ANNUAL REPORT

SCDOT State Planning & Research Program
Part II: Research

South Carolina Department of Transportation
Research & Innovation Unit
in cooperation with
U.S. Department of Transportation Federal Highway Administration

Fiscal Year 2024
October 1, 2023 through September 30, 2024

Photo: Carolina Crossroads Phase I

TABLE OF CONTENTS

List of Figures

List of Tables

RESEARCH CONTACTS

Address: **Office of Materials and Research**
1406 Shop Road
Columbia, South Carolina 29201
Phone: (803) 737-6681
Fax: (803) 737-6649

Merrill E. Zwanka, P.E.
Materials and Research Engineer
Phone: (803) 737-6681
E-mail: ZwankaME@scdot.org

Terry L. Swygert
Research Engineer
Phone: (803) 737-6691
Email: SwygertTL@scdot.org

Jade E. Watford
Research Program Manager
Phone: (803) 737-6697
E-mail: WatfordJE@scdot.org

Daniel C. Cook
Research Innovation Manager
Phone: (803) 737-6627
E-mail: CookDC@scdot.org

OVERVIEW

The Research & Innovation Unit handles the day-to-day operations of the research program. The unit assists with fulfillment of South Carolina Department of Transportation's (SCDOT's) mission and goals by conducting applicable research, disseminating information, and promoting national research programs. Goals established and achieved for the Research & Innovation Unit in FFY 2024 were:

- Began Research Topic Solicitation Process for FFY 25-26
- Continued developing research projects approved by the Research and Development Executive Committee (RDEC) for FFY 23-24
- Earned AASHTO Supplemental High Value Research Award.
- Created videos to market recently completed SPR high value research.
- Hosted Inaugural Innovation Challenge and Showcase

This annual report provides a description of the FFY 2024 SPR Research Program that includes the period from October 1, 2023, through September 30, 2024. The report is divided into four parts.

Part 1: Provides a description of the program and project funding and a summary of all items included in the FFY 2024 Research Program.

Part 2: Provides a summary of the Research & Innovation Unit's accomplishments.

Part 3: Gives a description of each study started during the year.

Part 4: Contains project summaries of studies completed during FFY 2024.

Research Program / Project Funding and Research Program Summary

PART I

PROGRAM FUNDING

In FFY 2024, the SPR Research Program received $4,327,978.00 in Federal funds. Figure 1 provides a general breakdown all items funded and amounts in FFY 2024 including appropriate matching funds and corresponding carry-over funds from previous fiscal years.

- Research Projects $3,098,939.00
- NCHRP $952,155.00
- Pooled-Fund Studies $654,000.00
- Transportation Technology Transfer Service (LTAP Center) $323,219.00
- TRB Core Program $170,823.00
- Next Generation AASHTOWare Bridge Management (BrM) Project $250,000.00
- AASHTO Technical Services Programs $148,000.00

