effectiveness of their price adjustment programs. Decision-makers can consider the results of this study to improve their risk management strategies for dealing with the risk material price variations.
Web Links (if available)	

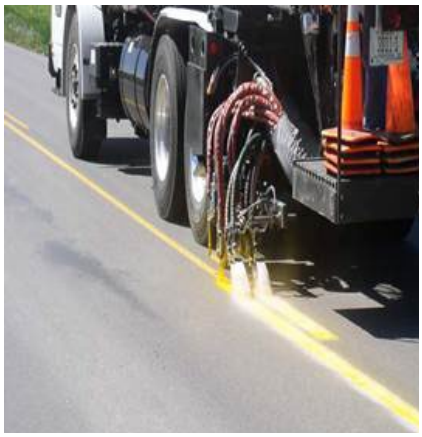
Idaho Department of Transportation

PROJECT INFORMATION	
Project Title	***Media Messages and Tools to Reduce Serious Single Vehicle Run-Off-the-Road Crashes Resulting from Impaired Driving***
ID	RP 209
Project Cost	$111,800
Duration	15 months
SUBMITTER	
Submitter Agency	Idaho Department of Transportation
Submitter Contact	Ned Parrish Research Program Manager P.O. Box 7129 Boise, ID 83707-1129 (208) 334-8296 ned.parrish@itd.idaho.gov
RESEARCH PROGRAM	
Sponsor Contact	Idaho Transportation Department P.O. Box 7129, 3311 West State Street Boise, ID USA 83707-1129 http://www.itd.idaho.gov
Brief Summary of Research Project	The Idaho Transportation Department (ITD) identified single-vehicle Run-Off-the-Road (SV-ROR) crashes as a significant traffic safety problem in its Strategic Highway Safety Plan. Between 2008 and 2010, SV-ROR crashes contributed to 49 percent of traffic fatalities in Idaho. Alcohol was found to be the leading contributing factor for this type of crash. In order to combat this significant traffic safety and public health issue, the ITD contracted with the Western Transportation Institute (WTI) at Montana State University (MSU) to provide research on the use of the Positive Community Norming approach to work toward the elimination of death and serious injury as a result of impaired driving. Based on analysis of crash records and a sample of crash reports, the researchers recommended that ITD focus on reducing impaired driving, which was a contributing factor in 42 percent of SV-ROR crashes. Researchers then conducted a survey to better understand how adults in Idaho perceive impaired driving and to assess their support for various strategies to reduce this risky behavior. The survey responses indicated that most Idaho adults do not drive within 2 hours of drinking alcohol (82 percent), support strong enforcement of impaired driving laws (95 percent), and would be willing to intervene to prevent impaired driving. However, the survey also showed that many respondents thought their views were not representative of others. For instance, 95 percent of respondents believed that most Idaho adults do drive and drive.

PROJECT INFORMATION (CONT.)	
RESEARCH AND RESULTS	
	Researchers recommended that a campaign be implemented to convey the positive norms identified in the survey and to encourage bystanders to help prevent impaired driving. Key messages identified by the researchers included: 1. "Most Idaho adults do not drink and drive." 2. "Most Idaho adults agree they would try and prevent a stranger from driving after drinking." 3. "Most Idaho adults agree with strongly enforcing impaired driving laws." It was recommended that these messages be coupled with information about how to intervene to prevent impaired driving. They stressed that the intervention needs to be safe, simple and straight-forward with easy to remember language. The core concepts they proposed for the intervention were that impaired drivers: • Need to stay and not drive. • Ride with someone else. • Be reported to law enforcement if they chose to drive. The research team also recommended using secondary messages that would foster dialog about safe driving behaviors among all drivers. These messages would encourage individuals to: Plan, Ride or Don't Drink. Research has shown that if individuals develop a plan about their drinking behaviors before they engage in drinking, they are more likely to stay within limits and less likely to engage in risky behaviors. ITD leadership voiced strong support for implementing the recommendations, and felt the approach offered a positive alternative to traditional fear-based campaigns. Representatives of health, education, and law enforcement agencies were also brought in discuss the proposed messaging strategy. Many of these individuals also expressed support for the approach. ITD's Office of Highway Safety subsequetly initiated a pilot project in three Idaho Communities. Department staff, working with the researchers, engaged the leadership of these communities to become involved in this project. As part of community engagement, focused print ads, billboards, and radio and television messaging were generated for use in these communities. An evaluation will be done at the completion of the pilot project. If the Positive Community Norming approach (including the associated messaging) is found to be effective, Idaho's Office of Highway Safety plans to implement this on a statewide basis. The Highway Safety Manager is also interested in using the positive community norms approach to engage communities to increase seat belt use and reduce distracted and aggressive driving.
Web Links (if available)	http://itd.idaho.gov/highways/research/archived/reports/Final%20RP209.pdf

Illinois Department of Transportation

PROJECT INFORMATION	
Project Title	***Restoration Progress and Flood Disturbance at IDOT Wetland Mitigation Sites***
ID	R27-114
Project Cost	$81,214
Duration	18 months
SUBMITTER	
Submitter Agency	Illinois Department of Transportation
Submitter Contact	Amy M. Schutzbach, P.E. Bureau of Materials and Physical Research 126 East Ash Street Springfield, IL 62704-4766 (217) 782 - 2631 Amy.Schutzbach@illinois.gov
RESEARCH PROGRAM	
Sponsor Contact	Illinois Department of Transportation Bureau of Materials and Physical Research 126 East Ash Street Springfield, IL 62704-4766 (217) 782 - 2631
RESEARCH AND RESULTS	
Brief Summary of Research Project  Figure 1. Photos of inundation, sedimentation, and ice damage due to flooding of wetland mitigation projects. Photos show (a) inundation and ice formation around newly planted trees, (b) ice damage to trees after year 3 of restoration, (c) an early-growing-season flood that did not inundate most trees but killed plants in the herb layer, and (d) a late-season flood that coated plants and trees with sediment.	Under the Federal Clean Water Act and the Inter-agency Wetland Policy Act of 1989, IDOT is mandated to develop mitigation sites to compensate for unavoidable losses to wetlands resulting from the construction of highway improvements. The majority of Illinois wetlands and most IDOT wetland mitigation sites are located in floodplain areas. These areas are subject to varying degrees of flooding depending on their location within a given watershed and their climate zone within the state. This project evaluated the effect of flood disturbance on species' composition and vegetation structure and the achievement of performance standards. The project used information previously collected for regulatory purposes at IDOT wetland mitigation sites. Results of the study suggest that landscape position and flood frequency and intensity should be considered when formulating performance criteria to judge success of a wetland mitigation project. Potential applications of this research are using flood regime in a landscape context to guide floodplain wetland mitigation site selection with particular consideration for vegetation-based functional replacement goals; adjusting mitigation planting plans based on existing flood exposure; and adjusting mitigation site design to alter the depth and duration of flooding where appropriate. This approach will allow IDOT to shift from the one-size-fits-all approach and ensure better performance from the sites selected.
Web Links (if available)	http://ict.illinois.edu/Publications/report%20files/FHWA-ICT-13-016.pdf

PROJECT INFORMATION	
Project Title	***Evaluating Pavement Markings on Portland Cement Concrete (PCC) & Various Asphalt Surfaces***
ID	R27-077
Project Cost	$369,284
Duration	47 months
SUBMITTER	
Submitter Agency	Illinois Department of Transportation
Submitter Contact	Amy M. Schutzbach, P.E. Bureau of Materials and Physical Research 126 East Ash Street Springfield, IL 62704-4766 (217) 782 - 2631 Amy.Schutzbach@illinois.gov
RESEARCH PROGRAM	
Sponsor Contact	Illinois Department of Transportation Bureau of Materials and Physical Research 126 East Ash Street Springfield, IL 62704-4766
RESEARCH AND RESULTS	
Brief Summary of Research Project  	The Illinois Department of Transportation (IDOT) uses a variety of different pavement marking systems and has experienced a wide range of pavement marking performance. The purpose of this project was to develop a pavement marking selection guide based on performance results on both Portland cement concrete (PCC) and hot-mix asphalt (HMA) pavements over a period of four years, in an effort to maximize marking performance by optimizing pavement marking selection. This project evaluated the durability of various Illinois approved pavement markings on a variety of pavement types, traffic conditions, and snowfall events. A pavement marking installation and inspection guide that includes a cost benefit analysis was developed. The comprehensive Pavement Marking Selection Guide will be posted on the Materials Website. Because the successful performance of a marking depends largely on controlling many variables during the installation of the marking, this guide includes pavement marking installation inspection methods for use by IDOT inspectors, allowing the district to select the adequate type of pavement marking for each application. This guide also includes pricing and durability information for all different types of pavement markings studied, allowing the user to make a life cycle cost analysis and aid in the decision making process. The Bureau of Construction will implement check-sheets and the Bureau of Operations will update the pavement marking policy, TRA-14.
Web Links (if available)	http://ict.illinois.edu/Publications/report%20files/FHWA-ICT-13-033.pdf

PROJECT INFORMATION	
Project Title	***Improved Design For Driven Piles On A Pile Load Test Program In Illinois***
ID	R27-069
Project Cost	$457,091
Duration	41 months
SUBMITTER	
Submitter Agency	Illinois Department of Transportation
Submitter Contact	Amy M. Schutzbach, P.E. Bureau of Materials and Physical Research 126 East Ash Street Springfield, IL 62704-4766 (217) 782 - 2631 Amy.Schutzbach@illinois.gov
RESEARCH PROGRAM	
Sponsor Contact	Illinois Department of Transportation 2300 S. Dirksen Parkway Springfield, IL 62764
RESEARCH AND RESULTS	
Brief Summary of Research Project	The objectives of this project were to increase the maximum nominal required bearing that designers can specify to reduce the number and/or weight of piles; decrease the difference between estimated and driven pile lengths to reduce cutoffs and splice lengths by development of local bias factors for predictive methods used in design; increase reliance of pile setup to increase the factored resistance available to designers; reduce the risk of pile driving damage during construction; and increase the resistance factor (decrease in factor of safety) based on increased data and confidence from load tests in and near Illinois. All objectives were addressed by conducting a dynamic and static testing field study in which 45 piles were tested utilizing different testing methods. Measured values were compared to several different predictive methods. Current Illinois specific methods were revisited to provide better agreement between predicted pile lengths and embedment lengths observed in the field, and provide better data to designers specifically for Illinois. A Simplified Stress Formula was developed to provide inspectors a method to verify capacity and avoid overstressing piles. This project provides better prediction methods for stresses during driving, thereby reducing the potential overstress of piles, better prediction methods for pile capacities using resistance factors for driven piling based on local calibrations that consider the effects of pile setups, allowing for more accurate pile lengths prediction and material saving,; and collections of static and dynamic load test data focused on Illinois soils and geology, to further refine the design process. A second phase study is underway to validate this study's findings.
Web Links (if available)	http://ict.illinois.edu/Publications/report%20files/FHWA-ICT-12-011.pdf

PROJECT INFORMATION	
Project Title	***Improvement for Determining The Axial Capacity of Drilled Shafts in Illinois Shales***
ID	R27-099
Project Cost	$172,500
Duration	17 months
SUBMITTER	
Submitter Agency	Illinois Department of Transportation
Submitter Contact	Amy M. Schutzbach, P.E. Bureau of Materials and Physical Research 126 East Ash Street Springfield, IL 62704-4766 (217) 782 - 2631 Amy.Schutzbach@illinois.gov
RESEARCH PROGRAM	
Sponsor Contact	Illinois Department of Transportation 2300 S. Dirksen Parkway Springfield, IL 62764
RESEARCH AND RESULTS	
Brief Summary of Research Project	Over a five-year period (2007-2011), the Illinois Department of Transportation's annual budget for pile foundation systems was constant at approximately $12 million per year, while over the same time period, use of drilled shafts has increased from less than $1 million per year to almost $6.5 million per year. This project studied the load transfer mechanisms of drilled shafts that are partially or fully embedded in weak clay based sedimentary rock (e.g., shale) encountered in Illinois, and developed a design procedure to improve safety and reduce construction costs. A database was established based on an extensive literature review of existing drilled shaft design and load testing for drilled shafts on clay-based sedimentary rock. Five bridge sites were evaluated in order to develop new testing methods to characterize the in-situ condition of shales commonly encountered in Illinois. The database and the information found using the new testing methods was utilized to develop correlations for the design of drilled shafts in weak shale, and resistance factors for designing drilled shafts using a load and resistance factor design (LRFD) framework. Drilled shafts at three of the five sites studies were able to be redesigned with the newly developed guidelines. The new design method developed by this research is expected to reduce the depth of drilled shafts in rock by 20%. Assuming future use of drilled shafts will average $6.5 million per year (conservatively assuming no growth) and using the historical fact that 1/3 of the drilled shaft cost has been for the

PROJECT INFORMATION (CONT.)	
	portion of the shaft in rock, the expected construction cost savings would be close to $450,000 per year. Additional cost savings will be realized during the subsurface investigation where expensive rock coring and unconfined compression testing will be greatly reduced when the new testing methods are implemented.
Web Links (if available)	http://ict.illinois.edu/Publications/report%20files/FHWA-ICT-13-017.pdf

Indiana Department of Transportation

PROJECT INFORMATION	
Project Title	***Electrical Testing of Cement Based Materials: Role of Testing Techniques, Sample Conditioning, and Accelerated Curing***
ID	3657 & 3509
Project Cost	$158,840
Duration	35 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
RESEARCH AND RESULTS	
Brief Summary of Research Project	There has been substantial recent emphasis placed on assessing the transport properties of the concrete used in transportation infrastructure, since this can be related to long term durability performance. Several groups have sought to develop test methods to assess the quality of concrete's resistance to chloride ingress and corrosion of reinforcing steel; however, traditional transport test methods are difficult to implement due to their significant preparation, conditioning, and testing times. This has led to interest in performing rapid electrical measurements. Rapid electrical tests utilize economical testing equipment and can be completed in a short amount of time, on the order of one minute per test. While electrical tests show great potential, there are several technical challenges that need to be addressed to ensure consistent results. This work has developed approaches to address these challenges considering the influ-

PROJECT INFORMATION (CONT.)	
	ence of testing variability, sample geometry, partial saturation, temperature, high temperature curing, and ionic leaching from the sample. A series of testing devices were purchased for the INDOT district testing labs for the purpose of providing training and providing information on the variability associated with testing. A round robin study has shown that a coefficient of variation of 4.36 % was obtained leading to a within laboratory precision of 12.8 % and a multi-laboratory precision of 36.0%. This work has shown that temperature can dramatically influence the resistivity. The research has shown that, once these factors are accounted for, the testing procedure can provide accurate, consistent data. This study has worked on the development of a standard testing protocol and training INDOT district testing engineers and their technicians with the equipment and tools to conduct these tests. The benefit of this testing is the cost savings in performing transport tests, as these methods are much less expensive than existing tests like Rapid Chloride Penetration (RCP) or chloride ponding. This can also lead to concrete that is designed and placed with improved resistance to chloride ingress, leading to a longer lasting infrastructure.
Web Links (if available)	http://dx.doi.org/10.5703/1288284315229

PROJECT INFORMATION	
Project Title	***Updating, Upgrading, Refining, Calibration and Implementation Of Trade-Off Analysis Methodology Developed for INDOT***
ID	3500
Project Cost	$100,675
Duration	22 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906

PROJECT INFORMATION (CONT.)	
Brief Summary of Research Project	For highway agencies that seek to carry out meaningful trade-off analyses as part of their asset management functions, one of the biggest challenges is to simultaneously evaluate the programs and projects funded from the same pool but addressing different asset types and yielding performance impacts that have different units. These metrics include the direct (agency) costs and indirect (user) costs in dollars, safety enhancements in number of crash reductions, urban mobility in delay or speed units, economic development in jobs, asset preservation in condition units, or asset remaining life in years. This study developed and implemented a framework that could be used by a highway agency to carry out scaling and amalgamation of the different units of these performance metrics and therefore to analyze the different kinds of trade-offs for asset management purposes. These trade-offs include the relationship between budget level and system-wide performance; the relationships for various pairs of conflicting or non-conflicting performance measures under different budgets; and the analysis of system-wide performance consequences of shifting funds across the program areas (management systems). The research product includes a case study that demonstrates how highway agencies could apply the trade-off analysis framework using data pertaining to their specific state. Thus, the research product includes a set of flexible and easy-to-use spreadsheets that implement the tradeoff framework. Overall, this research provides decision support for alternative investments across the different program areas on the basis of a broad range of multiple, non-commensurate performance metrics and against the background of possible caps and lower-bounds on the budgets and performance, for each of the program areas.
Web Links (if available)	http://dx.doi.org/10.5703/1288284315036

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Costs And Revenues Associated With Overweight Trucks In Indiana***
ID	3502
Project Cost	$200,000
Duration	29 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	This study estimated and analyzed highway pavement and bridge damage costs and the adequacy of permit revenues to cover these costs. The study began with an extensive review of the literature on the subject, thus facilitating identification of the gaps in the existing practice and research. The framework involves the development of asset families and establishment of realistic types and timings of reconstruction, rehabilitation, and maintenance, as well as traffic volumes and growth projections. The cost of damage was estimated for each asset family and age group, and the sensitivity of asset damage cost with respect to key policy and analysis variables was explored. Finally, the study examined cost and operational issues associated with the enforcement of overweight truck policies. In addressing the gaps in

PROJECT INFORMATION (CONT.)	
	existing research, this study showed that the damage cost of highway assets due to overweight trucks is influenced significantly by the asset type and age. For pavement assets, the pavement damage cost estimates were found to range from $0.006 per ESAL-mile on interstates to $0.218 per ESAL-mile on non-national highways. The results also suggested that the pavement damage cost estimates are highly sensitive to the pavement life-cycle length, interest rate, rest period, and the costs and service lives of rehabilitation treatments. For bridge assets, the incremental methodology was found to be suitable to estimate the cost of bridge damage due to overweight vehicles. The present study showed that bridge damage cost is not just a factor of gross vehicle weight but a function of all three vehicle variables: gross vehicle weight, axle spacing, and axle loads. Adopting a permit structure on the basis of gross vehicle weight only will result in some vehicles underpaying by as much as 92% of their actual contribution to bridge damage. Finally, the study examined cost and operational issues associated with the enforcement of overweight truck policies and identified a number of locations that could be considered for establishing new weigh stations and other enforcement facilities.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Measurement and Monitoring of the Performance of Highway Investment***
ID	3503
Project Cost	$200,000
Duration	29 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906

PROJECT INFORMATION (CONT.)	
Brief Summary of Research Project	Performance-based programming has become increasingly important because it leads to efficient allocation of constrained resources, facilitates the development and justification of budget proposals, and holds decision-makers accountable to the public. Historical network-level expenditure and performance data from the Indiana Department of Transportation (INDOT) were used to perform an ex-post facto program evaluation. In contrast to performance measures that are often used on a project-by-project basis during project planning, the study quantified the relationships between money that was spent and the resulting measured network performance. Post-implementation program evaluation, as demonstrated in the study, is a tool for validating the effectiveness of investment. The results of ex-post facto program evaluation can be communicated to legislative bodies responsible for funding decisions and also to the general public. There are four levels of measureable impact from highway improvements: 1. physical results, such as changes in the pavement and bridge condition; 2. tangible operational improvements, such as reductions in the number of crashes and reduction in congestion; 3. economic growth; and 4. externalities such as improvements to air quality and reduced energy use. Physical, operational, and economic levels of return were quantified. Linear regression models were used to represent the ex-post facto relationships between INDOT expenditure in various program areas (Pavements, Bridges, Safety, Mobility) with physical and operational improvements over a 10-year period (2000 to 2009, inclusive). Economic input-output analysis was used to estimate the additional jobs (179,905) and increased total earnings ($9.53 billion) due to transportation investment between 1995 and 2010. Short-term economic impacts were estimated because economic impacts occur in both the short- and long-term and are dependent on the availability of land, labor, and capital. Long-term economic impacts generally occur beyond the span of typical surface transportation reauthorization legislation; therefore, short-term estimable impacts are the appropriate economic measures for performance-based programming. Recommendations were made to refine web-based reporting tools to provide relevant performance and expenditure data to the public. Improvements to the condition of physical assets and performance of operational assets should be more visibly acknowledged. Additional recommendations were made to compare previously published estimates of performance (via annual reports) to the actual measured performance on a recurring basis. The post-implementation program evaluation can be routinely performed in
Web Links (if available)	http://docs.lib.purdue.edu/jtrp/1534/

PROJECT INFORMATION	
Project Title	***Use of Barriers in Rural Open Road Conditions—A Synthesis Study***
ID	3515
Project Cost	$35,000
Duration	16 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	The objective of this study was consistent with the Practical Design approach – a design paradigm that has been implemented in several states and is drawing strong interest across the country. The study analyzed existing design guidelines and research reports to determine whether medians and clear zones on existing rural four-lane interstates could be narrowed to accommodate two additional traffic lanes without widening the current right-of-way (ROW). Recent experience with Indiana's I-69 corridor challenges the current design practice with regard to sizing of medians and clear zones in rural areas. Significant cost savings could be realized by the Indiana Department of Transportation (INDOT) if the medians and clear zones on new and reconstructed facilities were narrower than required by the current design standards. Modern protective devices, such as high-tensioned cable barriers, offer protection with a lower risk of vehicle damage and personal injury than traditional concrete barriers and guardrails. Although the increasing cost of ROW was the drive for this synthesis study, rapidly growing personal injury medical costs must also be considered. The work presented in this report was conducted by the Purdue University research team in order to understand the mechanism of roadway departure crashes and to identify the effects of several potential strategies. This report provides an overview of crash statistics at the national level, a literature review from the United States as well as countries where narrow or no clear zones are used, and a simulation study. Potential strate-

PROJECT INFORMATION (CONT.)	
	gies for restricted ROW scenarios were identified along with opportunities for future research directions. The results of this study are applicable to depressed medians without barriers– the typical cross-section of Indiana rural freeways. The findings are summarized in tables and are ready to implement. The findings were especially timely, as Indiana had beenplanning to widen most of its rural freeways from four to six lanes. The proposed design approach, which accomplishes this without widening the ROW, will bring considerable cost savings. It has been recommended that the design recommendations of the study and its corresponding tables should be discussed by the INDOT Division of Highway Design and Technical Support and considered for implementation where feasible by means of appropriate revisions to the Indiana Design Manual and incorporation into INDOT's developing Practical Design principles.
Web Links (if available)	http://dx.doi.org/10.5703/1288284314670

PROJECT INFORMATION	
Project Title	***Development and Verification of Web-based Bridge Monitoring Interface***
ID	3554
Project Cost	$69,197
Duration	30 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279. 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	As part of SPR–3554, a web-based camera was installed at the Virginia Avenue Bridge in Indianapolis to document and characterize the nature of overheight truck collisions with a bridge over I-65. On February 22, 2013, one of those collisions resulted in closing Northbound I-65 and Eastbound I-70 for 3 days to repair part of the bridge structure. As part of INDOT's ongoing monitoring of system performance and programming capital projects, this section of I-65 was programmed for reconstruction in the fall of 2014. That project involved the complete closure of a section of I-65 for 59 days. INDOT and Purdue University partnered to develop a follow-on fast track project,

PROJECT INFORMATION (CONT.)	
	SPR 3850 South Split Communication Project, to assemble a series of short video clips as part of INDOT's broad media outreach (http://www.in.gov/indot/3154.htm) for that accelerated construction project. These videos included: • Pre Closure Outreach http://youtu.be/HoisCDmpSsU • Pavement Removal http://youtu.be/MifC43qGvuM • Ramp Construction http://youtu.be/vutoeAEkSTA • Progress http://youtu.be/lMmVYs4MpCM • Bridge Beam Replacement http://youtu.be/x8CkXTwhjAU • Substantial Completion http://youtu.be/h6NSBRAwpk4 This media outreach was very favorably received by the media and public. Several media outlets integrated the videos clips into their ongoing project coverage. Those videos received over 20 million views from those media outlets. This construction project was substantially completed in 45 days. Following the conclusion of the project, a summary 10-minute construction video was developed to show the major construction activities and quantities. • 10-minute Time Lapse http://youtu.be/YrSV-TgBW5g One of the lasting impacts of this project was that INDOT institutionalized the implementation of this web-based video abstract mechanism by hiring a full-time staff videographer to produce additional web content for media and public outreach.
Web Links (if available)	http://dx.doi.org/10.5703/1288284315215

PROJECT INFORMATION	
Project Title	***Updated Methods for Traffic Impact Analysis, Including Evaluation of Innovative Intersection Designs***
ID	3605
Project Cost	$98,000
Duration	26 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279. 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov

PROJECT INFORMATION (CONT.)	
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	In 1991, the Permits Section of Indiana Department of Transportation had a problem. Too often, developers of property along state highways would apply for driveway permits as their projects were nearing completion. Sometimes, the driveway location preferred by the developer conflicted with INDOT's standards for safe and efficient operation of the state highway. Lacking a procedure for the fairly new practice of Traffic Impact Analysis (TIA), INDOT commissioned project HPR-2039 Guidelines for Traffic Analysis of Developments Along State Highways. Researchers from Purdue University convened meetings of (1) consultants who represented developers and (2) members of INDOT's Permit Section. The results were a technical report and two guides—one for applicants and one for reviewers—which were published in 1993. The guides reflected a common desire for procedures that were consistent but flexible. A flow diagram was devised that would help consultants and INDOT decide early in the development project when something short of a full Traffic Impact Study (TIS) was necessary, avoiding unnecessary delays to the project. Standard formats for the scoping meeting and TIS report were agreed upon. The 1993 TIA guides were used for nearly 20 years, but it became apparent that conditions called for a review of the guides. Surveys of past and potential users were conducted and the consulting community was again included in the research study, as were representatives of local public agencies. The new guides were written in a way to encourage their use by cities and counties, and to encourage coordination between governments when a development may affect a roadway in another jurisdiction. Other features of the new guides included: • Compatibility with the current editions of the ITE Recommended Practice, INDOT's Access Management Guide, and INDOT's Design Manual • Legal issues and best practices regarding impact fees and right-of-way • Use of traffic microsimulation software to evaluate non-traditional intersections. These changes are expanding the use of the guides to all levels of government throughout the state, improving the safety and efficiency of traffic in response to new developments, thanks to the consistency and flexibility that the guides offer.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Performance of Portland Limestone Cements: Cements Designed to be More Sustainable that Include up to 15% Limestone Addition***
ID	3611
Project Cost	$150,000
Duration	26 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279. 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248 e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	Currently, the cement/concrete industry produces 5 to 8% of the world's CO2 emission. This research focused on reducing the CO2 emissions as a way of improving sustainability of concrete construction. Portland limestone cement (PLC) provides an opportunity to reduce the CO2 that is embodied in the built infrastructure by approximately 10% and is designed to have minimal/no impact on the construction process. PLC is deigned to be a direct replacement for conventional Portland cement. PLC is finer with a reduction in the coarse clinker particles (> 20µm) and an increase in fine particles that are primarily limestone. Calorimetry and chemical shrinkage results indicate that these PLC materials would be able to be used interchangeably with OPC in practice as it relates to the rate of reaction. The PLC mortars exhibited similar activation energies and mechanical properties (time of set, the modulus of elasticity, compressive strength, flexural strength, drying shrinkage, and restrained autogenous shrinkage). The PLC has a similar volume of permeable voids as their OPC counterparts and the chloride diffusion coefficients in these systems may range from 30% lower to 30% higher than the OPCs. This suggests that, for the properties examined, the PLC can be used in place of OPC resulting in similar performance and a 10% reduction in CO2 emission, thereby creating a more sustaninable infrastructure. PLC has the potential to dramatically improve the sustainability of the built infrastructure. For example, replacing ordinary Portland cement with PLC throughout the US industry would be equivalent to removing 840,000 cars from the roadways annually in terms of CO2 production.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Cost & Energy-efficient (LED, Induction and Plasma) Roadway Lighting***
ID	3613
Project Cost	$54,470
Duration	25 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279. 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248; e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	There is an increasing interest in using new lighting technologies such as light emitting diode (LED), Induction, and Plasma light sources in roadway lighting. The most commonly claimed benefits of the new lighting systems include increased reliability, improved efficiency, and reduced maintenance costs. Before adopting the new lighting technologies, the Indiana Department of Transportation (INDOT) would like to determine if they meet required light output and are cost effective. Moreover, it is necessary for INDOT to establish standardized guidelines for evaluating the new lighting systems prior to the formal adoption. This study first conducted literature reviews on the new lighting technologies. Surveys were also conducted to identify the perceptions of state highway agencies and local cities towards the new lighting technologies, including LED, Induction, and Plasma, and their experiences in use of these new lighting technologies. Various luminaires, including HPS, LED, Plasma, and Induction luminaires from different manufacturers were installed and evaluated for both conventional and high mast lightings at a test site over a period of 12 months. Illuminance measurements were made to determine the light levels and illuminance uniformities produced by those LED, Plasma, and Induction luminaires with the existing lighting infrastructures. Comparisons were also made between the light performances produced by different luminaires. Electric currents were measured to determine the energy consumptions by different luminaires. A life-cycle cost analysis was also conducted to determine if the new lighting sources are cost-effective compared to the corresponding HPS lighting sources and to assess the possible return or payback periods for the LED, Plasma, and Induction luminaires evaluated in this study. Illuminance measurements were also made for two urban street lightings to map the light performances of LED and Plasma luminaires with different lighting layouts. Findings and recommendations were made to assist INDOT Traffic Engineering in upgrading their lighting policies and developing technical specifications for adopting the new lighting technologies.
Web Links (if available)	http://dx.doi.org/10.5703/1288284315221

PROJECT INFORMATION	
Project Title	***Striping Truck Utilization at Crawfordsville and Greenfield***
ID	3722
Project Cost	0
Duration	0
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279. 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248; e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	At the time this project was launched, INDOT was operating two paint trucks per district (one edge line truck and one center line truck). This project was launched to determine the feasibility of painting all the lane miles in each district with a single paint truck per district. The Greenfield and Crawfordsville districts were chosen to develop and test ideas to enable the transition to painting with just one truck per district. Teams from both districts including paint truck drivers, painters, and managers participated in a series of Value Stream Mapping (VSM) sessions facilitated by Purdue Technical Assistance Program (TAP). The Value Stream Maps were used to identify inefficiencies in the painting operation and opportunities for improvement. These improvement ideas included both process changes and physical alterations to existing paint trucks. An action plan was created for each district to enable them to test the ideas during the second half of the 2013 and first half of the 2014 paint season. The action plans were completed and progress was tracked regarding the performance of the modified trucks and processes. Although the Crawfordsville and Greenfield districts implemented different approaches, both were able to complete painting all of their scheduled lane miles during the season with just one truck apiece. The results of this project demonstrated the viability of reducing the statewide fleet of INDOT paint trucks from 12 to 6. At an approximate cost of $400,000 per truck, this translates into an approximate savings of $2,400,000 as the current fleet of 12 aging trucks is replaced with 6 trucks rather than 12. The process changes implemented in this project also demonstrated operational efficiency improvements, which resulted in productivity improvements of approximately 10% while using half the number of paint striping trucks.
Web Links (if available)	http://dx.doi.org/10.5703/1288284315229

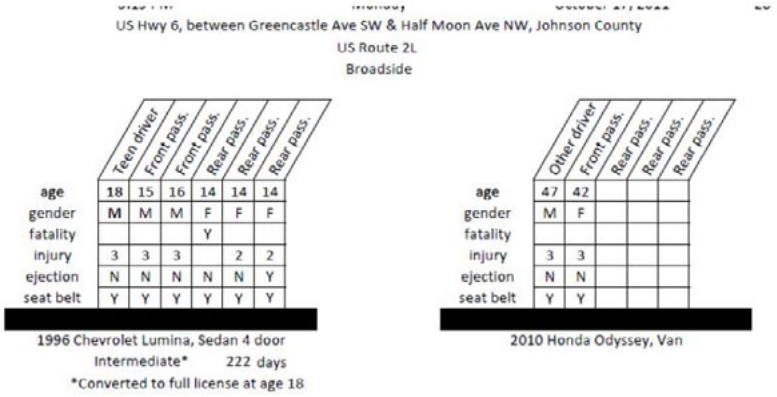
PROJECT INFORMATION	
Project Title	***South Split Communication Project***
ID	3850
Project Cost	$19,486
Duration	4 months
SUBMITTER	
Submitter Agency	Indiana Department of Transportation
Submitter Contact	Tommy E. Nantung Division of Research and Development P.O. Box 2279. 1205 Montgomery Street West Lafayette, IN 47906 Phone: (765) 463-1521 ext. 248; e-mail: tnantung@indot.in.gov
RESEARCH PROGRAM	
Sponsor Contact	Indiana Department of Transportation Division of Research and Development P.O. Box 2279 1205 Montgomery Street West Lafayette, IN 47906
Brief Summary of Research Project	As part of SPR–3554, a web-based camera was installed at the Virginia Avenue Bridge in Indianapolis to document and characterize the nature of over height truck collisions with a bridge over I-65. On February 22, 2013, one of those collisions resulted in closing Northbound I-65 and Eastbound I-70 for 3 days to repair part of the bridge structure. As part of INDOT's ongoing monitoring of system performance and programming capital projects, this section of I-65 was programmed for reconstruction in the fall of 2014. That project involved the complete closure of a section of I-65 for 59 days. INDOT and Purdue University partnered to develop a follow-on fast track project, SPR 3850 South Split Communication Project, to assemble a series of short video clips as part of INDOT's broad media outreach (http://www.in.gov/indot/3154.htm) for that accelerated construction project. These videos included: • Pre Closure Outreach: http://youtu.be/HoisCDmpSsU • Pavement Removal: http://youtu.be/MifC43qGvuM • Ramp Construction: http://youtu.be/vutoeAEkSTA • Progress: http://youtu.be/IMmVYs4MpCM • Bridge Beam Replacement: http://youtu.be/x8CkXTwhjAU • Substantial Completion: http://youtu.be/h6NSBRAwpk4 This media outreach was very favorably received by the media and public. Several media outlets integrated the videos clips into their ongoing project coverage. Those videos received over 20 million views from those media outlets. This construction project was substantially completed in 45 days. Following the conclusion of the project, a summary 10 minute construction video was developed to show the major construction activities and quantities.

