

South Carolina



by Terry Koon, Hongfen Li, and John Caver, South Carolina Department of Transportation

Unbeknownst to many, South Carolina is home to the fourth largest state-owned highway system in the United States, with approximately 41,500 miles of roadways and 8400 bridges. According to the 2020 U.S. Census, South Carolina is the third fastest-growing state, putting additional strain on the existing infrastructure.

In the past decade there has been a dramatic increase in funding for an aggressive interstate improvement program, as well as for road safety and maintenance programs, with nearly 200 bridges constructed and another 75 under construction in South Carolina. Despite all the headway, a surge in bridge funding is needed over the next decade.

Design Standards and Challenges

Of the 8400 state-owned bridges, more than 1700 are over 60 years old; approximately 1150 of them were built more than 75 years ago and are rapidly approaching the time for replacement or repair. As part of a 10-year bridge

replacement effort and to help standardize and guide the design and construction of current and future bridge projects, policy documents such as the South Carolina Department of Transportation's (SCDOT's) *Bridge Design Manual*,¹ *Bridge Drawings and Details*,² and *Seismic Design Specifications for Highway Bridges*³ are under contract to be updated.

Bridge designs in South Carolina have to address challenging environmental conditions such as the following:

- **Marine environment.** Along the South Carolina coast, corrosion due to saltwater exposure is a big issue. Given the relatively flat topography of the coastal area, bridges are often built near the water. These bridges are exposed to salt intrusion into the concrete substructures, support members, and the bottoms of concrete decks. This corrosion risk is a constant threat to bridge durability and longevity. SCDOT is currently evaluating ways to extend the service lives of bridges in these environments.
- **Hurricanes.** Hurricanes are a constant

threat for the SCDOT infrastructure system, especially along the coast. Wind is a definite hazard to be considered in bridge design; however, storm surge, inland flooding, and embankment or substructure scour cause the greatest concern.

- **High seismic-risk areas.** South Carolina is considered one of the highest seismic-risk areas on the East Coast. SCDOT has incorporated seismic design and detailing requirements for new bridge construction since before 2001. Incorporating accelerated bridge construction (ABC) with precast concrete construction is challenging because proven high-seismic connections between ABC bridge components are still emerging. The potential for soil liquefaction is another challenge when designing any bridge to withstand anticipated seismic forces and displacements.

The revised policies and guidelines will assist the design work of both SCDOT staff and outside consultants in designing for both challenging

A design-build contract was awarded in April 2023 for a project to replace Interstate 20 bridges over Wateree River and rehabilitate Wateree Swamp overflow bridges in Kershaw County. Shown here are existing spans carrying the interstate. All Photos: South Carolina Department of Transportation.





Secondary Route 770 Bridge over Hanging Rock Creek used modified Northeast Extreme Tee D beams (in foreground) in one end span; prestressed concrete cored slabs in the two center spans; and prestressed concrete solid slabs in the other end span. The structure is being monitored to evaluate the performance of the various types of beams and connection details.

and relatively routine conditions. The intent is not to limit staff and consultants from innovating, but rather to encourage more cost-effective and technically sound solutions. The new standards will conform to the ninth edition of the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*.⁴

Design Templates

For the replacement of low-volume crossings, SCDOT is using bridge design templates to expedite project development and drawing details. The agency encourages consultants to use these accepted means and methods when designing short slabs, box beams, and other simple spans. This approach is similar to other states' efforts to update and standardize current practices, avoid redundancies, and accelerate project development. The template concept is intended to speed up the time to contract award for repetitive-type structures.

In addition to standardizing design practices, SCDOT is also standardizing bridge components. Many local precasters maintain Florida I-beam (FIB) forms and other girder sections common in the region. SCDOT has been using FIBs and similar girder shapes for years, which helps with consistency, especially on the alternative delivery side. The same applies to bulb-tee sections, which were modified for SCDOT's preferred shapes and sizes.

Modified NEXT D Beam

SCDOT typically relies on solid and hollow precast, prestressed concrete beams with conventional grouted keyways for bridges with low traffic volumes. However, the longitudinal shear keys of many of South Carolina's bridges have deteriorated, resulting in reflective cracking in the bridge decks. This deterioration can be costly because water can migrate through the cracks and corrode the beam's reinforcement and prestressing strands, leading to the need for repairs and shortening service life.

To combat this durability issue, SCDOT

teamed with Clemson University to investigate more-durable alternatives. Their research led to a viable alternative that could be used with ABC: a modified Northeast Extreme Tee (NEXT) D beam with ultra-high-performance concrete (UHPC) connections. The smallest standard NEXT D beam is 28 in. deep with webs spaced at 5 ft, whereas the modified NEXT D beam has a depth of 21 in. and a web spacing of 3 ft.