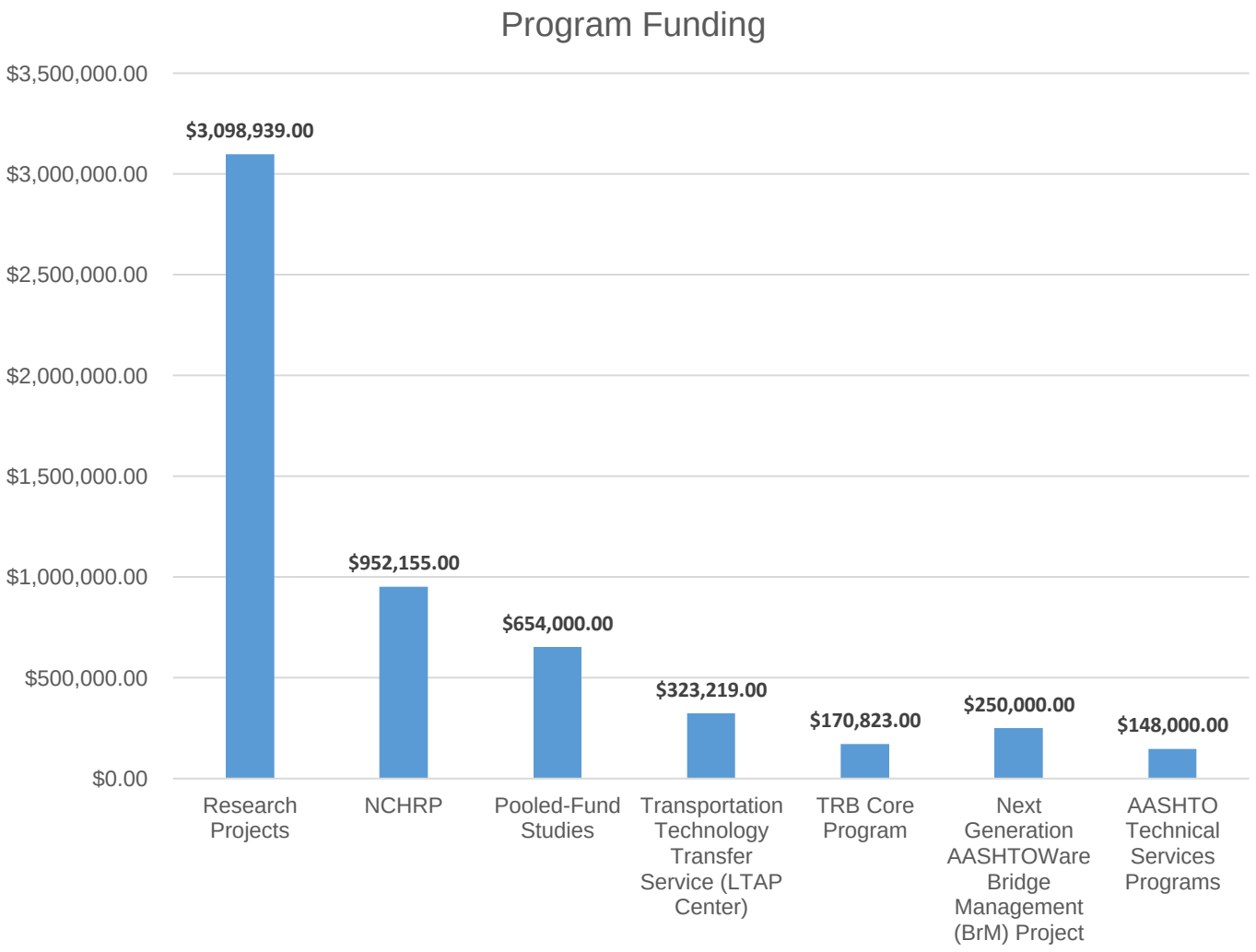

Figure 1. FFY 2024 Research Program Funding

PROJECT FUNDING

A total of twenty-four (24) projects were included in the program. Six (6) research project were initiated in FFY2024. Six (6) studies were completed during the year. Figure 2 shows how the funds obligated for research projects in FFY 2024 were distributed by general area and amounts.

- Preconstruction Management $905,881.00
- Traffic Safety $295,563.00
- Materials $487,605.00
- Hydrology and Hydraulics $559,856.00
- Bridge Maintenance $850,034.00

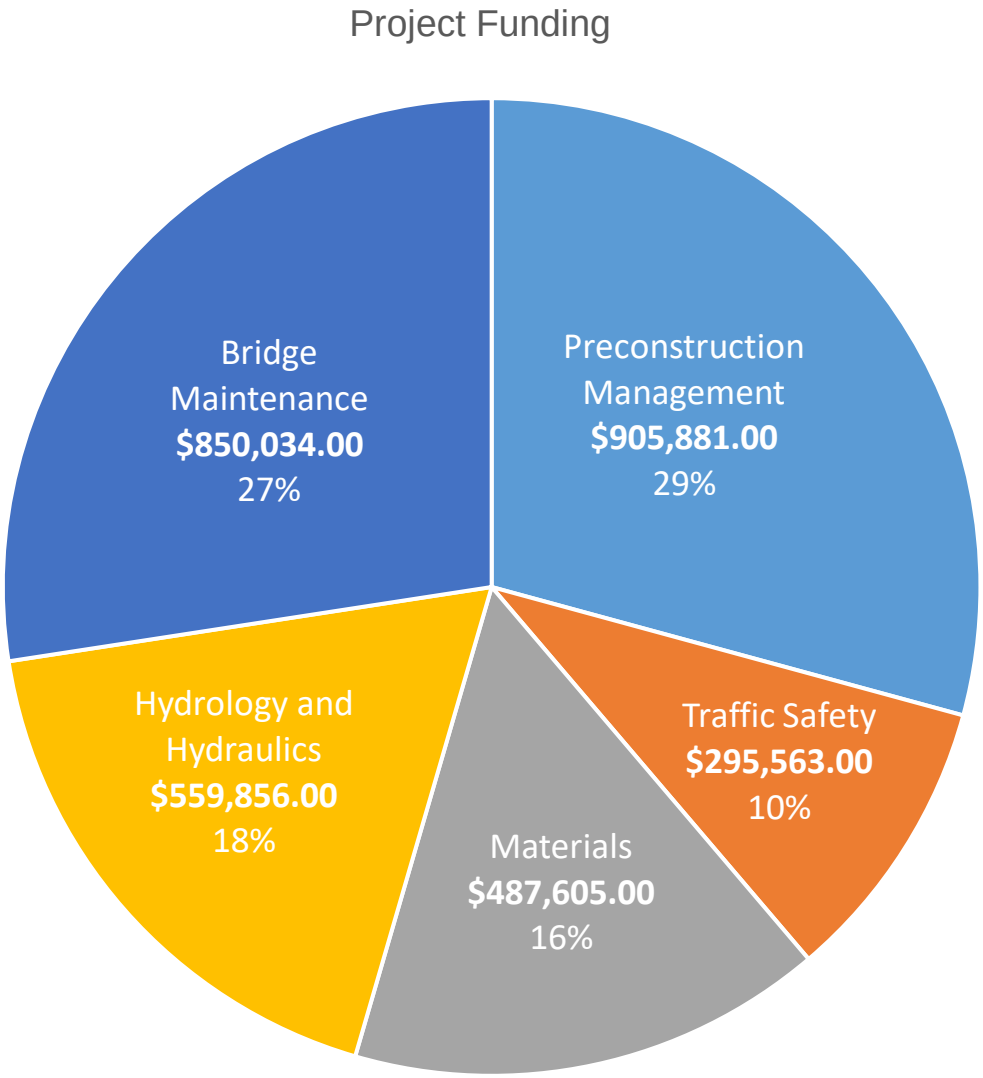

Figure 2. FFY 2024 Research Project Funding

RESEARCH PROGRAM SUMMARY

Table 1 below lists all items included in the FFY 2024 SPR Research Program. The total funding, with amount obligated previously and/or during the year, is given for each item. Also, the percent split between Federal and State funds is shown for money obligated in FFY 2024.