PROJECT INFORMATION (CONT.)	
	• Ten Minute Time Lapse http://youtu.be/YrSV-TgBW5g One of the lasting impacts of this project was that INDOT institutionalized the implementation of this web based video abstract mechanism by hiring a full-time staff videographer to produce additional web content for media and public outreach.
Web Links (if available)	

Iowa Department of Transportation

PROJECT INFORMATION	
Project Title	***Moving Beyond Teen Crash Fatality Statistics (The Go-Team Study)***
ID	GOTM-000
Project Cost	$145,733
Duration	50 months
SUBMITTER	
Submitter Agency	Iowa Department of Transportation
Submitter Contact	Linda A. Narigon, P.E. SP&R Research Administrator, Research Implementation Engineer Office of Research and Analytics Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010 515-239-1471 linda.narigon@dot.iowa.gov
RESEARCH PROGRAM	
Sponsor Contact	Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010
RESEARCH AND RESULTS	
Brief Summary of Research Project	This project went beyond standard state-wide crash factors to evaluate teen fatalities due to motor vehicle crashes. This research helped clarify principals and causal factors in vehicle crashes, gaps in Iowa crash data, and insight to roadway design and safety policy enhancements that could reduce crash fatalities. A detailed case study was conducted for each teen fatality crash in 2009, 2010, and 2011 to evaluate specific details and context of each crash. A total of 126 crashes involving 131 teen drivers that resulted in 143 fatalities were analyzed. The project model included a "Go-Team" of experts gathering comprehensive data quickly for each crash. The Go-Team included the following experts:

PROJECT INFORMATION (CONT.)	
	• police crash reconstruction and reporting, • medical examiner, • traffic engineer analysis, • human factors specialists, • crash epidemiologists, • crash reconstructionist engineer, and • trauma staff. For each crash, news reports and public civil trial records were assessed where available. Contributing factors for each crash were summarized. Key findings include: • High vehicle occupancy was associated with single vehicle crashes; in the 32 single vehicle crashes where the teen driver was transporting passengers, two or more passengers were present 72% of the time. • Single vehicle roadway departures were the most common type of crash, likely due to lack of driving experience for the younger teen drivers and alcohol or drug impairment for the older teen drivers. This type of crash was most likely to occur in the early morning in suburban counties. • Driving too fast for conditions or speeding contributed to about one fourth of the crashes in which the teen contributed to the crash. • Alcohol or drug impairment was a factor in about one fourth of all crashes, in 42% of crashes caused by speeding, and in 29% of crashes caused by running off the road. • Relative to national statistics, teen MVC fatalities in Iowa are more likely to occur from midnight to 6 a.m. and from 9 a.m. to noon, and are less likely in the early afternoon, evening, and late evening. • Only half of the occupants in the teens' vehicles (including the driver) were wearing seat belts. Teens in the front seat were buckled up 60% of the time while those in the back seat were buckled up only 20% of the time. More than half the front seat occupants who were unbelted experienced fatal injuries compared to less than a third of those who were using seat belts. • There was an association between prior crashes and prior speeding violations and the teen being at fault in the fatal crash.



PROJECT INFORMATION (CONT.)	
	Implementation: • The duration requirement for teen drivers to hold an instructional permit changed from 6 months to 12 months; implemented on January 1, 2014. • Teen driver passenger restrictions, commensurate with the level of graduated licensure (GDL), went into effect January 1, 2014. • Teen drive curfew/time restrictions commensurate with the GDL. • Prohibition of use of electronic devices; effective July 1, 2010, for GDL. • Seat Belt use: The Go-Team study was followed with a 2013 analysis of Iowa seat belt policy. A policy brief was prepared for the 2014 Iowa legislative session. The final report is anticipated to be posted to the Iowa DOT website by April 2014. • Development of educational and awareness efforts such as a TEXTL8R campaign. This research has been instrumental in Iowa DOT's goal of driving down the number of fatalities and injuries on Iowa roadways. TAC: Kim Snook, Scott Falb, Sandra Larson, Jeremey Vortherms, Linda Narigon, Research Team
Web Links (if available)	http://www.iowadot.gov/research/reports/Year/2013/fullreports/MovingBeyondTeenCrashFatalityStats_Complete.pdf

PROJECT INFORMATION	
Project Title	***Measuring Salt Retention***
ID	RB02-013
Project Cost	$25 000
Duration	6 months
SUBMITTER	
Submitter Agency	Iowa Department of Transportation
Submitter Contact	Linda A. Narigon, P.E. SP&R Research Administrator, Research Implementation Engineer Office of Research and Analytics Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010 515-239-1471 linda.narigon@dot.iowa.gov
RESEARCH PROGRAM	
Sponsor Contact	Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010

PROJECT INFORMATION (CONT.)	
Brief Summary of Research Project	Each percent reduction in salt lost at application could either save $140,000 in salt by allowing reduced application rate (because less is immediately lost to the ditch), or improve the level of service provided to the public by having more deicer present and working on the roadway (because the salt that would have been lost is now working on the road). This research developed and completed a field evaluation of salt distribution equipment. Three types of salt spreaders (conventional, chute, or zero velocity) were compared in terms of the amount of salt delivered across the roadway. "Zero-velocity" spreaders, chutes, and the practice of prewetting the solid deicer have been shown to increase the likelihood that the material will land where intended, and reduce the amount bounced and scattered off the roadway. A grid collection area was prepared on a closed section of road. Several combinations of truck speed, prewet rates, and applicator types were used to apply a set amount of material over the grid. After each pass, the amount of salt in each grid was collected and weighed. The spatial distribution of the salt for each pass was analyzed to determine which technique resulted in the most accurate placement and the least amount scattered to the far edges of the grid. Each spreader was evaluated at different speeds (20, 30, and 40 mph) and brine rates (10, 20, and 30 gal. per lane mile). A full-factorial experimental design was used to study the three variables distinctly at three levels with a total of 27 runs. Six additional runs with no brine at 25 and 40 mph for each spreader type were added at the request of a district staff person for comparative purposes and not as a comparative variable for this study. Overall, a total of 33 truck runs were completed. To measure salt distribution laterally, a 3- x 24-ft. wide rubber mat was installed to allow for the salt and brine to be removed from the mat after each run. The mat was segmented into eight 3- x 3-ft. squares. All samples were labeled by run number (identifying spreader, truck speed, and brine rate) and sample for each 3- x 3-ft. square. The trucks followed a paint line on the roadway to travel over the mat at the same location each time. A total of 264 samples were processed and measured. These results compare each spreader by total salt delivered, delivery by sample square on the mat, and the combinations of speed and brine rates. High-speed video enhanced DOT abilities to see each of the three salt spreaders in motion and to observe salt placement and loss across the lane.

PROJECT INFORMATION	
	Once the results were distributed, it was discovered that other types of spreaders were in use (crafted by individual garages). After obtaining feed back from field crews, it was determined that follow-up research was desired. The follow-up research (Phase II) was conducted by DOT and field staff and included the impact of different pre-wet rates on spreader performance. Six spreader types were evaluated (the three standard spreaders evaluated in Phase I and three Iowa garage created). For the Phase II work, several IA DOT district mechanics as well as members of the winter steering committee, equipment committee, and de-icing committee assisted with the tests. The Iowa DOT is continuously evaluating its processes and assessing areas for efficiencies. The results are being used to guide more-detailed comparisons such as material loss, material migration after application, truck calibration by speed, and the effectiveness of varied brine rates as well as salt and brine delivery methods.
Web Links (if available)	http://www.iowadot.gov/research/winter_road_maintenance.html

PROJECT INFORMATION	
Project Title	***Evaluation of Low-Cost Treatments on Rural Two-Lane Curves***
ID	TR-579
Project Cost	$80,000
Duration	49 months
SUBMITTER	
Submitter Agency	Iowa Department of Transportation
Submitter Contact	Mark Dunn Operations Research Engineer Iowa Departmet of Transportation 800 Lincoln Way Ames, Iowa 50010 515-239-1447
RESEARCH PROGRAM	
Sponsor Contact	Iowa Highway Research Board Iowa Departmet of Transportation 800 Lincoln Way Ames, Iowa 50010 515-239-1447 The Midwest Transportation Consortium Principal Investigator: Shauna Hallmark, Transportation Engineer Center for Transportation Research and Education Iowa State University shallmar@iastate.edu
RESEARCH AND RESULTS	
Brief Summary of Research Project	The objective of this project was to evaluate low-cost measures to reduce speeds on high-crash horizontal curves. As agencies attempt to improve safety, they are often looking for low-cost measures that they can apply quickly and economically. Several low-cost treatments—such as post-mounted delineators, on-pavement curve warning signs, raised pavement markings, and wider edge lines—have been used to provide additional delineation around curves.

PROJECT INFORMATION (CONT.)	
	Even though agencies have been applying a number of different low-cost treatments, the effectiveness of those treatments toward improving safety is not well understood or documented. This report discussed the results of a study that evaluated two different low-cost curve treatments. The first treatment involved adding retroreflective sheeting material to existing chevron posts in an attempt to provide additional curve delineation. The team evaluated the addition of retroreflective post treatments at four rural two-lane sites in Iowa. The second treatment involved adding on-pavement curve warning signs. The team evaluated the addition of on-pavement signs at two rural two-lane roadway sites in Iowa. This report summarizes how the research team selected sites and collected data, and the results. The team selected six sites. Retroreflective post treatments were added to existing chevrons at four sites and on-pavement curve markings were added at two sites. The researchers collected speed data before and after installation of the two treatments. The study compared several speed metrics to assess the effectiveness of the treatments. Overall, both were moderately effective in reducing speeds. The most significant impact of the treatments was in reducing the percentage of vehicles traveling over the posted or advisory speed by 5, 10, 15, or 20+ mph. Overall, both treatments were moderately effective in reducing mean and 85th percentile speeds. The results suggest that the treatments are most effective in reducing high-end speeds.
Web Links (if available)	http://www.iowadot.gov/research/reports/Year/2013/fullreports/TR-630%20Final.pdf

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Western Iowa Missouri River Flooding - Geo-Infrastructure Damage Assessment, Repair, and Mitigation Strategies***
ID	TR-638
Project Cost	$100,000
Duration	19 months
SUBMITTER	
Submitter Agency	Iowa Department of Transportation
Submitter Contact	Vanessa Goetz Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010 515-239-1382 vanessa.goetz@dot.iowa.gov
RESEARCH PROGRAM	
Sponsor Contact	Iowa Highway Research Board and SPR Part II Mark Dunn, P.E., Operations Research Engineer Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010 515-239-1447 mart.dunn@dot.iowa.gov Iowa DOT and FHWA through the SP&R Part II Program Linda Narigon, SPR Part II Administrator Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010 515-239-1471 linda.narigon@dot.iowa.gov
RESEARCH AND RESULTS	
Brief Summary of Research Project	The 2011 Missouri River flooding caused damage to many geo-infrastructure systems including levees, bridge abutments/foundations, paved and unpaved roadways, culverts, and embankment slopes in western Iowa. The total reported direct cost to repair flood-damaged transportation infrastructure on primary and secondary roadways in western Iowa was about $63.5 million. The extent of damage was in some cases directly observable, i.e., where segments of the roadway were washed away, but in many cases was undetermined, i.e., where the damage was below the pavement surface or around bridges. The main goals of this research project were to evaluate and document rapid assessment of damage to geo-infrastructure by deploying and using advanced technologies and to develop guidance for repair and mitigation strategies for use during future flood events.

PROJECT INFORMATION (CONT.)	
	Findings include: • FWD tests obtained shortly (< 30 days) after flooding indicated that the average modulus values in flooded zones were about 1.3 to 3.6 times lower than the values in non-flooded zones. In some areas, the foundation layers within the flooded zone gained strength over time, likely as the degree of saturation in the subgrade decreased. However, many sections did not show much improvement. • FWD surface modulus measurements were influenced more so by the subgrade layer (which was relatively weaker) than the surface gravel layer on unpaved roads. • Ground penetrating radar scanning identified changes in gravel layer thicknesses, culvert locations, weep holes under roadways, voids beneath pavements, and voids in bridge approach backfill materials. • Three-dimensional (3D) laser scanning was performed at a breach site to demonstrate rapid and accurate volumetric calculations. • A flow chart relating the damages, assessment techniques, and 20 different potential repair/mitigation solutions was developed. • The state of Iowa experienced severe geo-infrastructure damage due to flooding in 2008, 2010, and 2011. The flood damage assessment methods and repair and mitigation solutions presented in the report will aid city, county, state, and federal agencies in future flood events.
Web Links (if available)	http://www.iowadot.gov/research/reports/Year/2013/fullreports/TR-638%20Final.pdf

Kansas Department of Transportation

PROJECT INFORMATION	
Project Title	***A Study of the Impact of Roundabouts on Traffic Flows and Business***
ID	K-TRAN: KSU-09-10 & RE-0495-01 & C1817
Project Cost	$45,000
Duration	50 months
SUBMITTER	
Submitter Agency	Kansas Department of Transportation
Submitter Contact	Rick Kreider Chief Bureau of Research Kansas Department of Transportation 2300 SW Van Buren Topeka, KS 66611-1195
RESEARCH PROGRAM	
Sponsor Contact	Kansas Department of Transportation Eisenhower State Office Building 700 SW Harrison Street Topeka, KS 66603-3745
Brief Summary of Research Project	For a number of years there has been a controversy regarding whether installing roundabouts in a business area are good for business in the area, or whether they have negative impacts on business in the area. This study attempts to answer this question with emphasis on Kansas cities, particularly Topeka, Kansas; however, it does use examples and data from other cities and studies that are relevant to this study. This study reviewed the literature and all sources where national data or reliable case studies addressed the issue of the impact of roundabouts on business to serve as a basis for Kansas studies. Some data that was initially thought to be available; namely, business profits, before and after economic data like sales taxes, property values, building permits and so forth, were not generally available and/or beyond the scope of the project. The study concentrated on the literature, surveys to businesses, and case studies that showed roundabouts' ability to move traffic more efficiently. Conclusions were based on the widely accepted assumption that businesses and business areas that have good vehicle and pedestrian access and traffic flow should prosper and grow and, conversely, businesses that do not have good access and good traffic flow will not. Case studies that were found in the literature, and from personal contacts, are reported in the study report. Surveys were conducted and sent to several Kansas cities as well as Carmel, Indiana, which is known to have a great number of roundabouts in the city. Personal contact was also made with a number of business managers and/or owners in Topeka. Since no reliable before and after corridor data could be found that would lead to definite conclusions, a task was added to do a simulation

PROJECT INFORMATION (CONT.)	
	study of a business corridor in Topeka, Kansas. The study used VISSIM software to simulate a hypothetical before and after study of converting several traditional intersections in the corridor to roundabouts. The most relevant study found in the literature was a study of South Goldman Road in Golden, Colorado, where four roundabouts were built in a business corridor with many positive results which led to the conclusions that "yes, roundabouts are good for business." Survey results, reported in detail in the full report, were generally positive albeit mixed. For example, the survey results from businesses in Topeka indicated that 76.9% of businesses answered that the impact of the addition of roundabouts was fair, good or very good, and only a combined 15.2% indicated they were bad or very bad. Personal contact with business managers and owners in Topeka found that they were of the opinion that roundabouts in their area were good for business. The simulation study of the Topeka business area, assuming several intersections were replaced with roundabouts, showed significant reductions in delay and queuing for most all significant traffic movements. Based on the authors' assumption that better traffic flow and access are good for business, it was concluded that the addition of roundabouts in this corridor would have been good for business. The overall conclusion of the study was that roundabouts have a positive impact on traffic flows and business.
Web Links (if available)	http://www.ksdot.org/

PROJECT INFORMATION	
Project Title	***Evaluation of Innovative Traffic Safety Devices at Short-Term Work Zones***
ID	K-TRAN: KU-09-5 & RE-0501-01
Project Cost	$60,000
Duration	59 months
SUBMITTER	
Submitter Agency	Kansas Department of Transportation
Submitter Contact	Rick Kreider Chief Bureau of Research Kansas Department of Transportation 2300 SW Van Buren Topeka, KS 66611-1195
RESEARCH PROGRAM	
Sponsor Contact	Kansas Department of Transportation Eisenhower State Office Building 700 SW Harrison Street Topeka, KS 66603-3745

SWEET SIXTEEN

PROJECT INFORMATION (CONT.)	
Brief Summary of Research Project	The objective of this study was to investigate and evaluate the usage and effectiveness of innovative traffic control devices that can be used in short-term work zones. Any device to be used in short-term work zones should command the respect of drivers, be durable, have an easily understood meaning, be low cost, be quick and easy to install and remove, and be reusable. This study was conducted in three sections: a literature review of previously published research, a nationwide usage survey, and a field test for a selected device, portable plastic rumble strip (PPRS). Review and Survey Results of Innovative Traffic Control Devices: The usage and the effectiveness of portable devices/systems that possibly could be used at short-term work zones were investigated. The survey focused on innovative or unique safety devices that any state is using or has used in the past and their states' comments on the devices' perceived effectiveness. A total of 26 states responded to the survey. Existing research, implementation, and available evaluation results as well as the survey results for these devices were also reviewed and summarized by device. Field Test of Innovative Portable Rumble Strips: Portable plastic rumble strips (PPRSs), which have been tested on a closed course, were found to be a device potentially suitable for use at short-term work zones. This field study was to investigate the effects of the PPRSs and drivers' response to them at three short-term maintenance work zones in Kansas. The results showed that the effect of PPRSs in speed reductions was more significant on cars than on trucks. The PPRSs reduced car speeds by 4.6 to 11.4 mph. They also created 5.0 to 11.7 mph mean speed reduction for trucks, but the reductions were only at two test sites. It was observed that 30 to 80% of truck drivers activated their brakes (indicated by brake light illumination) when they approached the PPRSs. In addition, about 5% of car and truck drivers swerved around the PPRSs. This indicates that additional signage or other supplemental traffic devices would be needed when the PPRSs are implemented. Recommendations Based on a literature review, nationwide survey, and a field test of a device that was currently available on the market, it was shown that indeed there are useful applications for several innovative traffic safety devices. Thus, these devices should be strongly considered for usage where appropriate in addition to existing typical traffic control devices. Portable Plastic Rumble Strips: The effectiveness of this product has been confirmed through both closed course and field tests. They are easy to install (compared to adhesive-based strips), easy to remove, and are reusable. The field test results also found that they were effective in alerting drivers resulting in speed reductions for both cars and trucks. Two sets of four strips at 36

PROJECT INFORMATION (CONT.)	
	inches spacing are recommended for short-term work zones in addition to existing traffic control devices in the temporary traffic control plan. However, since about 5% of drivers were observed to swerve around the PPRSs during the field test, additional driver information such as a supplemental advisory sign may be needed to assure the public that these devices are indeed meant to be traversed. Additionally, future research into appropriate signage or other supplemental traffic control is needed to minimize drivers avoiding the PPRS. Portable Speed Monitoring Signs: The portable speed monitoring display has been found to be a very effective device in speed reduction. The speed monitoring display installed in a portable sign instead of being installed in a trailer is recommended based on the low cost and effort of the installation. This sign could easily be integrated into the existing temporary traffic control plans for short-term work zones. Vehicle-Activated Signs: Similar to the portable speed monitor display, the vehicle-activated signs are easy to set up to alert drivers who are over the speed limit. They can also be embedded into standard temporary traffic control plans for short-term work zones. Intrusion Alert System: The idea of an intrusion alarm systems is positive. However, the effectiveness of this device was not shown. Demonstration results from other states found that this device still has some deficiencies such as the inadequate sound and excessive time required for installation. The application of this device at short-term work zones is not recommended until this product space has matured and obtains approval by the demonstration states.
Web Links (if available)	http://www.ksdot.org/

PROJECT INFORMATION	
Project Title	***Identification of Safety Belt Restraint Usage Characteristics Related to Four- to Thirteen-Year-Olds***
ID	K-TRAN: KSU-09-5 & RE-0490-01 & C1816
Project Cost	$40,000
Duration	48 months
SUBMITTER	
Submitter Agency	Kansas Department of Transportation
Submitter Contact	Rick Kreider Chief Bureau of Research Kansas Department of Transportation 2300 SW Van Buren Topeka, KS 66611-1195
RESEARCH PROGRAM	
Sponsor Contact	Kansas Department of Transportation Eisenhower State Office Building 700 SW Harrison Street Topeka, KS 66603-3745
Brief Summary of Research Project	Introduction: Even though overall level of safety on United Sates roadways has improved over the last few decades because of significant vehicle and occupant safety regulations and programs, further improvement is needed. In 2009, 33,808 fatalities and another 2.2 million injuries were reported on U.S. roadways due to motor vehicle crashes. Ninety percent of victims in traffic crashes were occupants, accounting for 24,474 fatalities in 2009 (NHTSA 2009b). Injuries to occupants of motor vehicle crashes claim the lives of more people between five and 34 years of age than any other cause of injury (CDC 2010). An average of four children, 14 years and younger, are killed and 490 are injured each day in United States (U.S.) traffic crashes, based on 2009 statistics. Child passengers are innocent victims in crashes because they may not be the decision makers for the trips or any other factors associated with the trip (NHTSA 2009b). Involvement in road traffic crashes as vehicle occupants is a leading cause of death and serious injury among children. Project Objective: The objective of this study was to investigate child safety restraint-use characteristics and crash-severity factors in order to identify effective countermeasures to increase children's safety. Project Description : Crash data were obtained from the Kansas Department of transportation from 2004 to 2008 for this study. Children were divided into two groups, ages four to seven and eight to 13, considering Kansas child-restraint laws. Detailed frequency analysis was carried out. Frequencies, percentages, and odds ratios were used to investigate restraint-use characteristics, seating positions, and injury severity. Logistic regression models were developed to identify risk factors which increased injury severity.

PROJECT INFORMATION (CONT.)	
	Project Results: About 3% of children ages four to seven years children group and about 4% of eight to 13 year olds were not restrained. Restraint use among children involved in crashes decreased with increasing age of the child, or number of other occupants in the vehicle. Further, data were analyzed with the Chi-Square test of independence to see whether there was a relationship between restraint use and other variables. Results showed children not restrained, riding with drunk drivers, and riding in older vehicles were more vulnerable for injuries when they were in crashes. The most frequent contributory causes related to children involved in crashes in Kansas were inattention in driving, failure to yield right of way, driving too fast, wet roads, and animals in the road. Based on the identified critical factors, countermeasures to improve child traffic safety were suggested which included age- and size-appropriate seat belt restraints, and the child being in the rear seat. It is important for parents and children to gain better education about these safety measures that are helpful to increase child safety on the road.
Web Links (if available)	http://www.ksdot.org/

PROJECT INFORMATION	
Project Title	***Accommodating Oversize/Overweight Vehicles at Roundabouts***
ID	K-TRAN: KSU-10-1 & TPF-5(220) & KSUTC-10-7
Project Cost	$254,788
Duration	37 months
SUBMITTER	
Submitter Agency	Kansas Department of Transportation
Submitter Contact	Rick Kreider Chief Bureau of Research Kansas Department of Transportation 2300 SW Van Buren Topeka, KS 66611-1195
RESEARCH PROGRAM	
Sponsor Contact	Kansas Department of Transportation Eisenhower State Office Building 700 SW Harrison Street Topeka, KS 66603-3745
Brief Summary of Research Project	A literature review uncovered no published reports on OSOW accommodation per se; however, much information on the advantages of having designated truck and OSOW networks is analyzed and reported. The authors make an argument that states should consider conducting a study to develop a freight network, which includes segments where OSOW need to be accommodated, in accordance with state and federal commerce laws and policies and the state's economy. The study should include determining all motor vehicles whose size and turning movements are critical to developing routes on which all segments will accommodate these vehicle. To obtain information on the state-of-the –art of OSOW accommodation, the authors turned to personal contacts, unpublished material, case studies and surveys. Examples of accommodating OSOW in general, and various turning movements, found in the literature, surveys, and personal contacts are provided in the report as examples of ideas and concepts that could be considered, and possibly adapted to the needs of a specific site. Several examples from England, France, and Germany, and other countries, were also found and are presented. Also, cutting edge research and a state's recent policy on accommodating low, ground clearance vehicles that could "hang up" are presented. Four surveys were developed, executed and analyzed: a general survey on permitted vehicles to the 50 states; a second survey to the 50 states on specific roundabout issues, a survey to regional managers of the Specialized Carriers and Rigging Association (SC&RA), and a survey developed and conducted in partnership with the American Transportation Research Institute (ATRI) and sent to their membership. The complete analysis and some actual answers are contained in the report and its appendices.
Web Links (if available)	

Kentucky Department of Transportation

PROJECT INFORMATION	
Project Title	***Fluorescing Coatings for Improved Inspection During Bridge Maintenance Painting***
ID	KYSPR-09-377
Project Cost	$140,000
Duration	48 months
SUBMITTER	
Submitter Agency	Kentucky Transportation Cabinet
Submitter Contact	Jason J. Siwula, P.E., Innovation Engineer Kentucky Transportation Cabinet State Highway Engineer's Office 200 Mero Street Frankfort, KY, 40622 Telephone - 502.564.3730 jason.siwula@ky.gov
RESEARCH PROGRAM	
Sponsor Contact	Kentucky Transportation Cabinet State Highway Engineer's Office 200 Mero Street Frankfort, KY, 40622
RESEARCH AND RESULTS	
Brief Summary of Research Project	Optically active pigments (OAPs) fluoresce under light exposures with wavelengths (<200 to 400 nm) producing emissions in the visible spectra (380 to 740 nm). They are used as paint pigments to aid visual inspection of applied coatings for defects such as pin-holing and incomplete coverage. OAP coatings are widely used in various industries outside of bridge maintenance painting. This study addressed the laboratory evaluation and field trial of an OAP coating for KYTC bridges. Bridge coatings utilizing OAPs were evaluated for inspectability and performance in laboratory testing. The first part of the laboratory evaluation included fabrication of mock girders with details replicating those typically found on bridge girders. OAP coatings were then applied with designed defects and subjected to timed inspections by certified coatings inspectors using conventional white light and fluorescing light. Results indicated a 15 percent increase in coating defect detection using fluorescing light to highlight the coating defects. Coatings previously tested and included on KYTCs' List of Approved Materials (LAM) were formulated with OAP, and then tested with the same accelerated weathering protocol used by KYTC to populate the LAM. OAP coatings met all performance criteria established by KYTC with no measurable differences from non-OAP coatings. After successful laboratory performance, OAP coatings were specified for a KYTC bridge painting project incorporating two deck-girder bridges.

PROJECT INFORMATION (CONT.)	
	One bridge was coated with an OAP zinc urethane primer/non-OAP epoxy mid-coat/OAP urethane top-coat system. The second bridge was coated with a non-OAP zinc urethane primer/OPA epoxy mid-coat/non-OAP urethane top-coat. Field observations revealed that OAP coatings improved inspectability by making uncoated and thinly coated areas more readily identifiable. This study revealed that use of OAP technology could facilitate and improve coatings inspection on KYTC bridge maintenance painting projects. This will result in faster inspections, especially in conditions of poor ambient lighting. Inspectors will be able to readily detect the most common bridge painting defects (e.g., misses and thin coatings) that are difficult to detect under normal lighting conditions. The technology is also adaptable for use by painting contractors allowing painters to see coating flaws "on the fly" and eliminate them. That will improve coating quality and limit/eliminate time-consuming rework. The technology is fully developed and ready to implement. A limited amount of training will be needed for KYTC coatings inspectors to properly use the technology.
Web Links (if available)	http://www.ktc.uky.edu/files/2013/10/KTC_12_15_SPR_377_09_1F.pdf

PROJECT INFORMATION	
Project Title	***Kentucky's PRISM-Based Automated Ramp Screening System Implementation and Evaluation***
ID	RSF27-12
Project Cost	$494,900
Duration	50 months
SUBMITTER	
Submitter Agency	Kentucky Transportation Cabinet
Submitter Contact	Jason J. Siwula, P.E., Innovation Engineer Kentucky Transportation Cabinet State Highway Engineer's Office 200 Mero Street Frankfort, KY, 40622 Telephone - 502.564.3730 jason.siwula@ky.gov
RESEARCH PROGRAM	
Sponsor Contact	Kentucky Transportation Cabinet State Highway Engineer's Office 200 Mero Street Frankfort, KY, 40622
Brief Summary of Research Project	In late 2010, Kentucky implemented a PRISM-based automatic ramp screening system (PARSS) at the Boone County inspection facility to screen commercial vehicles as they travel along ramp. This system utilizes a license plate reader, USDOT number reader, and scene camera technology to collect and process identifying information from the vehicle. The system is integrated with the ramp weigh-in-motion scale and sorting system. The information from the vehicle is checked against the Kentucky Clearinghouse and Commercial Vehicle Information Exchange Window (CVIEW) for safety, credential, and registration problems. If the commercial vehicle is identified as having a potential problem, the driver is notified through the weigh station signage. All vehicle records are displayed on the PARSS user interface in the inspection station for use by enforcement personnel. Vehicles with a potential problem (based on the criteria that personnel have chosen to use for screening) are clearly marked by PARSS. PARSS also allows manual corrections to be made when needed. These screening systems have allowed enforcement personnel to quickly identify and check thousands of trucks as they come through the weigh station. Enforcement personnel are able to choose good candidates for inspection and identify credential and registration problems as the vehicle travels along the weigh station ramp. Based on the success of the PARSS system at the Boone County inspection facility, a second system was installed at the NB Laurel County inspection facility.

