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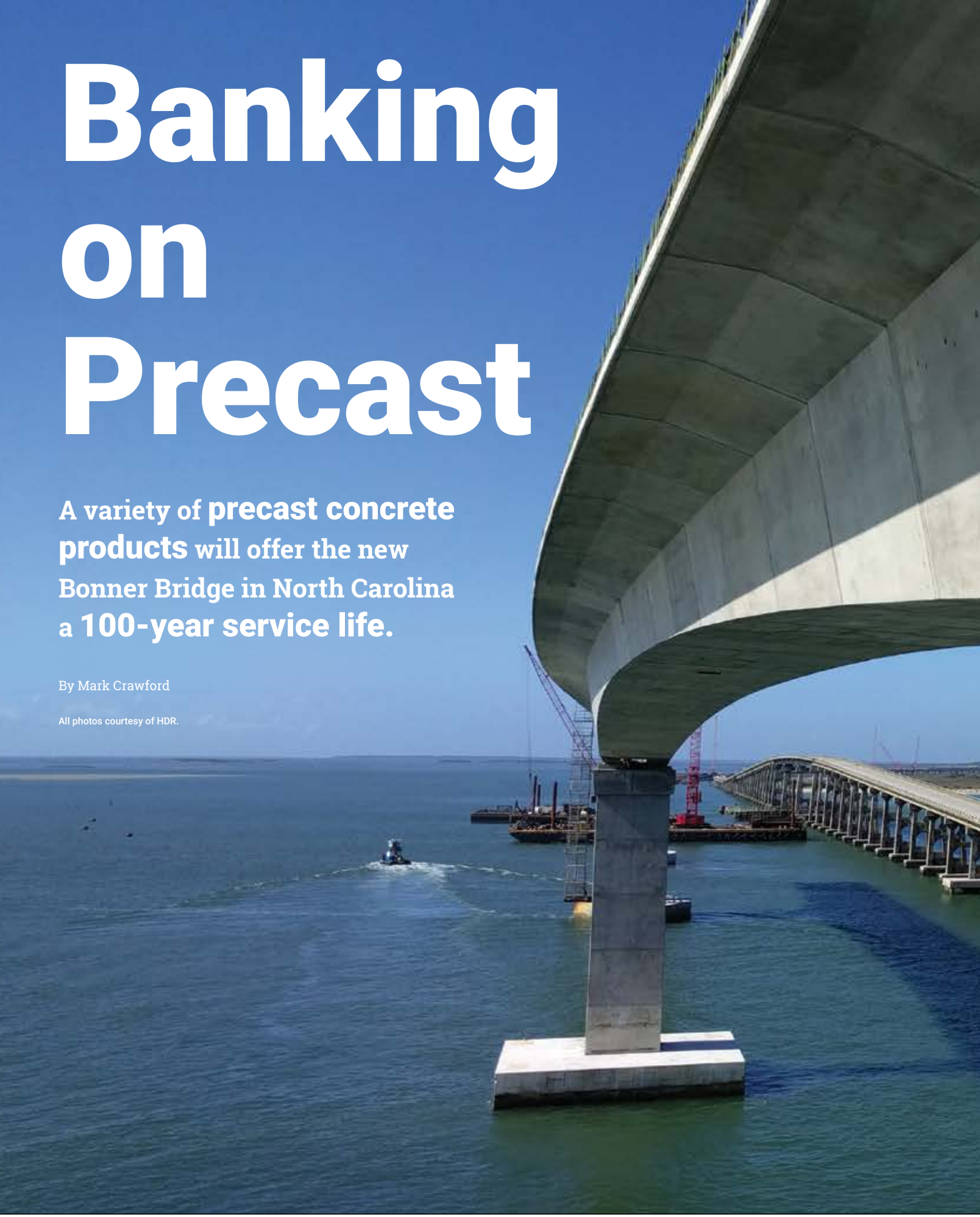
THE TRANSPORTATION ISSUE

Banking on Precast

A variety of precast concrete products will offer the new Bonner Bridge in North Carolina a 100-year service life.

By Mark Crawford

All photos courtesy of HDR.



According to the 2017 Bridge Report by the American Road & Transportation Builders Association, more than 185 million vehicles cross nearly 56,000 structurally deficient bridges every day in the U.S. As such, deteriorating bridges are a big part of the country's ailing transportation infrastructure.

Bridges play a vital role in connecting communities. They serve as the main route for delivering products and supplies and connecting residents to their jobs. They also provide the only evacuation route when disaster strikes. These links are particularly important for island residents. For them, bridges are more than just a crossing – they are a lifeline.

Take, for example, the Herbert C. Bonner Bridge, which connects Hatteras Island and Bodie Island in the Outer Banks of North Carolina, providing a critical transportation link for the area's coastal communities. More than 50 years old, the bridge serves as a hurricane evacuation route to the mainland and a busy travel corridor for the state's tourism industry. Due to severe deterioration and scour problems created by the strong Atlantic Ocean currents, the North Carolina Department of Transportation decided to replace this critical structure. In 2011, NCDOT teamed up with PCL Civil Constructors of Denver, Colo., and HDR of Omaha, Neb., on a new, 2.8-mile, $246 million replacement bridge with a 100-year service life.