SPR No.	Item	Previously Funded	FFY 2024 Funds	% Split Fed-State
732	Calibration of the AASHTO Pavement Design Guide to SC Conditions - Phase II	$1,762,300.00		80-20
745	Update to SCENARIO_PC	$1,274,033.00		80-20
751	SC StreamStats Phase II: Additional Tools and Layers for Enhanced Workflow and Efficiency	$972,522.00		80-20
754	Optimization of Cement Modified Recycle Base (CMRB) Mixture Design	$320,999.00		80-20
755	Investigation and Assessment of Effective Patching Materials for Concrete Bridge Decks	$286,493.00		80-20
756	Impact of Utility Delays on Project Delivery	$414,996.00		80-20
757	A Preliminary Cost Estimating Model for Transportation Projects	$149,996.00		80-20
758	Field Trials for Cost-Effective Strengthening of SC Load Posted Bridges	$960,000.00		80-20
759	Best Practices on Collecting Asset Information from the Construction Stage	$150,049.00		80-20
760	Reducing Crash Risk at Work Zones in South Carolina	$250,879.00		80-20
761	Streamlining Permitting and Mitigation Processes to Improve SCDOT Project Delivery	$442,281.00		80-20
762	Ultra-High-Performance Concrete (UHPC) Used as a High Friction Surface Treatment (HFST) on Pavements & Bridges	$299,822.00		80-20
763	Does Design-Build Always Expedite Project Delivery: Insights from SCDOT's Historical Data from the Past Decade	$300,000.00		80-20
764	Develop or Improve Construction Scheduling Methods and Models for Construction Projects	$199,470.00		80-20
765	Investigation of Scour at Piers Located with the Influence of Abutment Scour and Development of Secondary Piers Sour Envelope Curves for South Carolina		$255,800.00	80-20
766	Evaluate, Update, and Rewrite SCDOT Seismic Design Policy and Procedures	$1,561,367.00		80-20

SPR No.	Item	Previously Funded	FFY 2024 Funds	% Split Fed-State
767	Development of Rideability Specifications	$180,000.00		80-20
768	Modernizing SCDOT Pavement Design Tools	$200,000.00		80-20
769	Utilization of Traffic Speed Deflectometer for Pavement Management Phase-II	$550,000.00		80-20
770	Data Driven Decision Making for Consultant Scope of Services and Fee Development, Update, and Maintenance		$905,881.00	80-20
771	Safety Analysis of Highway Curves Where Crashes Occur in South Carolina		$295,563.00	80-20
772	Cost-Effective Screening, Assessment, and Repair of Timber Piles		$850,034.00	80-20
774	Investigation of Current and New Generation Cementitious and Supplementary Cementitious Materials for SCDOT Concrete		$487,605.00	80-20
775	Updating Techniques for Estimating Magnitude and Frequency of Floods for Urban Streams in GA, SC, and NC		$304,056.00	80-20

Table 1. Research Program Summary

Pooled-Fund Studies Funded in FFY 2024

TPF No.	Item	FFY 2024 Funds	% Split Fed-State
5(430)	Midwest Roadside Safety Process Fund Program	$67,000.00	100-0
5(437)	Technology Transfer Concrete Consortium (FY20-FY-24)	$12,000.00	100-0
5(441)	No Boundaries Transportation Maintenance Innovations	$10,000.00	100-0
5(447)	Traffic Control Device (TCD) Consortium	$10,000.00	100-0
5(449)	Robust Wireless Skin Sensor Networks for Long-term Fatigue Crack Monitoring or Bridges	$30,000.00	100-0
5(461)	Soil and Erosion Testing Services for Bridge Scour Evaluations	$15,000.00	100-0
5(463)	Pavement Surface Properties Consortium: Phase III – Managing the Pavement Properties for Improved Safety	$20,000.00	100-0
5(464)	Hydrologic and Hydraulic Software Enhancements (SMS, WMS, Hydraulic Toolbox, and HY-8)	$10,000.00	100-0
5(465)	Consortium for Asphalt Pavement Research and Implementation (CAPRI)	$20,000.00	100-0
5(480)	Building Information Modeling (BIM) for Infrastructure	$30,000.00	100-0
5(488)	Southeast Transportation Consortium - Phase II	$15,000.00	100-0
5(518)	Implementation of Structural Data from Traffic Speed Deflection Devices	$15,000.00	100-0
5(522)	National Partnership to Improve the Quality of Pavement Preservation Treatment Construction & Data Collection Practices (PG Phase III)	$50,000.00	100-0
5(531)	Accelerated Performance Testing on the 2024 NCAT Pavement Test Track with MnROAD Research Partnership	$350,000.00	100-0

Other Items Funded in FFY 2024

TPF No.	Item	FFY 2024 Funds	% Split Fed-State
5(424)	NCHRP - FY 24	$952,155.00	100-0
5(511)	TRB Core Program Services	$170,823.00	100-0
-	AASHTO Engineering Technical Service Programs (FY24)	$148,000.00	100-0
-	Next Generation AASHTOWare Bridge Management (BrM) (FY24)	$250,000.00	100-0
-	* Transportation Technology Transfer (T3) Service (LTAP Center) (FY24)	$323,219.00*	80-20

* Additional $210,000.00 funded by FHWA Local Technical Assistance Program (LTAP)

Accomplishments

PART II

ACCOMPLISHMENTS

The Research & Innovation Unit established and achieved the following goals in the FFY 2024 program.