PROJECT INFORMATION (CONT.)	
	Since the implementation of the PRISM-based ramp screening system at the Laurel County NB inspection facility, safety has improved and collection of revenue has increased. The evaluation showed that when the system is utilized to identify trucks for inspection, the vehicle out-of-service rate (34%) is significantly higher than the national out-of-service rate (approximately 20%). In addition, from 6/30/12 – 12/30/12, the facility collected just over $24,000 and sold 35 temporary permits. During the same 6-month period in 2013, after the PARSS system was installed, the facility collected just over $140,000 and sold 411 temporary permits. The revenue collected from impounds increased by 583% and the number of temporary permits rose by 1174%. The PRISM-based ramp screening system has the potential to dramatically improve safety, increase compliance from carriers, and help Kentucky recover lost revenue.
Web Links (if available)	http://www.ktc.uky.edu/files/2013/11/KTC_13_21_RSF_27_12_1F.pdf

Louisiana Department of Transportation & Development

PROJECT INFORMATION	
Project Title	***Repair of Morganza Spillway Bridge Bent Pile Cap Using Carbon Fiber Reinforcement (CFR)***
ID	12-3ST
Project Cost	$0
Duration	0 months
SUBMITTER	
Submitter Agency	Louisiana Department of Transportation and Development
Submitter Contact	Vijaya (VJ) Gopu, Ph.D., P.E. 4101 Gourrier Ave. Baton Rouge, LA, 70808 225-767-9102 v.gopu@la.gov
RESEARCH PROGRAM	
Sponsor Contact	Louisiana Department of Transportation and Development Louisiana Transportation Research Center 4101 Gourrier Ave Baton Rouge, LA, 70808

PROJECT INFORMATION (CONT.)

RESEARCH AND RESULTS

Brief Summary of Research Project

The Louisiana Transportation Research Center provided research implementation support for demonstrating the use of high-strength composites for structural repair. The pile cap of an end bent of the Morganza Floodway Bridge suffered extensive damage at the girder bearing locations. The damage was due to the pounding of the girders at the bearing locations by the adjacent concrete deck located on the approach side of the bent. The pounding caused heavy spalling of the concrete on the west face of the pile cap at the girder bearing locations and the spalling extended all the way to bearing plates.

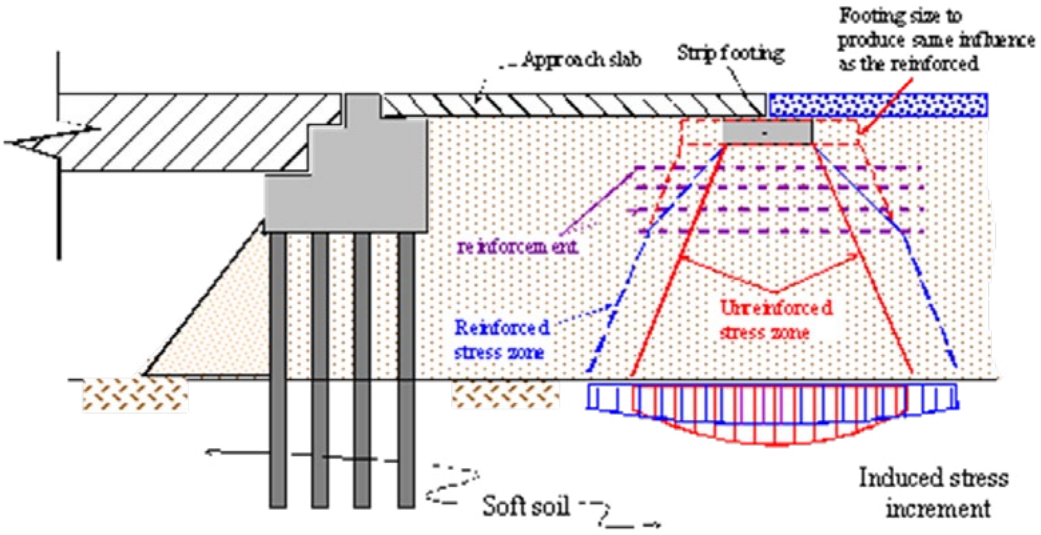
The repair demonstration of the damaged pile cap was carried out in conjunction with a major repair that was being undertaken on the bridge. The installation of the carbon fiber composite was carried out by a team from the Civil Engineering Department at Rutgers University. The spalled concrete was removed, the surface cleaned, and epoxy concrete utilized to repair the damaged areas. Structural grade high-adhesive epoxy concrete was utilized to patch the damaged areas of the pile cap. The repaired areas of the pile cap—namely, the bearing plate locations—were strengthened to prevent delamination of the repair material by confining it with high modulus carbon composite wrapping. An inorganic polymer coating that provides UV protection and prevents mold and mildew growth was utilized. The carbon fiber composite has complete chemical adhesion with the pile cap and its high modulus fibers will not allow the repair material to separate from parent concrete material. The fibers were bonded to the top and bottom of bent to generate the needed anchorage.

The project demonstrated a useful implementation of existing technology for cost-effective rehabilitation of bridge structures. The overall cost of the repair ($15,000) using carbon fiber and inorganic polymer coating was one-third the cost of providing an external reinforcement retrofit, one-sixth the cost of replacing the pile cap, and one-tenth the cost of utilizing VARTM cap repair. The project clearly demonstrates the significant cost-savings that can be realized from effective implementation of existing composites technology for repairing and rehabilitating damaged components of the nation's highway infrastructure.

Web Links (if available)

PROJECT INFORMATION	
Project Title	***Field Demonstration of New Bridge Approach Slab Designs and Performance***
ID	05-1GT
Project Cost	$0
Duration	0 months
SUBMITTER	
Submitter Agency	Louisiana Department of Transportation and Development
Submitter Contact	Murad Abu-Farsakh 4101 Gourrier Ave. Baton Rouge, LA, 70808 225-767-9147 cefars@lsu.edu
RESEARCH PROGRAM	
Sponsor Contact	Louisiana Department of Transportation and Development Louisiana Transportation Research Center 4101 Gourrier Ave Baton Rouge, LA, 70808
RESEARCH AND RESULTS	
Brief Summary of Research Project 	A bridge approach slab is a reinforced concrete slab that connects a bridge deck to an adjacent paved roadway to provide a smooth and safe transition for vehicles moving from roadway pavements to bridge structures and vice versa. The approach slab is supported on one side by the bridge abutment and on the other side by the embankment. However, a serious ride quality "or bump" problem can be generated at the end of the bridge as a result of the differential settlement between the approach slab and the bridge deck. The bump problem is very common in southern Louisiana where bridge embankments are often constructed over deep, highly compressible organic soils. The approach slab can lose its contact with and support from the soil when the embankment settles, causing a sudden change in slope at the joint between the approach slab and the bridge deck (S/D joint) and/or causing a fault at the joint between the roadway pavement and the approach slab (R/S joint). The Louisiana Transportation Research Center has completed research projects to study, and potentially mitigate, the bridge bump problem at locations where other pre-load or accelerated-settlement techniques are cost prohibitive or not successful. As a result, a new design for the approach slabs was proposed for locations where differential settlement is expected. The new design involves increasing the flexural stiffness of the slab to allow loss of contact with and support from the embankment without detrimental deflection. The weight of the slab and the traffic load are carried by the two ends of the slab rather than distributed over its length. A footing, with geosynthetic reinforcement of the soil beneath

PROJECT INFORMATION (CONT.)	
	the footing, is designed for construction at the R/S joint. Reinforcement increases the soil's bearing capacity and reduces the footing settlement by distributing the slab and traffic loads over a wider area. To validate/verify the new design, each approach slab at the Bayou Courtableau bridge was fully-instrumented and monitored over a two-year period. The west approach slab of the bridge was designed using the new method, and the east approach slab was designed using the traditional method. The monitoring program showed that the new design performed as predicted, with roughness profiles superior to those from the traditional design. The 25-ft. continuous IRI, measured after 18 months, was ~300 in/mi for the new design compared to ~600 in/mi for the traditional design. (A common rule-of-thumb equates 300 in/mi of 25-ft. IRI with 100 in/mi of standard IRI.) The Louisiana Department of Transportation and Development has adopted the new design methodology for bridge approach slabs at locations where differential settlement is anticipated. Extra costs associated with the new design method are minimal when compared with the savings realized from the reduced requirement for maintenance and repair.
Web Links (if available)	



SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Safety Improvement from Edge Lines on Rural Two-Lane Highways / A Comprehensive Study on Pavement Edge Line Implementation***
ID	07-7P / 13-2P
Project Cost	$0
Duration	0 months
SUBMITTER	
Submitter Agency	Louisiana Department of Transportation and Development
Submitter Contact	Doc Zhang 4101 Gourrier Ave. Baton Rouge, LA, 70808 225-767-9162 doc.zhang@la.gov
RESEARCH PROGRAM	
Sponsor Contact	Louisiana Department of Transportation and Development Louisiana Transportation Research Center 4101 Gourrier Ave Baton Rouge, LA, 70808
RESEARCH AND RESULTS	
Brief Summary of Research Project	Reducing the number of run-off-road (ROR) crashes is a top priority for the 5,600 miles of narrow, rural two-lane highways (pavement width less than 22 ft. and bigger than or equal to 20 ft.) in Louisiana. An inexpensive countermeasure was investigated to reduce the higher percentage of crashes and fatalities associated with this type of highway. The original study and follow up implementation study compared the crash difference before and after edge line placement. The research concluded that: (1) Placing pavement edge lines on rural two-lane highways in Louisiana not only changes vehicle lateral positions but also reduces crashes. (2) Based on the Empirical Bayes method, the most reliable Crash Modification Factor (CMF) for edge lines on narrow, rural two-lane highways is 0.85, which means there is a 15% expected crash reduction in edge line implementation on narrow, rural two-lane highways. (3) The crash reduction is consistent in all crash types and particularly significant in single vehicle crashes. Most of single vehicle crashes are ROR crashes. (4) The benefits overwhelmingly offset the cost associated with edge line implementation. The most conservative estimation for benefit and cost ratio is 19 to 1. The studies recommend the use of edge lines on narrow rural two-lane highways whenever it is financially and operationally feasible. The recommendation helped DOTD plan for safety improvements on rural two-lane highways. Based on the study results, the Traffic Engineering Management section of DOTD is seeking more safety funds for each district to conduct systematic edge line striping projects on narrow rural two-lane highways due to its high benefit. The DOTD Pavement Marking standards and safety management procedures have been updated to add this safety measure and crash reduction factor.
Web Links (if available)	http://www.ltrc.lsu.edu/pdf/2012/fr_487.pdf

PROJECT INFORMATION	
Project Title	***Geotechnical Information Database - Phase 2***
ID	10-2GT
Project Cost	$0
Duration	0 months
SUBMITTER	
Submitter Agency	Louisiana Department of Transportation and Development
Submitter Contact	Gavin Gautreau 4101 Gourrier Ave. Baton Rouge, LA, 70808 225-767-9110 gavin.gautreau@la.gov
RESEARCH PROGRAM	
Sponsor Contact	Louisiana Department of Transportation and Development Louisiana Transportation Research Center 4101 Gourrier Ave Baton Rouge, LA, 70808
RESEARCH AND RESULTS	
Brief Summary of Research Project	Accessing historical geotechnical data and combining it with new data for the purpose of design, analysis, visualization, and reporting has proven difficult over the years because the data has been generated by disparate systems and stored as hard copies, scanned images, various digital formats, or other non-digital formats such as microfilm. To alleviate this problem, an initial geotechnical database was completed by the Louisiana Transportation Research Center (LTRC) in 2008 to preserve and allow quick access to some historical data via a geographic information system (GIS). Subsequent requests from the Louisiana Department of Transportation (DOTD) Geotechnical Design section led to this follow-up study to expand the geotechnical information system and database. The web-based GIS map converts the DOTD geotechnical data into a valuable asset that can be reused over time. The map-based interface provides a simple and direct way for DOTD personnel and its consultants to find historical geotechnical data, generate reports, and ultimately get the data in a digital format so it can be re-used on future projects. The system allows for the integration of historically acquired (likely in non-digital format), recently acquired (likely in digital format), and future acquired data (in digital format) to create a composite database for a particular project that not only benefits that project, but also becomes part of a larger knowledge base available for use on other future projects undertaken by DOTD. The research created a plan to integrate and implement a customized data management system for DOTD.

PROJECT INFORMATION (CONT.)	
	The project ultimately developed a comprehensive geotechnical data management system to streamline the processes for borehole, lab testing, CPT, in-situ vane, and test pile load test data, while providing long-term availability of the data via a web-based GIS portal. By standardizing the database structure, incorporating validation rules, and creating custom reports, DOTD personnel in various sections can more easily access and report their geotechnical data while simultaneously improving the quality and reliability of the data. The GIS interface can access many different sources and types of data within and outside the Department. The quick and easy access to valuable data, including the mapping applications in the GIS, will streamline and facilitate the analysis of data. The project is currently being utilized by the Geotechnical Design section and Materials Testing section, and it will allow for more accurate and cost effective design decisions. This database resource tool will continue to grow over time as more data is uploaded/entered by DOTD and its consultant partners. If DOTD were to try to re-create this same data by reinvestigating the same sites (~600 boreholes and ~1100 CPT soundings), the cost is estimated at $9,300,000 ($10,000 per borehole/$3,000 per CPT sounding). Accordingly, the potential benefit of this work is extraordinary as approximately $200,000 was expended to turn $9,300,000 worth of data into a usable asset. The return on investment of this asset going forward will be realized as new projects utilize the geotechnical database to supplement knowledge and reduce the amount of future site investigations needed for the design analysis.
Web Links (if available)	http://www.ltrc.lsu.edu/pdf/2013/FR_498_web.pdf

PROJECT INFORMATION	
Project Title	***Implementation of Slag Stabilized Blended Calcium Sulfate (BCS) in a Pavement Structure***
ID	13-2GT
Project Cost	$0
Duration	0 months
SUBMITTER	
Submitter Agency	Louisiana Department of Transportation and Development
Submitter Contact	Mark Morvant 4101 Gourrier Ave. Baton Rouge, LA 70808 225-767-9131 mark.morvant@la.gov
RESEARCH PROGRAM	
Sponsor Contact	Louisiana Department of Transportation and Development Louisiana Transportation Research Center 4101 Gourrier Ave Baton Rouge, LA, 70808
RESEARCH AND RESULTS	
Brief Summary of Research Project	The Louisiana Department of Transportation and Development (DOTD) began to use blended calcium sulfate (BCS) as an alternative base material in the 1990s. Raw BCS base without further chemical stabilization can achieve relatively high strength and stiffness in a dry environment. However, it is associated with severe moisture susceptibility problems in a wet environment. Free moisture in BCS can cause short-term construction difficulties and potentially long-term performance problems if the moisture reaches significant levels. The Louisiana Transportation Research Center (LTRC) has conducted several research projects on BCS to improve the performance of this base course alternative. One LTRC research project (03-8GT) was a laboratory study that led to a better understanding of BCS-strength deterioration in a wet environment and ways to eliminate or reduce such deterioration by stabilizing BCS with various suitable cementitious agents. A major result from this research indicated that BCS stabilized with 120-grade ground granulated blast furnace slag (GGBFS) at 10 percent by volume can serve as a good pavement base. Another LTRC research project (03-2GT) was an accelerated loading project conducted at LTRC's Pavement Research Facility utilizing a slag-stabilized BCS layer as a base course. The field evaluation demonstrated the dramatically improved performance of BCS after slag stabilization. This research project (13-2GT) included full test sections on the shoulders of US 61 (Airline Highway in Sorrento, just south of the LA 22 intersection) that were exposed to significant moisture intrusion from the surface.

PROJECT INFORMATION (CONT.)	
	The project was initiated after old calcium sulfate was found in the base course of the shoulders during rehabilitation operations. District forces were challenged with the costly alternative of removing and replacing the old calcium sulfate with crushed stone (stone is not native to Louisiana and is costly to import). GGBFS was successfully used for stabilizing the weak calcium sulfate, thereby eliminating the need for excavation and replacement. The cost for cutting slag into the existing calcium sulfate material was $19.50/s.y. per the contractor's change order. The cost for removing and replacing the material with stone would have been approximately $35/s.y. based on the contractor's bid prices for this project. The total savings realized on this project alone for implementing the test sections was over $55,000. The slag-treated BCS test sections were well received by the District forces, so much so, they have requested funding for additional BCS stabilization projects along the same US 61 corridor for continued shoulder repair.
Web Links (if available)	http://www.ltrc.lsu.edu/pdf/2013/FR_498_web.pdf

PROJECT INFORMATION	
Project Title	***Evaluation of Warm Mix Asphalt Technology in Flexible Pavements***
ID	736-99-162407-1B
Project Cost	$325,420
Duration	24 months
SUBMITTER	
Submitter Agency	Louisiana Department of Transportation
Submitter Contact	Bill King 4101 Gourrier Ave. Baton Rouge, LA 70808 225-767-9129 bill.king@la.gov
RESEARCH PROGRAM	
Sponsor Contact	Louisiana Transportation Research Center 4101 Gourrier Avenue Baton Rouge LA USA 70808 http://www.ltrc.lsu.edu/

PROJECT INFORMATION (CONT.)	
RESEARCH AND RESULTS	
Brief Summary of Research Project	The Louisiana Transportation Research Center (LTRC) recently completed the research on their evaluation of WMA technologies. In general, production temperatures for HMA mixtures are between 300ºF and 350º F and the absolute minimum compaction temperature necessary to achieve acceptable density is 180º F. A total of 20 mixtures from 6 construction projects were evaluated through an extensive suite of laboratory tests to compare predicted performance of WMA mixtures to HMA mixtures. To simulate field testing of plant produced mixtures, LTRC utilized their mobile laboratory to collect mixtures as they were delivered, and make the test specimen onsite at each contractor's plant. In addition, several projects included emissions evaluation during construction at both the plant and the roadway. The project also evaluated the constructability of the different mixtures, by monitoring the compaction efforts, temperature of the mixtures during production, and temperatures of the mixtures during laydown. Some notable advantages of using WMA mixtures in lieu of HMA mixtures include reduced aging (less oxidation), reduced plant and roadway emissions, lower fuel cost, and increased densities with less compaction effort. LTRC's research revealed that production and laydown temperatures can be reduced, and subsequently reduce energy consumption as compared to HMA mixtures. WMA technologies offer improvements in workability, cost, and environmental sustainability such as reduced fuel usage and reduced greenhouse gas emissions while enhancing worker health and safety conditions. The results of the research showed that the reduction in production and placement temperatures had no negative performances when compared to conventional HMA mixtures. Reduced energy consumption resulted in fuel savings of 12% - 14% for WMA mixtures and an average energy savings of $1.61 per ton of mixture as compared to HMA mixtures. The latest estimates indicate that Louisiana produces three million tons of asphalt mixture per year, of which, approximately 2 million are produced using the WMA technologies. Therefore, Louisiana estimates an annual cost savings of $3.22 million on fuel savings alone when WMA mixtures are used in lieu of HMA mixtures. Specifications developed as part of this research for qualification of WMA technologies were implemented in the Louisiana Standard Specifications for Roads and Bridges.
Web Links (if available)	

Maine Department of Transportation

PROJECT INFORMATION	
Project Title	***Analysis of Projected Replacement and Costs for Potential Aquatic Barriers maintained by MaineDOT***
ID	12-08
Project Cost	$25,000
Duration	14 months
SUBMITTER	
Submitter Agency	Maine Department of Transportation
Submitter Contact	Dale Peapody MaineDOT, 16 SHS Augusta, Maine 207-624-3305 dale.peabody@maine.gov
RESEARCH PROGRAM	
Sponsor Contact	MaineDOT 16 SHS Augusta, Maine 207-624-3305
RESEARCH AND RESULTS	
Brief Summary of Research Project 	Recent discussions around State and federal stream crossing regulations have focused on resolving existing barriers to fish movement created by pipe culverts associated with transportation infrastructure. Approximately 30% of Maine has been surveyed for stream barriers through the joint efforts of state and federal fisheries agencies and non-government organizations, which have mapped this data via GIS. These same entities are currently working toward prioritizing identified barriers according to potential habitat value and species status. The resulting database contains location information, but does not differentiate crossings for which the state is responsible from those under local or private responsibility. This lack of distinction makes it near to impossible to quantify specific future costs to MaineDOT other than on a crossing by crossing basis. Because the database does not account for the age of individual structures, it is not possible to determine if barriers have been exacerbated by recent replacements and rehabilitations or if the barriers to fish movement are historic and therefore likely to be remedied in the relatively near future through standard MaineDOT maintenance protocols. The overall project was focused on continued development of the Maine Barrier Database, integrating MaineDOT crossings with that database, and supporting the development of the Maine Stream Habitat Viewer as a tool to be used by MaineDOT, municipalities and others for viewing aquatic habitat

PROJECT INFORMATION (CONT.)	
	data in association with stream crossings. The final dataset developed for use by MaineDOT includes important attributes associated with fisheries habitat values, as well as cost estimates for evaluating addition of projects to work plans. There are two major outcomes from this work that are already benefitting MaineDOT. (1) Completion of GIS aquatic barrier work that was started under other sponsorship: The results were delivered to MaineDOT as ArcMAP coverages and to the Maine Office of GIS for incorporation into the Maine Stream Habitat Viewer accessible via the internet. MaineDOT has been using both products on a regular basis. The products have been of great value in enabling the Environmental Office staff to deliver quick preliminary assessments of aquatic habitat that might affect MaineDOT projects. (2) Application of culvert replacement cost model for providing fish passage: Several years ago University of Southern Maine/Muskie School developed a cost model for culvert replacement. The focus was on replacement culverts that would be accepted as providing fish passage. This cost model was applied to data generated from his GIS data in (1) above. The results show order-of-magnitude implications for various replacement strategies. The results also brought shortcomings in the cost model that could be improved for more reliable results.
Web Links (if available)	http://mapserver.maine.gov/streamviewer/streamdocHome.html

Maryland Department of Transportation

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Automated Low-Cost and Real-Time Truck Parking Information Systems***
ID	SP209B4M
Project Cost	$100000
Duration	21 months
SUBMITTER	
Submitter Agency	Maryland Department of Transportation and Development
Submitter Contact	Allison R. Hardt Deputy Director, Office of Policy and Research Maryland State Highway Administration 707 N. Calvert St., C-412 Baltimore MD 21202 410-545-2916, ahardt@sha.state.md.us
RESEARCH PROGRAM	
Sponsor Contact	Maryland State Highway Administration 707 N Calvert Street Baltimore, MD USA 21202
RESEARCH AND RESULTS	
Brief Summary of Research Project	Lack of available truck parking is a significant safety concern nationwide. Commercial drivers seeking to comply with the Federal Motor Carrier Safety Administration's Hours of Service regulations often park illegally on freeway shoulders and ramps when parking in a truck parking facility is either not available, or the availability is not easily known. The Maryland State Highway Administration (SHA) has an interactive emergency truck parking map, but real-time parking availability information is not yet provided. The main objective of this project was to develop an inexpensive and scalable wireless sensor network prototype, which encompasses a cost-effective and reliable architecture for real-time detection of trucks and other vehicles in truck parking facilities. The vehicle detection system consists of four main components: sensing, collecting, processing and user interface (UI). The sensing component refers to networks of magnetic sensors that measure the magnetic field at parking spots. The sensors are enabled by a microcontroller using IEEE 802.15.4 protocol, and wirelessly communicate with the collectors, and are powered by two 1.5 volts triple-A batteries. The collecting component using the same microcontroller collects the data measured by the sensors, and is powered by solar panels and lithium acid batteries as backup. A cellular broadband component is used to forward the collected data to remote servers. A camera can optionally be utilized to capture ground truth images from empty and occupied spots for validation purpose. The processing component consists of a central database located at remote stations. A TCP/IP data logger application is designed for receiving the incoming packets from collectors and saving data in the database. The processing application connects to the data-

PROJECT INFORMATION (CONT.)	
	base, processes the data, and updates the status of each spot in real time. The UI component enables remote connection to the servers and parking availability updates in real-time. The UI can be customized for any type of internet enabled device on various operating platforms. The system was deployed and tested at the I-95 Northbound Welcome Center from January 2013 to May 2013. Several experiments were conducted and ground truth information was also collected to measure the system performance. The overall error rate during the experiment was 3.75%, and can potentially be lowered by using more sensors at each spot and employing repeaters to avoid signal blockings. Unlike imagery based methods, magnetic truck detection is completely anonymous and privacy of drivers is not compromised. It is also independent of parking layout. In addition to providing real-time parking availability information to the truckers, analyzing historical facility usage data could facilitate efficient operations. If all truck parking facilities in Maryland were equipped with such a system, truckers could be directed to the closest available facility and utilization of all facilities could be optimized.
Web Links (if available)	http://www.roads.maryland.gov/OPR_Research/MD-13-SP209B4M_TRUCK-PARKING_Report.pdf

PROJECT INFORMATION	
Project Title	***Slope Failure Investigation Management System***
ID	SP009B4N
Project Cost	$111,140
Duration	41 months
SUBMITTER	
Submitter Agency	Maryland Department of Transportation
Submitter Contact	Allison R. Hardt Deputy Director, Office of Policy and Research Maryland State Highway Administration 707 N. Calvert St., C-412 Baltimore MD 21202 410-545-2916, ahardt@sha.state.md.us
RESEARCH PROGRAM	
Sponsor Contact	Maryland State Highway Administration 707 N Calvert Street Baltimore, MD USA 21202
Brief Summary of Research Project	Highway slopes are exposed to a variety of environmental and climatic conditions, such as deforestation, freeze-thaw cycles, and heavy storms. Over time, these climatic conditions, in combination with other factors such as geological formations, slope angle and groundwater conditions can influence slope stability. These factors contribute to slope failures that are hazardous to highway structures and to the traveling public, and are extremely expensive to repair. Consequently, it is crucial to have a management system that tracks, records, evaluates, analyzes, and reviews the soil slope failure and remediation data so that cost effective and statistically efficient remedial plans may be developed. In this project, the Maryland State Highway Administration (SHA) created a Soil Slope Failure Reporting database that can be expanded to cover all geohazards on SHA Rights-of-Way. The Office of Materials Technology (OMT) implemented the database in the SHA eGIS Portal, a web-based mapping application. Once slope failures are reported by various technical offices and districts in eGIS, OMT slope failure team is notified via email. The team is responsible for reviewing and approving reported slope failure and assigning them for remediation. SHA's eGIS system allows engineers to quickly search for slope failures geographically and by attribute while presenting failure statistics and summary charts to senior managers. The geospatial and tabular information captured in eGIS can help to identify slope failure trends over time. OMT plans to use the information collected to direct design and construction policy changes to reduce the number of slope failures in the future.

PROJECT INFORMATION (CONT.)	
	Benefits: Prior to the implementation of Slope Failure Investigation Management System, few analyses were conducted on historical slope failures and remediation costs. The database tracks slope failure projects starting from failure identification stage, through construction and maintenance stages. It documents post-construction data including as-built plans, total cost, and pictures. With the current data on 60 (and counting) slope failures in the system, trends in geographic distributions, soil and hydraulic conditions of slope failure areas can be identified and incorporated in future earthwork designs. Geotechnical engineers are also using relevant content in the eGIS system such as geology maps and highway as-built plans in conjunction with the slope failure content for project level studies for future projects. Long term Benefits: Most slope failures are progressive in nature and get worse with time. With the database, it is anticipated that more slope failures will be report ed, and the cost of repairs will be reduced by allowing the right repairs to be conducted at the right time before the failures progress to a critical stage. Once more slope failure data is collected, statistical analysis can be conducted to identify the likely failure causes for a given area. These types of studies will inform policy changes in design or construction to minimize future slope failures in the same geographical area. Quantitative slope failure prediction models and hazard maps can then be developed by incorporating factors such as location, geology, climatic conditions and slope geometry.
Web Links (if available)	http://www.roads.maryland.gov/OPR_Research/MD-13-SP009B4N_Soil-Slope-Failure-Investigation_Report.pdf

Michigan Department of Transportation

PROJECT INFORMATION	
Project Title	***Effect of Pile-Driving Induced Vibrations on Nearby Structures and Other Assets***
ID	2010-0296 Z5
Project Cost	$229,371
Duration	24 months
SUBMITTER	
Submitter Agency	Michigan Department of Transportation
Submitter Contact	Michael Townley Research Project Administration Manager Michigan Department of Transportation 8885 Ricks Rd. , P.O. Box 30049 Lansing, MI 48909 (517) 636-0144, townleym@michigan.gov
RESEARCH PROGRAM	
Sponsor Contact	Michigan Department of Transportation 425 W. Ottawa St. Lansing, MI 48933 www.michigan.gov/mdot
RESEARCH AND RESULTS	
Brief Summary of Research Project	Transportation departments strive to minimize property damage during construction. Throughout bridge construction, the close proximity to existing buildings, utilities, or traffic-filled lanes of an old bridge makes this challenging. Bridge foundation pile driving can induce vibrations causing ground settlement yet engineers have not been able to predict the extent of the effect without a practical model. The Michigan Department of Transportation and the University of Michigan developed a predictive tool to better determine safe pile driving distances from existing structures. For the first time ever, accelerometers were installed underground at varying depths and distances to measure the vibrations emanating from driven piles. Data was collected at bridge construction sites throughout the state. Models were calibrated and a spreadsheet tool was developed, which estimates recommended standoff distances from sensitive structures or facilities to prevent likelihood of settlement due to impact pile driving of H-piles. Engineers input the soil profile stratum for cohesionless loose to medium dense sandy soils, the pile driving hammer type, and additional information. The model provides standoff distances. MDOT is applying this new tool in the bridge design stage to minimize property damage during construction.
Web Links (if available)	http://www.michigan.gov/documents/mdot/RC1600_451885_7.pdf

PROJECT INFORMATION	
Project Title	***Improving Bridges with Prefabricated Precast Concrete Systems***
ID	2010-0297 Z2
Project Cost	$410,672
Duration	38 months
SUBMITTER	
Submitter Agency	Michigan Department of Transportation
Submitter Contact	Michael Townley Research Project Administration Manager Michigan Department of Transportation 8885 Ricks Rd. , P.O. Box 30049 Lansing, MI 48909 (517) 636-0144, townleym@michigan.gov
RESEARCH PROGRAM	
Sponsor Contact	Michigan Department of Transportation 425 W. Ottawa St. Lansing, MI 48933 www.michigan.gov/mdot
RESEARCH AND RESULTS	
Brief Summary of Research Project	This research project was designed to address decision making gaps by documenting current national and international state-of-the-art accelerated bridge construction (ABC) practices and developing decision making software. Researchers developed Mi-ABCD software to compare accelerated vs. conventional construction for a particular bridge project. The Microsoft Excel based software utilizes project-specific data, available user-costs, and life-cycle costs to make informed decisions when selecting ABC or not. This study also presents an ABC constructability checklist to prevent repeated mistakes of the past and guide projects in efficient and cost effective practices. Finally, standard details for deck connections are presented, constructability challenges, and demolition techniques for each of the selected prefabricated bridge elements are discussed. The results of this study informed MDOT through the design of ABC projects planned for construction.
Web Links (if available)	http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249_24251-319152--,00.html

PROJECT INFORMATION	
Project Title	***Roadsides Corridor Planning***
ID	2010-0298 Z8
Project Cost	$190,000
Duration	14 months
SUBMITTER	
Submitter Agency	Michigan Department of Transportation
Submitter Contact	Michael Townley Research Project Administration Manager Michigan Department of Transportation 8885 Ricks Rd. , P.O. Box 30049 Lansing, MI 48909 (517) 636-0144, townleym@michigan.gov
RESEARCH PROGRAM	
Sponsor Contact	Michigan Department of Transportation 425 W. Ottawa St. Lansing, MI 48933 www.michigan.gov/mdot
RESEARCH AND RESULTS	
Brief Summary of Research Project	Evaluating requests for nontraditional right of way development, such as solar and wind power generation, biofuel production, and environmental remediation projects, can be difficult. MDOT initiated this research to develop a roadside suitability assessment model that can be used to support nontraditional right of way use decision-making. Researchers created ratings assessing the compatibility of existing roadside features with proposed farming, alternative energy production, vegetation management, and green infrastructure. These compatibility ratings indicate the most and least appropriate areas along the corridor for a given type of development. Researchers demonstrated the roadside suitability assessment model using a 20-mile pilot section of I-94 in southwest Michigan. This landscape-level model will help MDOT identify func¬tions, limitations and opportunities when handling requests for nontraditional development in roadside rights of way. The recommended system is more efficient than the department's current approach, saving money and improving statewide decision-making consistency.
Web Links (if available)	http://www.michigan.gov/documents/mdot/Roadside_Corridor_Planning_Spotlight_441751_7.pdf

Minnesota Department of Transportation

PROJECT INFORMATION	
Project Title	***Culvert Repair Best Practices***
ID	2010-037
Project Cost	$79,972
Duration	26 months
SUBMITTER	
Submitter Agency	Minnesota Department of Transportation
Submitter Contact	Nick Busse Marketing and Communication Manager MnDOT Research Services & Library 295 John Ireland Blvd., MS330 St. Paul, MN 55155 nick.busse@state.mn.us, 651-366-3738
RESEARCH PROGRAM	
Sponsor Contact	Minnesota Department of Transportation 295 John Ireland Blvd. MS330 St. Paul, MN 55155
RESEARCH AND RESULTS	
Brief Summary of Research Project	By providing a channel for water and wildlife to pass under roadways, culverts are a critical component of roadway infrastructure. However, culverts deteriorate over time due to erosion, corrosion, freeze-thaw cycles, loading, and many other causes. This deterioration can cause severe damage to the roadway above the culvert, even to the point of collapse, if not properly addressed. Proper maintenance and repair are necessary for both safety and economic reasons. The state of knowledge regarding culvert repair practices has evolved significantly in recent years. While this increased knowledge is ultimately beneficial for practitioners, it can be difficult for individual engineers to keep abreast of new developments that come from a wide variety of sources. MnDOT wanted to gather current information related to culvert repair in a single place so state engineers could easily find the information they need. The goal of this project was to develop best practices guidelines, special provisions, and standard details for several methods of culvert repair based on the current state of knowledge. This report is part of a project to develop guidance for repairing centerline culverts that are 24 to 72 inches in diameter. The report implements the existing body of knowledge regarding culvert repair, including guid-

PROJECT INFORMATION (CONT.)	
	ance and research from the Federal Highway Administration; the National Cooperative Highway Research Program; the American Association of State Highway and Transportation Officials; and many states, including Minnesota, California, and Maine. Investigators first conducted a Web survey and interviewed personnel from MnDOT, Minnesota cities and counties, and contractors. These surveys inquired about 11 specific culvert repair methods and about the types of repairs agencies had performed; specifications, standard details and cost information; concerns with the various repair methods; and contact information for contractors and suppliers. A similar survey was then administered to other states through the AASHTO Research Advisory Committee. The results of these surveys and a review of literature, specifications, drawings, and cost information were collected in Transportation Research Synthesis 1209, Culvert Repair Best Practices, Specifications, and Special Provisions: Task C. Investigators used information from the survey and literature to generate best practices guidelines for replacement, rehabilitation, and repair methods for deteriorating culverts. These guidelines present the most commonly used methods in detail, while other methods are described generally. Investigators also wrote special provisions and standard details for several processes. The report includes detailed discussions of rehabilitation and repair methods for paved inverts, cured-in-place pipe liners, sliplining, centrifugally cast concrete mortar liners, spall repair, joint repair, and filling voids outside the culvert. For each of these methods, the report covers best practices, technical and safety issues related to repair, appropriate materials to use, and postrepair maintenance. Investigators also prepared special provisions and standard details for each of these methods. MnDOT uses these documents to provide construction details (that can be adapted to the needs of a specific project) for practices where full specifications are unavailable. MnDOT has not had many special provisions related to culvert repair, so engineers who wanted to use an experimental procedure often had to write their own procedures—an inherently time-consuming process made more difficult by not knowing what practices have been tried in other jurisdictions. Twelve other methods for culvert rehabilitation, repair, or replacement are described more generally. An appendix provides a table that compares most methods, describing the materials needed, relative construction cost, size of culvert appropriate for each method, the specific issues each resolves, and each method's advantages and limitations.

