3rd Regional (East Coast) Peer Exchange for Sustainable Eco-Resilient Bridges & Structures

EPxSERB-2025

Technical Program

Constructed Facilities Laboratory

Department of Civil, Construction, and Environmental Engineering

North Carolina State University

Raleigh, NC

August 4-5, 2025



Meeting venue: Fitts-Woolard Hall | FWH 2331
Centennial Campus, NC State University
915 Partners Way
Raleigh, NC 27606

Parking Permits: Virtual permits will be emailed to participants for the Oval West Parking Deck, across the street from Fitts-Woolard Hall.

Technical Program

Day 1, August 4, 2025 | FWH 2331

12:00 – 1:00	**Buffet Lunch | FWH 2nd Floor South Lobby (by Hunt Library)**
1:00 – 1:20	**Welcome and Introduction** Rudi Seracino, NC State University Steven Nolan, FL DOT
Session: **Chair:**	**Resilient Infrastructure and Case Studies** **Trey Carroll, NC DOT**
1:20 – 1:40	**Bridge Research Opportunities at the Colorado Department of Transportation and Beyond** Thien Tran, Colorado DOT
1:40 – 2:00	**Chimney Rock Bridges Post Hurricane Helene** Nicole Brown, STV
2:00 – 2:20	**Low Battery Seawall in Charleston, SC: A Landmark Application of GFRP Reinforcement** Fabio Matta, University of South Carolina
2:20 – 2:40	**Is the Most Sustainable Bridge the One You Already Have?** Jacob Bowers, and Brandon Ross, Clemson University
2:40 – 3:00	**Marc Basnight Bridge - Economy, Durability, Resilience** Domenic Coletti, HDR
3:00 – 3:30	**Coffee Break**
Session: **Chair:**	**Concrete Reinforcement Alternatives** **Taylor Brodbeck, NC State University**
3:30 – 3:50	**Manufacturing Glass FRP Reinforcing Bar** Bogdan Patrascu, Mateenbar Composite Reinforcements
3:50 – 4:10	**Advancing GFRP-Reinforced Concrete: Fire Performance, Seismic Behavior, and Sustainability Insights** Borna Hajimiragha, MST Rebar Inc.
4:10 – 4:30	**Designing with GFRP: Key Specs and AASHTO LRFD Highlights** Khaled Mohamed, VROD
4:30 – 4:50	**A New Reinforcing Method for the Systemic Evolution of the Built Environment** Mark Schumacher, FSC Technologies Inc.
4:50 – 5:10	**Next Generation Coatings for Rebar ASTM A1124/A1124M-23: Standard Specification for Textured Epoxy-Coated Steel Reinforcing Bars** Jeffrey Rogozinski, The Sherwin Williams Company
5:10 – 6:30	**Constructed Facilities Laboratory Tour**
6:30 – 8:00	**Buffet Dinner | FWH 2nd Floor South Lobby (by Hunt Library)**

Day 2, August 5, 2025 | FWH 2331

8:00 – 9:00	**Continental Breakfast | FWH 2nd Floor South Lobby (by Hunt Library)**
Session: **Chair:**	**Earthquake Engineering and Coastal Flooding** **Cabell Garbee, Garbee Engineering**
9:00 – 9:20	**Estimating Seismic Demands for Bridges Incorporating Site Effects into Rapid Post-Earthquake Assessments** Jungmin Lee, and Ashly Cabas Mijares, North Carolina State University
9:20 – 9:40	**Rapid Seismic Evaluation of Bridge Inventories via Direct Displacement-Based Approach** Ana Paula Bona, and Mervyn Kowalsky, North Carolina State University
9:40 – 10:00	**The Effects of Large-Scale Roadway Adaptations on Barrier Evolution: Breaching Processes and Management Strategies for Pea Island's Coastal Highway** Roya Sahraei, and Katherine Anarde, North Carolina State University
10:00 – 10:20	**Evaluation of Chronic Coastal Flooding Inundation of Low-Lying Roadways and Impacts to Community Livability** Ryan McCune, and Katherine Anarde, North Carolina State University
10:20 – 10:50	**Coffee Break**
Session: **Chair:**	**Vulnerable Roadways and Steel Reinforcing Bar Corrosion** **Mohammad Qambar, NC State University**
10:50 – 11:10	**Identification and Prioritization of Vulnerable Roadway Segments for Proactive Resilience Planning and Response** Matheus Jesus Ribeiro Araujo, and Shane Underwood, North Carolina State University
11:10 – 11:30	**Halls River Bridge Bulkhead: Seven-year Evaluation of FRP Concrete Reinforcements from Seawater Concrete** Osama Omar, Alvaro Ruiz, Antonio Nanni, and Francisco De Caso, University of Miami
11:30 – 11:50	**Corrosion Mitigation in Concrete Bridge Decks Using Soybean Methyl Ester (SME)** Jaedoh Han, G.C. Gonzalez-Berrios, and Moe Pourghaz, North Carolina State University
11:50 – 12:10	**Behavior of FRP Repaired Prestressed Concrete Bridge Beams after 2 Years in Service** Kendon Gann, Greg Lucier, and Rudi Seracino, North Carolina State University
12:10 – 12:30	**Discussion and Closing** Richard Krolewski, FRP Institute Rudi Seracino, North Carolina State University
12:30 –	**Box Lunch | FWH 2nd Floor South Lobby (by Hunt Library)**