1. Began Research Topic Solicitation Process for FFY 25-26

Every two years, the SCDOT solicits research topics from within the Department, the U.S. Geological Survey, other State and Federal agencies, in-state institutions of higher education, and in-state trade organizations. The purposes for doing this are two- fold: (1) to identify a wide array of potentially beneficial research topics for consideration by the SCDOT RDEC for funding as SPR research projects; and (2) as a condition for FHWA Part B funding pursuant to 23 CFR § 420.209.

At the August RDEC meeting, the Research & Innovation Unit proposed a timeline of deadlines for the submission and review of topics, which was approved. On September 3, 2024, announcement emails were sent encouraging research topics submission using an online form. Sixty-eight (68) topics were submitted by the September 27, 2024 deadline. The submissions were reviewed by the Research & Innovation Unit, separated by subject matter, and forwarded to the appropriate Director and/or Deputy Secretary for their review and consideration. The Directors and/or Deputy Secretaries are asked to eliminate any topics unsuitable for further consideration that are deemed to be not beneficial for the Department. Given the number of topics received and the limited number that can be funded as projects, eliminating those that are obviously not suitable for research will provide more time for meaningful discussion and consideration of viable topics. This review also helps the Director and/or Deputy Secretary in identifying participants for the upcoming meetings from the units they supervise.

The Research Topic Solicitation Forum was held on November 13, 2024. The morning session for each category was attended by topic submitters and interested invitees, where each topic was presented and discussed in detail. The afternoon session was attended by SCDOT and FHWA personal, who voted to identify the higher priority topics and appoint a SCDOT champion who will then submit a problem statement for consideration for funding by RDEC at their winter meeting.

2. Continued developing research projects approved by the Research and Development Executive Committee (RDEC) for FFY 23-24

The Research Staff began development of the ten (10) projects from the 2022 Research Topic Solicitation Forum and two (2) Phase II projects that were approved and prioritized by the RDEC on February 6, 2023. During FFY 2024, agreements were signed on six (6) projects and 1 was assigned to in-house researchers. The rest of the projects are still in the development stage.

3. Received supplemental award for AASHTO High Value Research

Every January, AASHTO's Research Advisory Committee's (RAC) Value of Research Task Force solicits projects for consideration as high value research projects. Each year supplemental awards are also given in the most popular category and the category of safety. For 2024, SPR 752, "Safe and Cost-Effective Reduction of Load Postings for SC Bridges" was awarded the supplemental award for the most popular category Maintenance, Management and Preservation.

4. Creation of videos to market recently completed SPR high value research projects

At both national conferences and RDEC meetings, the Research & Innovation Unit has received praise for the research project videos produced with 9/8 Central Studios in Greenville, SC. Two more videos were produced in FFY 24 which highlighted projects SPR 752, **"**Safe and Cost-Effective Reduction of Load Postings for South Carolina Bridges**"** and SPR 756, "Utility Delays in Project Delivery." Links to both videos are listed below:

SPR 752: https://www.youtube.com/watch?v=gV_Zx0ZhMLw&list=PL1No24bVMn8-6U23rpDZzgt1bGwPjVqyS&index=2

SPR 756: https://www.youtube.com/watch?v=09bUD7-QkLE&list=PL1No24bVMn8-6U23rpDZzgt1bGwPjVqyS&index=6

5. Hosted Inaugural Innovation Challenge and Showcase

In 2024, SCDOT Research & Innovation (R&I) developed and administered its inaugural Innovation Challenge and Showcase. After researching and gathering information through their 2023 peer exchange, as well as suggestions from experts in the field of innovation, R&I teamed up with SCDOT's Director of Maintenance staff to develop a plan for their first Innovation Challenge. This plan would include *starting small, keeping things as simple as possible, and looking for innovations that are already in-use out in the field.* The group quickly decided that the best way to start off small and keep things simple was to focus on submissions from SCDOT Maintenance field staff.

With a tentative plan in place, R&I's next step was to create an Innovation Council to assist with developing the program, rating submissions, and planning the Innovation Showcase. Due to the challenge focusing on maintenance staff, members from the Director of Maintenance office were asked to join the council as well as three SCDOT maintenance retirees. This group offered over 100 years of combined SCDOT maintenance experience that contributed to a very successful first year.

After presenting the plan to RDEC, R&I received positive remarks and approval. The first action taken was creating a website to host information about the challenge and accept submissions

through a digital form. The website made the challenge accessible by all SCDOT maintenance offices throughout the state. Innovation manager, Dan Cook, also visited many of these offices to generate interest face-to-face. The SCDOT Office of Public Engagement created a short video outlining the challenge details that was also shared statewide.

The 2024 Innovation Challenge was officially kicked off on January 2, 2024, and SCDOT Maintenance field staff were able to submit their innovations through April 19, 2024. For its first year, the challenge received a total of eighteen (18) *in-use* innovations from district field offices. Each submission included a brief description of the innovation and how it benefits SCDOT. The council reviewed, discussed and rated each of the submissions on the following criteria: *Increased Safety, Improved Efficiency, Cost Savings, and Ingenuity* and selected winners for the 2024 SCDOT Innovation Challenge Showcase.