PROJECT INFORMATION (CONT.)	
	cost, size of culvert appropriate for each method, the specific issues each resolves, and each method's advantages and limitations. This guide should be useful to engineers who need to determine the most effective repair methods for the culverts within their jurisdiction. The special provisions and standard details developed will likely evolve as they are used and may ultimately become boilerplate documents for wider use. To complete this project, investigators will conduct a brief feasibility study to identify which culvert repair methods can be observed and tested to document the cost, longevity and effectiveness of repairs. Outreach efforts will include a webinar about the guidelines to MnDOT personnel. The hydraulics section of MnDOT's Bridge Office will also distribute the guide on its website, include it in its training processes and provide ongoing support to district offices.
Web Links (if available)	http://mndot.gov/research/HVR2014-01.html

PROJECT INFORMATION	
Project Title	***Protocols and Technologies for Monitoring Non-Motorized Traffic***
ID	2011-011
Project Cost	$99,948
Duration	25 months
SUBMITTER	
Submitter Agency	Minnesota Department of Transportation
Submitter Contact	Nick Busse Marketing and Communication Manager MnDOT Research Services & Library 295 John Ireland Blvd., MS330 St. Paul, MN 55155 nick.busse@state.mn.us, 651-366-3738
RESEARCH PROGRAM	
Sponsor Contact	Minnesota Department of Transportation 295 John Ireland Blvd. MS330 St. Paul, MN 55155
Brief Summary of Research Project	Background: Many parties in Minnesota are interested in measuring bicycle and pedestrian travel, but adequate bicycle and pedestrian traffic data is unavailable statewide. MnDOT has received many requests from local agencies to develop consistent counting methodologies that ensure accuracy and compatibility with other data sources. Guidance about automated counting technologies is also needed. While loop detectors, infrared sensors, and other devices can collect large quantities of data, their accuracy is limited and they don't supply data that short-term manual counts can provide such as gender or helmet use. Goal: This project's goal was to launch the Minnesota Bicycle and Pedestrian Counting Initiative by developing guidance and count protocols and coordinating pilot field counts. It also sought to analyze automated continuous counts in the state to develop adjustment factors to extrapolate annual traffic volumes from short-duration counts. Project: After assessing current non-motorized traffic monitoring programs in Minnesota and other states, and counting protocols used by the National Bicycle and Pedestrian Documentation Project and other organizations, researchers developed guidance for manual non-motorized traffic counts. MnDOT hosted five workshops and a webinar to introduce local officials to the initiative and to recruit participants for pilot field counts. After the pilot counts, researchers surveyed count managers for feedback and analyzed existing automated counts to illustrate how they can be used with field counts to extrapolate daily or annual data.

PROJECT INFORMATION (CONT.)	
	Results: As of 2012, six agencies in Minnesota count non-motorized traffic, and even though comprehensive bicycle and pedestrian data are not yet available, Minnesota is a leader in this type of monitoring with more than 1,000 manual count locations and 32 automatic count sites. Because of Minnesota's experience, researchers were able to collaborate with the National Cooperative Highway Research Program's national Methodologies and Technologies for Collecting Pedestrian and Bicycle Volume Data research project, due for release in 2014, and contribute to the Federal Highway Administration's efforts to update its Traffic Monitoring Guide to include a chapter on non-motorized traffic. The guidance researchers developed for manual non-motorized traffic counts includes standard forms, checklists to ensure completion of valid counts, training materials, public information for distribution to passers-by, links to smartphone applications that provide counting locations, and spreadsheets for reporting results. Pilot field counts took place at 133 locations in 43 municipalities of varying sizes. Average volumes at all sites were 7.5 bicycles per hour and 19.3 pedestrians per hour, with significantly higher traffic levels in the largest cities. Count managers reported that training materials were useful, but the spreadsheet for reporting traffic levels was awkward to complete. Both automatic and manual counts are necessary to get a complete picture of non-motorized traffic rates. Automatic counts obtain continuous data, but they cannot capture attributes such as gender and bicycle helmet use, and many cannot differentiate between bicyclists and pedestrians or only count one type of traveler. Manual counts can capture this information but are too labor-intensive for large-scale counts. Analysis showed that the techniques currently used to extrapolate motorized traffic data from short-term counts should be adaptable to bicycle and pedestrian traffic data. Next Steps: To evaluate automated counting methods, MnDOT has begun an implementation project, *Implementing Bicycle and Pedestrian Traffic Counts and Data Collection*, planned for completion in fall 2014. This project will install and evaluate several types of equipment (such as loop detectors, infrared sensors and portable equipment) in trails, bike lanes and shoulders, and other facilities in urban and rural areas around the state. MnDOT Traffic Forecasting & Analysis is evaluating how to incorporate non-motorized traffic data into its existing traffic database. Researchers further recommend that MnDOT institutionalize its coordination of statewide bicycle and pedestrian counts, improve methods for reporting field counts, deploy and demonstrate the feasibility of new automated counting technologies, and work with local agencies to establish a network of permanent automated monitoring sites across the state.
Web Links (if available)	http://mndot.gov/research/HVR2013-24.html

PROJECT INFORMATION	
Project Title	***Effect of Signing and Lane Markings on the Safety of a Two-Lane Roundabout***
ID	2011-031
Project Cost	$105,000
Duration	34 months
SUBMITTER	
Submitter Agency	Minnesota Department of Transportation
Submitter Contact	Nick Busse Marketing and Communication Manager MnDOT Research Services & Library 295 John Ireland Blvd., MS330 St. Paul, MN 55155 nick.busse@state.mn.us, 651-366-3738
RESEARCH PROGRAM	
Sponsor Contact	Minnesota Department of Transportation 295 John Ireland Blvd. MS330 St. Paul, MN 55155
Brief Summary of Research Project	Background: Many drivers still do not fully understand roundabout traffic rules, particularly at multi-lane roundabouts, and this can lessen the roundabout's safety advantages. In Richfield, Minnesota, the intersection at East 66th Street and Portland Avenue South was converted from a signalized intersection to a two-lane, two-entrance roundabout in 2008. After completion, the site maintained a higher rate of collisions than is typically experienced after an expected learning stage has passed. Though the roundabout was working well, engineers from Richfield, Hennepin County and MnDOT had several ideas for changing signage and striping at the roundabout to reduce driver confusion and further improve safety. Goal: This project sought to implement and test the impact on driver behavior of changes to signage and striping at the two-lane roundabout in Richfield. Project: During August 2011, several changes were made to signage and lane markings at the test site: • Turn arrows on the roundabout lanes and approaches and on signs were changed from the curved "fish-hook" style, intended to represent the flow of traffic around the center island, to the standard style. • Additional turn arrows and lane designation signs were added approximately 450 ft. upstream of yield lines. • The solid line extending from the yield line was lengthened from 50 to 250 ft.

PROJECT INFORMATION (CONT.)	
	• Lane marking widths were increased from 4 to 6 in., lane markings in the middle of the roundabout were made 3 ft. long with a 1-ft. gap, and 4- x 4-in. "cat track" concentric-spiral lane markings replaced solid lane markings. • Signs were lowered to improve visibility, and "Roundabout Ahead" signs were moved to 500 ft. from the roundabout. Researchers used driver behavior as a surrogate for crash rates to expedite the evaluation and produce results in less than one year. (Using crash rates traditionally requires three to five years of data after changes are implemented.) They studied 216 hours of video to identify and count traffic violations, with equal amounts of footage from before the changes, shortly after the changes, and one year after the changes. Results: Turning violations, in which drivers turn right from the inner lane of the roundabout or turn left from the outer lane, caused nearly half of the crashes at this roundabout (44 out of 89 collisions in the 35 months after its construction). The signage and striping changes had significant impacts on the rate of turning violations. After these changes were implemented, violation rates decreased 48 percent—from 1.16 percent of vehicles before the changes to 0.6 percent of vehicles after the changes. The violation rate stayed near that lower level one year after the changes. According to Richfield personnel, changing from fish-hook to standard style arrows, extending the solid line, and adding signs further from the intersection were the primary causes for this reduction. Yielding violations were the other primary cause of crashes, responsible for 38 incidents. Striping and signage changes did not have as clear an impact on yielding violations, which initially dropped from 1.04 percent of vehicles before the changes to 0.85 percent after, but rebounded to 1.36 percent of vehicles one year later. Researchers suggested that extra enforcement and education immediately after the changes led to the initial, unsustainable decrease in yield violation rates, while increased traffic at the roundabout (with more opportunities for violations) caused the greater violation rates a year later. The public reacted positively to the changes. In particular, comments received by the city expressed appreciation for the lowered signs.

PROJECT INFORMATION (CONT.)	
	Next Steps: Richfield will continue to monitor this roundabout to collect better information about the impacts of the signage and striping changes on overall crash rates. The rate of yield violations remains a significant concern, and Richfield personnel suggested that drivers might not understand what "yield" actually means. The city is working with a group to develop a video to educate the public about yield procedures, but other educational efforts would likely be worthwhile. While this project offers useful information about the Richfield site, a single experiment on a single roundabout does not offer enough information to recommend changes in design guidelines. MnDOT has recently approved another project, *Evaluation of Safety and Mobility of Two-Lane Roundabouts*, to study three roundabouts, which should increase the amount of data available and better inform conclusions that can help to shape design guidelines.
Web Links (if available)	http://mndot.gov/research/HVR2014-04.html

PROJECT INFORMATION	
Project Title	***Improving the Friction and Quietness of Concrete Pavements***
ID	930282008-044
Project Cost	$118,760
Duration	59 months
SUBMITTER	
Submitter Agency	Minnesota Department of Transportation
Submitter Contact	Nick Busse Marketing and Communication Manager MnDOT Research Services & Library 295 John Ireland Blvd., MS330 St. Paul, MN 55155 nick.busse@state.mn.us, 651-366-3738
RESEARCH PROGRAM	
Sponsor Contact	Minnesota Department of Transportation 295 John Ireland Blvd. MS330 St. Paul, MN 55155
Brief Summary of Research Project	Background: After concrete pavements are placed, the surfaces are textured to ensure that they have sufficient friction and skid resistance. The most common texture for North American pavements is the transverse tine, produced by dragging metal prongs laterally across the surface before it has fully cured. Because this texture can cause a significant amount of tire-pavement contact noise, in 1998 MnDOT began using a method that involves dragging an inverted strip of AstroTurf over the surface, resulting in a finer texture that produces significantly less tire-pavement noise. Another method that has been shown to provide even greater benefits is diamond grinding. Developed to restore friction to older pavements worn smooth with age, diamond grinding involves cutting longitudinal grooves into the pavement surface using closely spaced, diamond-coated saw blades. In 2005, Purdue University's Institute for Safe, Quiet and Durable Highways conducted research to optimize diamond grind blade configurations in the laboratory, developing several textures to make pavements even quieter while preserving friction. To evaluate the friction and noise characteristics of these textures in the field, in 2006 Transportation Pooled Fund study TPF-5(134) was initiated with Minnesota as the lead state. Goal: The objective of this project was to provide a quiet grinding configuration with sufficient skid resistance and ride improvement. Project: Researchers evaluated the following diamond-ground textures (also known as next generation concrete surfaces) on 500-foot portland cement concrete test cells at Minnesota's MnROAD pavement research facility:

PROJECT INFORMATION (CONT.)	
	• Cell 8 (ground in 2007), the conventional grind: Consists of grooves that are 0.125 inches deep and 0.125 inches wide, with 0.125-inch tire landing areas. • Cell 7 (ground in 2007), the innovative grind: Consists of landing areas made wider—0.375 inches—and made flush by shaving a thin layer off the top of the pavement. Grooves were the same width and slightly less deep at 0.12 inches. • Cell 9 (ground in 2008), the ultimate grind: Modifies the innovative grind by making landing areas even wider—0.502 inches—and corrugating them with an additional pass by grinding machinery. Grooves were more than twice as deep at 0.309 inches and somewhat wider at 0.129 inches. • Cell 71 (ground in 2011), the new ultimate grind: Also uses the corrugated surface and wider and deeper grooves of the ultimate grind, but returns to the 0.375-inch landing area of the innovative grind. As a control, researchers also evaluated the transverse tine on MnROAD Cell 12. From the date of grinding until June 2012, researchers measured the following surface characteristics both before grinding and at regular intervals: • Noise levels, using onboard sound intensity testing. • Friction and skid resistance. • Ride quality, with the lightweight profiler. • Mean profile depth of texture. Researchers also evaluated the use of ambient air temperatures to correct noise data and the use of various statistical analysis methods to evaluate data trends. Results: For long-term performance (after 4 million equivalent single axle loads in the driving lane and 1 million in the passing lane): • The ultimate grind (NGCS) had the least noise. • NGCS is an overall improvement over the conventional grind, particularly in quietness, ride improvement and durability. • Increased use of NGCS has reduced grinding cost. • The conventional grind had the best ride quality. • The innovative grind had the best friction for smooth tires, and the ultimate grind had the best friction for ribbed tires. • The innovative grind had the best texture skid resistance for smooth tires followed by the ultimate grind. • Although the ultimate grind involves more elaborate blade stacking and may occasionally be a two-stage grinding process, increased use has reduced grinding cost. Researchers also found that noise measurements could be better compared over time by correcting data for air temperature and sound intensity. Next steps: Researchers recommend monitoring test cells for surface characteristics, developing innovative grinding configurations and implementing temperature correction of noise measurements so that values can be compared over the long term. Other research products include Report 2013-16, and future research will continue to evaluate the rolling resistance of diamond-ground MnROAD test cells.
Web Links (if available)	http://mndot.gov/research/HVR2013-18.html

PROJECT INFORMATION	
Project Title	***Designing Asphalt Pavements That Resist Cracking at Low Temperatures***
ID	89261 WO#1032007-093
Project Cost	$475,000
Duration	50 months
SUBMITTER	
Submitter Agency	Minnesota Department of Transportation
Submitter Contact	Nick Busse Marketing and Communication Manager MnDOT Research Services & Library 295 John Ireland Blvd., MS330 St. Paul, MN 55155 nick.busse@state.mn.us, 651-366-3738
RESEARCH PROGRAM	
Sponsor Contact	Minnesota Department of Transportation 295 John Ireland Blvd. MS330 St. Paul, MN 55155
Brief Summary of Research Project	Background: Building long-lasting asphalt pavements in cold climates can be a challenge. To address this problem, MnDOT and several other states formed pooled fund study TPF-5(080) in 2004 with the goal of developing methods to better characterize the behavior of asphalt at low temperatures. They evaluated a number of tests that involve measuring how materials respond to certain stresses, including the traditional indirect tensile (IDT) test and the newly developed fracture mechanics tests, including the semi-circular bend (SCB) test and disk-shaped compact tension (DCT) test. Completed in 2007, TPF-5(80) showed that fracture mechanics tests were best at predicting field performance and with further research should be incorporated into specifications. To accomplish this goal, TPF-5(80) was extended to a second phase, TPF-5(132). Goal: The objective of this pooled fund study was to continue the development of fracture mechanics-based specifications for determining the low temperature properties of asphalt mixtures; continue Phase I testing of additional samples using recycled and other materials; investigate the physical hardening effects for modified asphalt binders; and continue to develop computer models that make use of fracture mechanics properties. Project: As a continuation of the Phase I study, researchers conducted laboratory tests—including the IDT, SCB and DCT—on nine asphalt mixtures modified with recycled asphalt pavement, polyphosphoric acid and polymers. They compared these with specimens taken from MnROAD test sections and evaluated the effects of aging by conditioning laboratory mixtures for five days at 85 degrees Celsius. Researchers also investigated the physical hardening of asphalt binders and developed a comprehensive model for predicting this hardening without lengthy tests.

PROJECT INFORMATION	
	Researchers proposed a thermal cracking specification using the DCT and SCB tests, and validated the proposed DCT specification by using it with 11 mixtures from pavement sections constructed in Olmsted County, Minnesota, during the 2006 construction season. They proposed and validated a method for obtaining mixture creep compliance (how a material deforms permanently when subjected to stresses) from DCT and SCB results. They also explored the feasibility of predicting mixture creep compliance from asphalt binder creep compliance. Finally, researchers developed a thermal cracking computer model called ILLI-TC and conducted a comprehensive experimental and modeling investigation into the contraction and expansion of asphalt mixtures due to thermal cycles. Results: Laboratory tests on asphalt mixtures showed that fracture tests could distinguish between different mixtures, with the DCT and SCB generally providing similar results. Research into the physical hardening of asphalt binders showed that it causes significant changes in their creep response at temperatures below or near the glass transition (the temperature below which a polymer becomes brittle). The rate of physical hardening decreases rapidly with the amount of time the binder is stored at a constant low temperature and is not significantly changed by using various polymer additives. This hardening affects material stresses caused by contraction from cooling. The DCT specification proposes a 15 percent increase in fracture energy to account for mixture aging and suggests a higher fracture energy threshold to limit thermal cracking to lower levels on critical projects. DCT test validation showed that the test reasonably predicted the initial field performance data available at the conclusion of the project. The new ILLI-TC thermal cracking model significantly improves current models in handling fracture simulations. Researchers also developed a thermal stress model that accounts for the glass transition and physical hardening of asphalt mixtures, providing a foundation for developing mixtures that resist cracking through multiple temperature cycles. Next Steps: MnDOT is conducting a follow-up study, "DCT Low Temperature Fracture Testing Pilot Project," in which the DCT will be used as part of the specification during the mix design process for several pavements. A related project, "Laboratory Performance Test for Asphalt Concrete," will compare the historical performance of in-service pavements to that predicted by DCT and other laboratory tests, helping MnDOT to refine its low temperature cracking specification.
Web Links (if available)	http://mndot.gov/research/HVR2012-23.html

Mississippi Department of Transportation

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Performance Evaluation of Roundabouts for Traffic Delay and Crash Reductions in Oxford, MS***
ID	213
Project Cost	$70,920
Duration	25 months
SUBMITTER	
Submitter Agency	Missisippi Department of Transportation
Submitter Contact	Cynthia J. (Cindy) Smith, P.E. Asst State Research Engineer Mississippi DOT Research Div 86-01 PO Box 1850 Jackson, MS 39215-1850 (601) 359-7648, cjsmith@mdot.ms.gov
RESEARCH PROGRAM	
Sponsor Contact	Missisippi Department of Transportation PO Box 1850 Jackson, MS 39215-1850
RESEARCH AND RESULTS	
Brief Summary of Research Project	Due to increased traffic volume, congestion, and capacity limitations, two roundabouts were constructed on South Lamar Boulevard ramp intersections with MS Highway 6 in Oxford, MS. Roundabouts replaced the existing signalized intersection on the north and stop controlled intersections on the south side of the South Lamar Boulevard and MS Highway 6 Interchange. The overall objective of this study was to assess the performance of the roundabouts in Oxford with respect to traffic flow, capacity, and safety improvements, and to determine the public perception of roundabouts by means of an opinion survey. Detailed post-roundabout traffic movement volume and crash data were collected and compared with the pre-roundabout data to assess the in-service performance of the roundabouts. Traffic flow microsimulation and capacity analysis methods were used to evaluate performance of the roundabouts. The results of the

PROJECT INFORMATION (CONT.)	
	Oxford roundabout study showed significant improvement in traffic flow, crash reduction, and reduction in vehicle emissions. It was found that the conversion of the intersections to roundabouts improved traffic flow by reducing average delay by 24%, idling time by 77%, and fuel wastage by 56%. Overall vehicle emissions from idling were reduced significantly including 56% in CO2, 80% in VOC, and 77% in CO, NOx, and PM10. This conversion of stop-controlled intersections to roundabouts increased the average speed by 67% and improved level of service of both roundabouts. The roundabout conversion increased the mean speed on the South Lamar interchange by 67% and improved level of service for both intersections. The roundabout junctions improved safety performance through a 37.5% reduction in crashes and a 60% reduction in the number of crashes resulting in injury. The reduction in overall crashes in the study area reduced comprehensive cost by 54.4%. Total user cost saving from reductions in travel time, fuel wastage, and crash cost combined is $806,018 annually. These benefits paid off the total cost of construction of the two roundabouts within two years. The resulting B/C ratio is 6.2 over a period from 2009 to 2016. Additionally, significant societal benefits are expected from reductions in vehicle emissions. Also, an anonymous public opinion survey overwhelmingly demonstrated favorable results and provides support to consider more roundabout junctions in place of stop-controlled intersections. The study results indicate that roundabouts are performing well as intended. Some constructive comments suggested by the public, such as flashing lights on signs, can be implemented by the Mississippi DOT to enhance traffic flow and safety. Over three years after this study, MDOT is building more roundabouts throughout the state.
Web Links (if available)	http://mdot.ms.gov/documents/research/Reports/Interim%20and%20Final%20Reports/State%20Study%20No.%20213%20Performance%20Evaluation%20of%20Roundabouts%20for%20Traffic%20Delay%20and%20Crash%20Reductions%20in%20Oxford.pdf

PROJECT INFORMATION	
Project Title	***Evaluation of Fertility Practices During Roadside Establishment in MS to Minimize Nonpoint Source Pollutants (Mississippi DOT State Study 240)***
ID	240-MS
Project Cost	$292,186
Duration	38 months
SUBMITTER	
Submitter Agency	Missisippi Department of Transportation
Submitter Contact	Cynthia J. (Cindy) Smith, P.E. Asst State Research Engineer Mississippi DOT Research Div 86-01 PO Box 1850 Jackson, MS 39215-1850 (601) 359-7648, cjsmith@mdot.ms.gov
RESEARCH PROGRAM	
Sponsor Contact	Missisippi Department of Transportation PO Box 1850 Jackson, MS 39215-1850
RESEARCH AND RESULTS	
Brief Summary of Research Project	Turf on Mississippi roadsides is typically established with one large fertilizer application at the time of planting without soil test recommendations. There is great concern for runoff of sediment and nutrients from roadside turf sites. Nutrient and sediment losses from highway construction sites are inevitable due to the lack of vegetation and sloped land. Our objective is to provide guidelines for maximizing the efficiency of fertilizer use with rapid plant establishment and minimal runoff. Experiments were conducted to compare the current single application rate with other methods that are based on soil test recommendations. Rain simulations will provide a consistent and precise data flow that will result in fertilization best management practices for road construction in Mississippi. The study recommended that MDOT adjust specifications on which types of grass to plant at different times of the year. Also recommended was a 1/4 reduction in fertilizer amount. This will result in less runoff and pollution due to fertilizer. MDOT is in the process of review and approval of the adjusted specification.
Web Links (if available)	http://mdot.ms.gov/documents/research/Reports/Interim%20and%20Final%20Reports/State%20Study%20240%20-%20Evaluation%20of%20Fertility%20Practices%20during%20Roadside%20Establishment%20in%20MS%20to%20Minimize%20Nonpoint%20Source%20Pollutants.pdf

PROJECT INFORMATION	
Project Title	***Evaluating Alternative Mowing Regimen and the use of Native Grasses and Wildflowers on Roadside Right of Ways (Mississippi DOT State Study 228)***
ID	228-MS
Project Cost	$135,044
Duration	47 months
SUBMITTER	
Submitter Agency	Missisippi Department of Transportation
Submitter Contact	Cynthia J. (Cindy) Smith, P.E. Asst State Research Engineer Mississippi DOT Research Div 86-01 PO Box 1850 Jackson, MS 39215-1850 (601) 359-7648, cjsmith@mdot.ms.gov
RESEARCH PROGRAM	
Sponsor Contact	Missisippi Department of Transportation PO Box 1850 Jackson, MS 39215-1850
RESEARCH AND RESULTS	
Brief Summary of Research Project	This study (SS228) evaluated mowing regimes, changes in native and non-native plant communities, deer presence in the research plots and public perception of various management practices on ROWs. No significant difference was found in the height of vegetation 3 weeks after each mowing between research plots mowed 4 times per year and plots mowed only once in respective uplands or lowlands near bridges. We observed that native plants increased in plots mowed only once per year and deer preferred the frequently mowed plots where clovers and vetches had been seeded. The greatest numbers of deer were observed in the lowland plots along streams. Increasing the carrying capacity of the lowlands, with more extensive plantings of clover and vetch, may attract deer away from the uplands and thus encouraging them to browse in the lowlands and use the underpasses beneath bridges making the ROWs safer. The public perceptions survey found strong support for wildflowers on ROWs and a distaste for litter. Further, respondents would tolerate a less manicured ROW if it saved money, made the roads safer and hide litter. Overall the study suggest that ROWs would be less costly to maintain, safer and more attractive to motorist if mowing was reduced to once per year in late fall after seed set. However, from the survey it also appeared that a public education program would be critical to bolster the publics' understanding of the management strategy being implemented.

PROJECT INFORMATION (CONT.)	
	The cost savings from a reduced mowing regimen could be substantial. Mississippi mows approximately 139,253 acres of roadsides four times per year at a cost per acre of greater than $250 or a total annual cost of around $35 million. A reduction by the equivalent of one mowing per year could save approximately $8.7 million. This research failed to find support more than one comprehensive mowing per year which could result in a savings of over $15 million per year. A safety margin adjacent to the highway will always need to be mowed 4 times per year for safety and visibility.
Web Links (if available)	http://mdot.ms.gov/documents/research/Reports/Interim%20and%20Final%20Reports/State%20Study%20240%20-%20Evaluation%20of%20Fertility%20Practices%20during%20Roadside%20Establishment%20in%20MS%20to%20Minimize%20Nonpoint%20Source%20Pollutants.pdf

Missouri Department of Transportation

PROJECT INFORMATION	
Project Title	***Recycled Asphalt Shingles***
ID	TPF-5(213)
Project Cost	$765,000
Duration	58 months
SUBMITTER	
Submitter Agency	Missouri Department of Transportation
Submitter Contact	Jennifer Harper Missouri Dept. of Transportation 1617 Missouri Blvd. Jefferson City, MO 65109 573-526-3636, Jennifer.harper@modot.mo.gov
RESEARCH PROGRAM	
Sponsor Contact	Missouri Dept. of Transportation 1617 Missouri Blvd. Jefferson City, MO 65109
RESEARCH AND RESULTS	
Brief Summary of Research Project	Recycled Asphalt Shingles (RAS) are an environmentally friendly alternative to using 100% virgin asphalt binder. Asphalt binder is an expensive and limited resource; whereas, asphalt shingles typically end up in a landfill. While many states have adopted using RAS waste from the shingle production process, MoDOT led a Pooled Fund Study TPF 5(213) on Performance of Recycled Asphalt Shingles in Hot Mix Asphalt to look at using "tear-off shingles," or shingles that have been removed from a roof. Study partners included FHWA and seven other states (CA, CO, IA, IL, IN, MN, and WI). The Pooled Fund study concluded at the end of 2013 and was completed by Iowa State University. Each year approximately 10 million tons of post-consumer shingles are placed in landfills in the United States. These shingles contain 20% to 30% asphalt by weight which can be used to replace virgin asphalt binder, in turn decreasing pavement costs and reducing the burden on landfill space. Utilizing tear-off shingles allows the DOTs to save money on constructing pavements, while at the same time positively impacting the environment and increasing rutting resistance. Historically, as the cost of virgin binder continues to increase, utilizing RAP and RAS helps agencies offset rising costs. As part of the study, each state highway agency proposed a unique field demonstration project that investigated different aspects of asphalt mixes containing RAS specific to their state needs. The results showed that RAS can be successfully processed and incorporated into asphalt mixtures that meet state agency requirements for asphalt content, volumetrics and density. The tear-off shingles also contain fibers that can help reduce rutting.