Bridge Research Opportunities at the Colorado Department of Transportation and Beyond

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The Colorado Department of Transportation (CDOT), like all states, conducts a program of research and innovation (R&I) funded through the Federal Highway Administration's (FHWA) State Planning and Research Subpart B program (SPR-B). Bridges are a large and important part of this program as we seek to improve bridge management and operations, control maintenance and repair costs, and increase bridges' usable life and their resilience to changing hazards. The Office of Applied Research (OAR) of the Colorado Department of Transportation conducts and manages many bridge-related research projects as part of a broad portfolio of applied research. CDOT/OAR continuously looks for needs and opportunities within CDOT that can be addressed through research, as well as external research opportunities such as pooled fund projects that can advance the Department's goals and serve the traveling public. The overarching goal of CDOT research is to develop innovative, research-driven solutions to the complex transportation challenges facing our state. CDOT's program is strongly focused on projects that produce implementable findings to improve the ways in which we operate. More than a dozen bridge-related research projects are currently underway on topics such as bridge deck preservation, bridge scour, robotic inspection, guardrail design, building information modeling (BIM) for bridges, protection of bridges from overweight vehicle impact, and more. Our research also covers new methods and technologies such as new or improved materials, and application of new methods to solve problems such as the use of machine learning.

Chimney Rock Bridges Post Hurricane Helene

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In response to the widespread destruction caused by Hurricane Helene in September 2024, NCDOT initiated the replacement of key infrastructure along the US 74A corridor between Bat Cave and Chimney Rock, where multiple bridges over the Broad River were heavily damaged or destroyed. Currently in the design phase, this effort is being delivered through North Carolina's first Progressive Design-Build (PDB) contract, with STV serving as Lead Structural Designer.

The project includes the replacement of two critical bridge structures and associated roadway improvements, with a primary focus on long-term resiliency and structural performance. Advanced 2D hydraulic modeling is guiding structural layout decisions and informing the design of substructure systems.

Structural analysis efforts are centered on optimizing foundation design, pier configurations, and span arrangements around the hydraulic constraints while maintaining constructability within a constrained mountain corridor. Temporary bridge strategies and staged construction are being integrated into the design to preserve traffic operations throughout implementation.

By prioritizing resilient structural systems, hydraulically informed design, and close coordination between design and construction teams, this project represents a forward-looking approach to rebuilding critical infrastructure in the wake of extreme weather events.

Low Battery Seawall in Charleston, South Carolina: A Landmark Application of GFRP Reinforcement

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The City of Charleston has embarked on a landmark project to redesign and rebuild the concrete seawall and adjoining sidewalk along the City's Low Battery waterfront. The objectives are to ensure longevity, provide resiliency against sea level rise, and enhance the accessibility of the historic waterfront. The project started in 2019 and its final phase is slated for completion in mid-2025. A distinctive feature of the project is the use of glass fiber-reinforced polymer (GFRP) reinforcement in lieu of steel reinforcement to ensure resistance to corrosion, which is notoriously the major instrument of degradation of reinforced concrete (RC) exposed to saltwater. This presentation showcases this project by discussing: (i) first cost and its role in the City's decision to rely on a less familiar technology; (ii) structural design and detailing, also including a comparison between GFRP RC and steel RC counterparts and how salient differences were addressed; (iii) constructability and speed of construction, which played a key role in transitioning to an all-GFRP solution in Phases III-IV; and (iv) takeaways from the design and field experience of this first large-scale GFRP RC public infrastructure project in South Carolina.