On July 19, 2024, the SCDOT Innovation Challenge Showcase was held at the Columbia Metropolitan Convention Center. The 81 attendees consisted of submitters, their supervisors, RDEC, and other SCDOT maintenance employees. SCDOT officials were present to give an introduction of the program and the processes which led to the challenge and showcase. Following the opening ceremony, attendees were able to see the innovations up-close. Every innovation had a highlight poster while many submitters brought their physical innovation for a live display. The council selected 7 of the 18 innovations to receive "Outstanding Innovation" awards. The closing awards ceremony at the showcase allowed the Chief Engineer for Operations and Director of Maintenance to present each winner with a plaque, custom "road" sign, and notification of a $500 bonus.

2024 Outstanding Innovation Award:

- **Vertical Work Zone Sign Stand Rack – Paul Phillips & Ed Matthews**
- **Hydraulic Equipment Trailer Ramps – Wayne Anderson & Len Stokes**
- **Stake Pocket Step Ladder & Backhoe Door Travel Lock – Bryan Cavanagh**
- **Anderson Rail Clipper – Christopher Barrick & Michael Anders**
- **Guardrail Debris Cleaner – Lenn Gardner, Lee McDaniel, & John Ives**
- **Guardrail High Shoulder Clipper – Hulee Harvey**

Description of the Studies Initiated in FFY 2024

PART III

SPR 765 Investigation of Scour at Piers Located with the Influence of Abutment Scour and Development of Secondary Piers Sour Envelope Curves for South Carolina

Organization: *USGS*
PI: *Bradley Huffman*
Start Date: *11/1/2023*
Completion Date: *10/31/2027*

Objective:

- Develop an improved method for estimating scour for piers influenced by abutment scour.
- Develop a family of secondary clear-water and live-bed pier scour envelope curves.
- Establish guidance for applying the new methodology from objectives 1 and 2 and update the scour template Excel spreadsheet for the SC Envelope Curves, created by Benedict and others (2016), as a web-based application.

The methods developed in this study will aid SCDOT in creating more efficient scour design methods. Utilizing abutment scour, pier scour, or a variation of the two, rather than the more conservative combination and minimizing the residual error throughout the pier scour envelope curves, would result in significant cost savings for the hydraulic, geotechnical, and structural design efforts at the SCDOT. Additionally, the findings and methods may be beneficial to the Federal Highway Administration (FHWA), the National Cooperative Highway Research Program (NCHRP), and other state DOTs. Updates to the scour template Excel spreadsheet for the SC Envelope Curves will provide ease of access to the guidance provided from the proposed work and an intuitive graphical interface to SCDOT.

Beyond the local benefits for SCDOT, this project also achieves the USGS Water Mission Area goals to "Anticipate and respond to water-related emergencies and conflicts" and "Deliver timely hydrologic data, analyses, and decision-support tools seamlessly across the Nation to support water-resource decisions" (Evenson and others, 2013). Completion of the proposed work will build on previous USGS studies and improve estimation of bridge scour, which would, in turn, result in time and cost efficiencies for bridge designers. If successful, other states, federal agencies, and engineering/design firms will benefit by having access to updated methodology and web-based tools to support bridge design decisions.

SPR 770 Data Driven Decision Making for Consultant Scope of Services and Fee Development, Update, and Maintenance

Organization: *Clemson University*
PI: *Dr. Ehsan Mousavi*
Start Date: *3/1/2024*
Completion Date: *2/29/2028*

Objective:
The research objectives for developing a data-driven decision-making (D3M) tool for consultant scope of services and fee development, update, and maintenance are as follows:

a. Strategically engage other State DOTs and FHWA that have acquired similar tools to understand their current practice on user accessibility, content updating procedures, and software maintenance.
b. Study the performance, efficiency, user-friendliness, and barriers to implementing the developed online platform as part of Phase 1 (SRP 753).
c. Understand SCDOT Man-hour & Fee Estimate (MFE) template and approach for contract fee estimate and negotiations and identify best practices for linking SOS and MFE documents.
d. Develop machine learning algorithms to predict project features, costs, and requirements from the SCDOT historical data.
e. Develop an online software for the agency that will take input from the project manager and returns editable contract documents (SOS, MFE, etc.) based on the findings of objectives (a) through (d).
f. Provide the initial assistance and support to champion the tool developed per objective (e).

SPR 771

Safety Analysis of Highway Curves Where Crashes Occur in South Carolina

Organization: *Clemson University*
PI: *Dr. Wayne Sarasua*
Start Date: *2/1/2024*
Completion Date: *1/31/2026*

Objective:

The overall goal of this research is to enhance safety on highway curves in South Carolina. Several objectives were outlined in the SCDOT problem statement and included: (i) develop a work flow that leverages curve inventory data, road characteristics data, and crash data to facilitate highway curve safety analysis; (ii) identify why some curves have a higher crash frequency than others with similar design curve radii; (iii) develop a prioritized list of highway curves with a high crash frequency and associated countermeasures; (iv) identify MUTCD compliance issues of signage at curves that may adversely affect safety; and (v) improve the existing circular curve inventory to facilitate future safety analysis of highway curves. The research team has further developed these objectives with additional details to help clarify the inputs and outputs. Approach provided in the current SDS, a risk assessment analysis will be performed to account for the new SC seismic hazard (currently being updated by the SCDOT) and detailed information of a bridge (e.g., type of bridge, location, traffic volume, etc.). Results will provide the new SDM with the new design philosophy that includes the appropriate performance criteria for bridges and other structures specifically for SC. The new manual will cover seismic design for other structures (e.g., retaining walls, special structures). The procedures will consider not only the most recent AASHTO guidance on seismic design, but also full consideration of west coast methodologies (e.g., Caltrans) and other guidance developed for similar structures (e.g., ASCE 61, MOTEMS) and reflect all seismic related SCDOT design memos.