Since 2016, bridge replacement projects have been used to evaluate how the performance of the modified NEXT D beam sections with the UHPC closure pours compares with that of traditional cored- or solid-slab sections with grouted shear keys. On the four-span Secondary Route 770 Bridge over Hanging Rock Creek replacement project, 21-in.-deep, 40-ft-span modified NEXT D beams were used for one end span; 24-in.-deep, 70-ft-span prestressed concrete cored slabs comprised the center spans; and 21-in.-deep, 40-ft-span prestressed concrete solid slabs were used on the other end span. Three different types of longitudinal connections

were used, but each type used UHPC. The superstructure and longitudinal connections are being monitored, and a report of the findings has been released.⁵

Among the lessons learned from the construction side of the project are the following:

- **UHPC is presently expensive.** With the development of more UHPC mixture options, the cost should decrease. There was only one manufacturer of UHPC at the time of the project. A proprietary UHPC mixture was used instead of attempting to use a mixture with local materials.
- **Watertight seals are critical for UHPC installation.** Given the flowable nature of UHPC, watertight seals are needed for forming to ensure no loss of material before the concrete hardens.
- **Crews must take safety precautions when handling UHPC mixtures.** Respiratory protection is required when mixing. The steel fibers are sharp, and exposed fibers need to be handled carefully.

Deterioration of longitudinal shear keys is a durability issue for many of South Carolina's bridges. Hoping to avoid such deterioration in the future, the South Carolina Department of Transportation teamed with Clemson University and developed a modified Northeast Extreme Tee (NEXT) D beam with ultra-high-performance concrete (UHPC) longitudinal connections that can be used for accelerated bridge construction. The reinforcement projecting from the top flange will be encapsulated in an 8-in.-wide UHPC closure pour.





Rendering of the proposed bridge crossing Mackay Creek, part of the U.S. Route 278 corridor providing the sole link between Bluffton, S.C., on the mainland and Hilton Head Island. The new structure would provide a new six-lane roadway that would meet the current seismic design standards and increase safety along the route.

- **Larger closure pours are beneficial.** Installation of UHPC is easier in wider closure pours of the NEXT D beams compared with the typical narrow opening used for cored-slab shear keys.
- **Quality-control/quality-assurance provisions should be developed specifically for UHPC.** SCDOT used a prequalification specification for acceptance of the UHPC mixture but did not have standard quality-control procedures for installation, sampling, and curing of concrete. Standard requirements for typical concrete mixtures were not adequate.

Alternative Delivery

After the successful completion in 2005 of the Arthur Ravenel Jr. Bridge in Charleston, S.C., the SCDOT design-build program was initiated. A dedicated group was established to oversee alternative delivery and all design-build projects in the state. Although design-build contracts account for a much larger portion of the funding for bridge work currently under contract in South Carolina, design-bid-build bridge replacements are still an important and necessary part of the bridge program for SCDOT. SCDOT needs both contract methods to keep a variety of large and small bridge contractors working in South Carolina and to improve the overall condition of the state's bridge inventory.

Most of the time, design-build contracts gain efficiencies and cost savings and enable the team to move through the design phase faster. SCDOT encourages innovation through the alternative technical concept process and scores added value as part of its best-value criteria. New bridge types, materials, and methods are discussed privately with proposers and vetted by a multidisciplinary team of engineers during procurement. Some innovations are carried forward into requests for proposals for future projects.

SCDOT is also achieving increased efficiencies through bundled bridge arrangements. Under the Closed and Load-Restricted Bridge Program, the agency annually awards several bridge packages grouped by type, complexity, and

location. The number of bridges in a bundle ranges from 4 to 16, depending on industry availability, feedback, and determination of how to maximize efficiency. Certain low-volume routes qualify for less-stringent design criteria, whereas primary route bridges are grouped together because of their greater complexity. The design-build teams bring their expertise as well as means and methods to the table, adding value, innovation, and cost savings through a collaborative approach. Concrete cored slabs and box beams are typically the bridge design of choice for low-volume routes, whereas concrete beam bridges with cast-in-place concrete decks are used most often on main routes for durability and reduced maintenance costs. ABC concepts are also encouraged.

Carolina Crossroads

The Carolina Crossroads project is the largest design-build project in the state to date. With a budget of more than \$2 billion over five phases, the infrastructure project encompasses 43 new bridges, 7 reconstructed interchanges, and 132 new lane miles that will take 9 years to complete.