Is the Most Sustainable Bridge the One You Already Have?

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The South Carolina Department of Transportation has approximately 9000 bridges in its portfolio. Most of these bridges are on rural route, decades old, and not designed for modern truckloads. This presentation will describe completed and ongoing work developing retrofit strategies for different bridge types in South Carolina. The retrofits aim to increase structural capacity and/or improve load distribution. Their effectiveness has been evaluated in field and lab conditions. Trade-offs between retrofitting old bridges versus building replacement bridges will be discussed.

Marc Basnight Bridge - Economy, Durability, Resilience

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Oregon Inlet is one of the most dangerous inlets on the Atlantic coast. Treacherous currents, constantly shifting bathymetry, and violent storms are normal occurrences. But the surrounding North Carolina Outer Banks, a 200 mile long series of barrier islands, are also renowned for their scenic beauty, pristine beaches, and great fishing. Access along the Outer Banks is provided by NC Highway 12, which crosses Oregon Inlet on the Herbert C. Bonner Bridge, a critical link between Hatteras and Bodie Islands. Unfortunately, the Bonner Bridge has suffered from severe scour and deterioration in the harsh marine environment, and has required nearly continual maintenance, repair, and retrofit by the North Carolina Department of Transportation (NCDOT) since its completion in 1962.

In 1993 NCDOT undertook a planning study to evaluate alternatives for replacement of the Bonner Bridge. The problem was more complicated than simply replacing the bridge; NC 12 south of the Bonner Bridge runs through the Pea Island National Wildlife Refuge, and Hatteras Island in this area has proven to be susceptible to frequent breaches and washouts during storm events. The entire NC 12 corridor was studied, and a "phased construction" alternative was developed which addressed different segments of NC 12 over time.

In 2011, NCDOT awarded a design-build contract for the first phase of the overall NC 12 project – the replacement of the Bonner Bridge – to a design-build team lead by PCL Civil Constructors, with HDR as the lead designer. NCDOT's contract specified a 100-year service life, design for up to 84' of scour, and minimal environmental impacts. The associated design and construction challenges created opportunities for innovation and creativity. The design-build team divided the 2.8 mile long bridge into five design regions based on scour depth and subsurface conditions, required vertical and horizontal clearances, vessel collision requirements, and construction and environmental constraints. Simple, repetitive structural details took advantage of economies of scale in the long structure and facilitated the extensive use of precast concrete construction, contributing to high levels of construction quality, durability, economy, constructability, and environmental sensitivity. Innovative, environmentally sensitive construction approaches and extensive coordination and collaboration with permitting agencies alleviated concerns about large-scale construction activities in this highly sensitive site. PCL's winning bid of $215.8 million, approximately $64 million less than its nearest competitor, illustrates that achieving these kind of desirable results can be accomplished economically.

This presentation will discuss the team's innovative solutions to multiple challenges, and will highlight the differences in the approaches taken to the design of the Bonner Bridge in the 1960s versus the Basnight Bridge 50 years later.

Manufacturing Glass FRP Reinforcing Bar

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This presentation will provide a high-level overview of the pultrusion process used for manufacturing fiberglass reinforcing bars. Additional highlights will be made to quality and testing requirements prescribed by the ASTM material specifications.

Advancing GFRP-Reinforced Concrete: Fire Performance, Seismic Behavior, and Sustainability Insights

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Glass Fiber-Reinforced Polymer (GFRP) bars offer a compelling alternative to steel reinforcement in concrete structures, providing key benefits such as corrosion resistance, high tensile strength-to-weight ratio, electromagnetic neutrality, and long-term durability. These advantages have positioned GFRP as a preferred solution in aggressive environments and infrastructure applications where service life, maintenance, and sustainability are critical considerations. As the adoption of GFRP reinforcement continues to expand, recent research and development initiatives have sought to address outstanding performance parameters to support broader code acceptance and engineering confidence.

