Environmentally friendly bridge design stands up to location challenges

The new $252 million, 2.8 mi (4.5 km) long Marc Basnight Bridge along the North Carolina coast, winner of a Sustainable Design Award as part of PCI's 2020 Design Awards, spans a channel with treacherous currents, constantly shifting depths, and high winds, making it one of the most dangerous channels along the Atlantic Coast.

Designers and others involved with the project were challenged by the fact that the bridge would be required to have a 100-year service life while subject to an extremely harsh saltwater environment.

One of the keys to the success of the project was using precast concrete to provide a high-quality, economical, resilient, and low-maintenance structure that could resist erosion, hurricane-level winds, and the impacts of passing ships.

Another reason for the decision to use precast concrete was the need for the project to be environmentally friendly. Using precast concrete minimized environmental disruption to the vulnerable barrier islands and also reduced the risk of construction affecting the area's 20 legally protected species, including manatees, bald eagles, peregrine falcons, and five turtle species.

For example, by minimizing the number of driven precast, prestressed concrete cylinder piles in the approach structure, the team reduced the impact on submerged aquatic vegetation beds.

Given the comprehensive requirements of the project, there were some significant challenges for precaster Coastal Precast Systems of Chesapeake, Va., not least of which was the number of pieces required for the project: five hundred thirty-six 36 in. (914 mm) voided square piles, two hundred eighty-six 96 in. (2438 mm) and eighteen 45 in. (1143 mm) Florida I-beam girders, 264 segmental box girders, one hundred thirty-eight 54 in. (1371 mm) cylinder piles, one hundred two 12 in. (305 mm) sheet piles, 69 approach and transition span caps, 66 transition span column segments, 40 navigation span column segments, 12 navigation span column caps, and nine 20 in. (508 mm) square piles.

One design challenge related to the precast concrete caps. "They were originally too heavy for us to ship by truck," says Bert Richardson, project manager. "We had to redesign them hollow and prestressed. This saved weight, allowing them to be trucked. They had to be filled at the jobsite with ready-mix, which required stainless steel rebar."

To withstand the saltwater environment, stand up to hurricane winds, protect vulnerable species, and achieve a 100-year service life, the Marc Basnight Bridge in North Carolina was constructed with precast concrete. Photo courtesy of HDR Inc.: © 2019.

Construction of the Marc Basnight Bridge in North Carolina was a dangerous feat with treacherous currents, constantly shifting depths, and high winds. Photo courtesy of HDR Inc.: © 2019.

The Marc Basnight Bridge, right, along the North Carolina coast won a 2020 PCI Sustainable Design Award. It replaces the Bonner Bridge, left, which opened in 1963, and most of which will be demolished. Photo courtesy of HDR Inc.: © 2019.

Another design challenge was that the girders and piles were massive, and traditional fabrication tolerances had to be updated and expanded on.

During manufacturing, the precasting plant had to double stack the segmental box girders. "We also had to store segments on a three-point dunnage arrangement to prevent warping," Richardson says. "If warped, the segments would not go back together correctly, resulting in damage or misaligned spans." In addition, segments had varying vertical depths, which created the arch at the bottom of the navigation spans. "We used oak lumber and stacked sandbags as dunnage," he says.

To ensure that the mass concrete curing occurred properly, the plant purchased remote live-viewing data loggers so temperatures could be monitored remotely.

"When precasting the segments, constant geometry control had to be applied to each piece. This ensured that the spans would end up in the correct locations." —Bert Richardson, Coastal Precast Systems project manager

For the segmental box girders, each segment had to be carefully surveyed before and after casting in order to ensure that the geometry of the bridge would be correct. "Elevation and centerline measurements had to be taken and inputted into MC3D, a geometry control program," Richardson says. The setup tolerance was 0.004 ft (.0012 m).

There were also several challenges during shipping. Deliveries by truck had to be arranged for nighttime delivery in order to avoid Outer Banks tourist traffic. "With products produced in Virginia and shipped to North Carolina, travel restrictions had to be accounted for in each state," he says. Because night travel is not typically permitted by North Carolina, the company had to obtain project-specific permission.

The majority of the piles and girders were delivered by truck. Girder heights were 96 in. (2413 mm), and the lengths were roughly 160 ft (48.8 m). With such long loads, specialized trailers with rear steering were required to enable the trucks to make sharp turns.

Except for the navigation spans, the majority of the precast concrete pieces had to be delivered by truck because of the shallow water. "In situations where product was shipped by barge, care had to be taken to avoid running aground, and sands were constantly shifting," Richardson says.

Installation also posed some challenges. "When erecting the segmental box girders, the as-cast geometry values had to be referenced to ensure that the bridge was tracking correctly," he says. "When precasting the segments, constant geometry conctrol had to be applied to each piece. This ensured that the spans would end up in the correct locations."

In addition, segmental box girders and column segments were match cast. "If a match-cast surface was damaged and needed repair, it would have to be fixed on-site after it was installed," Richardson says. "If it was repaired beforehand, the match-cast surfaces would not fit back together, which would result in damage or geometry issues." Once a piece that needed repair was erected, a special trip had to be made to the jobsite to fix it. "As such, we took additional care in order to reduce the frequency of these occurrences," he says.

The key to the success of the project, Richardson says, was the teamwork among the North Carolina Department of Transportation; HDR, the engineer of record; PCL, the contractor; and Coastal Precast Systems.

—William Atkinson