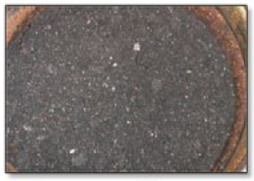
PROJECT INFORMATION (CONT.)	
	Two years after construction, field studies were performed at the test sites and found no signs of rutting, wheel path fatigue cracking or thermal cracking. Some transverse reflective cracking from underlying jointed concrete pavement was identified in a few locations. The research project found that states can successfully use tear off shingles in asphalt mix designs. In 2013, MoDOT incorporated 62,500 tons of recycled shingles into new asphalt pavements.
Web Links (if available)	http://www.intrans.iastate.edu/research/documents/research-reports/ras_pooled_fund_w_cvr.pdf

Recycled Asphalt Shingle (RAS) Pooled Fund Field Demonstration Project (Missouri DOT)

US Route 65 south of Springfield, MO

Stockpile of Pre-Processed Post-Consumer Shingles

Fine RAS Stockpile and Sample Collection



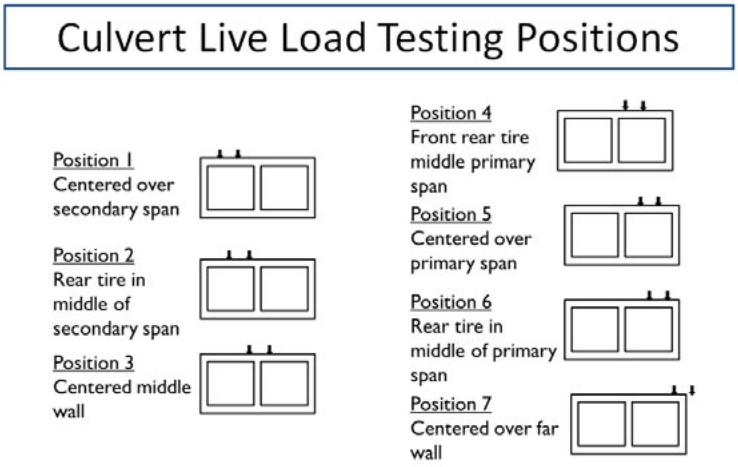
Close-up of Fine RAS

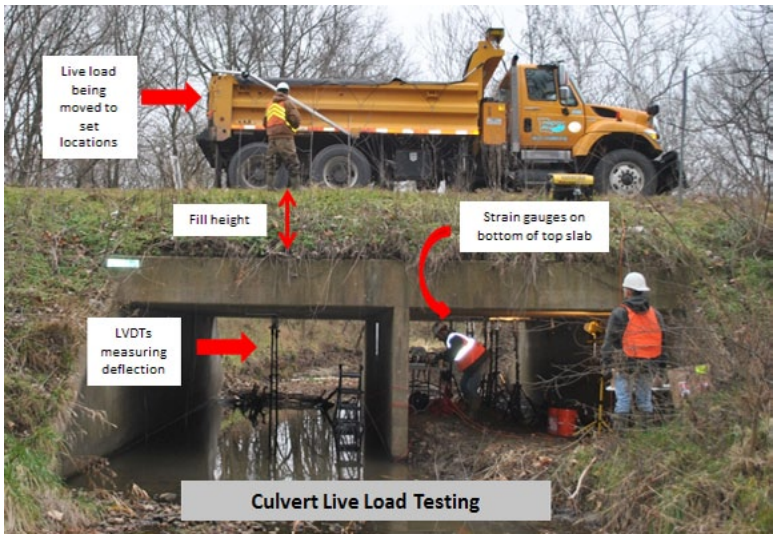
Close-up of Coarse RAS

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Live Load Effect in Reinforced Concrete Box Culverts Under Soil Fill***
ID	TR201314
Project Cost	$80,000
Duration	7 months
SUBMITTER	
Submitter Agency	Missouri Department of Transportation
Submitter Contact	Andrew Hanks Missouri Dept. of Transportation 1617 Missouri Blvd. Jefferson City, MO 65109 573-526-4325, andrew.hanks@modot.mo.gov
RESEARCH PROGRAM	
Sponsor Contact	Missouri Dept. of Transportation 1617 Missouri Blvd. Jefferson City, MO 65109
RESEARCH AND RESULTS	
Brief Summary of Research Project	FHWA currently requires the load rating of all culverts (with a minimum span length of 20 feet measured along center line of roadway) with fill less than the culvert span lengths up to 45 feet of fill. This is a requirement that must be met to comply with National Bridge Inspection Standards. This requirement was generally considered overly conservative, but prior to this project there was no way to prove this to be the case. The Live Load Effect in Reinforced Concrete Box Culverts under Soil Fill research project load tested box culverts under soil fills between 2.5 and 13.5 feet to determine the level of fill in which live load becomes negligible in comparison to dead load. These load tests utilized a loaded dump truck parked at specific locations to maximize strains on the culvert. The effects of these loadings were recorded via strain transducers, LVDT displacement transducers, and an accelerometer attached to the culverts. Tests were conducted in two rounds. The first round tested five culverts with similar geometrics but greatly varying fill heights. The second round focused on various cell sizes, arrangements, and design loads at depths near where live loads became negligible during the first round of testing. In addition to field tests, computer models of each culvert were created to fully analyze and understand the results. The results of this project showed live loads become less than 10% of the dead load at fills above six foot, at which point load rating will no longer be necessary. In addition to this, the study showed current design methodology is much more conservative for live loads than previously believed.

PROJECT INFORMATION (CONT.)	
	As a state with over three thousand NBI length box culverts, the impact of this study could be a significant reduction of man-hours to load rate culverts with adequate fill to negate this requirement. In addition, due to the conservative nature of our current culvert design and load rating methods, there was potential that this unnecessary load rating could result in posted culverts with minimal live load effects. Depending on the location of needlessly posted culverts, the economic impact could potentially be tremendous.
Web Links (if available)	http://library.modot.mo.gov/RDT/reports/TR201314/cmr14-009.pdf





PROJECT INFORMATION	
Project Title	***Evaluation of Effectiveness of Alternate Geometric Designs in Missouri - J-Turns and Other Novel Designs***
ID	TRyy1304
Project Cost	$27,635
Duration	17 months
SUBMITTER	
Submitter Agency	Missouri Department of Transportation
Submitter Contact	Andrew Hanks Missouri Dept. of Transportation 1617 Missouri Blvd. Jefferson City, MO 65109 573-526-4325, andrew.hanks@modot.mo.gov
Submitter Email	andrew.hanks@modot.mo.gov
RESEARCH PROGRAM	
Sponsor Contact	Missouri Dept. of Transportation 1617 Missouri Blvd. Jefferson City, MO 65109
RESEARCH AND RESULTS	
Brief Summary of Research Project 	A large percentage of crashes that take place on high-speed rural expressways occur at intersections with minor roads. Right-angle collisions are generally considered one of the most severe collision types. J-turns (also known as a restricted crossing U-Turn or RCUT and Superstreet intersection) are a low-cost alternative design for improving the safety of at-grade intersections on expressways. These intersections provide a safer merge operation instead of a crossing action. This reduces both right angle collisions and collisions in general. There are tradeoffs to this design including increased travel time, potential for driver confusion due to the unique design, various design considerations may be required due to site geometric issues, and potential negative public perception. This project used field studies, traffic conflict analysis, crash analysis, and a public survey to evaluate J-turn installations in Missouri, comparing them to traditional two-way stop controlled intersections. The results of this study proved the safety benefits of the J-turn in decreased frequencies of crashes, especially disabling injury and fatal crashes; and in significantly increased average time-to-collision (considered a positive result). Although the travel time was increased by approximately one minute at these locations, the public perception of J-turns was mixed. Concerns raised by the public included driver confusion, difficulty merging with insufficient acceleration and deceleration lanes, and insufficient U-turn radius.

PROJECT INFORMATION (CONT.)	
	The results of this study provide justification for this low cost safety improvement and a better understanding of driver needs and expectations which will help ensure that future installations are as accommodating as possible. Since J-turn installations are very cost effective and are so successful at increasing driver safety, this project will allow the proper usage of limited construction funds to make Missouri roads safer while maintaining public satisfaction.
Web Links (if available)	http://library.modot.mo.gov/RDT/reports/TRyy1304/cmr14-005.pdf

PROJECT INFORMATION	
Project Title	***Work Zone Software Phase I and Phase II***
ID	TRyy1306
Project Cost	$30,649
Duration	20 months
SUBMITTER	
Submitter Agency	Missouri Department of Transportation
Submitter Contact	Jennifer Harper Missouri Dept. of Transportation 1617 Missouri Blvd. Jefferson City, MO 65109 573-526-3636, Jennifer.harper@modot.mo.gov
RESEARCH PROGRAM	
Sponsor Contact	Missouri Dept. of Transportation 1617 Missouri Blvd. Jennifer.harper@modot.mo.gov
RESEARCH AND RESULTS	
Brief Summary of Research Project	In 2008, the University of Missouri evaluated several software programs for work zone traffic impact analysis and identified appropriate analytical tools for assessing traffic impacts at different types of work zones. The research project looked at QuickZone, CA4PRS, and VISSIM. As part of the research project, a work zone spreadsheet was developed. The spreadsheet produces queue length and delay estimates with a minimum amount of input data. Traffic engineers at MoDOT have found the software easy to use and a valuable tool when designing a work zone. The research found that for rural interstates, divided roadways and multilane undivided highways in Missouri, the custom work zone spreadsheet should be used to estimate the traffic impacts of work zone lane closures. For work zones in urban areas where lane closures on a roadway may impact the traffic on neighboring roadways, the VISSIM program should be used. For two-way one-lane work zone with flaggers, Quick Zone should be evaluated as a first

PROJECT INFORMATION (CONT.)	
	option. However, in situations with high input volumes and/or where close detour routes are not available, Quick Zone does not work well and VISSIM should be used. A follow-up project was started in 2012 to use real Missouri work zone data to validate the results of the work zone spreadsheet and the VISSIM program. During the 2013 construction season, data from work zones was collected from traffic sensors and video monitoring systems. Calibration factors were developed for both the Custom Work Zone spreadsheet and the VISSIM program. The study found that calibration based on delay or travel time exhibited better overall performance than calibrating based on queue length.
Web Links (if available)	http://library.modot.mo.gov/RDT/reports/TRyy1306/cmr14-004.pdf

Montana Department of Transportation

PROJECT INFORMATION	
Project Title	***Montana Rest Area Usage: Data Acquisition and Usage Estimation***
ID	8202
Project Cost	$150,601
Duration	18 months
SUBMITTER	
Submitter Agency	Montana Department of Transportation
Submitter Contact	Sue Sillick Manager Research Programs Montana Department of Transportation PO Box 201001, 2701 Prospect Avenue Helena MT 59620-1001 Phone: 406-444-7693, E-mail: ssillick@mt.gov
RESEARCH PROGRAM	
Sponsor Contact	Montana Department of Transportation 2701 Prospect Ave PO Box 201001 Helena, MT 59620-1001 Phone: 406-444-7693
RESEARCH AND RESULTS	
Brief Summary of Research Project	The Montana DOT (MDT) research project "Montana Rest Area Usage: Data Acquisition and Usage Estimation" resulted in data collection and analysis to support various aspects of future rest area planning, design, and operations in the state of Montana. Usage data from rest areas throughout the state was used in the research to develop guidance, related to various aspects of rest areas including parking, patron visitation, water usage, and wastewater

PROJECT INFORMATION (CONT.)	
	generation. A key piece of guidance recommends a water usage value of 2.0 gallons per patron, which correlated to the same value per patron for wastewater generation. This is a significant departure from the existing guidance provided by AASHTO's "Guide for Development of Rest Areas on Major Arterials and Freeways", which recommends the use of 3.5 gallons per patron. This 1.5 gallon difference has significant implications on the sizing and associated cost of each system and advanced wastewater treatment component, the land area necessary for a drainfield, and resulting operations and maintenance of the constructed system. The application of this finding in designs for new and renovated rest areas was the most immediate outcome from the short-term implementation of the research. In just the next two years, there are six rest areas scheduled for wastewater system rehabilitation. The savings realized at these sites is over $1.3 million. When applied in the design calculations of systems at thirty additional Montana rest areas requiring wastewater system rehabilitation over the next twenty years (through 2032), the reduced wastewater figure is expected to produce savings of between $65,445 and $513,750 per site. The collective savings generated by this revised guidance will total $6,308,060 in present value (2013). The present cost of the research (2013) is $206,031. These savings and the research cost were used when calculating the benefit-cost ratio (31:1) of the research and the return on investment (30). In addition, reductions in sizing of wastewater treatment systems will minimize the impacts to the environment, particularly at sites with septic systems.
Web Links (if available)	http://www.mdt.mt.gov/research/projects/planning/rest_area.shtml

PROJECT INFORMATION	
Project Title	***Impacts to Montana State Highways Due to Bakken Oil Development***
ID	8219
Project Cost	$117,047
Duration	12 months
SUBMITTER	
Submitter Agency	Montana Department of Transportation
Submitter Contact	Sue Sillick Manager Research Programs Montana Department of Transportation PO Box 201001, 2701 Prospect Avenue Helena MT 59620-1001 Phone: 406-444-7693, E-mail: ssillick@mt.gov
RESEARCH PROGRAM	
Sponsor Contact	Montana Department of Transportation 2701 Prospect Ave PO Box 201001 Helena, MT 59620-1001 Phone: 406-444-7693
RESEARCH AND RESULTS	
Brief Summary of Research Project	Recent improvements in oil extraction technology have increased the economic viability of production from shale oil formations. Because of these technological innovations and continued interests in fostering energy independence, the Bakken formation in western North Dakota and eastern Montana has become a major focus of current and future energy development plans. Both western North Dakota and eastern Montana are experiencing rapid oil and gas development, which has resulted in large-scale highway needs and suggests the possibility of substantial investment requirements in the near future in affected areas of Montana. Studies to project infrastructure needs in order to facilitate energy development have been conducted in North Dakota. Since this oil development and production activity has had an impact on Montana's infrastructure and Montana possesses geology that is similar to western North Dakota, similar oil and gas developments may be mirrored in the affected region within the next few years. In fact, exponential growth in oil and gas well permits has occurred in Montana since the last half of 2011. Moreover, this rate of growth is expected to continue into the near future. Given the recent history of western North Dakota and escalating activity levels in Montana, the MDT developed an understanding of the current and future demands and traffic patterns that are resulting and will result from the origins and destinations of fracking materials, as well as the transportation infrastructure needed to move both inbound materials and outbound products to transfer locations or market. This information is essential to forecasting the highway impacts of future oil development and production in the

PROJECT INFORMATION (CONT.)	
	state and identifying potential infrastructure funding gaps and solutions that will be critically important to the development and implementation of a comprehensive highway transportation plan to sustain Montana's needs. The research products included: (1) Traffic Estimation Model, (2) Pavement Impact Report, (3) Transportation and Economic Impact Report, (4) Various Corridor Studies, and a 5) Final Research Report. These products are being used to support construction and maintenance projects in the affected area; the estimated increase in construction-only costs (not including design, construction oversight, and maintenance activities) is any where from $51 - $58 million annually, and $1 - $1.2 billion over a 20-year design life, depending on the number of new oil rigs.
Web Links (if available)	http://www.mdt.mt.gov/research/projects/pave/oil.shtml

PROJECT INFORMATION	
Project Title	***Steel Pipe Pile/Concrete Pile Cap Bridge Support Systems: Confirmation of Connection Performance***
ID	8203
Project Cost	$117,337
Duration	39 months
SUBMITTER	
Submitter Agency	Montana Department of Transportation
Submitter Contact	Sue Sillick Manager Research Programs Montana Department of Transportation PO Box 201001, 2701 Prospect Avenue Helena MT 59620-1001 Phone: 406-444-7693, E-mail: ssillick@mt.gov
RESEARCH PROGRAM	
Sponsor Contact	Montana Department of Transportation 2701 Prospect Ave PO Box 201001 Helena, MT 59620-1001 Phone: 406-444-7693
RESEARCH AND RESULTS	
Brief Summary of Research Project	The Montana Department of Transportation (MDT) has found concrete-filled steel tube (CFT) piles connected at the top by a concrete pile cap to be a very cost effective support system for short and medium span bridges. This type of system offers low initial cost, short construction time, low maintenance requirements, and a long service life. From a structural engineering perspective, these systems must provide acceptable performance under gravity (i.e., self weight and vehicle loads) and lateral loads (i.e., extreme ice, wind, and seismic events). While the gravity load performance of these systems is well understood, their strength and ductility under extreme lateral loads is more difficult to reliably predict using conventional design procedures. Therefore,

PROJECT INFORMATION (CONT.)	
	MDT sponsored three phased research projects at Montana State University (MSU) to investigate the performance of these systems under extreme lateral loads. Based on the results of the first two phases of research, in conjunction with established structural engineering principles, MDT developed a design procedure to determine the reinforcing steel required in the pile cap to produce the desired system performance under lateral loads. The objective of the project phase discussed herein was to validate this new connection design methodology by physically testing connections designed according to this procedure. A total of six half-size connection specimens were tested under axial and lateral load until failure. Based on the results of this investigation, several observations were made regarding the efficacy of the MDT design methodology, and suggestions were made to improve its effectiveness. MDT plans on implementing the recommended modifications to this design guide, and this process is currently underway. The potential cost-savings of this system were calculated by comparing the cost of this system to a drilled-shaft system commonly used by MDT. In particular, a single 6-foot diameter drilled concrete shaft and column system was compared to a driven CFT pile system with five 20-inch diameter piles. This analysis showed a potential cost-savings of $50,000 per bridge for the CFT pile system. It is anticipated that this system will now be used approximately 2 times per year in place of the drilled-shaft system, for a total of $100,000 per year in savings. The life of this research product (new CFT connection design methodology) is anticipated to be 20 years. This results a B/C of 6.78:1 and a return on investment of 5.78.
Web Links (if available)	http://www.mdt.mt.gov/research/projects/structures/seismic.shtml

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Testing & Evaluation of Recovered Traction Sanding Material***
ID	8213
Project Cost	$55,531
Duration	24 months
SUBMITTER	
Submitter Agency	Montana Department of Transportation
Submitter Contact	Kris Christensen MDT Research Programs 2701 Prospect Avenue Helena, MT 59620 406-444-6125, email: krchristensen@mt.gov
RESEARCH PROGRAM	
Sponsor Contact	Montana Department of Transportation 2701 Prospect Ave PO Box 201001 Helena, MT 59620-1001 Phone: 406-444-7693
RESEARCH AND RESULTS	
Brief Summary of Research Project	Large amounts of abrasive traction sanding material (traction sand) are applied to roadways in northern climates every winter season to increase tire-road friction and improve traction control. The deployed traction sand is typically collected from roadways in the spring as part of roadway maintenance operations, which include: sweeping and vacuuming roadway surfaces, shoveling accumulated material from between guardrail posts, and cleaning and collecting material from road shoulders and borrow ditches. While removing accumulations of material helps to alleviate problems alongside highways, it can create storage/disposal problems unless cost-effective alternatives are identified and implemented. The recovery and reuse of this material represents a potentially desirable option to reduce the quantity of landfilled materials and to conserve natural resources. However, when used without any further treatment, recovered traction sand may create problems, including sedimentation in streams, clogging of culverts, and environmental contamination from chemicals, heavy metals, and volatile organic compounds. The practical suitability and cost effectiveness of a statewide program for recycling and reusing traction sand on Montana roadways was evaluated in this study. This study included the sampling and testing of traction materials used in Montana to investigate viable options for their reuse. The research included the development of a protocol for sampling stockpiled traction material, a focused synthesis of current literature on the topic, material sampling at Lookout Pass and Bozeman Pass, geotechnical and chemical testing, evaluation of alternatives, and a cost– benefit analysis that compares the recycling option to current practices that primarily utilize virgin materials. These two locations were selected because they experience relatively large quantities of snowfall and prolonged periods of sub-freezing temperatures during the winter months, especially in the higher elevations.

PROJECT INFORMATION	
	Consequently, large amounts of traction sand are used in these areas as part of winter maintenance operations. A cost-benefit analysis of reuse and recycle options of salvaged traction sand was conducted using results of mechanical and chemical tests conducted on samples collected along the Bozeman Pass and the Lookout Pass areas. The results indicate there are viable alternatives to landfilling or roadside dumping of collected traction sand. The most appealing and cost- effective option is to reuse the collected material as traction sand in subsequent winters. Research conducted during this study indicates a potential secondary option would be to process and mix (co-mingle) collected sand with gravel to produce a material that meets MDT gradation specifications for imported aggregate. The most promising co-mingling options are those that only necessitate the addition of finer aggregate and do not require extra coarse particles. It was determined in this study that MDT materials including plant mix surfacing, cement treated base, shoulder gravel, and crushed top surfacing could be economically pro duced by co-mingling collected traction sand with additional aggregate. The amount of screening and processing could be minimized by separating collected materials during spring maintenance. For example, material cleaned from side ditches is likely to contain excessively large coarse material and other debris. This material could be isolated (stockpiled separately) and evaluated apart from the other collected sand because it will likely require a higher level of processing in comparison to material that is swept or vacuumed off of the roadway surface. Likewise, depending on the topography, material cleaned from the roadway shoulder and from between guardrail posts may have different characteristics than sweepings and ditch material. Separating these materials will result in a more efficient reuse process and could minimize the amount of screening and washing required before the material is suitable for reapplication. The gradation curves obtained during this study indicate that a significant percentage (90 to 95%) of collected material from the shoulders could be re-used with only basic processing to remove trash and debris, and a small percentage of oversize soil particles. Estimated cost savings for various applications are as follows: • 152% for Crushed Top Surfacing 3B • 75% for Traction Sand • 55% for Plant Mix surfacing Grades A & B • 27% for Crushed Top Surfacing 2A • 8% for Shoulder Gravel • 1% for Cement Treated Base It was not found to be cost-effective to use this recycled material for cover material, and crushed base course A & B. MDT expects to realize substantial savings as a result of this research project. Additional benefits include reduced landfill materials and conservation of materials.
Web Links (if available)	http://www.mdt.mt.gov/research/projects/env/recycling.shtml

New Hampshire Department of Transportation

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	*Performance of W-Beam Guardrail after Height Adjustment*
ID	MPS 2010-02
Project Cost	$10,000
Duration	32 months
SUBMITTER	
Submitter Agency	New Hampshire Department of Transportation
Submitter Contact	Ann Scholz, P.E. 5 Hazen Drive Concord, NH 603-271-8995 ascholz@dot.state.nh.us
RESEARCH PROGRAM	
Sponsor Contact	New Hampshire Dept. of Transportation 5 Hazen Drive Concord, NH
RESEARCH AND RESULTS	
Brief Summary of Research Project	Guardrail height from the pavement surface is decreased after many types of roadway resurfacing. Previous testing of W-beam guardrail at lower heights, especially on high-speed facilities, demonstrated that the guardrail was not redirecting larger passenger vehicles as designed. After a two-year observation period, the Federal Highway Administration NH Division approved a process of raising the wooden offset blocks and rail while leaving the posts as they were initially installed in order to re-establish that acceptable height. This research project provided the Department with substantial savings while still maintaining an appropriate degree of safety and security for the traveling public. These important measures are tracked in the Department's Balanced Scorecard objectives of Effectively Managing Financial Resources and Improve System Safety and Security respectively. Savings realized by resetting guardrail blocks and rail verses what the expense would have been to replace it with new post with beam guardrail have been over $5.2 million since 2009.
Web Links (if available)	http://www.nh.gov/dot/org/projectdevelopment/materials/research/projects/documents/FINALMPS2010-02.pdf

New Jersey Department of Transportation

PROJECT INFORMATION	
Project Title	***Correlation between Multiple Stress Creep Recovery (MSCR) Results and Polymer Modification of Binder***
ID	FHWA-NJ-2014-02
Project Cost	$330,801
Duration	50 months
SUBMITTER	
Submitter Agency	New Jersey Department of Transportation
Submitter Contact	Giri Venkiteela, RPM NJDOT, 1035 Parkway Avenue Trenton, NJ 08625 609-530-8038 Giri.Venkiteela@dot.state.nj.us
RESEARCH PROGRAM	
Sponsor Contact	New Jersey Department of Transportation 1035 Parkway Avenue Trenton NJ USA 08625 http://www.state.nj.us/transportation/
RESEARCH AND RESULTS	
Brief Summary of Research Project	***Background:*** Nationwide traffic loads are increasing, pushing conventional asphalt to its limit. In New Jersey matters are made worse by the heavy use of the Northeast Corridor. Polymer modification of asphalt, which can improve both low and high performance, is already available; however, in many cases traditional Superpave testing is not sensitive enough to quantify the impact of modification, dimensioning its use. Elastic Recovery and Forced Ductility, Superpave Performance Grade Plus tests, are sensitive to polymer modification but are time intensive and costly. These obstacles have lead the New Jersey Department of Transportation (NJDOT) to require styrene-butadiene or styrene-butadiene-styrene (SBS) to be incorporated in all modified binder to ensure performance, causing supply shortages and rising cost in the state. A relatively new test developed by the Federal Highway Administration, Multiple Stress Creep Compliance (MSCR) offers a simpler procedure using the Dynamic Shear Rheometer (DSR), thus it does not require the expense of purchase additional testing equipment. ***Research Objectives:*** The main objectives of the study are: • Verify and qualify the MSCR parameter, non-recoverable compliance Jnr, as a standard measure of modified binder performance. • Conduct traditional Superpave binder tests (AASHTO M 320 Table 1), Superpave PG Plus testing Elastic Recovery and Forced Ductility, to be compared to the non-recoverable creep compliance parameter Jnr. • Perform performance testing to link the non-recoverable creep compliance parameter J_{nr} to performance.

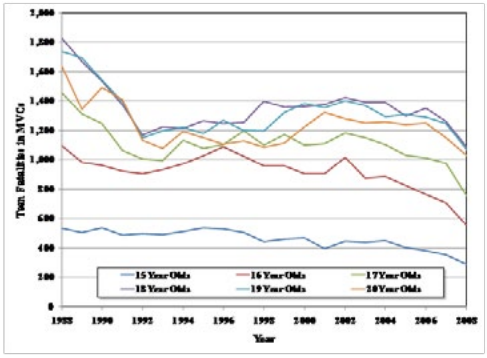
PROJECT INFORMATION (CONT.)

	• Develop a Microsoft access database of binder and mix data so that the state of New Jersey can select appropriate binders and mixtures that can meet the target values. ***Recommendations:*** The following are the recommendations from the study: • MSCR testing using the parameter J_{nr} should become a standard means to evaluate polymer modified binders in New Jersey. The guidelines set forth by AASHTO MP 19-10, in which the binders are graded according to traffic (ESALs) by using J_{nr}, are recommended. • The New Jersey DOT should use the access database system as a pre-screening process for binder selection, alleviating extraneous binder testing and the cost associated with them. • New Jersey DOT could eliminate the use of elastic recovery, thus saving almost $15,000 on capital cost of equipment and up to $500 per binder characterization considering labor and depreciation cost. These could lead to considerable savings of thousands of dollars over several years. • Low non-recoverable creep compliance (J_{nr} < 0.5 kPa^-1) coupled with high MSCR recovery at 3.2 kPa (recovery greater than 40%) and G*/ sin(delta) high enough to pass the next high grade will ensure that the binder selected will withstand heavy or extreme traffic. ***Adoption of AASHTO MP 19 Specification:*** New Jersey DOT should immediately decide to adopt the AASHTO MP 19 specifications based on the recommendations of the study and remove the use of Elastic Recovery as a PG plus specifications. The AASHTO MP 19 uses the same Dynamic Shear Rheometer that is already required in AASHTO M320 with no additional specimen preparation time needed. ***Impact of Elimination of PG Plus Elastic Recovery Test:*** The elastic recovery tests require different equipment, which cost approximately $15,000 and the specimen preparation and time is significantly longer than that of the MSCR specifications. The impact of removing the Elastic Recovery leading to additional savings of approximately$500 per binder testing. This will eventually save thousands of tax dollars of binder characterization over a given construction season. ***Impact of Access Database:*** The MS Access database is an easy to use tool to identify appropriate binders that will meet the AASHTO MP19 specifications. In addition, it also compares the binder properties to the PG plus and the AASHTO M320 and the mix data, such as flow time. This tool will make it easier for the state to transition to the new specifications. ***Broaden the use of Polymer Modified Binders in New Jersey:*** New Jersey DOT could potentially open the market to a broad range of polymers modified binders other than SBS, as long as it meets the AASHTO MP 19 specifications for the given traffic level. This will significantly drop the cost of polymer modified binders and save the state millions of dollars.
Web Links (if available)	http://www.state.nj.us/transportation/refdata/research/ReportsDB.shtm

PROJECT INFORMATION	
Project Title	***GO Bus Impact Analysis***
ID	FHWA-NJ-2013-005
Project Cost	$193,605
Duration	12 months
SUBMITTER	
Submitter Agency	New Jersey Department of Transportation
Submitter Contact	Paul Thomas, RPM NJDOT, 1035 Parkway Avenue Trenton, NJ 08625 Paul.Thomas@dot.state.nj.us
RESEARCH PROGRAM	
Sponsor Contact	New Jersey Department of Transportation 1035 Parkway Avenue Trenton NJ USA 08625 http://www.state.nj.us/transportation/
RESEARCH AND RESULTS	
Brief Summary of Research Project	Background: New Jersey Transit (NJ TRANSIT) launched GO Bus service, an enhanced Bus Rapid Transit (BRT)-like bus service, with features that include improved bus stops with redesigned shelters, limited stop services to reduce running time, traffic signal priority, branding for visibility and other features that provide a convenient commuting experience and efficient connections for corridor residents and commuters. GO bus Route 25, introduced in April 2008, serves a 4.8 mile corridor between Irvington Bus Terminal and Newark Penn Station. GO Bus Route 28, launched in October 2009, serves a 12.1 corridor between Bloomfield, Downtown Newark and Newark Liberty International Airport. Research Objectives: The main objectives of this research study are: • To conduct and analyze an onboard survey on GO 25, GO 28, as well as parallel local routes along the GO Bus corridors. • To design and perform focus groups and a stated preference survey to assess the impact of GO Bus on the daily lives of riders, potential riders and other stakeholders • To identify and understand travel pattern shifts, including auto diversions, induced ridership and time saving benefits derived from the introduction of GO Bus services. • To analyze both on-board and stated preference survey to highlight the impact of various transit attributes on ridership and customer satisfaction. • To provide data to support GO Bus business planning activities and marketing programs. Recommendations: • Municipalities, transit agencies and their customers can benefit from the introduction of enhanced bus services, even if they are not full-scale Bus Rapid Transit.