This presentation highlights two major areas of recent advancement: the fire performance and seismic behavior of GFRP-reinforced concrete elements. Results from full-scale fire testing programs and emerging findings from ongoing seismic studies will be presented, providing valuable insights into the structural response of GFRP systems under extreme conditions. In addition, updates to the Environmental Product Declaration (EPD) for GFRP bars will be discussed, illustrating the material's low embodied carbon footprint. Sustainability case studies will also be shared, showcasing how GFRP reinforcement contributes to durable, low-maintenance, and environmentally responsible construction

Collectively, these developments represent significant milestones in advancing GFRP technology and enhancing its role in modern, resilient, and sustainable infrastructure.

Designing with GFRP: Key Specs and AASHTO LRFD Highlights

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The presentation covers the mechanical and durability properties of GFRP bars in accordance with ASTM D7957 and D8505, emphasizing test methods and minimum performance requirements. This establishes clear benchmarks for designers to set acceptance criteria for GFRP reinforcement. Key equations and critical limits from the AASHTO LRFD GFRP Design Guide, including flexure, shear, serviceability, development lengths, and splices, will be reviewed, highlighting the parameters that govern GFRP-reinforced bridge deck designs. Additionally, the presentation addresses current gaps in design and research—particularly regarding seismic design and detailing—and proposes interim practices based on recent experimental findings.

A New Reinforcing Method for the Systemic Evolution of the Built Environment

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FSC has created a new reinforcing technology for ceramic behaving materials which consists of wrapping a concrete element with a resin impregnated continuous FRP fiber, tensioned at its quasi-creep limit, around the element to be reinforced. Specifically for civil structures and infrastructures, we have already performed several full-scale lab tests proving a significant improvement in performance metrics paired with a significant cost reduction vs. elements and structures using embedded steel or pultruded composite reinforcements.

The tensioned wrapping creates a strategically located compression in the concrete elements and its surface position improves its structural efficiency. By employing the tensioned wrapping, the concrete to composite stresses are not transmitted by the surface shear created by the concrete/resin component gluing. At each path variation of the composite wrapping, the fiber tension creates a localized compression on the concrete element which is creating a friction based anchoring of the reinforcement to the element and as well a fiber to fiber friction stress transfer. The absence of shear for transmitting tensile stresses between the concrete and its reinforcement, the method also permits the use of lightweight aggregates.

Due to the unique anchoring, the fire resistance is determined only from the fiber capacity, the resin glass temperature transition is not affecting the operating temperature of the element. Since each single roving is already pre tensioned at its admissible force, even in the case of very large composite sections, there is almost zero shear lag in the composite, thus a negligible ultimate stress reduction vs smaller sections.

The method opens up a new way to create large structures by assembling standardized smaller elements. The assembly can happen by either gluing the surface tensioned composite of one part vs. its homologue on adjacent parts, but also using the tensioned wrapping to hold cast in accessories with threaded bushings. This second method permits the creation of inexpensive dry full moment joints which are also fully demountable.

A third method permits to assemble thin UHPC shells with more massive elements (in the high shear zones) and using the tensioned wrapping to obtain a total structural cooperation of the single elements. This method, initially envisioned for demanding offshore floating structures that need to have a ratio between loads and self-weight close to reticular steel structure, should also be applicable on civil infrastructures as bridges since it maximizes the use of UHPC efficiency by employing easy to produce and design optimized thin shells, reducing cost and improving service life on bridge elements.

To date we have already performed tests on concrete pipes (hydraulic pressure and crushing), railways sleepers, slabs, walls, bridge deck precast elements, and a multi-story frame for buildings which have been tested as single elements and also as a node. In addition to this new method of concrete reinforcing, the technology is developing also in energy applications such as H2 high pressure storage and ultra-high temperature applications in the nuclear energy arena since it permits significant improvements and cost reductions vs. SiC SiC composites. The method is also proving very efficient on blast proof structures and anti-ballistic shields.