Because costs were projected to exceed \$1.5 billion for the first half of the program, the mega-project was split into sections to accommodate the bonding capacity of contractors. The first two of five phases are currently under construction. Phase 1 includes the construction of a new full-access interchange at Colonial Life Boulevard to improve traffic flow by removing the weave on Interstate 26 (I-26) westbound between Interstate 20 (I-20) and Interstate 126 (I-126). This phase is also lengthening the I-26 eastbound exit ramp to U.S. Route 378/Sunset Boulevard to prevent stopped vehicles on the interstate shoulders. Phase 2 improves access for vehicles moving from I-20 westbound to I-26 westbound and enhances the Broad River Road interchange at I-20. Phase 3 includes a system-to-system interchange in Columbia, S.C., and will be awarded at the end of 2023. Phases 4 and 5 include the widening of I-26 north of the interchange with I-126; these will be design-

bid-build projects that will be constructed after earlier phases are completed.

Recent and Current Projects

A major bridge replacement project, the 20-span, 3340-ft-long U.S. Route 21 Harbor River Bridge in Beaufort County, was opened to traffic in April 2021. The bridge, which connects the mainland to several islands, is designed to withstand tidal action, hurricane-force winds, seismic events, vessel collisions, and significant long-term scour, while preserving the environmentally sensitive and picturesque setting. (The Harbor River Bridge is featured in the Summer 2023 issue of *ASPIRE*®.)

As additional funding becomes available, SCDOT is also advancing large (more than \$100 million) interstate bridge replacement projects over major rivers and lakes. The first project is the replacement of eastbound and westbound bridges of I-20 over the Wateree River in Kershaw County. It features a 1515-ft-long, 11-span river-crossing bridge with a cast-in-place reinforced concrete deck supported on prestressed concrete FIB girders.

A project to improve Interstate 95 (I-95) over the Great Pee Dee River system near Florence, S.C., was recently awarded a federal planning grant, and work has started on a feasibility study to determine the number of bridges that will be replaced in the 7-mile-long floodplain. The grant money will allow SCDOT to mitigate the effects of flooding on bridges along this major hurricane evacuation route for residents and visitors along the coast.

Preliminary engineering for I-95 over Lake Marion in Santee, S.C., is underway to replace twin bridges, more than 4500 ft long, that bisect the lake. The goal is to get ahead of the replacement timeline for these critical lifeline structures, built in the 1960s and 70s, before they require load posting.

Future Project

SCDOT is embarking on a project to improve the U.S. Route 278 corridor between Bluffton and Hilton Head Island. The purpose of the project

is to address structural deficiencies in existing structures and reduce congestion. The proposed six-lane, 7264.5-ft-long structure would connect the mainland to Hilton Head Island and include access ramps for Pinckney Island National Wildlife Refuge. The new structure would cross Mackay Creek and Skull Creek, providing a new six-lane roadway that would meet the current seismic design standards and increase safety along this route.

The superstructure would consist of 45 prestressed concrete beam spans combined into 13 continuous units. Florida I-beams are proposed for all but three spans, with spans ranging from 120 to 171.5 ft. Crossing Skull Creek, which is part of the Intracoastal Waterway, created more of a challenge. The three-span—225, 280, and 225 ft—continuous unit over the Skull Creek channel will consist of haunched, spliced and post-tensioned, prestressed concrete modified AASHTO bulb-tee beams. Construction on the project is scheduled to start in early 2024.

Digital Project Delivery

SCDOT has moved to a digital delivery system and accepts only electronic submissions for all plan sets including review submittals, sealed plans, and shop drawings. This move has facilitated better collection and use of data for project management, including the use of digital as-builts. Transitioning from traditional paper-based workflows has helped the agency accumulate information for future use.

The agency currently maintains a searchable online inventory of as-built records that handles more than 700,000 searches per year and contains as-built records dating back almost 100 years. More than 2.5 million plan sheets are available online. New project

The five-phase Carolina Crossroads project is one of the largest construction ventures in South Carolina. It is designed to alleviate congestion along 14 miles of the Interstate 20, 26, and 126 corridor in Columbia, S.C. This ramp from Interstate 26 to westbound Interstate 126 uses a combination of cast-in-place and precast concrete bridge components.




The U.S. Route 21 over Harbor River replacement bridge in Beaufort County used Florida BT-78 beams. The 3350-ft-long, high-level structure replaced an 80-year-old swing-span bridge over a tidal waterway and navigable channel.

as-builts are submitted as digital PDFs with advanced features such as searchable text, vector graphics, and layers of information for easier navigation.

South Carolina looks to the future with its comprehensive plan to address highway safety, structurally deficient bridges, and an aggressive interstate program. The state is making significant strides toward improved infrastructure that supports continued growth.

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Terry Koon is structural design support engineer, Hongfen Li is structural policy design engineer, and John Caver is alternative delivery structural engineer for the South Carolina Department of Transportation in Columbia.