SPR 772

Cost-Effective Screening, Assessment, and Repair of Timber Piles

Organization: *Clemson University*
PI: *Dr. Brandon Ross*
Start Date: *5/15/2024*
Completion Date: *11/14/2027*

Objective:

There are approximately 75,000 timber piles supporting South Carolina's bridges. Many of these piles are decades old. Recent pile failures in South Carolina highlight the need for efficient and effective screening, assessment, and analysis techniques. The proposed research will consider existing and novel pile assessment technologies, including stress wave-based methods, ground penetrating radar, thermography, and automated interpretation of hammer sounding. These will be compared to 'ground truth' data from borings and removed piles that are evaluated in structures laboratories. Load tests will link the assessment results to the likely capacity of piles having various types and amounts of deterioration.

The research objectives are to:

- Identify the causes, factors, and types of timber pile degradation in SC bridges,
- Evaluate existing and novel means of screening, assessing, and analyzing timber piles,
- Evaluate the cost- and technical-effectiveness of timber pile screening, assessment, and analysis methods for SC.

SPR 774 Investigation of Current and New Generation Cementitious and Supplementary Cementitious Materials for SCDOT Concrete

Organization: *Clemson University*
PI: *Dr. Prasad Rangaraju*
Start Date: *8/1/2024*
Completion Date: *7/31/2027*

Objective:

The main objective of this research is to conduct a comprehensive study to investigate the characteristics of new generation of cementitious and supplementary cementitious materials and the impact of these materials on a range of fresh and hardened properties of structural grade concrete mixtures. In addition, the principal objective is also to assess whether the minimum performance thresholds (ex: minimum compressive strength at a certain age, etc.) specified in the SCDOT Standard Specifications for Highway Concrete can be achieved in an efficient and timely manner. Through these findings, any necessary modifications to qualification test procedures for the cementitious materials and the concrete mix design procedures will be proposed to realize the full potential of the benefits from the new generation of cementitious materials.

The secondary objective of this study is to assess the impact of new generation of cementitious materials and concrete on the structural performance of reinforced concrete, and determine if the existing provisions for design details, such as development length of reinforcement in concrete, can be achieved with the new generation concrete mixtures. Work pertaining to this objective will be conducted in Dr. Fabio Matta's lab at the University of South Carolina (USC). The objective of the collaboration with USC is twofold:

- Assess compliance of representative new-generation (e.g., Portland-limestone cement) concrete investigated at Clemson University with current SC design provisions for bond and development of conventional (black) steel bars.
- Establish whether the mechanical interaction between steel bars and representative new generation concrete mixes for South Carolina is comparable to that with standard Portland cement concrete, based on the extensive ACI 408 Tension Lap Splice Database (last updated in April 2021).

SPR 775

Techniques for Estimating Magnitude and Frequency of Floods for Urban Streams

Organization: *USGS*
PI: *Toby Feaster*
Start Date: *7/1/2024*
Completion Date: *12/31/2027*

Objective:

The scope of the SC part of the project will include USGS continuous-record streamgages and crest-stage gages at urban basins in SC, where an urban basin is being defined as a basin with 10 percent or more of impervious area. To enhance the available data set, the USGS also will investigate the potential inclusion of urban streamgages from nearby States that share similar ecoregions as GA, SC, and NC. In the previous urban flood-frequency investigation in GA, SC, NC, Feaster and others (2014) included urban streamgages from Florida (2), GA (43), New Jersey (16), NC (40), and SC (15). Along with the criteria that the urban streamgages from other states need to share similar ecoregions as GA, SC, and NC, the period of record from the urban streamgages needs to represent a period with relatively stable urbanization.

The objectives of the urban flood-frequency project are to:

- Update the magnitude and frequency of peak-streamflows (hereafter referred to as peak flows) at USGS urban streamgages,
- Update basin characteristics for the urban basins to include the most recent versions such as percent of impervious area and percent of development,
- Update the regional urban flood-frequency equations for the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probability (AEP) streamflows for GA, SC, and NC.
- Update the USGS StreamStats application to include the new equations and as needed, provide training to SCDOT staff on proper application of the equations using StreamStats. The USGS StreamStats application will also be updated to include the regulated regression equations that were recently developed by Feaster and Musser (2023).

Along with the urban streamgages, this investigation also will leverage the rural flood-frequency statistics that were updated as part of the rural flood-frequency investigation also done in cooperation with the SCDOT and published in Feaster and others (2023). Using the flood-frequency statistics computed at rural streamgages, the urban flood-frequency investigation will test the validity of developing a single set of flood-frequency equations that would apply to both rural and urban basins. If successful, this would simplify the SCDOT methods for applying the USGS flood-frequency regression equations and improve the consistency of flood-frequency estimates for rural and urban basins.

Summaries of SPR Studies Completed in FFY 2024

PART IV

SPR 732

Calibration of the AASHTO Pavement Design Guide to SC Conditions - Phase II

Organization: *University of South Carolina*
PI: *Dr. Sarah Gassman*
Completion Date: *12/31/2023*

Objective:

The overarching goal of this multi-phase research effort is to reduce design bias and increase the precision of the model predictions used in the MEPDG with full consideration of South Carolina local conditions. The objective of Phase II was to build upon the studies in Phase I to obtain local calibration factors and improve distress predictions by collecting new data of high priority.