Next Generation Coatings for Rebar
ASTM A1124/A1124M-23: Standard Specification for Textured Epoxy-Coated Steel Reinforcing Bars

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Concrete faces durability challenges due to the corrosion of steel reinforcements (rebar) embedded inside. The reinforcing steel increases the concrete's tensile strength to help it resist cracking and breaking. However, rebar can also weaken concrete when it corrodes. While most rebar is uncoated – leaving it vulnerable to corrosion – some receives an epoxy coating that has well-documented benefits and drawbacks. However, an innovative secondary coating for rebar has been proven to improve on the qualities of both uncoated and epoxy-coated rebar (ECR), offering the concrete and construction industries a superior option that delivers long-term benefits. Known as textured epoxy coating (TEC), this innovative technology is officially recognized under the newly approved ASTM A1124/A1124M-23: Standard Specification for Textured Epoxy-Coated Steel Reinforcing Bars guidelines. TEC offers enhanced protection for ECR, which is commonly known as green bar and is the industry's most-used method of corrosion protection. In bond strength, damage tolerance and corrosion resistance, rebar coated with a TEC (TEC rebar) offers significant improvements over both ECR and uncoated rebar, known as black bar. As such, TEC presents a compelling case for adoption – promising cost savings, extended asset life and a more sustainable approach to infrastructure development. This presentation reviews the new specification ASTM A1124/A1124M-23: Standard Specification for Textured Epoxy-Coated Steel Reinforcing Bars.

Estimating Seismic Demands for Bridges Incorporating Site Effects into Rapid Post-Earthquake Assessments

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Rapid post-earthquake assessment for bridge inspection prioritization requires efficient and accurate seismic hazard definitions. Spectral displacements can be used because they correlate better with damage potential in bridges than acceleration does. Additionally, local site conditions can significantly change the amplitude, frequency content, and duration of earthquake ground motions, so a comprehensive understanding of geotechnical properties of the subsurface materials is required. In this study, we examine efficient hazard definitions for rapid post-earthquake assessment of bridges to estimate the spectral displacements while incorporating site effects. In addition, a framework is proposed for effectively incorporating site effects into rapid post-earthquake assessments as the seismic hazard can be characterized by multiple approaches depending on the amount and type of available information. Two case studies are described to obtain displacement response spectra. The first case study estimates spectral displacements using existing ground-motion models. Selected ground-motion models are used to compare estimates of the corresponding displacement response spectra at selected bridges and nearby ground-motion recording stations in Anchorage, Alaska. The time-averaged shear-wave velocity in the top 30 m, known as Vs30, is one of the commonly used site parameters, and it is considered here to incorporate site effects into ground-motion models. Second, we implement simple modification to ground-motion records to provide an alternative method to the consideration of site effects. The 2018 Anchorage earthquake is selected to obtain empirical displacement response spectra for comparison purposes.

Rapid Seismic Evaluation of Bridge Inventories via Direct Displacement-Based Approach

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Following a potentially damaging earthquake, rapidly assessing the performance of impacted structures accelerates decision-making and helps mitigate indirect losses. Bridges, in particular, serve as critical lifeline structures by offering alternative routes for emergency response and evacuation. In recent years, rapid assessment tools, such as ShakeCast (by USGS), have been employed by DOTs to help prioritize bridge inspections before deploying engineers for on-site evaluations. Nonetheless, two main limitations have been identified in these tools. First, they typically rely on Ground Motion Intensity Measures (IM) based on acceleration (e.g., peak ground acceleration). However, it is widely acknowledged that the correlation between acceleration and structural damage is inadequate, with spectral displacements being recognized as a more robust and reliable IM. Secondly, the outcomes provided by the existing tools tend to be insufficient due to the limited structural data employed to obtain the system's capacity curve. These limitations preclude accurate performance assessment. To address these limitations, a Direct Displacement-Based Assessment (DDBA) framework was tailored for multi-span bridges, in order to forecast the performance of bridges under seismic events. This presentation outlines the application and example outcomes of this approach to multi-span RC bridge inventories.