PROJECT INFORMATION (CONT.)	
	• Focus resources on bus services that reduce travel times for customers, while branding this service, to help draw attention to the service as a unique premium service. Impact, or Potential Impact, of Implementing Research Results • Roughly 13% of GO Bus customers switched from driving alone or carpooling which shows the potential of enhanced bus services to attract a broader spectrum of customers, who have replaced some vehicle trips with public transit. • Replacement of vehicle trips with public transit: reduces traffic congestion and fuel consumption; and therefore, supports smart development, livable communities and a greener economy. • The American Public Transportation Association (APTA) estimates that $9,242 is the average annual savings for a person riding public transportation instead of driving a Single Occupancy Vehicle (SOV). Therefore, GO Bus 25 and 28 service would be approximately $4 million dollars of savings annually, assuming 13% of GO Bus new customers were previously SOV and total average daily ridership for GO Bus 25 and 28 is 800 and 2,500, respectively.
Web Links (if available)	http://www.state.nj.us/transportation/refdata/research/ReportsDB.shtm

PROJECT INFORMATION	
Project Title	***Teen Driver Safety Metrics, Effectiveness of NJ's GDL Law***
ID	FHWA-NJ-2014-004
Project Cost	$366,188
Duration	10 months
SUBMITTER	
Submitter Agency	New Jersey Department of Transportation
Submitter Contact	Edward Stephen Kondrath
Submitter Email	Giri.Venkiteela@dot.state.nj.us
RESEARCH PROGRAM	
Sponsor Contact	New Jersey Department of Transportation 1035 Parkway Avenue Trenton NJ USA 08625 Ed.Kondrath@dot.state.nj.us
RESEARCH AND RESULTS	
Brief Summary of Research Project	Since the publication of the Commission's report in 2008, New Jersey has implemented many of the recommendations in the report as well as other enhancements to the NJ GDL. On September 17, 2008, the New Jersey Attorney General placed a ban on plea-agreements for traffic violations charged to teen drivers. Previously, teen traffic offenses were believed to be frequently plea-bargained to 'Unsafe Operation' – a citation which carried no points and hence would not trigger MVC remedial programs for teens. In addition, in May 2010, the State of New Jersey modified the GDL program to include the following: • Passenger Restrictions. Restrict teen drivers with a learner's permit or probationary license to carry only one passenger unless the parent/guardian was in the vehicle. • Night Driving Restriction. For teen drivers with either a learner's permit or probationary license, no driving is allowed between 11:01pm to 5am. Previously the curfew was midnight to 5am for probationary licenses. • Probationary License Placard (Kyleigh's Law). Teen drivers a probationary license -must display an identifying placard on their vehicles. The objective of this study is to determine the effectiveness of the New Jersey Graduated Driver's License (GDL) program in reducing teen crashes, traffic fatalities and traffic violations.
Web Links (if available)	http://www.state.nj.us/transportation/refdata/research/ReportsDB.shtm



New Mexico Department of Transportation

PROJECT INFORMATION	
Project Title	***Bridge Information System - Phase I (SABIS)***
ID	NM08SP-03
Project Cost	$0
Duration	67 months
SUBMITTER	
Submitter Agency	New Mexico Department of Transportation
Submitter Contact	Robert C. McCoy 9500B Pan American Freeway NE Albuquerque, NM 87109 (505) 798-6741 (505) 490-0998 robert.mccoy@state.nm.us
RESEARCH PROGRAM	
Sponsor Contact	New Mexico Department of Transportation 9500B Pan American Freeway NE Albuquerque, NM 87109
RESEARCH AND RESULTS	
Brief Summary of Research Project	This project will result in the development of a bridge information system that provides data processing and reporting services to local, tribal, state and federal agency personnel. The has produce a prototype software application that demonstrated the feasibility of using publicly available data files to provide information services to its end users. The National Bridge Inventory (NBI) database constitutes the most comprehensive source of publicly available information on the condition of the nation's bridges over a 20-year period. The information is readily available through public sources; however, the data is provided in an encoded text file format that makes the information difficult to understand by casual users. Phase I of the project served to demonstrate the feasibility of using rapid application development (RAD) software tools to process this data and to produce maps and reports of commonly requested information of interest to a variety of end users, including researchers, state cultural resources personnel and federal oversight agencies. Services provided by this application are separate and distinct from services provided by the PONTIS Bridge Management System currently used by the Department's Bridge Bureau, and the application serves a different set of users. The project is sponsored by the Research Bureau and is advocated by the New Mexico Division Federal Highway Administration. Because the application is driven by publicly available data sources, the program does not rely upon Department data sources, nor is interaction with Department-maintained IT network resources required.
Web Links (if available)	

New York State Department of Transportation

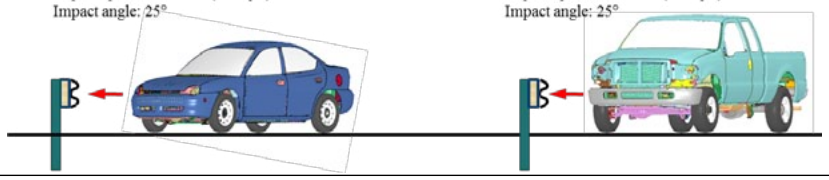
SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Field Methods for Determining Lead Content in Bridge Paint Removal Waste***
ID	C-08-19
Project Cost	$441,848
Duration	49 months
SUBMITTER	
Submitter Agency	New York State Department of Transportation
Submitter Contact	Gary Frederick 50 Wolf Road, Mail POD 51 Albany, New York 12232 Phone: (518) 457-4645 gary.frederick@dot.ny.gov FAX: (518) 457-8171
RESEARCH PROGRAM	
Sponsor Contact	New York State Department of Transportation 50 Wolf Road, Mail POD 51 Albany, New York 12232
RESEARCH AND RESULTS	
Brief Summary of Research Project	NYSDOT previously used the conservative approach of classifying all paint waste from bridge painting projects involving bridges that were originally painted with lead-based paint (LBP) as hazardous waste. This was true even in cases where the LBP was removed and the bridge was subsequently repainted with non-LBP prior to the current painting project, because of the possibility of residual lead rendering the waste hazardous. This practice has likely resulted in the unnecessary disposal of non-hazardous waste as hazardous, which adds direct expense and additional administrative costs to painting projects. It also uses up finite space in hazardous waste landfills that could be better used by actual hazardous wastes. For the purpose of developing a model for pre-determining the waste classification of paint waste from bridge painting projects, in-situ paint and paint waste was sampled at 24 bridge painting projects across the NYS. Sites were selected based upon previous paint removal and re-painting after NYS ceased using lead-based paint on bridges. Samples were analyzed using both field-portable X-ray fluorescence (XRF) meters and a variety of laboratory methods. As a result of the project, it was discovered that the initial classification of the paint waste from the subject bridges depends on the previous abrasive blasting standard (SSPC 6 vs. SSPC 10) used when the original LBP was removed from the bridge, as well as the iron content of the paint

PROJECT INFORMATION (CONT.)	
	waste. Additional analyses were performed to determine if the classification of the waste might change after disposal (important for determining long-term liability for the waste generator). NYSDOT has already updated the paint waste specification (Standard Specification 571) to reflect what was learned as a result of this project. Benefits to NYSDOT from this research project include: reduced hazardous waste generation; decreased administrative and compliance costs; and fewer annual hazardous waste fees and quarterly reporting fees
Web Links (if available)	https://www.dot.ny.gov/divisions/engineering/technical-services/trans-r-and-d-repository/C-08-19%20%20Final%20Report_12-2013_0.pdf

North Carolina Department of Transportation

PROJECT INFORMATION	
Project Title	***Fleet Management Performance Modeling***
ID	2012-07
Project Cost	$335,174
Duration	24 months
SUBMITTER	
Submitter Agency	North Carolina Department of Transportation
Submitter Contact	John Kirby North Carolina Department of Transportation 104 Fayetteville St. Raleigh, NC 27610
RESEARCH PROGRAM	
Sponsor Contact	North Carolina Department of Transportation Research and Development 1549 Mail Service Center Raleigh, NC USA 27699-1549 http://www.ncdot.org/doh/preconstruct/tpb/research/
RESEARCH AND RESULTS	
Brief Summary of Research Project 	The goals of this study were to determine, for six North Carolina Department of Transportation (NCDOT) equipment classes (three on road and three off road), a methodology for evaluating aging (or depreciation), disposal points, and overall utilization. The primary deliverable was development of a decision model which would help reduce cost, improve the age of the fleet and its readiness to serve the public, and improve overall utilization. The study identified an approach to segment or tier equipment utilization based on usage purpose so that specific needs and supporting equipment could be more readily identified by management. The study examined salvage values and identified trends in market value decline based on historical records. Using internal cost information, the study identifies trends in cost of operation and use as equipment ages. This information was integrated into an optimal economic life model based on equivalent uniform annual cost to identify the optimal disposal point for the six classes. The analytical models developed in the study provide a foundation for long term analysis of fleet size and the cost effectiveness of disposal points. A strategic goal was to develop, test, and refine a flexible and capable analytical model which can serve the long term management needs of the NCDOT Fleet and Material Management Unit.
Web Links (if available)	https://apps.dot.state.nc.us/Projects/Research/ProjectInfo.aspx?ID=2361

PROJECT INFORMATION	
Project Title	***Performance Evaluation of 27-inch W-beam Guardrail under MASH TL-2 Conditions***
ID	2012-11
Project Cost	$216,446
Duration	24 months
SUBMITTER	
Submitter Agency	North Carolina Department of Transportation
Submitter Contact	Ernest Morrison Research Staff Engineer NCDOT Research and Development 1549 Mail Service Center Raleigh, NC, 27699-1549
RESEARCH PROGRAM	
Sponsor Contact	North Carolina Department of Transportation Research and Development , 1549 Mail Service Center Raleigh NC USA 27699-1549 http://www.ncdot.org/doh/preconstruct/tpb/research/
RESEARCH AND RESULTS	
Brief Summary of Research Project	This report summarizes the research efforts of using finite element modeling and simulations to evaluate the performance of W-beam guardrails for different heights under MASH Test Level 2 (TL-2) and Test Level 3 (TL-3) impact conditions. The modeling and simulation work was conducted on W-beam guardrails placed at a height of 27, 29 and 31 inches with vehicular impacts of a 1996 Dodge Neon and a 2006 Ford F250. All three W-beam guardrail placement heights were evaluated and compared to MASH TL-2 conditions, i.e., both vehicles were tested at an impact speed of 44 mph (70 km/hour) and a 25 degree impact angle. The 29- and 31-inch W-beam guardrails were also evaluated under MASH TL-3 conditions, i.e., both vehicles were tested at an impact speed of 62 mph (100 km/hour) and a 25 degree impact angle. The simulation results demonstrated the effectiveness of the 27-, 29- and 31-inch guardrails under MASH TL-2 conditions. They also showed the effects of guardrail heights on the vehicles' post-impact responses such as redirection, snagging and large exit angles. The use of finite element simulations was shown to be both effective and efficient because they were nondestructive, repeatable, modifiable, and inexpensive. Furthermore, finite element simulations can be used to study crash scenarios that are difficult and/or extremely expensive to conduct with physical crash testing. **MASH TL-2 Conditions** Vehicle: 1100C (passenger car) Impact speed: 70 km/hr (44 mph) Impact angle: 25° Vehicle: 2270P (pickup truck) Impact speed: 70 km/hr (44 mph) Impact angle: 25° 
Web Links (if available)	https://apps.dot.state.nc.us/Projects/Research/ProjectInfo.aspx?ID=2703

Ohio Department of Transportation

PROJECT INFORMATION	
Project Title	***Effectiveness of Noise Barriers Installed Adjacent to Transverse Grooved Concrete Pavement***
ID	134365
Project Cost	$188,307
Duration	21 months
SUBMITTER	
Submitter Agency	Ohio Department of Transportation
Submitter Contact	Cynthia Gerst 1980 West Broad Street Mail Stop 3280 Columbus, OH 43223
RESEARCH PROGRAM	
Sponsor Contact	Ohio Department of Transportation 1980 West Broad Street Mail Stop 3280 Columbus, OH 43223
RESEARCH AND RESULTS	
Brief Summary of Research Project	This research project was initiated to address noise barrier design issues associated with the abatement of traffic noise from random transverse grooved concrete pavement and provide accurate traffic noise model noise predictions when modeling these random pavements. This research provided validation for modification to ODOT's Construction and Materials Specifications (C&MS), provided a cost savings alternative for addressing noise complaints, and enhanced ODOT's knowledge. The research demonstrated that transverse grooved pavement could be diamond grinded then re-grooved longitudinally in order to diminish noise. This discovery provided a lower cost solution for noise abatement in lieu of the installation of a traditional noise wall. Based on these findings, thus far, diamond grinding has been used specifically to alleviate noise on four separate projects. The total cost difference between diamond grinding and the construction of a traditional wall on these four projects is approximately $4,548,000. Furthermore, this research provided a solution for locations with noise issues that do not meet the cost criteria for noise wall construction. Additionally, this research provided support to modify ODOT C&MS 451.09 shifting pavement grooving from transverse to longitudinal.

PROJECT INFORMATION (CONT.)	
	As a result of this project, a new surface texture specification was developed for concrete pavements to replace the current specification in order to reduce tire/pavement noise levels while maintaining or improving safety and durability characteristics. Research Return – Impacted ODOT Specification – C&MS 451.09 – Produced cost savings in excess of $4,548,000 resulting in a ROI of 2,315% – Enhanced knowledge – Sponsored university students (1)
Web Links (if available)	http://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Reports/2009/Safety/134365_ES.pdf

PROJECT INFORMATION	
Project Title	***Development of a TL-3 Deep Beam Tubular Backup Bridge Rail***
ID	134394
Project Cost	$73,346
Duration	33 months
SUBMITTER	
Submitter Agency	Ohio Department of Transportation
Submitter Contact	Cynthia Gerst 1980 West Broad Street Mail Stop 3280 Columbus, OH 43223
RESEARCH PROGRAM	
Sponsor Contact	Ohio Department of Transportation 1980 West Broad Street Mail Stop 3280 Columbus, OH 43223
RESEARCH AND RESULTS	
Brief Summary of Research Project	The retrofitted ODOT Deep Beam bridge rail design was shown to be successfully able to pass NCHRP Report 350 test level 3 assessment criteria as shown. This conclusion is based on engineering strength analysis and nonlinear finite element simulation. The added rail on the top of the bridge rail helped reduced potential vehicular dynamics instability that may occur if only the original rail (less height) was used. Also, the additional lower rail (rub rail) provided protection against tire snagging in the opening between the main rail and the deck. This snagging mode could be detrimental for small vehicle impacts due to the subsequent excessive deformation of the vehicle and increased occupant risk factors. This design has been implemented in the field since the FHWA Office of Safety accepted the research results (FHWA letter HSSI/B-207

PROJECT INFORMATION (CONT.)	
	dated November 10, 2010). The modified design presented herein represents a retrofit that can be installed by a qualified construction crew. Implementing this retrofit resulted in savings of $550K and an ROI of 650% for the research.
Web Links (if available)	http://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Reports/2011/Structures/134394-ES.pdf

Oklahoma Department of Transportation

PROJECT INFORMATION	
Project Title	***Expected Life of Silane Water Repellant Treatments on Bridge Decks***
ID	SP&R 2229SPRY-0010(52)RS/3459
Project Cost	$198,337
Duration	23 months
SUBMITTER	
Submitter Agency	Oklahoma Department of Transportation
Submitter Contact	Gary Hook 200 NW 21 Oklahoma City, OK 73105 405-522-1042 ghook@odot.org
RESEARCH PROGRAM	
Sponsor Contact	Oklahoma Department of Transportation 200 NE 21st Street Oklahoma City OK USA 73105
RESEARCH AND RESULTS	
Brief Summary of Research Project	With the ever increasing costs to the maintenance of concrete bridge decks due to corrosion of reinforcing steel from the environment and routine maintenance applications of salt, it is important to have a better understanding of the effectiveness and durability of silane-treated bridge decks. Historically, bridge decks in Oklahoma are treated once at the time of construction. Little is known of the time frame for which silane remains as an effective barrier to prevent the intrusion of corrosive salts into the bridge deck. Through an extensive literature search, survey of state Departments of Transportation (DOT's), and coring and analyzing of bridge deck cores from bridges of various ages, the researcher will determine the life expectancy of a onetime application of silane. The Oklahoma Department of Transportation (ODOT) Bridge Division will assist the Principal Investigator (PI) in the selection of bridges to be used in this study. It is expected that an effective duration range can be determined. With these findings it is expected that a routine maintenance practice can be established for the re-treatment of bridge decks based on environment, salt application, regional and age considerations resulting in extended bridge deck life expectancy and lower life cycle costs.
Web Links (if available)	

Pennsylvania Department of Transportation

PROJECT INFORMATION	
Project Title	***Evaluation of Pennsylvania's Motorcycle Safety Program***
ID	061001
Project Cost	$138,357
Duration	24 months
SUBMITTER	
Submitter Agency	Pennsylvania Department of Transportation
Submitter Contact	Sean Oldfield 400 North St, 6th Floor Harrisburg, PA 17120 717-783-2444 soldfield@pa.gov
RESEARCH PROGRAM	
Sponsor Contact	Pennsylvania Department of Transportation Bureau of Planning and Research Commonwealth Keystone Building 400 North Street, 6th Floor Harrisburg, PA 17120-0064 http://www.dot.state.pa.us
RESEARCH AND RESULTS	
Brief Summary of Research Project	Consistent with national trends, from 2000 to 2007 Pennsylvania's motorcycle crashes increased by 44.6%. One important route to increase motorcycle safety began with an examination of the effectiveness of the Pennsylvania Motorcycle Safety Program (PAMSP). The PAMSP, in operation since 1985, is intended to help improve driving habits among motorcyclists by teaching drivers of all experience levels the fundamental knowledge and skills needed to reduce risk and to operate safely via a Basic Rider Course (BRC) geared toward beginning motorcycle drivers, and an Experienced Rider Course (ERC) that emphasizes advanced skills. Upon successful completion of the BRC, riders are awarded a class-M (motorcycle) license. The final report for this research project described an evidence-based evaluation of quantitative and qualitative information, with recommendations to improve the PAMSP, motorcycle driver education, and other practices related to motorcycle safety. PennDOT has made significant progress in implementing these recommendations in the past four years. Motorcycle fatalities declined by 23% from an all-time high of 236 in 2008 to 181 in 2013. For this reason, this study is being nominated as a high-value research project. A summary of the research projects impact has been attached (HVR-Motorcycle_Safety-Research_Impact.pdf) as well as the final report and executive summary.
Web Links (if available)	http://www.livefreeridealive.com/

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	*Improving Mature Driver Safety Efforts*
ID	080601
Project Cost	$189,049
Duration	12 months
SUBMITTER	
Submitter Agency	Pennsylvania Department of Transportation
Submitter Contact	Sean Oldfield 400 North St, 6th Floor Harrisburg, PA 17120 717-783-2444 soldfield@pa.gov
RESEARCH PROGRAM	
Sponsor Contact	Pennsylvania Department of Transportation Bureau of Planning and Research Commonwealth Keystone Building 400 North Street, 6th Floor Harrisburg, PA 17120-0064 http://www.dot.state.pa.us
Brief Summary of Research Project	Drivers aged 65 and older currently make up almost 17 percent of Pennsylvania's licensed driving population. By 2020, the Pennsylvania Department of Aging projects the number of Pennsylvanians over 65 will increase 21 percent from recent levels, yielding increases in total number of mature drivers and their percentage of the total driving population. Pennsylvania DOT undertook this research, Improving Mature Driver Safety, a comprehensive evaluation of the mature driver population in Pennsylvania, because it will enable the Department to better equip the driving population in Pennsylvania to more effectively prepare for mobility as these drivers age. The research was especially timely and had high potential to provide evidence-based guidance for future actions. A Mature Driver Symposium accomplished through this project brought together over 60 representatives of the diverse community engaged in facilitating and improving mature driver safety. The symposium enabled PennDOT to more effectively implement recommendations from the research as well as identified opportunities for new and enhanced collaborative efforts. Findings of the research included

PROJECT INFORMATION (CONT.)	
	analyses of medical conditions, crashes, and violations and enabled PennDOT to address programmatic and operational strategies based on evidence-based data. This research project produced high value results as it has provided for more competent mature drivers on Pennsylvania roadways who are increasingly more medically qualified to drive, have broader opportunities to keep driving skills up-to-date, and are better physically able to operate their personal vehicles. Furthermore, based on this effort, PennDOT is experiencing a more trusted relationship with the medical community who are providing more accurate reporting of medical conditions that pose serious risk to mature drivers and other motorists on Pennsylvania roadways, has stronger partnerships law enforcement as it lays a foundation for new tools to be used with on-road situations, and through applying recommended countermeasures is reducing older driver crashes on Pennsylvania roadways. A summary of the research projects impact has been attached (HVR-Improving_Mature_Driver_Safety-Research_Impact.pdf) as well as the final report and executive summary.
Web Links (if available)	

South Carolina Department of Transportation

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Rate of Deterioration of Bridges and Pavements as Affected by Trucks***
ID	SPR No. 694
Project Cost	$249,755
Duration	30 months
SUBMITTER	
Submitter Agency	South Carolina Department of Transportation
Submitter Contact	Mike Sanders 1406 Shop Road Columbia, SC 29201 803-737-6691 sanders@scdot.org
RESEARCH PROGRAM	
Sponsors	South Carolina Department of Transportation 1406 Shop Road Columbia, SC 29201
RESEARCH AND RESULTS	
Brief Summary of Research Project	It is known that the largest loads on public road systems disproportionately inflict the greatest damage to highway infrastructure. However over the years, the freight industry has been pushing the limits of traditional standards for truck size and weight. Additionally, competitive modern commerce is continuously demanding loads well in excess of current standards established by various federal and state transportation agencies. Like every other state department of transportation in the country, SCDOT faces the pressure of maintaining the roadways with ever-shrinking financial resources. A user fee was implemented in South Carolina decades ago for heavy vehicles over the legal weight limits to help off-set the excessive wear inflicted on the highway system. But with the changes in the freight industry and freight demand, SCDOT felt the need to reassess the impact of oversize and overweight loads as well as the fee structure used for permitting these exceptions. SPR 694, "Rate of Deterioration of Bridges and Pavements as Affected by Trucks," was initiated with Clemson University. The overall objectives were to investigate the impact of overweight trucks on bridges and pavements in South Carolina and develop policy recommendations based on technical analysis and the modern political and institutional environment in the state. The researchers developed estimates for the damage costs due to the additional weight (i.e., from legal weight limit to the maximum weight limit) allowed by typical SCDOT overweight permits (2012 dollars). (See table on page 2 of the attached Summary.)

PROJECT INFORMATION (CONT.)	
	User fees to recover costs for overweight vehicles assessed by others were examined and found to be of five basic structures: flat, distance based, weight based, weight and distance based, and axle based. Each type was found to have inherently unique characteristics related to fairness, precision of allocation, and implementation complexity. Detailed comparisons were made for each fee structure. Also, trucking stakeholders across South Carolina were interviewed to determine their perspectives on the issues. The interviews showed that fundamentally, South Carolina's trucking stakeholders do not hold common ideas on the objective of overweight permits and fee structures but some common points did emerge from multiple interviews. Concern was expressed that rising fees will encourage illegal trucking without permits and the effectiveness of enforcement is nationally unclear since staffed weight stations have given way to automated transponders. Other considerations should include effects of overweight fee policies across jurisdictions and consistency in mega-regions. The findings indicated that to recover additional costs of damage imparted by overweight trucks for load in excess of the legal weight limit in an axle based fee structure, the damage fee will vary between $24 and $175 per trip for different overweight truck types, while a flat fee structure will charge all overweight trucks $65 per trip. Consideration of axle load, axle configuration, and trip length in fee structure will reflect damage imparted by each overweight truck more accurately. The fee estimates provided in the study did not consider user fees paid through fuel tax, vehicle registration, or other fees. Under the current fee structure, overweight trucks in South Carolina pay $30 for a single trip permit and $100 dollars for an annual permit which is equivalent to 3.33 trips. These flat fees do not consider the relative incremental increases in vehicle weights and trip distances. An Ohio DOT study found that with an annual permit, on average, 24.8 trips were made by an overweight truck. Finally, it was stated that SCDOT will not likely find fee revisions politically viable until consensus develops among stakeholders on the objectives of overweight permitting and fees. One of the many recommendations made was that SCDOT initiate multi-meeting focus groups with the trucking stakeholders to gain a common, comprehensive understanding of the issues from both the engineering and the economic standpoint. The quantitative information provided by this study will greatly aid SCDOT in formulating informed decisions concerning permitting policies for overweight trucks and for the validation of those decisions. The study also presented some of the trucking stakeholders' perspectives and provided recommendations for holding meaningful dialogue with all involved in the issue to help make reaching a viable solution possible.
Web Links (if available)	http://scdot.scltap.org/Portals/29/Documents/Reports/FINAL_REPORT_SPR-694.pdf

PROJECT INFORMATION	
Project Title	***Improving Techniques to Estimate the Magnitude and Frequency of Floods on Urban Streams in South Carolina, North Carolina, and Georgia***
ID	SPR No. 691
Project Cost	$388,229
Duration	43 months
SUBMITTER	
Submitter Agency	South Carolina Department of Transportation
Submitter Contact	Mike Sanders 1406 Shop Road Columbia, SC 29201 803-737-6691 sanders@scdot.org
RESEARCH PROGRAM	
Sponsors	South Carolina Department of Transportation P.O. Box 191 Columbia, SC USA 29202 http://www.dot.state.sc.us/ Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC USA 20590 http://www.fhwa.dot.gov
RESEARCH AND RESULTS	
Brief Summary of Research Project	Reliable estimates of the magnitude and frequency of floods are essential for the design of transportation and water-conveyance structures, flood-insurance studies, and flood-plain management. Such estimates are particularly important in densely populated urban areas. In order to increase the number of streamflow-gaging stations (streamgages) available for analysis, expand the geographical coverage that would allow for application of regional regression equations across State boundaries, and build on a previous flood-frequency investigation of rural U.S Geological Survey streamgages in the Southeast United States, a multistate approach was used to update methods for determining the magnitude and frequency of floods in urban and small, rural streams that are not substantially affected by regulation or tidal fluctuations in Georgia, South Carolina, and North Carolina. The at-site flood-frequency analysis of annual peak-flow data for urban and small, rural streams (through September 30, 2011) included 116 urban streamgages and 32 small, rural streamgages, defined in this report as basins draining less than 1 square mile. The regional regression analysis included annual peak-flow data from an additional 338 rural streamgages previously included in U.S. Geological Survey flood-frequency reports and 2 additional rural streamgages in North Carolina that were not included in the previous Southeast rural flood-frequency investigation for a total of 488 streamgages included in the urban and small, rural regression analysis. The at-site flood-frequency analyses for the urban and small, rural streamgages included the expected moments algorithm, which is a modification of the Bulletin 17B log-Pearson type III method for fitting the statistical distribution to the logarithms of the annual peak flows. Where applicable, the flood-frequency analysis also included low-outlier and historic information.

PROJECT INFORMATION (CONT.)	
	Additionally, the application of a generalized Grubbs-Becks test allowed for the detection of multiple potentially influential low outliers. Streamgage basin characteristics were determined using geographical information system techniques. Initial ordinary least squares regression simulations reduced the number of basin characteristics on the basis of such factors as statistical significance, coefficient of determination, Mallow's Cp statistic, and ease of measurement of the explanatory variable. Application of generalized least squares regression techniques produced final predictive (regression) equations for estimating the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probability flows for urban and small, rural ungaged basins for three hydrologic regions (HR1, Piedmont–Ridge and Valley; HR3, Sand Hills; and HR4, Coastal Plain), which previously had been defined from exploratory regression analysis in the Southeast rural flood-frequency investigation. Because of the limited availability of urban streamgages in the Coastal Plain of Georgia, South Carolina, and North Carolina, additional urban streamgages in Florida and New Jersey were used in the regression analysis for this region. Including the urban streamgages in New Jersey allowed for the expansion of the applicability of the predictive equations in the Coastal Plain from 3.5 to 53.5 square miles. Average standard error of prediction for the predictive equations, which is a measure of the average accuracy of the regression equations when predicting flood estimates for ungaged sites, range from 25.0 percent for the 10-percent annual exceedance probability regression equation for the Piedmont–Ridge and Valley region to 73.3 percent for the 0.2-percent annual exceedance probability regression equation for the Sand Hills region. This project has been completed by the USGS and released as Scientific Investigations Report 2014-5030. This report supersedes Scientific Investigations Report 2004-5030. The previous report (SIR 2004-5030) was based on 20 streamflow-gaging stations. The drainage areas for these gages ranged from 0.18 to 41 square miles. The new report (SIR-2014-5030) is based 488 streamflow-gaging stations. The drainage areas for these gages ranged from 0.1 to 378 square miles. The big difference in this study versus the previous study is that it goes well outside of the state of South Carolina for data. The new multistate approach allows for many more gages with a much wider range in drainage areas allowing the equations to be much more accurate and applicable to larger drainage areas. These equations will produce much more accurate discharge computations to design culverts and bridges in South Carolina.
Web Links (if available)	http://pubs.usgs.gov/sir/2014/5030/pdf/sir2014-5030.pdf

South Dakota Department of Transportation

PROJECT INFORMATION	
Project Title	***Updated Performance Curves for SDDOT's Pavement Management System***
ID	SD2011-04
Project Cost	$150,000
Duration	19 months
SUBMITTER	
Submitter Agency	South Dakota Department of Transportation
Submitter Contact	David L. Huft South Dakota Department of Transportation 700 East Broadway Avenue Pierre, SD 57501-2586 dave.huft@state.sd.us
RESEARCH PROGRAM	
Sponsor Contact	South Dakota Department of Transportation 700 East Broadway Avenue Pierre, SD 57501-2586
RESEARCH AND RESULTS	
Brief Summary of Research Project	This project successfully accomplished three important objectives. First, an updated methodology for creating, updating, and assessing the quality of pavement performance curves from historical data was developed and incorporated into software. Second, South Dakota's pavement performance curves were updated using the methodology and software. Third, the relationship and application of historical pavement data to Mechanistic-Empirical Pavement Design was described. The methodology and software will allow SDDOT's pavement management staff to continuously update pavement performance curves essential to the statewide network optimizing pavement management system. Previously, the several person-weeks that would have been required prevented staff from regularly updating curves. The benefit of the research is not just the several person-weeks of effort saved, but also making update possibe at all. The study of relationships between historical pavement data and data needed for the MEPD meethod will enable SDDOT to modify its pavement evaluation methods so a single data collection effort serves both pavement management and pavement design. This will save duplication of effort every year going forward. User fees to recover costs for overweight vehicles assessed by others were examined and found to be of five basic structures: flat, distance-based, weight-based, weight- and distance-based, and axle-based. Each type was found to have inherently unique characteristics related to fairness,

PROJECT INFORMATION (CONT.)	
	precision of allocation, and implementation complexity. Detailed comparisons were made for each fee structure. Also, trucking stakeholders across South Carolina were interviewed to determine their perspectives on the issues. The interviews showed that fundamentally, South Carolina's trucking stakeholders do not hold common ideas on the objective of overweight permits and fee structures but some common points did emerge from multiple interviews. Concern was expressed that rising fees will encourage illegal trucking without permits and the effectiveness of enforcement is nationally unclear since staffed weight stations have given way to automated transponders. Other considerations should include effects of overweight fee policies across jurisdictions and consistency in mega-regions. The findings indicated that to recover additional costs of damage imparted by overweight trucks for load in excess of the legal weight limit in an axle based fee structure, the damage fee will vary between $24 and $175 per trip for different overweight truck types, while a flat fee structure will charge all overweight trucks $65 per trip. Consideration of axle load, axle configuration, and trip length in fee structure will reflect damage imparted by each overweight truck more accurately. The fee estimates provided in the study did not consider user fees paid through fuel tax, vehicle registration, or other fees. Under the current fee structure, overweight trucks in South Carolina pay $30 for a single trip permit and $100 dollars for an annual permit which is equivalent to 3.33 trips. These flat fees do not consider the relative incremental increases in vehicle weights and trip distances. An Ohio DOT study found that with an annual permit, on average, 24.8 trips were made by an overweight truck. Finally, it was stated that SCDOT will not likely find fee revisions politically viable until consensus develops among stakeholders on the objectives of overweight permitting and fees. One of the many recommendations made was that SCDOT initiate multi-meeting focus groups with the trucking stakeholders to gain a common, comprehensive understanding of the issues from both the engineering and the economic standpoint. The quantitative information provided by this study will greatly aid SCDOT in formulating informed decisions concerning permitting policies for overweight trucks and for the validation of those decisions. The study also presented some of the trucking stakeholders' perspectives and provided recommendations for holding meaningful dialogue with all involved in the issue to help make reaching a viable solution possible.
Web Links (if available)	

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Effects of Wide Base Super-Single Tires on Pavements***
ID	SD2012-01
Project Cost	$60,000
Duration	4 months
SUBMITTER	
Submitter Agency	South Dakota Department of Transportation
Submitter Contact	David L. Huft South Dakota Department of Transportation 700 East Broadway Avenue Pierre, SD 57501-2586 dave.huft@state.sd.us
RESEARCH PROGRAM	
Sponsor Contact	South Dakota Department of Transportation 700 East Broadway Avenue Pierre, SD 57501-2586
Brief Summary of Research Project	This study was initiated in response to the South Dakota Trucking Association's proposal to introduce legislation to allow wide base (445 mm and 455 mm) super single tires to carry the same legal load as standard dual tire configurations. Because of the short time frame available before the 2013 legislative session, the research relied on a review of others' comparisons based upon instrumented roadways, accelerated pavement testing, and numerical modeling. The study determined that, on portland cement concrete pavement and thick asphalt pavements, allowing the same load on super-single tires would impose no additional damage; in some cases, less damage would be expected. However, on thin asphalt pavements, the super single tires would cause significantly more damage than standard dual tire configurations. Based on the outcome of ths study, SDDOT was able to accept legislation allowing super single tires to carry equivalent loads on main freight routes, which were constructed with concrete or thick asphalt pavements. The legislation, which was passed in 2013, excluded other state routes and essentially all local roads, which are typically surfaced with thin asphalt or gravel. The research reduced hauling cost, fuel consumption, and exhaust emissions on competent freight routes, while avoiding extra damage to state and local pavements.
Web Links (if available)	

Tennessee Department of Transportation

PROJECT INFORMATION	
Project Title	***Evaluation of Thin Overlay Systems for Concrete Bridge Decks and Pavements***
ID	RES2011-06
Project Cost	$82,000
Duration	23 months
SUBMITTER	
Submitter Agency	Tennessee Department of Transportation
Submitter Contact	Stephanie Vincent Research Administrator Suite 900, James K. Polk Building Nashville, TN 37243 stephanie.vincent@tn.gov, (615)741-2203
RESEARCH PROGRAM	
Sponsor Contact	Tennessee Department of Transportation - Materials & Test Division Danny Lane, Technical Sponsor 6601 Centennial Boulevard Nashville, TN 37243 danny.lane@tn.gov, (615)350-4175 Tennessee Department of Transportation - Research Office Stephanie Vincent , Research Administrator Suite 900, James K. Polk Building Nashville, TN 37243 stephanie.vincent@tn.gov, (615)741-2203
RESEARCH AND RESULTS	
Brief Summary of Research Project	Thin overlay systems are used throughout Tennessee on both roadways and bridge decks. Benefits of such systems include heightened safety through improved skid resistance and preservation of the underlying wearing surface through waterproofing. The Tennessee Department of Transportation currently has three different systems approved (depending on application) that consist of (1) polymer modified cementitious mixtures, (2) epoxy and/or urethane based systems, and (3) low modulus epoxy systems. Typical systems result in an overlay thickness of less than ½ inch. Official evaluation of these systems includes compressive strength, slant shear, a ponding test, and subsequent chloride testing at a prescribed depth with an upper limit on chloride ion concentration for product approval. These products are an extremely valuable tool for management of roadway and bridge deck condition throughout the state and thus need to be evaluated both thoroughly and appropriately.