Results:

To support the local calibration of the distress and performance models of the MEPDG, extensive laboratory and field studies were performed to collect high-priority, high-quality materials data for flexible and rigid pavements in South Carolina. A review of historic pavement design files produced 11 asphalt concrete (AC) pavement sections and 11 Portland cement concrete (PCC) pavement sections for this Phase II study. These sections were further subdivided into smaller segments based on FWD testing and manual distress surveys, resulting in a total of 76 AC pavement segments (66 for "Flexible New AC" models and 10 for "Flexible New Semi-Rigid" models) and 24 PCC pavement segments (for "Rigid New JPCP" models) available for calibration. The results of this study should allow the SCDOT to produce more accurate pavement designs for current conditions with a high degree of reliability. This is due to the development of new South Carolina-specific distress and performance relationships using data obtained through extensive field and laboratory studies of local materials and pavement performance, considering high volumes of truck traffic and new pavement materials.

SPR 754

Optimization of Cement Modified Recycled Base (CMRB) Mixture Design

Organization: *Clemson University*
PI: *Dr. Prasad Rangaraju*
Completion Date: *8/31/2023*

Problem:

Maintaining South Carolina's extensive road network within budgetary limits poses a challenge for SCDOT. The current approach to Cement-Modified Recycled Base (CMRB) design is based on achieving desired unconfined compressive strength and maximum density at optimum moisture content (OMC) and lacks emphasis on durability performance of the CMRB. This study aims to scrutinize existing practices and enhance CMRB planning, design, and testing to improve long-term durability and performance.

Objectives:

To assess CMRB performance, base soils from four different regions representing different lithologies in SC were analyzed. Chemical stabilizing agents including Portland cement, lime, lime kiln dust, and Portland Limestone cement were investigated. Laboratory testing focused on properties such as unconfined compressive strength, flexural strength, split tensile strength, indirect tensile strength, drying shrinkage, and durability under wetting/drying (W/T) and freeze/thaw (F/T) cycles. Key findings highlight optimal cement dosages, the impact of clay content, and the role of Recycled Asphalt Pavement (RAP) in mixture design.

Results:

The study recommends refining soil sampling techniques, permitting larger RAP particles, and increasing minimum cement content for UCS testing, particularly in clay-rich soils. It also advocates for slurry application, although production phase concerns with controlling the moisture content needs to be addressed. Factoring in drying shrinkage and ensuring precise moisture control in the production phase will significantly improve the service life, however, further research is needed to establish threshold levels shrinkage for acceptable performance. Additionally, a novel use of a test method for determining the shrinkage using the restrained shrinkage ring is proposed, facilitating its inclusion in CMRB mixture design.

Implementation of these adjustments in FDR mixture design is projected to enhance CMRB effectiveness. These modifications address sampling accuracy, RAP particle size, and cement content testing, while also considering mixing, compaction, and quality assurance. These changes aim to boost pavement condition scores in future, presenting a cost-efficient road management solution for South Carolina pavements.

SPR 756 Impact of Utility Delays on Project Delivery

Organization: *Clemson University*
PI: *Dr. Kalyan Piratla*
Completion Date: *2/29/2024*

Problem:

Many types of utilities including but not limited to potable water, sewer, gas, telecom, and power commonly use the right of way (ROW) of public roads as allowed by laws, regulations, and policies. However, the right of way, especially in urban and suburban regions, is becoming increasingly congested with buried and above ground utility infrastructure. In South Carolina, transportation construction projects often conflict with existing utilities, and these conflicts need to be resolved. Finding these conflicts is not a trivial process because location data for existing utility facilities with the required accuracy is not always readily available. In addition, the project ROW and many design details are also not known upfront, further making the conflict identification a complex and time-consuming process. As a result, many such conflicts are typically not recognized before it is too late to change the project design to avoid them. Most conflicts are resolved by relocating the utilities, which might result in additional issues, particularly during construction, if not managed properly. In general, several uncertainties are often associated with the entire utility coordination and conflict resolution process, from the identification of conflicting utilities to having any needed relocations completed within the scheduled timeframe. The overarching objective of this research study is to develop recommendations for minimizing utility relocation related delays to improve project delivery efficiency on SCDOT's construction projects.

Results:

The following are a few best practices recommended for consideration:

- Engage utility owners early in the project and maintain frequent communication
- Provide sufficient time for utilities to plan and relocate, and improve the requirements of the utility relocation schedules
- Promote the use of adequate utility investigations including below and aboveground facilities in accordance with the ASCE 38-22 Standard
- Train SCDOT personnel to manage utility conflicts more effectively
- Try to avoid late design changes; when unavoidable, effectively communicate these changes with relevant utility owners and compensate utility owners for the design and relocation rework
- Extend utility coordination into the construction phase
- Have construction engineering and inspection (CEI) consultants handle inspection and as-built documentation of utility relocations in accordance with the ASCE 75-22 Standard
- Modify the encroachment permit language suggesting potential liquidation of damages if relocations for utilities without prior rights were to delay the transportation project