The Effects of Large-Scale Roadway Adaptations on Barrier Evolution: Breaching Processes and Management Strategies for Pea Island's Coastal Highway

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Sandy barrier islands are low-lying, dynamic landforms that continuously change shape in response to natural coastal processes. Once developed, human decisions to protect infrastructure can alter these natural processes in ways that make barriers lower and narrower over time. In some cases, this vulnerable state can cause parts of the barrier to breach during periods of high-water levels. In our research, we examine the role of breaching in the evolution of developed barrier islands. We use the CoAStal Community-lAnDscape Evolution (CASCADE) model – a geomorphic barrier island evolution model – with new functionality to represent inlet and breaching processes, to simulate historical and potential future changes to Pea Island, a low-lying sandy barrier island along the North Carolina Outer Banks. The North Carolina Department of Transportation (NCDOT) has been protecting a coastal highway (NC-12) on Pea Island by using sandbags, removing overwash, and maintaining dunes since the mid-1900s. Assessments are ongoing for potential roadway relocations, including building bridges that bypass certain areas (see Figure below), as the highway has become increasingly vulnerable with barrier lowering and narrowing relative to sea-level rise. Here, we use model hindcasts to tune model parameters and forecasts to examine the influence breaching may have on the success of future roadway management strategies. The findings from this research will provide coastal managers and decision-makers with valuable insights into potential long-term outcomes from decisions about roadway retrofits in response to climate impacts.

Evaluation of Chronic Coastal Flooding Inundation of Low-Lying Roadways and Impacts to Community Livability

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Routine high tides, wind, and rainfall acting on rising sea levels are chronically flooding low-lying coastal communities. These floods are often shallow, hyper-local, and short-lived, but due to their high frequency, can result in significant impacts to local communities including lost business revenue, disruptions to commutes and school, and the slow degradation of infrastructure. These impacts will continue to affect communities as these floods are only expected to become more frequent with continued sea-level rise. Here, we present data and modeling of present and future flood risk along low-lying roadways in Down East, a collection of 13 rural, unincorporated communities in Carteret County, NC. Over one year, sensors installed in one of these communities recorded roadway flooding on 122 days. We use a hydrodynamic model (SFINCS) to decompose factors that contribute to flooding (tides, wind, and rain) and model potential flood mitigation strategies desired by communities, including raising roadways, constructing new causeways and bridges, and cleaning ditches. The "utility" of flood mitigation infrastructure is assessed by examining changes in flood frequency, durations, and accessibility to places identified through interviews as important to the community. Modeling results are being presented iteratively through a series of community meetings and online platforms to engage the community in conversations about roadway retrofits and inform scientific understanding of how risk tolerance and perceptions of livability may change with different management decisions. This work lays the foundation for community-driven identification and analysis of potential infrastructure adaptation strategies to balance infrastructure resilience with community values.

Identification and Prioritization of Vulnerable Roadway Segments for Proactive Resilience Planning and Response

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Flooding events caused by tropical storms and hurricanes can significantly damage pavement infrastructure. Some of the most common issues reported by the North Carolina Department of Transportation are usually associated with immediate damage or long-term effects including failures caused by erosion and weakened sub-bases and subgrade. In addition, infrastructure issues related to these extreme events, such as embankment failures, landslides, and completely washed-out bridges, significantly impact mobility, requiring substantial resources to rebuild and rehabilitate the road network. In this regard, given the increasing frequency of these weather events, the main objective of this project is to identify the characteristics that contribute to aggravating the vulnerability of roads due to flooding and which features might play a role in creating more resilient structures in the face of repeated inundation. Initially, sections expected to be recurrently flooded will be identified through data sources such as the RIT (Roadway Inundation Tool, software that uses LiDAR data to predict riverine and coastal flooding within different recurrence time intervals), official reports, division information, and road closure records. Subsequently, sites reported as damaged after hurricanes and tropical storm events and sections predicted to be constantly flooded will be further inspected to evaluate the main factors associated with the damage and possible continued effects. Ultimately, the project aims to analyze the relationship between flood-induced pavement deterioration and the common properties that contribute to less resilient road sections, towards the development of more durable structures.

Halls River Bridge Bulkhead: Seven-year Evaluation of FRP Concrete Reinforcements from Seawater Concrete