PROJECT INFORMATION (CONT.)	
	The research program completed included some of the currently approved evaluation methods and additional testing techniques (rapid chloride permeability, bond testing, etc.) that focused on several important factors (freeze thaw exposure, ultraviolet exposure, etc.) that may result in deterioration/reduced service life of the overlay material. TDOT is using the application of thin overlay systems on existing, quality, prepared decks to increase service life, maintain safety of the concrete deck, reduce life-cycle cost, and reduce repair and user cost and is considering the use of thin overlay systems in new bridge construction to immediately provide protection of the concrete deck, decrease likelihood and lengthen elapsed time until repairs are needed, lengthen service life, and ultimately reduce life-cycle cost.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Developing Rating Aids for the Evaluation of Existing Concrete Culverts in Tennessee***
ID	RES2011-11
Project Cost	$118,000
Duration	28 months
SUBMITTER	
Submitter Agency	Tennessee Department of Transportation
Submitter Contact	Stephanie Vincent Research Administrator Suite 900, James K. Polk Building Nashville, TN 37243 stephanie.vincent@tn.gov, (615)741-2203
RESEARCH PROGRAM	
Sponsor Contact	Tennessee Department of Transportation - Materials & Test Division Danny Lane, Technical Sponsor 6601 Centennial Boulevard Nashville, TN 37243 danny.lane@tn.gov, (615)350-4175 Tennessee Department of Transportation - Research Office Stephanie Vincent , Research Administrator Suite 900, James K. Polk Building Nashville, TN 37243 stephanie.vincent@tn.gov, (615)741-2203
Brief Summary of Research Project	Federal Regulations, 23 CFR § 650.313(c), require each State Highway Department to load rate each public bridge to determine its safe live load capacity for highway traffic. Given that Tennessee has almost 20,000 highway bridges, this is a costly and manpower intensive task. The most common bridge type, in Tennessee, is a concrete box culvert with or without a bottom slab.

PROJECT INFORMATION (CONT.)	
	This type of structure comprises over 42% of Tennessee's bridge inventory or over 8,000 highway bridges. These bridges vary from other designs in that they are generally designed to a limited number of standard sizes. Whenever a new culvert needs to be built, the hydraulic demand is determined for the bridge site and then an appropriately sized standard culvert is selected. These standards have been revised over the decades so that the total number of standard drawings now number over 1,300. Tennessee, like many states, used general "assigned" load rating values for these structures in the past. However, assigned ratings are only approximate, and it is more desirable to have accurate load rating values based upon site-specific conditions. However, the labor cost of completing a load rating study and computer model for each culvert is severe. Each such study could easily require 3 to 4 man-hours per culvert or over 20,000 man-hours for the complete inventory of Tennessee culverts. Such manpower resources are simply not available. The purpose of this research project was to meet the Federally-required need to load rate the existing inventory of culverts in an efficient manner that would significantly reduce the labor burden. This research project accomplished the following tasks: • It performed a literature search for methods and software to efficiently load-rate culverts. • It identified and collated the 1,300+ standard drawings used during the 20th and early 21st centuries in Tennessee. • It created load rating models for these standard culverts with each model adapted to variable fill depths within its design parameters. • The results of the computer modeling were then incorporated into a Concrete Box Culvert Load Rating Aid (built as an excel spreadsheet). By using this aid, a load rating engineer can input a limited amount of information (approximate year of construction, size and number of barrels, skew angle, whether the culvert contains a bottom slab or not) and the load rating aid will quickly identify the likely Standard Drawing used to build the culvert and provide the rating factors resulting from the computer modeling of this standard design. This results in an enormous labor savings in load rating these culverts. A normal 3- to 4-hour effort, per culvert, can be reduced to 15 minutes with a resulting 90% labor savings in meeting the Federal Load Rating requirements, while still maintaining a technically rigorous analysis result.
Web Links (if available)	

PROJECT INFORMATION (CONT.)	
Project Title	***Piling Framed Retaining Wall: Extension of Data Collection, Design Refinement and Verification***
ID	RES2011-16
Project Cost	$139,000
Duration	23 months
SUBMITTER	
Submitter Agency	Tennessee Department of Transportation
Submitter Contact	Stephanie Vincent Research Administrator Suite 900, James K. Polk Building Nashville, TN 37243 stephanie.vincent@tn.gov, (615)741-2203
RESEARCH PROGRAM	
Sponsor Contact	Tennessee Department of Transportation - Materials &Test Division Danny Lane, Technical Sponsor 6601 Centennial Boulevard Nashville, TN 37243 danny.lane@tn.gov, (615)350-4175 Tennessee Department of Transportation - Research Office Stephanie Vincent , Research Administrator Suite 900, James K. Polk Building Nashville, TN 37243 stephanie.vincent@tn.gov, (615)741-2203
Brief Summary of Research Project	The Tennessee DOT has developed a new retaining wall concept referred to as the "Piling Framed Concrete Retaining Wall for use in areas with limited Right of Way." To gain an understanding of the soil pressures acting on the wall and evaluate the existing design method, structural instrumentation was installed on a wall as part of the Smart Fix I-40 project during 2008-2010. The instrumentation suggested that the wall was performing well, but the duration of the data collection after completion of the wall was insufficient to adequately determine that all the forces were being transferred to the wall. A second phase of the research documented here included the continuation of the field data collection and analysis, along with the development of a refined wall design method. A simplified design approach was developed following a comprehensive parametric study conducted using the Finite Element Method (FEM). The FEM analyses were conducted on a range of wall geometries for both "clay" and "sand" soils to reflect the range of properties likely to be encountered in practice.

PROJECT INFORMATION (CONT.)	
	The results suggested that the pressures on the inclined face could be reasonably represented by a uniform distribution of pressure, which varied with wall height, wall inclination, presence of inclined backfill, and soil properties. To predict the overturning forces acting on the wall, a simplified approach based on traditional earth pressures theory was developed. From the wide range of configurations investigated in the parametric study, analytical approximations were developed to predict the equivalent uniform pressures and the overturning moments as a function of the wall geometry and the soil properties. The resulting method was shown to provide a reasonable approximation to both the FEM results and the field measured pressures on the wall, and will eliminate the need to do a distinct FEM analysis on each wall as this innovative system is used in the future.
Web Links (if available)	

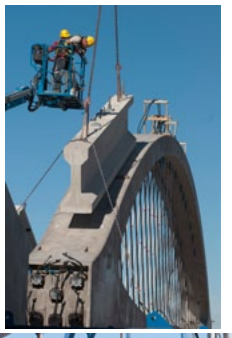
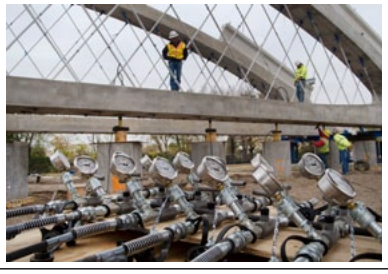
Texas Department of Transportation

PROJECT INFORMATION	
Project Title	***Oversize/Overweight Vehicle Fees Study***
ID	0-6736
Project Cost	$472,383
Duration	12 months
SUBMITTER	
Submitter Agency	Texas Department of Transportation
Submitter Contact	Shannon Crum Attn: RTI Texas Department of Transportation 125 E. 11th Street Austin, TX 78701 512-416-4730 Shannon.crum@txdot.gov
RESEARCH PROGRAM	
Sponsor Contact	Texas Department of Transportation 125 E. 11th Street Austin, TX 78701
RESEARCH AND RESULTS	
Brief Summary of Research Project	There is a lack of clear understanding among the general public regarding the damage that oversized and overweight (OS/OW) vehicles' traffic cause on the transportation infrastructure and the related operational costs. During this project the research team evaluated the damage that OS/OW vehicles (including exempt vehicles) cause to the transportation infrastructure (including roads and bridges). Based on this evaluation, the researchers performed a thorough cost analysis to quantify all direct and indirect cost associated with this damage and associated expenses that result from this damage. Once all cost elements were determined, the researchers provided recommendations for permit fees and fee structure adjustments including highway maintenance fees to properly compensate for the damages caused. To address the damage determination, the researchers calculated the ratio of the overall impacts to the infrastructure between freight vehicles operating within defined, legal GVW and axle load limits and those the state allows to operate beyond those limits. This was done by applying the concepts of Load Equivalency Factor (LEF) and Equivalent Damage Factor (EDF). A mechanistic approach calibrated to Texas conditions was applied that is consistent with the approach proposed by Federal Highway Administration (PaveDAT) and based on the Mechanistic-Empirical Pavement Design Guide (MEPDG), which is endorsed by AASHTO. By selecting this approach, the research provided TxDOT and the State a method that is also supported and promoted at the federal and state levels.

PROJECT INFORMATION (CONT.)	
	After reviewing and summarizing existing databases, representative axle configurations and vehicles, routes and pavement structures were identified to calculate an average fee structure for the state; however, the developed methodology was implemented in an Excel spreadsheet that enables the calculation of specific fees for a given vehicle configuration on a given route.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Texas Technology Task Force***
ID	0-6803
Project Cost	$213,750
Duration	9 months
SUBMITTER	
Submitter Agency	Texas Department of Transportation
Submitter Contact	Shannon Crum Attn: RTI Texas Department of Transportation 125 E. 11th Street Austin, TX 78701 512-416-4730 Shannon.crum@txdot.gov
RESEARCH PROGRAM	
Sponsor Contact	Texas Department of Transportation 125 E. 11th Street Austin, TX 78701
Brief Summary of Research Project	As with most aspects of modern life, technology has transformed transportation for decades. However, the pace is about to accelerate, as the capacity to fully integrate information systems with transportation vehicles promises to substantially reduce the role of human participation in mobility. Texas has not been strongly positioned to best implement, finance, or otherwise leverage emerging technologies in the near and mid-term due to (1) lack of awareness of those technologies and their interactions with the transportation system, (2) dated planning and financing mechanisms, and (3) conflicts between new technologies and existing enforcement frameworks. Texas needs to develop the capacity to be a thought leader on emerging technologies and their potential to enhance the transportation system. The Technology Task Force (TTTF) convened in March 2013 and was charged with examining and evaluating innovative transportation technologies for purposes of cost savings, reducing traffic congestion, enhancing safety, and increasing economic productivity.

PROJECT INFORMATION (CONT.)	
	In order to meet the goals outlined above, the TTTF was charged with three main tasks to complete in its first phase, which are listed below. 1. Assemble a panel of Subject Matter Experts (SME) drawn from industry and the public sector. The distinguishing feature of the task force membership is that it is not composed of academic researchers, transportation engineers, or policy makers, but well-respected experts in the fields of economic development, telecommunications, information technology, renewable energy, telematics, and other industrial sectors. Their "out of the box" ideas were brought to bear on transportation problems. 2. Convene the Task Force to identify key emerging technologies and outline a path to implementation, which considers policy, economic, and institutional barriers. 3. Make recommendations regarding an Initial Program of Work for a Public-Private Consortium and next steps. The first implementation of the initial set of recommendations from the task force was the establishment in January 2014 of the Accelerate Texas Center, which forms the core of a public-private partnership that will research, develop, commercialize, and implement new transportation-related technologies with an initial specific focus on efforts relating to the autonomous vehicle and how such vehicles may impact transportation systems in Texas. The center will serve the broad range of needs of TxDOT, other agencies, and the private sector by establishing a framework for fostering cooperation among organizations working towards the development of autonomous vehicles and the integration of autonomous vehicles into existing transportation systems. These efforts may include identifying and soliciting participants, fostering public awareness, providing opportunities for collaboration, and identifying public and private funding sources in support of the center's mission.
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Monitoring Stresses and Placing Sweep Control System in Innovative Pre-stressed, Precast Concrete Arches***
ID	5-5253-03
Project Cost	$286,000
Duration	38 months
SUBMITTER	
Submitter Agency	Texas Department of Transportation
Submitter Contact	Shannon Crum Attn: RTI Texas Department of Transportation 125 E. 11th Street Austin, TX 78701 512-416-4730 Shannon.crum@txdot.gov
RESEARCH PROGRAM	
Sponsor Contact	Texas Department of Transportation 125 E. 11th Street Austin, TX 78701
Brief Summary of Research Project   	This is the last in a series of projects, beginning with TxDOT research projects 0-4563 and 0-5253 that has led to the construction of an innovative and low-cost bridge design that addresses many challenges: quick construction (arches, beams, and deck are all pre-cast); beauty; improved mobility; and a large hydraulic opening during floods, all on a restricted budget. Costs are minimized by the fact that the arches in the bridge are identical and can be cast horizontally offsite, rotated into a vertical position, transported, and set into place. The results of this work has been implemented in a bridge project that replaces the old 7th Street bridge in Fort Worth, Texas. The 12-arch, pre-cast concrete structure opened to traffic in fall 2013. The arches were constructed at a nearby casting yard donated by Chesapeake Energy. Each arch is 163.5 ft. long and weighs 300 tons. Within the arch, there is a network of stainless steel hangers with clevises and tie-beam connections that protect pedestrians from traffic on the bridge while allowing both motorists and pedestrians to enjoy a nearly unobstructed view of the river. This new construction method resulted in seven fewer months of bridge closure compared to a typical 12 months or more using traditional methods. Photographs of the arches in transport and being set into place are included. The YouTube video describing bridge project is online at https://www.youtube.com/watch?v=lZ-9ASlV5Rg&feature=youtu.be
Web Links (if available)	

Utah Department of Transportation

PROJECT INFORMATION	
Project Title	***Dynamic Passive Pressure on Non-Skewed Abutments and Pile Caps***
ID	UT05.703, TPF-5(122), 06-9148
Project Cost	$265,000
Duration	63 months
SUBMITTER	
Submitter Agency	Utah Department of Transportation
Submitter Contact	David Stevens Utah Dept. of Transportation, PO Box 148410 Salt Lake City, UT 84114-8410 ph. 801-589-8340, davidstevens@utah.gov
RESEARCH PROGRAM	
Sponsors	Utah Department of Transportation David Stevens, davidstevens@utah.gov California Department of Transportation Anoosh Shamsabadi, anoosh.shamsabadi@dot.ca.gov Montana Department of Transportation Stephanie Brandenberger, stbrandenberger@mt.gov New York State Department of Transportation Paul Bailey, paul.bailey@dot.ny.gov Oregon Department of Transportation Jan Six, jan.l.six@odot.state.or.us
RESEARCH AND RESULTS	
Brief Summary of Research Project	This pooled fund study TPF-5(122) investigated the cyclic and dynamic lateral load response of a full-scale pile cap with nine different backfill conditions, more specifically being: (1) no backfill present (baseline response), (2) densely compacted clean sand, (3) loosely compacted clean sand, (4) densely compacted fine gravel, (5) loosely compacted fine gravel, (6) densely compacted coarse gravel, (7) loosely compacted coarse gravel, (8) a 3-ft. wide densely compacted fine gravel zone with loosely compacted clean sand backfill, and (9) a 6-ft. wide densely compacted fine gravel zone with loosely compacted clean sand backfill. The pile cap was loaded using a combination of hydraulic load actuators and an eccentric mass shaker. The results of this study include horizontal load versus displacement relationships for the pile cap with differing backfill conditions and earth pressure distributions along the pile cap face. The results also include comparisons between measured and theoretically based or calculated values. Additional results include descriptions of vertical displacement, horizontal displacement, and cracking of the backfill.

PROJECT INFORMATION (CONT.)	
	The stiffness and damping for the pile cap with the different backfill conditions were also determined. Recommendations based on the results were provided which could lead to significant cost savings and improved design. Five final reports were produced on different aspects of the research. Cost savings from implementation have not been documented yet. Benefits are mainly qualitative so far. For Utah DOT, results have helped answer design questions while providing a better understanding of the lateral load response behavior. Utah DOT has used the methods and reduction factors arrived at in the research, and some of the reduction factors have been included or will be included in the AASHTO design method. For pooled fund partner Montana DOT, the results of this study have changed how they evaluate the available dynamic passive resistance at abutments, along with how to determine the quality of the "load path" and interaction between the abutment fill and the structure. Implementation of results has led to a more realistic approach for using passive pressure as part of the earthquake resisting system in their structures. Montana DOT plans to incorporate the results of this research into standard design practice and also realize associated cost savings.
Web Links (if available)	http://www.pooledfund.org/Details/Study/354

PROJECT INFORMATION	
Project Title	***Maintenance Activity Planning Based on Crash Data***
ID	UT11.202, 12-9086
Project Cost	$45,000
Duration	16 months
SUBMITTER	
Submitter Agency	Utah Department of Transportation
Submitter Contact	David Stevens Utah Dept. of Transportation, PO Box 148410 Salt Lake City, UT 84114-8410 ph. 801-589-8340, davidstevens@utah.gov
RESEARCH PROGRAM	
Sponsors	Utah Department of Transportation Kevin Nichol PO Box 148410 Salt Lake City, UT 84114-8410 ph. 801-870-4033, knichol@utah.gov
RESEARCH AND RESULTS	
Brief Summary of Research Project	Highway maintenance operations have a profound impact on safety. Crash data feedback to these programs can be very useful in planning and fine-tuning these operations. This project outlines four programs aimed at utilizing selected crash data to make improvements or adjustments in these maintenance activities in the Utah Department of Transportation: Snow & Ice Crash Cluster Reduction Program, Wild Animal Fence Evaluation Program, Low Skid Number Correction Program, and Semi-Annual Inspection Crash Analysis Program. Researchers provided data needs, analysis methods, strategy selection, the key stakeholders, program deliverables, legal considerations, and feedback processes for each program. Recommended implementation methods, templates and examples, and estimates of the resources needed for each program were provided to aid in the implementation of these programs. The resource needs are minimal. The required budgets range from $3,000 to $20,000 to perform the recommended program activities and management. The Low Skid Number Correction Program and its relationship to wet pavement crash analysis have been implemented. Qualitative benefits for Utah DOT include the ability to identify and map areas of concern and establish correlations between wet pavement crashes and low skid numbers. No cost savings have been documented yet, but by recognizing and correcting problem areas with pavement surface friction defects, additional crashes could be prevented. Utah DOT is also looking into implementing the other recommended maintenance program activities from this study to improve highway safety.
Web Links (if available)	http://www.udot.utah.gov/main/uconowner.gf?n=8445522417366453

Virginia Department of Transportation

PROJECT INFORMATION	
Project Title	***Emergency Response SOP***
ID	1125002-0001
Project Cost	$50,000
Duration	23 months
SUBMITTER	
Submitter Agency	Virginia Department of Transportation
Submitter Contact	Jose P. Gomez, Ph.D., P.E. Director, Virginia Center for Transportation Innovation and Research Virginia Department of Transportation 434-293-1936 Jose.Gomez@VDOT.VIrginia.gov
RESEARCH PROGRAM	
Sponsors	Virginia Center for Transportation Innovation and Research 530 Edgemont Road Charlottesville VA USA 22903 http://www.VTRC.net
RESEARCH AND RESULTS	
Brief Summary of Research Project	Following the 2005 Hurricane Katrina disaster, the federal government instituted the National Incident Management System (NIMS), a national standard for coordinating emergency-response operations. However, because this standard was aimed at traditional emergency responders, it did not provide specific guidance for state transportation agencies. The need for a comprehensive emergency-response program was further underscored when a freak ice event hit Northern Virginia, paralyzing the roadway system and stranding motorists for more than 12 hours. While the Virginia Department of Transportation (VDOT) had decades of experience dealing with snow and clearing accidents, it had never before regarded "emergency response" as a core business function. Further, emergency response encompasses a wide range of events and involves a cross-section of separate functions, including maintenance and operations. VDOT needed to develop a single, consistent approach that encompassed all types of emergencies—including major weather events, hazardous material spills and terrorist attacks—and defined the roles of each VDOT responder. There was also a goal to ensure that individual knowledge based on long-term employees' experience could be developed into institutional knowledge, which could be shared effectively and efficiently with new employees. This study explored the different perspectives on emergency responses based on roles in the agency and type of emergency, through interviews and analysis of existing documentation.

PROJECT INFORMATION (CONT.)	
	Key stakeholders were brought together to form collaborative groups based on role and perspective to map out processes. They also identified critical conceptual discrepancies based on disparate knowledge backgrounds. The process was not simply directed from an administrative standpoint but was predicated on the input of those who actually perform the work and would be responsible for responding to each kind of emergency. These diverse perspectives were synthesized through an iterative process until consensus and shared understanding was reached. On this basis, VDOT established a comprehensive, command-and-control approach to emergency response, consistent with NIMS standards and requirements. The research created a new VDOT model of emergency response, designed to facilitate quick restoration of the transportation system to normal conditions that are safe, enable the easy movement of people and goods and enhance the economy. The study also resulted in a single guide with interlocked processes and integrated training for current and new employees. VDOT is routinely praised around the state for its efficient and timely response to storms and other crises, no matter the season. Resulting policy document posted in project file: VDOT 2011 EmergencyResponseSOP.pdf
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Real-Time Prediction of Vehicle Locations in a Connected-Vehicle Environment (VCTIR 14-R4)***
ID	102607
Project Cost	$60,417
Duration	14 months
SUBMITTER	
Submitter Agency	Virginia Department of Transportation
Submitter Contact	Jose P. Gomez, Ph.D., P.E. Director, Virginia Center for Transportation Innovation and Research Virginia Department of Transportation 434-293-1936 Jose.Gomez@VDOT.VIrginia.gov
RESEARCH PROGRAM	
Sponsors	Virginia Center for Transportation Innovation and Research 530 Edgemont Road Charlottesville, VA USA 22903 http://www.VTRC.net
RESEARCH AND RESULTS	
Brief Summary of Research Project	The wireless communication between vehicles and the transportation infrastructure, referred to as the "connected-vehicle environment," has the potential to improve driver safety and mobility immensely for drivers. The Virginia Department of Transportation (VDOT) has constructed a connected-vehicle test bed in Northern Virginia as part of the agency's long-term plan to continue to advance connected-vehicle application development and deployment. The rollout of connected-vehicle technologies in passenger vehicles, however, is expected to last 30 years or more, during which time traffic will be a mix of vehicles equipped with the technology and vehicles that are not. Most mobility applications tested in simulation, such as traffic-signal control and performance measurement, show greater benefits as a larger percentage of vehicles are equipped with connected-vehicle technologies. The purpose of this study was to develop and investigate techniques to estimate the positions of unequipped vehicles, based on behaviors of equipped vehicles. Two algorithms were developed for this purpose: one for use with arterials and one for use with freeways. Both algorithms were able to estimate the positions of a portion of unequipped vehicles in the same lane within a longitudinal distance.

PROJECT INFORMATION (CONT.)	
	Further, the two connected-vehicle mobility applications were able to use these estimates to produce small improvements in performance in simulation: 1. At low penetration rates of connected-vehicle technologies, when compared to using connected vehicle data alone; 2. With up to an 8 percent reduction in delay for a ramp-metering application; and 3. With a 4.4 percent reduction in delay for a traffic-signal control application. The study recommends that the Virginia Center for Transportation Innovation and Research (VCTIR), VDOT's research division, continue to assess the data quality of connected-vehicle field deployments to determine if the developed algorithms can be deployed. If data quality is deemed acceptable and if a connected-vehicle application is tested in a field deployment, VCTIR should evaluate the use of the location estimation algorithms to improve the application's performance at low penetration rates. This is expected to result in reduced delays and improved flow for connected vehicle mobility applications during times when few vehicles are able to communicate wirelessly.
Web Links (if available)	http://vtrc.virginiadot.org/PUBDetails.aspx?Id=298189

PROJECT INFORMATION	
Project Title	***Considerations for the Development of Work Zone Mobility Performance Measures and Thresholds for Virginia Freeways (VCTIR 14-R6)***
ID	CSC 11180190-RC00047
Project Cost	$80,000
Duration	2 months
SUBMITTER	
Submitter Agency	Virginia Department of Transportation
Submitter Contact	Jose P. Gomez, Ph.D., P.E. Director, Virginia Center for Transportation Innovation and Research Virginia Department of Transportation 434-293-1936 Jose.Gomez@VDOT.VIrginia.gov
RESEARCH PROGRAM	
Sponsors	Virginia Center for Transportation Innovation and Research 530 Edgemont Road Charlottesville VA USA 22903 http://www.VTRC.net
RESEARCH AND RESULTS	
Brief Summary of Research Project	The Federal Highway Administration has been encouraging states to improve their monitoring and tracking of the impacts work zones have on driver mobility. The use of mobility performance measures will enable agencies to: • Assess better the contribution of work zones have on network congestion; • Identify specific projects in need of remedial action; and • Potentially assess penalties on contractors, creating excessive and avoidable negative impacts. Although the Virginia Department of Transportation (VDOT) has defined allowable lane closure hours for the interstate system, VDOT has not defined specific performance measures and thresholds for what constitutes "unacceptable" work-zone mobility impacts. Performance measures and thresholds have been developed by a number of other states, so there was a need to determine whether VDOT could also adapt these. This study by VDOT's research division explored issues related to a potential work-zone mobility performance measurement program for Virginia. Issues investigated included identifying potential performance measures, defining performance thresholds and recommending data sources for performance- measurement calculations.

PROJECT INFORMATION (CONT.)	
	This data was synthesized from information regarding experiences of selected states and those from a series of case studies that used records from Virginia work zones. The review of experiences in selected other states found that both the delay length and queue length were the performance measures the states in the study most often used. The Virginia case studies focused on the use of private-sector data to generate mobility performance measures and found that the level of spatial aggregation in rural areas could inhibit the ability to generate accurate performance measures, although granularity was better on urban roads. The level of temporal aggregation also was found to influence performance measures. The research identified several key issues VDOT should consider as it develops a work-zone mobility performance measures program. The report recommends that VDOT develop a pilot program that focuses on urban interstates initially and convene a task group to develop formal policies and procedures for use in Virginia.
Web Links (if available)	http://vtrc.virginiadot.org/PUBDetails.aspx?Id=298191

PROJECT INFORMATION	
Project Title	***Concrete Pavement Overlays on U.S. 58***
ID	11180190-RC00038
Project Cost	$100,884
Duration	25 months
SUBMITTER	
Submitter Agency	Virginia Department of Transportation
Submitter Contact	Jose P. Gomez, Ph.D., P.E. Director, Virginia Center for Transportation Innovation and Research Virginia Department of Transportation 434-293-1936 Jose.Gomez@VDOT.VIrginia.gov
RESEARCH PROGRAM	
Sponsors	Virginia Center for Transportation Innovation and Research 530 Edgemont Road Charlottesville, VA USA 22903 http://www.VTRC.net
RESEARCH AND RESULTS	
Brief Summary of Research Project	Asphalt overlays are typically used to extend the life of continuously reinforced concrete pavement (CRCP) because they can be placed in one or more layers while traffic uses the adjacent lane and can be opened to traffic in a short time. ydraulic cement concrete overlays also have been used to extend the life of CRCP, but often have not been considered an alternative to asphalt because of the higher cost and longer curing time. In 2012, the Virginia Department of Transportation (VDOT) funded a demonstration project to construct and evaluate bonded and unbonded concrete overlays for extending the life of a continuously reinforced concrete pavement in southeastern Virginia. The project included the following tasks: • Site selected • Pavement designs prepared for bonded and unbonded overlays • Existing condition of pavement determined before construction • Construction steps monitored and documented • Concrete materials properties in fresh and hardened states measured as part of quality-control and quality-assurance program • Ride quality measured immediately after construction, before opening to traffic • Visual survey performed on pavement condition after four months of traffic and a winter season • Construction costs compared The project rehabilitated a 4.8-mile CRCP section of westbound U.S. 58 in Southampton County, using a 4-inch-thick bonded concrete overlay and a 7-inch-thick unbonded concrete overlay with a 1-inch asphalt separation layer.

PROJECT INFORMATION (CONT.)	
	The four-lane, divided primary highway has an 8-inch-thick CRCP placed over a 6-inch cement-treated aggregate layer. Saw cutting was used to form joints at 6-foot-by-6-foot panels for an unbonded overlay. Tie bars were used along the centerline of the pavement and along both shoulders. A concrete overlay was placed on the shoulders of the unbonded overlay, and asphalt was placed on the shoulders of the bonded overlay. Two layers of asphalt with a total thickness of 5 inches were placed on a 9.75-mile section of the eastbound lanes, which provided cost information to compare alternatives. Since traffic management was significantly different for the two projects, definitive conclusions could not be drawn. On the basis of material costs alone, concrete and asphalt can be competitive options for extending the service life of CRCP. The project concluded the following: • Construction of the concrete overlays was successfully executed on time; • Concrete was of high quality, with good strength and low permeability; and • The bonded overlay is well bonded. As constructed, ride quality was good for the unbonded section (IRI = 56 to 71 in/mile) and fair for the bonded section (IRI = 73 to 93 in/mile), but the ride quality for both was much better than for the original pavement. Using the initial cost of materials in-place, the bonded and unbonded overlays were approximately same, at an average of $36 to $38 per square yard. The unit cost of patching concrete pavements is approximately six times the cost of the bonded concrete overlay and approximately four times the cost of an unbonded overlay. Unbonded concrete overlays should be used when more than approximately 10 percent of the CRCP must be patched. On the other hand, bonded concrete overlays should be considered when the CRCP is in good condition. The project recommended that VDOT should: • Consider using bonded concrete overlays to extend the life of CRCPs in good condition and needing little patching before placing the overlay. • Consider using unbonded concrete overlays as an alternative to patching to extend the life of CRCP and JRC that need more than 10 percent patching. • Advertise overlay projects allowing alternate designs using stone-matrix asphalt and hydraulic cement concrete to determine if they are competitive alternatives. • Explore innovative traffic-management plans for pavement rehabilitation to reduce costs.
Web Links (if available)	Link to YouTube video on project: http://www.youtube.com/watch?v=ZeYqjlyQ4L8

Washington State Department of Transportation

PROJECT INFORMATION	
Project Title	***Emergency Response SOP***
ID	1125002-0001
Project Cost	$50,000
Duration	23 months
SUBMITTER	
Submitter Agency	Washington State Department of Transportation
Submitter Contact	Kathy Lindquist Research Manager, Office of Research and Library Services Engineering and Policy Innovation Division, WSDOT 310 Maple Park AV SE Olympia, WA 98504-7372 360-705-7976, lindquk@wsdot.wa.gov
RESEARCH PROGRAM	
Sponsor Contact	WSDOT Public Transportation Divison Stan Suchan 206-464-1192 cel: 206-473-8308
RESEARCH AND RESULTS	
Brief Summary of Research Project	This project developed a training manual and materials for use in the Ride-share Online Assistance for the website: http://www.rideshareonline.com/ RideshareOnline.com provides tools that help businesses and communities make their trip reduction efforts more effective, efficient, and accountable and help individuals save money, time, and the environment. The tools of-fer features that make sharing the ride, teleworking, walking, and bicycling easier and more rewarding. The new system is available to commuters, employers, and community organizations throughout Wash¬ington, Idaho and Oregon. This project developed user-friendly documentation and online training videos to help current transportation coordinators use the iCarpool/ RideshareOnline.com platform more effectively and efficiently and to assist new network administrators in more quickly learning to utilize the technol-ogy. The RideshareOnline project (officially, "RSO Online Assistance" or T4118-77) . No formal "Final Research Report" The files below constitue the final products for this project and are already in active use. ***Final Products Completed:*** Raw Demo Builders Files are used to create the training videos built for WSDOT and Metro. Those files can be modified as de-sired by anyone who has Demo Builder (and King County Metro has a copy), and used to create videos of any format desired. Metro (or WSDOT) can also purchase different voices as well if they decide they don't like the version of the voice. The second file (MP4 Files) contains the completed videos in MP4 format. WSDOT or Metro can regenerate the videos in a different video for-mat (e.g., WMV or Flash) easily enough from the raw Demo Builder files.