- Explore the possibility of acquiring ROW for utility relocations outside of the SCDOT's ROW, at least for utilities with property interests or prior rights
- Have an on-call service contract for pre-letting clearing and grubbing separately from the transportation project contract
- Continue to reimburse wet utilities for schedule-compliant relocations beyond the current senate bill timefram
- Explore the possibility of requiring right-of-way certification completed prior (~2 months) to utility certification

SPR 757 A Preliminary Cost Estimating Model for Transportation Projects

Organization: *Clemson University*
PI: *Dr. Kalyan Piratla*
Completion Date: *7/31/2024*

Problem:

Construction needs far exceed the budget limitations of SCDOT, like many other state highway agencies (SHAs). As a result, SCDOT is required to prioritize construction projects based on benefit to cost ratio. In this regard, early-stage cost estimates are significant for project feasibility. The planning phase is typically when these early cost estimates are developed to evaluate project feasibility. The challenge, however, is that no design detail is available at this stage, and the cost estimates would have to be based on broad project type, size, and location features.

Results:

The research focused on developing planning-level cost estimating models for road widening, bridge replacement, and intersection improvement projects, utilizing linear regression and artificial neural networks with inputs from project size and location features based on bid data from past SCDOT projects, aiming to create a user-friendly tool, PCET, to aid in rapidly generating planning cost estimates for transportation projects despite challenges in accuracy due to broad project features and occasional time constraints.

Further validation using new project data would increase confidence in the PCET tool for SCDOT, revealing that total project costs can be predicted based on a few key characteristics available during the planning stage, with caution needed for widening projects due to smaller sample size and the necessity for added contingency to estimates.

The research team suggests implementing the PCET tool in two phases: Phase 1 involves validating the tool against conventional methods for six months to a year, focusing on widening, bridge replacement, and intersection projects. Phase 2 broadens the tool's use with necessary adjustments and incorporates the SCHCCI for cost estimates. Additionally, it is recommended that the PCET tool be re-trained every two years or so using updated bid data to ensure accurate and informed cost predictions for future projects.

SPR 759

Best Practices On Collecting Asset Information from the Construction Stage

Organization: *Clemson University*
PI: *Dr. Robert Le*
Completion Date: *2/29/2024*

Problem:

Given that SCDOT spends around 50% of the total annual budget on maintenance and preservation for the transportation system, the need for updating transportation asset data after construction completion is tremendously significant. Construction records such as construction inspection results (i.e., material testing, and DWRs) or as-built plans are a great source of in-place asset data. For example, assets' location, materials, dimensions, and key dates (project start date, final inspection date, and date facility opens to traffic) are typically included. However, there is currently a disconnection between project delivery and asset operation and maintenance (O&M) at SCDOT. Very little, if any, of the as-built data collected by construction inspectors are passed and reused in the operation and management of the asset. This disconnection can lead to significant data loss and poor access to up-to-date data. At SCDOT, maintenance staff spends significant time and resources re-collecting those as-built data that may have already been captured in DWRs. The cost of this duplicated data collection issue can be substantial.

Results:

The research outcomes will have a direct impact on data collection practices within SCDOT. The proposed data collection technique resulting from this research will enable SCDOT to improve its existing asset management program. This study will provide SCDOT with new guidance and a reliable tool for quickly migrating construction data into asset data repositories. It could significantly reduce the duplication of data collection in the O&M stage by directly leveraging digital as-built project data. It is also expected that this project will contribute to SCDOT's asset management programs by helping highway maintenance staff obtain access to more accurate and complete

SPR 760 Reducing Crash Risks at Work Zones in South Carolina

Organization: *University of South Carolina*
PI: *Dr. Nathan Huynh*
Completion Date: *6/20/2024*

Problem:

Work zones alter the normal traffic flow requiring motorists to change their speeds, process information from roadside signs, make merging maneuvers, and travel next to cones or barricades. These activities can lead to vehicular crashes and injury to motorists and workers in the work zone. Despite these efforts and the introduction of the Workers' Safety Act (House Bill 4033) in 2017 where penalties include fines, jail time, and points assessed against an offender's driving record, the number of work zone-related crashes has remained high as shown in the figure above, which suggest that more can be done to improve work zone safety.

Results:

Several concrete findings are found from this study which would lead to a decrease in the number of injury crashes at work zones in South Carolina if implemented.

- To reduce truck-involved crashes at work zones, it is recommended that the SCDOT consider improving lighting conditions at work zones at night, prioritizing speed management measures in work zones (e.g., implementing speed enforcement strategies, enhancing signage, and utilizing traffic calming measures to encourage drivers to adhere to posted speed limits and adjust their speed according to roadway conditions), and target both male and female drivers in educational campaigns aimed at promoting the use of seat belts and avoiding distracted driving.
- To reduce the number of work zone rear-end crashes with collision speeds of 35 mph or higher, it is recommended that when promoting work zone safety, the SCDOT should consider getting the message to older drivers (50 and above). Other countermeasures to consider include educating both the trucking industry and the public about the danger of truck-involved crashes in work zones, improving traffic flow, and reducing congestion in the proximity of the first work zone sign.
- It is recommended that the SCDOT consider expanding the Safety Improvement Team Program in partnership with the South Carolina Department of Public Safety given that it was found the presence of law enforcement was found to be effective in reducing traffic speed through work zones.
- It is recommended that SCDOT consider using the developed work zone risk assessment tool to assess the crash risk of a work zone and the benefit-cost of implementing countermeasures to mitigate those risks.

SCDOT

RESEARCH & INNOVATION