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While many studies have evaluated the durability of FRPs through accelerated aging tests, limited research considered in-service performance. This study funded by the Florida Dept. of Transportation (FDOT) examines the durability of multiple fiber-reinforced polymers (FRPs) internal concrete reinforcements including: glass (GFRP), basalt (BFRP) rebars, and carbon (CFRP) strands extracted from the Halls River Bridge bulkhead after seven years of service. The characterization of the extracted FRPs included tensile strength, transverse and horizontal shear strength, moisture absorption, and scanning electron microscopy (SEM). Concrete characterization was also conducted. All specimens were obtained from three concrete blocks, extracted from the bulkhead. Although BFRP bars absorbed significantly more moisture (0.37%) than GFRP and CFRP (both <0.03%), all bar types demonstrated comparable tensile strength retention, around 80%. However, the excessive moisture uptake and pre-existing manufacturing imperfections, such as high internal voids and poor sizing appears to potentially compromise the long-term performance of BFRP bars used in this project. This was shown by their fiber exposure, resin matrix loss, and surface deterioration observed in BFRP bars post-extraction, compared to the more intact condition of GFRP and CFRP strands. Overall, this study confirms the good performance of BFRP, GFRP, and CFRP bars after seven years of service in concrete made with seawater. While all reinforcement types exhibited good tensile strength retention, BFRP bars showed signs of degradation, highlighting the need for carful quality control during manufacturing. Moreover, ground-penetrating radar (GPR) was successfully applied to detect FRP bars, with CFRP strands showing the highest detectability, while GFRP and BFRP bars were less detectable to electromagnetic signals.

Corrosion Mitigation in Concrete Bridge Decks Using Soybean Methyl Ester (SME)

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Corrosion of reinforcing steel in concrete is a primary deterioration mechanism affecting concrete bridge decks. The onset and rate of corrosion are directly related to the concrete's ability to resist the penetration of chloride ions from deicing salts or seawater. To enhance this resistance, surface-applied sealants are commonly used. However, the effectiveness of these sealants can be compromised by mechanical abrasion due to vehicular traffic. Soybean Methyl Ester (SME) is a penetrating sealant that infiltrates the pores of concrete, blocking the ingress of chloride ions. Despite its potential, several concerns remain regarding SME: (i) the depth of SME penetration into concrete is not well understood, (ii) its effectiveness in mitigating chloride-induced corrosion of steel reinforcement is not well documented in the published literature, (iii) there are concerns about reduced tire friction on bridge decks treated with SME, which can delay the reopening of bridges to traffic after application. This presentation addresses all three concerns. First, we quantify the depth of SME penetration in concrete using neutron radiography and demonstrate its ability to hinder the penetration of saltwater solutions. Next, we present findings from a three-year study evaluating the effectiveness of SME in preventing steel reinforcement corrosion, using ASTM G109 testing protocols. Finally, we discuss results from skid resistance tests conducted in accordance with ASTM E303 and propose a strategy to reduce the required time before bridges can be reopened to traffic. Our findings indicate that the application of SME can significantly enhance the durability of concrete bridge decks, providing a promising solution for long-term infrastructure performance.

Behavior of FRP Repaired Prestressed Concrete Bridge Beams after 2 Years in Service

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A prestressed mechanically-fastened FRP system was developed to retrofit deteriorated prestressed concrete bridges. The system gives state Departments of Transportation (DOTs) another option to increase the durability and service-life of degrading bridges, beyond load-postings, closures, or emergency replacements. In addition, the system is cost-effective compared to those traditional options. Rapid installation, no special equipment requirements, and ease of inspection are valuable attributes of this repair system, which can be installed on several different cross-sections. The efficiency of the system was demonstrated under laboratory conditions on full-scale prestressed C-channel beams and cored slab beams taken from bridges that were in service for more than 40 years. The system was designed as a short-term retrofit to restore the capacity and to extend the service life of degraded prestressed concrete bridges. Critically, significant load postings (or even closures) can often be avoided for the time required to replace the superstructure. The retrofit system was installed on three in-service prestressed concrete C-channel bridges in North Carolina. After extending the service life of these bridges for two years, the bridge superstructures were recently replaced. Five retrofitted C-channel beams were saved during the demolition of two of the bridges and delivered to the laboratory for testing. In addition, seven un-strengthened C-channel beams were retained to serve as control specimens and to allow for additional testing as necessary. Salvaging these existing aged bridge girders provided the unique opportunity to perform a comprehensive condition assessment and destructive testing to investigate the performance of the retrofit after being exposed to the environment on in-service bridges. The experimental campaign included material testing and full-scale destructive testing of the C-channel beams. The results show the condition and performance of the system after more than two years of service was as expected, with no indication of deterioration of the retrofit. After testing, several components of the system were recovered, inspected, and saved for future use if necessary, demonstrating the potential for a DOT to decrease the unit cost associated with this repair.