PROJECT INFORMATION (CONT.)	
	The third file contains example WMV format videos. These are duplicates of MP4 videos. The fourth file (RSO Manual Chapters) includes the new Users Guide for Administrators of the RideShareOnline software. Both the Word and PDF versions of these chapters are included. (The PDF files are all currently available on Smart Transportation, and changes to them are made based on continuing feedback from the users. Metro and WSDOT Public Transportation Division maintain them.) The final file (RSO Quick Instructions) contains information to help users get to work quickly. (The videos are posted by Metro to their training web site.)
Web Links (if available)	

PROJECT INFORMATION	
Project Title	***Summary Report on the Performance of Open-Graded Friction Course Quieter Pavements I-5 Lynnwood, SR-520 Medina, I-405 Bellevue***
ID	In-house
Project Cost	$0
Duration	86 months
SUBMITTER	
Submitter Agency	Washington State Department of Transportation
Submitter Contact	Kim Willoughby 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978 willouk@wsdot.wa.gov
RESEARCH PROGRAM	
Sponsor Contact	Washington State Department of Transportation 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978

PROJECT INFORMATION (CONT.)

RESEARCH AND RESULTS

Brief Summary of Research Project	This project developed a training manual and materials for use in the Ride-share Online Assistance for the website: http://www.rideshareonline.com/ RideshareOnline.com provides tools that help businesses and communities make their trip reduction efforts more effective, efficient, and accountable and help individuals save money, time, and the environment. The tools offer features that make sharing the ride, teleworking, walking, and bicycling easier and more rewarding. The new system is available to commuters, employers, and community organizations throughout Wash¬ington, Idaho and Oregon. This project developed user-friendly documentation and online training videos to help current transportation coordinators use the iCarpool/Ride-shareOnline.com platform more effectively and efficiently and to assist new network administrators in more quickly learning to utilize the technology. The RideshareOnline project (officially, "RSO Online Assistance" or T4118-77) . No formal "Final Research Report" The files below constitue the final products for this project and are already in active use. Final Products Completed: (Raw Demo Builders Files are used to create the training videos build for WSDOT and Metro. Those files can be modified as desired by anyone who has Demo Builder (and King County Metro has a copy), and used to create videos of any format desired. Metro (or WSDOT) can also purchase different voices as well if they decide they don't like the version of the voice. The second file (MP4 Files) contains the completed videos in MP4 format. (WSDOT or Metro can regener-ate the videos in a different video format (e.g., WMV or Flash) easily enough from the raw Demo Builder files. The third file contains example WMV format videos. These are duplicates of MP4 videos. The fourth file (RSO Manual Chapters) includes the new Users Guide for Administrators of the RideShareOnline software. Both the Word and PDF ver-sions of these chapters are included. (The PDF files are all currently available on Smart Transportation, and changes to them are made based on continu-ing feedback from the users. Metro and WSDOT Public Transportation Divi-sion maintain them.) The final file (RSO Quick Instructions) contain information to help users get to work quickly. (The videos posted by Metro to their training web site.)
Web Links (if available)	http://www.wsdot.wa.gov/research/reports/fullreports/817.1.pdf

PROJECT INFORMATION	
Project Title	***Performance-Based Design Factors for Pile Foundations***
ID	T4118-66
Project Cost	$200,000
Duration	45 months
SUBMITTER	
Submitter Agency	Washington State Department of Transportation
Submitter Contact	Kim Willoughby 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978 willouk@wsdot.wa.gov
RESEARCH PROGRAM	
Sponsor Contact	Washington State Department of Transportation 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978
Brief Summary of Research Project	The design of foundations requires criteria for acceptable performance of the foundation, and performance can be described in a number of different ways. Foundations have historically been designed to have the capacity to resist the maximum anticipated loading, with the assumption that a load greater than the capacity would cause failure of the foundation. In some cases, exceedance of capacity can lead to large and damaging deformations, but in other cases it may not. The notions of performance, which can be expressed in terms of loads and resistances, deformations and allowable deformations, or in terms of physical damage or losses are reviewed and compared. The notion of uncertainty and its effects on foundation performance are reviewed and procedures for its consideration in design, e.g., through reliability-based design are described. The implementation of reliability-based design through the use of load and resistance factors was introduced. Finally, the PEER framework for performance-based earthquake engineering evaluation is described and a modified version of it, suitable for the task of evaluating foundation performance, was developed. The research was directed toward development and implementation of a performance-based framework for the establishment of reliability-based design factors for pile foundations. The process of developing this framework in a form that could be applied to the multitude of possible bridge, foundation, site, and subsurface conditions that foundation designers must consider led to an extension of the PEER PBEE framework. That extension was pursued from both theoretical and practical perspectives. Finally, the numerical implementation of the procedures developed in this research were applied to different pile foundation systems located in different seismic regions.
Web Links (if available)	

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Evaluation of Recycled Concrete as Aggregate in New Concrete Pavements***
ID	T4120-32
Project Cost	$150,000
Duration	20 months
SUBMITTER	
Submitter Agency	Washington State Department of Transportation
Submitter Contact	Kim Willoughby 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978 willouk@wsdot.wa.gov
RESEARCH PROGRAM	
Sponsor Contact	Washington State Department of Transportation 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978
Brief Summary of Research Project	This study was performed for the Washington State Department of Transportation (WSDOT) and evaluated the use of recycled concrete as a replacement for natural aggregates in new portland cement concrete pavements. Recycled concrete aggregate (RCA) produced from demolished pavements in three geographically-dispersed locations in Washington state were used to perform tests on aggregate characteristics, fresh concrete properties, and hardened concrete properties. Variables included the source of the RCA, percent replacement of coarse natural aggregate with RCA (0%, 15%, 30% and 45%), and percent replacement of portland cement with type F fly ash (0% or 20%). Four tests were used to characterize RCA properties including specific gravity, absorption capacity, Los Angeles abrasion loss, degradation value in various conditions, and alkali-silica reactivity. The conditions for which the degradation value was determined included the as-delivered unprocessed RCA, the processed RCA, and processed RCA at mixed with natural aggregate at rates of 15%, 30%, and 45%. Overall, tests showed that RCA has a lower specific gravity, greater absorption capacity, and meets the WSDOT requirements on Los Angeles abrasion loss and degradation value once processed. Additional tests may need to be performed to evaluate potential deleterious expansion due to alkali-silica reactivity. Three tests were used to determine if RCA had any effects on the properties of fresh concrete including slump, air content by the pressure method, and density. Slump and air content were controlled parameters in the batching process, with targets specified by WSDOT of 1-3 in. for slump and 4-7% for air content. It was a goal during the mix process to make concrete mixtures within the low end of each of those ranges. Slump was controlled by withholding mix water or adding water-reducing admixture (WRA), and air content was controlled by the amount of air entraining admixture used in the batch. RCA was found to decrease

PROJECT INFORMATION (CONT.)	
	the slump and density of fresh concrete. RCA had no significant effect on air content. Five tests were used to determine the effects of RCA on hardened concrete properties including compressive strength, modulus of rupture, coefficient of thermal expansion, drying shrinkage, and freeze-thaw durability. Test results showed that up to a 45% replacement of coarse natural aggregate with RCA had no significant effect on any of the hardened concrete properties tested. In addition, all samples tested met WSDOT minimum strength requirements for use in concrete pavements. It should be emphasized that these results were obtained using RCA obtained from demolished pavements incorporating high-quality original materials. The results of this study indicate that RCAs of similar quality to those incorporated in this research would be viable for use in new concrete pavements. RCA had no significant effects on the compressive strength, modulus of rupture, coefficient of thermal expansion, drying shrinkage, or freeze-thaw durability of hardened concrete for up to a 45% replacement of coarse RCA for natural coarse aggregate. In addition, all results from tests on the RCA from the three sources and results concrete incorporating this RCA at up to 45% replacement met WSDOT requirements for use in new concrete pavements. Further study should be performed to determine the minimum criteria RCA must meet for use as an aggregate in concrete pavements as well as to evaluate higher RCA replacement rates. Based on the results of this study, WSDOT could use RCA as a replacement for coarse aggregate in PCCP up to 45% without any detrimental effects.
Web Links (if available)	http://www.wsdot.wa.gov/research/reports/fullreports/826.1.pdf

PROJECT INFORMATION	
Project Title	***Infrared Thermal Integrity Testing: Quality Assurance Test Method to Detect Drilled Shaft Defects***
ID	GCA5855
Project Cost	$99,992
Duration	28 months
SUBMITTER	
Submitter Agency	Washington State Department of Transportation
Submitter Contact	Kim Willoughby 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978 willouk@wsdot.wa.gov
RESEARCH PROGRAM	
Sponsor Contact	Washington State Department of Transportation 310 Maple Park Ave SE Olympia, WA 98504-7372 360-705-7978
Brief Summary of Research Project	Over the past three decades, a trend toward higher quality assurance in constructed drilled shafts has moved from monitoring only concrete quantities to refined slurry properties and post-construction, non-destructive testing. Although not always practical, the use of multiple test methods can provide more information and better assessment of shaft acceptability. These methods vary in the types of information obtained as well as the regions of the shaft that can be tested. However, recognizing the limitations of these state-of-the-art quality assurance methods to inspect these subsurface concrete columns, the Washington State Department of Transportation opted to entertain other technologies for their assessment. As a result, a relatively new testing method that uses the energy expended from hydrating concrete (and the associated temperature signature) was selected for this study. This thermal integrity approach provides an overall perspective of the shaft based on the presence or absence of intact heat producing concrete. The shaft shape, cage placement, cover and concrete health can all be monitored. Thermal testing provides various details of shaft integrity which include effective shaft size (diameter and length), anomaly detection inside and outside the reinforcement cage, cage alignment, and proper hydration of the concrete. The ability to detect concrete volumes outside the reinforcing cage is perhaps its strongest feature, unlike Cross-Hole Sonic Logging (CSL) tests. Implementation of this test method will allow a more comprehensive look at the concrete within the drilled shaft over the use of CSL testing, which can only provide a look at the quality of concrete inside the shaft's rebar cage. The concrete cover over the outside of the cage is critical in terms of the quality and performance of the drilled shaft. WSDOT is implementing this TIP technology on select projects with multiple drilled shafts as a part of the project. It has also been submitted as an Everyday Counts technology.
Web Links (if available)	http://www.wsdot.wa.gov/research/reports/fullreports/770.1.pdf

PROJECT INFORMATION	
Project Title	***RSO Online Assistance***
ID	T4118-77
Project Cost	$173,950
Duration	26 months
SUBMITTER	
Submitter Agency	Washington State Department of Transportation
Submitter Contact	Kathy Lindquist Research Manager, Office of Research and Library Services Engineering and Policy Innovation Division, WSDOT 310 Maple Park AV SE Olympia, WA 98504-7372 360-705-7976, lindquk@wsdot.wa.gov
RESEARCH PROGRAM	
Sponsor Contact	WSDOT Public Transportation Divison Stan Suchan 206-464-1192 , cell: 206-473-8308
Brief Summary of Research Project	This project developed a training manual and materials for use in the Ride-share Online Assistance for the website (see link below) RideshareOnline.com provides tools that help businesses and communities make their trip reduction efforts more effective, efficient, and accountable and help individuals save money, time, and the environment. The tools of-fer features that make sharing the ride, teleworking, walking, and bicycling easier and more rewarding. The new system is available to commuters, employers, and community organizations throughout Wash¬ington, Idaho and Oregon. This project developed user-friendly documentation and online training videos to help current transportation coordinators use the iCarpool/ RideshareOnline.com platform more effectively and efficiently and to assist new network administrators in more quickly learning to utilize the tech-nology. The RideshareOnline project (officially, "RSO Online Assistance" or T4118-77) . No formal "Final Research Report" The files below constitue the final products for this project and are already in active use. Final Products Completed: (Raw Demo Builders Files are used to create the training videos build for WSDOT and Metro. Those files can be modified as desired by any-one who has Demo Builder (and King County Metro has a copy), and used to create videos of any format desired. Metro (or WSDOT) can also purchase different voices as well if they decide they don't like the version of the voice. The second file (MP4 Files) contains the completed videos in MP4 format. (WSDOT or Metro can regenerate the videos in a different video format (e.g., WMV or Flash) easily enough from the raw Demo Builder files. The third file contains example WMV format videos. These are duplicates of MP4 videos.

PROJECT INFORMATION (CONT.)	
	The fourth file (RSO Manual Chapters) includes the new Users Guide for Administrators of the RideShareOnline software. Both the Word and PDF versions of these chapters are included. (The PDF files are all currently available on Smart Transportation, and changes to them are made based on continuing feedback from the users. Metro and WSDOT Public Transportation Division maintain them.) The final file (RSO Quick Instructions) contain information to help users get to work quickly. (The videos posted by Metro to their training web site.)
Web Links (if available)	http://www.rideshareonline.com/

West Virginia Department of Transportation

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Landslide and Slope Stabilization Using Piles and Micro-Piles Based on the LRFD***
ID	RP-213
Project Cost	$200000
Duration	40 months
SUBMITTER	
Submitter Agency	West Virgina Department of Transportation
Submitter Contact	Michael E. Pumphrey , P.E. West Virginia DOT Research & Special Studies Chestnut Ridge Research Bldg., Rm. 705 886 Chestnut Ridge Rd. PO Box 6884 Morgantown, WV 26506 (304) 206-8625, Michael.E.Pumphrey@wv.gov
RESEARCH PROGRAM	
Sponsor Contact	West Virginia Department of Transportation Chestnut Ridge Research Bldg., Rm. 705 886 Chestnut Ridge Rd. PO Box 6884 Morgantown, WV 26506
RESEARCH AND RESULTS	
Brief Summary of Research Project	Landslides (slope failure) is a critical issue in the state of West Virginia. The WVDOT often employs the use of driven, drilled or micro-piles to reduce the likelihood of, or to prevent slope failure or landslides. Prior to this research, simplified methods based on crude assumptions were used to design the driven, drilled, or micro-piles needed to stabilize slopes of bridge embankments or to reduce the potential for landslides from one season to another. A more sophisticated and proven analysis technique was needed to more realistically assess the destructive effect of the sliding soil mass on bridge foundation performance. Therefore, the main objective of the RP 213 research project was to develop a new technique (analytical method/design tool) to deal with slope stabilization using piles. The realistic characterization and determination of loads induced by lateral soil movement, and load transfer to piles based on soil-pile interaction were the core of the research. Achieved Objectives: Highlight limitations and drawbacks of existing procedures currently used to address slope stabilization using piles. • Provide a design procedure (methodology) for slope stabilization using driven, drilled, or micro-piles based on limit equilibrium analysis and the Strain Wedge method to assess the stability of vulnerable slopes before and after using driven piles to improve the slope stability.

PROJECT INFORMATION (CONT.)	
	• Improve the level of certainty related to the downslope soil movement (small shoulder slopes and large slopes) and the induced distributed load along the stabilizing piles. • Incorporate soil and pile properties, and pile spacing in the analysis of stabilized slopes. • The ability to input pre-existing landslide geometry and to estimate the resulting distributed driving forces. • Assess the shear force and moment developed along the pile based on the pile type (materials and dimensions) and the LRFD. • Provide a number of case studies and comparisons to validate and verify the research findings. • Establish a Windows-based computer program (PSSLOPE) and accompanying manual to deal with small shoulder slips and large slips. The PSSLOPE computer program is a design tool by which the designer can select an economic pile size to stabilize slopes. The PSSLOPE determines the mobilized driving force caused by a sliding mass of soil that needs to be transferred via installed piles to stable soil layers below the slip surface. The computer program developed provides very flexible graphic-user interface that facilitates entering the input data and the analysis/plot of the output results. The PSSLOPE software is written in both Fortran and Visual Basic. The software is customized to meet the needs of the WVDOH. Impact of Implementing Research Results: • The developed research work provides a reliable design procedure based on the LRFD that is compiled into the PSSLOPE program for the analysis of pile-stabilized slopes. In many cases, pile stabilization may be more effective and more appropriate than the other stabilization practices. • The use of an effective and reliable design technique (i.e., the PSSLOPE program) will lower the chance of catastrophic failure and the level of risk that the designers assume by using unreliable techniques based on questionable assumptions. • Cost savings or relief from a possible failure will be achieved. In addition, the tedious manual iterations required in the current practice will no longer be necessary. • The utilized design methodology demonstrates the suitability of pile-stabilized slopes to assist the WVDOT with incorporating pile stabilization systems into slope remediation (mitigation) practices. Therefore, a mitigation plan for vulnerable slopes and bridge embankments can be established based on such knowledge. The designer also has the ability to input pre-existing landslide geometry and to estimate the resulting driving forces.
Web Links (if available)	http://www.transportation.wv.gov/highways/programplanning/research/Documents/PSSLOPE_Manual.pdf

Wisconsin Department of Transportation

PROJECT INFORMATION	
Project Title	***Establishing a Methodology to Evaluate Teen Driver Training Programs***
ID	0092-12-11
Project Cost	$85,000
Duration	13 months
SUBMITTER	
Submitter Agency	Wisconsin Department of Transportation
Submitter Contact	Daniel Yeh 4802 Sheboygan Ave. Madison, WI 53707 608-267-6977 daniel.yeh@dot.wi.gov
RESEARCH PROGRAM	
Sponsor Contact	Wisconsin Department of Transportation 4802 Sheboygan Avenue Madison, WI USA 53707 http://www.dot.wisconsin.gov
RESEARCH AND RESULTS	
Brief Summary of Research Project	In the United States, teenage drivers are more at risk of being involved in crashes than any other age group. Statistics reveal a clear need for improving teenagers' driving skills, judgment and behavior. Driver education programs are a crucial part of training drivers. These programs are managed on a state-by-state basis, and therefore significant variability can exist between states, and to some degree even within each state. The crash risk in Wisconsin is similar to that in other states. In 2010, Wisconsin's teen drivers (16 to 19 years of age) represented 4.8% of the total Wisconsin licensed driver population but accounted for 10.8% of the total crashes. The Wisconsin Department of Transportation (WisDOT) is dedicated to supporting new driver education programs to improve the driving skills and behavior of teen drivers. WisDOT's Division of Motor Vehicles (DMV) oversees the certification and implementation of new commercial driver-training programs, while public, private and parochial school efforts fall under the oversight of Wisconsin's Department of Public Instruction (DPI). With the variety of driver education programs, there is a need for program assessment. While WisDOT has in place an exhaustive process to license driver-training schools, the Department does not have established methods to analyze the entire statewide construct of how young drivers are trained. The goal of this research effort was to develop a means of analyzing the current young-driver training efforts within Wisconsin to better understand the effectiveness of the state's different driver-training programs and the tools and approaches used.

PROJECT INFORMATION (CONT.)	
	The research team identified five data areas of information which could be used to assess components of effective driver-training programs: guardian involvement, education and training, coordination with graduated drivers licensing (GDL), instructor qualification, and program administration. It was determined that the program administration component wasn't appropriate at this time. The research team also prepared a Program Assessment Tool User Guide. The User Guide serves as a step-by-step set of instructions for WisDOT staff members–or schools themselves–to use in completing the program assessment tool. Activities related to increased guardian involvement have the potential to make the most difference in the education and GDL process. GDL programs have been proven effective in reducing the crash risk for teen drivers, especially when GDL requirements are combined with parental or guardian involvement efforts. Coordinated efforts are encouraged throughout the implementation plans.
Web Links (if available)	http://wisdotresearch.wi.gov/

PROJECT INFORMATION	
Project Title	***Aesthetic Coatings for Bridge Components***
ID	0092-11-07
Project Cost	$120,000
Duration	37 months
SUBMITTER	
Submitter Agency	Wisconsin Department of Transportation
Submitter Contact	Daniel Yeh 4802 Sheboygan Ave. Madison, WI 53707 608-267-6977 daniel.yeh@dot.wi.gov
RESEARCH PROGRAM	
Sponsor Contact	Wisconsin Department of Transportation 4802 Sheboygan Avenue Madison, WI USA 53707 http://www.dot.wisconsin.gov
RESEARCH AND RESULTS	
Brief Summary of Research Project	This project evaluated the aesthetic and durability properties of steel coating systems used in bridge applications. Over the past several years, the Wisconsin Department of Transportation (WisDOT) has experienced performance-related issues with aesthetic and protective coatings used on Wisconsin bridges. Public agencies make

PROJECT INFORMATION (CONT.)	
	significant investments in coating materials to enhance the aesthetics and durability of steel bridges and their components. It is expected that these coatings should have reasonably good quality and performance over the relatively long service life of such structures (between 50 and 100 years). Proper application of aesthetic/protective coatings on bridges should help achieve the expected service life and reduce associated maintenance cost. The intent of this research project was to evaluate the effectiveness of available aesthetic and protective coating materials for Wisconsin highway bridge applications and to develop recommended specifications and guidelines for future selection and application of coating materials. The primary causes of coating failures in bridge applications are ineffective surface preparation prior to application and improper material selection. Through selecting appropriate coating materials and using proper application processes, the service life of the coating can be increased. This will reduce the overall required cost for bridge maintenance, and enhance the longevity of the bridge structure. The primary problem that can result from poor choice and application of coating materials in steel bridges is corrosion of steel substrate. Even partial or local failure of a coating system can cause exposure of steel to harmful environments including exposure to chlorides that result in corrosion. Not only does corrosion affect the aesthetics of a bridge, but it can impact the structural integrity and reduce the overall life span of the structure. The following were the objectives of the study: 1. Identify appropriate coating materials that can enhance the aesthetics and durability of concrete and steel bridge components over a long period of service. 2. Conduct laboratory and field tests to verify long term perfomance and quality of the selected materials. 3. Develop guidelines and specifications language for appropriate selection, application, and maintenance of such coating materials. Three types of coating systems were selected for this study including: 2-coat zinc-rich systems, 3-coat zinc-rich systems, and duplex systems (coating over galvanized steel). Twelve steel coating systems were evaluated. These coating systems included 3-coat and 2-coat zinc-rich coating systems, duplex liquid coating systems, and duplex powder coated system. The selected coating systems were applied to the appropriate steel and galvanized substrates and their performances were compared using two different accelerated weathering tests. These accelerated tests included a Freeze/UV/Prohesion test and Xenon Arc test.
Web Links (if available)	http://wisdotresearch.wi.gov/

PROJECT INFORMATION	
Project Title	***Fatigue Risks in the Connection of Sign Support Structures Phase II***
ID	0092-09-07
Project Cost	$192,542
Duration	50 months
SUBMITTER	
Submitter Agency	Wisconsin Department of Transportation
Submitter Contact	Daniel Yeh 4802 Sheboygan Ave. Madison, WI 53707 608-267-6977 daniel.yeh@dot.wi.gov
RESEARCH PROGRAM	
Sponsor Contact	Wisconsin Department of Transportation 4802 Sheboygan Avenue Madison, WI USA 53707 http://www.dot.wisconsin.gov
RESEARCH AND RESULTS	
Brief Summary of Research Project	This research effort develops a reliability-based approach for prescribing inspection intervals corresponding to user-specified levels of fatigue-induced fracture risk. The latest edition of the AASHTO design specifications (AASHTO 2001) introduced provisions for fatigue design. However, many structures presently in service were designed before fatigue provisions were part of the design specifications. The fatigue design procedures now included in these specifications do not address the variability in fatigue life that is likely for structures in service, nor do these provisions allow engineers to quantify the risk of fatigue-induced fracture for structures that have been in service. As a result, Wisconsin undertook a research effort to assess the risk of fatigue-induced fracture in existing sign support structures that were designed before the latest AASHTO specification revisions. Wisconsin has encountered problems with the connections contained in, and the in-service performance of, several cantilevered mast-arm sign support structures. Several instances of cracks and failures in mast-arm sign support structures were observed in Osseo and other locations within the state. There is an unknown probability of future failures in mast-arm-to-pole connections typical of sign support structures in Wisconsin. The researchers aimed to achieve the following objectives: 1) Formulate, and apply a reliability-based procedure for quantifying the risk of fatigue-induced fracture in mast-arm sign support structures and to generate inspection protocols for these structural systems.

PROJECT INFORMATION (CONT.)	
	2) Identify mast-arm support structural system configurations that are likely to result in enhanced susceptibility to premature fatigue-induced cracking. 3) Identify regions within Wisconsin that may be more susceptible to having structures with fatigue problems. The researchers recommend that the Osseo-type mast-arm configurations should not be used, however, if they are, they should be inspected much more frequently than a Milwaukee-type mast-arm structure. It is suggested that an Osseo-type sign support be inspected annually. Inspecting a Milwaukee-type sign can be done much less frequently (e.g. at fabrication, then in 10-year intervals up to 50 years). In addition, inspection cycles vary based on location.
Web Links (if available)	http://wisdotresearch.wi.gov/

Wyoming Department of Transportation

SWEET SIXTEEN

PROJECT INFORMATION	
Project Title	***Managing Risks in the Project Pipeline***
ID	RS02212
Project Cost	$197,000
Duration	18 months
SUBMITTER	
Submitter Agency	Wyoming Department of Transportation
Submitter Contact	Tim McDowell Wyoming Department of Transportation 5300 Bishop Blvd Cheyenne, WY 82001
RESEARCH PROGRAM	
Sponsor Contact	Wyoming Department of Transportation 5300 Bishop Blvd Cheyenne, WY 82001
RESEARCH AND RESULTS	
Brief Summary of Research Project	Research on how highway projects are loaded into the "project pipeline" and delivered has shown that mismatches between available funding and the number of projects that are "ready to go" can result in significant financial costs to a Department Of Transportation. These costs have been defined as "Holding Costs" if there are too many projects on hand and "Hurry-Up Costs" if there are too few projects ready to go. The goal of the research was to identify significant process improvements to ensure projects are delivered on time and as intended, thus maximizing the miles paved and minimizing financial risks to the organization. Overall, a balance between Holding Costs and Hurry-Up Costs or inefficiencies must be maintained in order to deliver the maximum amount of projects over time. In order to explore the various aspects of this problem, a simulation tool was developed to perform scenario analyses to help balance the project pipeline. Significant savings in delivering highway projects can be possible by implementing the recommendations from this research. A 3 percent savings is representative based on the findings of the analysis. This would amount to a total savings of $90 million, for example, for a budget of 3 billion dollars over a 10-year period.

PROJECT INFORMATION (CONT.)	
	By minimizing the amount of projects held "on the shelf" and employing practices that minimize the risks of incurring Holding Costs due to revenue shortfalls, these savings can be maximized. Furthermore, using the Critical Project Method shifts the impact of revenue uncertainties from major rehabilitation projects to minor rehabilitation projects and provides a sound, core strategy for managing the risks in the project pipeline. After considering both the recommended Core Strategies and the System and Organizational Improvement Strategies, management can decide what processes they want to change or improve. Then, the Model, Measure, Manage approach can be used to guide the organizational change process and help the organization move towards a state of continuous improvement. Finally, plans can be outlined for additional research, which may be needed to support the new strategies and process improvements.
Web Links (if available)	http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Planning/Research/RS02212_1306F.pdf

PROJECT INFORMATION	
Project Title	***Criteria for a WYDOT Culvert Selection Policy***
ID	RS10211
Project Cost	$76,492
Duration	11 months
SUBMITTER	
Submitter Agency	Wyoming Department of Transportation
Submitter Contact	Tim McDowell Wyoming Department of Transportation 5300 Bishop Blvd Cheyenne, WY 82001
RESEARCH PROGRAM	
Sponsor Contact	Wyoming Department of Transportation 5300 Bishop Blvd Cheyenne, WY 82001
Brief Summary of Research Project	Culvert systems play an integral part in any transportation inventory. Currently, WYDOT is attempting to revamp their culvert selection and design policies to provide the highest quality transportation infrastructure system to its citizens and visitors of the state. This report intends to provide guidance and recommendations on how the agency can amend their standard specifications to accomplish this task. An extensive literature review and state DOT survey was completed which investigated numerous areas found to significantly influence a culvert's design life. The areas can be categorized into two groups: geotechnical and material considerations. One notable finding is that WYDOT currently does not consider thermoplastic materials as a viable product for culvert installations. It was determined that, if these products are installed with the strictest installation procedures and superior backfill materials, they can provide an equivalent design life compared to traditional culvert materials, especially in areas of highly corrosive and abrasive environments. In addition, the DOT surveys show inclusion of thermoplastics will set economical principals into effect and provide WYDOT with a more competitive price of culvert installations. For these reasons, it is ultimately recommended that thermoplastics should be considered an acceptable material for culvert installations. Other recommendations regarding culvert installations and procedures for all culvert materials are included in this report.
Web Links (if available)	http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Planning/Research/RS10211_1301F.pdf

PROJECT INFORMATION	
Project Title	***Developing a Roadway Safety Improvement Program for Indian Reservations***
ID	RS09(211)
Project Cost	$77,934
Duration	25 months
SUBMITTER	
Submitter Agency	Wyoming Department of Transportation
Submitter Contact	Tim McDowell Wyoming Department of Transportation 5300 Bishop Blvd Cheyenne, WY 82001
RESEARCH PROGRAM	
Sponsor Contact	Wyoming Department of Transportation Matt Carlson, P.E., State Highway Safety Engineer 5300 Bishop Blvd Cheyenne, WY 82001
Brief Summary of Research Project	A five-step methodology able to address the unique challenges on Tribal lands has been developed and successfully implemented on the Wind River Indian Reservation (WRIR). This methodology includes the following steps: 1. Crash data analysis 2. Level I field evaluation of roadway conditions 3. Combined ranking of crash and field ranks to identify potential high risk locations 4. Level II field evaluation to identify countermeasures 5. Benefit-cost analysis Immediately, gaps in the crash data were discovered. The WRIR law enforcement had no way to upload their crash reports to the state crash data base. This was resolved and several years of backlog was manually uploaded into the state system. However, crashes on these roads had no location because the WRIR roadway inventories could not be linked to WYDOT's inventories. WRIR contracted to have all the Indian Reservation Roads (IRR) inventoried in GIS so they can be linked to WYDOT. The 5-step methodology proceeded on the Fremont county roads that are located on the WRIR. Twelve county roads were identified for safety improvements and the benefit-cost analysis was performed. The proposed improvements were submitted to the county for taking action.

PROJECT INFORMATION (CONT.)	
	Since the crashes on IRR had no specific locations, they were analyzed separately and the following trends were identified: • Crash severity is higher on the reservation than throughout the state • Fixed objects are the highest first harmful obstacles • Most crashes occur off the roadway Based on these trends, the similarity in quality as the county roads, and the tribes' knowledge of crashes on these roads, a systemic approach to improvements was taken. Three system-wide improvement projects related to signs, pavement markings, and guardrail were submitted to WYDOT for funding and were approved. The WRIR also recognized the need to develop a strategic highway safety plan and requested assistance from the WYT2/LTAP to apply for a grant from the Federal Highway Administration (FHWA) and was one of the selected three pilots. The stakeholders involved include Tribal leadership, WYT2/ LTAP, the Northern Plains Tribal Technical Assistance Program (NPTTAP), Bureau of Indian Affairs (BIA), and law enforcement, and Indian Health Services (IHS) and other local partners. The first step in developing a Tribal Safety Management Program was to analyze crash data and identify trends to determine the problem areas. Crash trends confirmed that alcohol, young drivers, and safety equipment use are areas of concern. The Tribal community envisions raising safety awareness and improving the safety of all users of the roadways. The identified major safety issues include behavioral, roadway, vehicle, weather, non-motorized and others. Behavioral was recognized as the greatest concern and the goals include strategies to change the safety culture of the tribal people. The WRIR successfully developed a strategic plan utilizing the available crash data, identifying ways to improve crash reporting and incorporating the five-step safety improvement program into the strategic plan. WRIR now has a comprehensive safety program.
Web Links (if available)	http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Planning/Research/RS09211%201307F%20WRIR%20WYDOT%20Report%20(Final).pdf