BALANCED CANTILEVER DESIGN

The new bridge incorporates a balanced cantilever design – a preferred method for constructing long-span precast concrete bridges across challenging terrain where topographic or geotechnical conditions make conventional formwork unfeasible. The centerpiece of the design is a 3,550-foot-long, 11-span, segmental concrete box girder bridge. The bridge includes nine 350-foot spans, each of which can accommodate the shifting position of the navigation channel through the ever-changing Oregon Inlet. In comparison, the original bridge provides only

The new Bonner Bridge incorporates a balanced cantilever design featuring a wide variety of precast concrete products.

one navigational span with an opening of 130 feet. Bridge supports include a total of 673 pilings, ranging in length from 110 feet to 130 feet, manufactured by Coastal Precast Systems of Chesapeake, Va.

"The highly dynamic environment proved to be one of the most challenging aspects of the project for both the designers and the contractor," said Domenic Coletti, principal bridge engineer for HDR.

Varying conditions across the Oregon Inlet led the design team to divide the bridge into five "regions." Each region has a design customized to its subsurface and scour circumstances. Each design uses time-tested methods and a specific assortment of simple but reliable structural elements including piles, pile caps, girders and bents.

"The final design capitalizes on the use of repetitive precast concrete structural elements to improve constructability, quality and durability – key criteria for such a harsh marine environment," added Coletti. "This approach led to maximum optimization of the design, allowing the contractor to develop an extremely competitive construction bid."

THE PRECAST ADVANTAGE

Factors such as the harsh and corrosive ocean environment at the construction site, limited access, constrained easements, the remote location and an aggressive construction schedule made it easy for the design-build team to select precast concrete as the solution for the Bonner Bridge. Precast components include prestressed piles, bent caps, post-tensioned columns, prestressed Florida I-Beam girders and post-tensioned segmental box girder spans.

"Precast concrete provides unmatched quality and durability," said Sean Bush, construction manager for PCL. "Since fabrication is performed at an off-site precast yard under controlled conditions, precasting achieves a higher level of quality and durability than would have been possible with cast-in-place in this

The massive structure includes nine 350-foot spans.

harsh marine environment, which is subject to a constant barrage of salt-spray wetting and drying cycles."

The extensive use of precast concrete also helps address serious site-access challenges. The bridge is in a remote, environmentally sensitive location with only two-lane state Highway 12 available for overland deliveries. Consistent, timely delivery of large quantities of concrete for cast-in-place operations would have been challenging, especially during busy summer months with high tourism traffic.

"It proved much easier to transport already fabricated precast elements to the site," Bush added.

Also, with much of the area designated as a submerged aquatic vegetation habitat, environmental sensitivity is a top concern.

"Minimizing field construction work, construction duration and the placement of cast-in-place concrete on-site through the use of precast concrete is an environmentally friendly approach, reducing the duration and extent of temporary environmental impacts," said Nick Amico, senior bridge engineer for HDR.

Precast concrete offered other advantages for addressing environmental constraints. For example, drilled shaft construction was considered impractical due to restrictions on soil disposal in the environmentally sensitive area. The highly corrosive environment also precluded the use of steel piles. Only precast piles could address all of the environmental challenges for the foundations.

Use of precast elements also provides significant economical and schedule savings. Off-site fabrication is much less costly compared with delivering and placing cast-in-place concrete in the remote project location.

"Precasting also shortens the overall construction schedule by permitting manufacture of components while precursor operations are underway," Coletti said. "This minimizes the field construction work required from barges and the work trestle, leading to much faster and more streamlined construction."

To reduce the need for future maintenance and repairs, NCDOT specified numerous prescriptive durability criteria for achieving a 100-year service life. Requirements included using:

- Stainless steel reinforcing in all cast-in-place concrete
- Stainless steel post-tensioning in substructures up to 12 feet above mean high water
- Stainless steel bearing sole plates
- 99.99% aluminum metalizing of other steel elements
- Robust concrete mix designs with high percentages of fly ash or ground granulated blast furnace slag
- Low water-cement ratios
- Silica fume
- A calcium nitrite corrosion inhibitor admixture

"These concrete mix designs greatly enhance the durability and longevity of all concrete elements of the bridge," Amico indicated.

Thanks to the use of precast, the new Bonner Bridge will boast a 100-year service life.

ON-TIME COMPLETION EXPECTED

NCDOT broke ground on the Bonner Bridge replacement on March 8, 2016. Construction started in three areas: the south approach, the north approach and navigational spans. After completion of the north and south approaches, work will begin on the sections that connect each end with the high-rise portion, also known as the navigation zone. The new bridge will open to traffic in November 2018, with demolition of the existing bridge completed by September 2019.

The extensive use of precast concrete will result in an extremely durable, high-quality structure, while simultaneously contributing to greater constructability, a shorter timeline, lower overall costs and an environmentally friendly construction process.

"Precasting the majority of the structural elements allowed for extensive fabrication off-site, under controlled conditions, which naturally improves the quality and durability of these elements," Amico said. "The extensive use of precast concrete elements also allows for faster, easier, more streamlined construction in the difficult, dangerous conditions found in the Oregon Inlet. Also, any prestressed concrete elements are subject to a zero-tension design requirement under service conditions, further contributing to the enhanced longevity of the new bridge."

After more than two decades of planning, the completed bridge will provide a revitalized connection for Outer Banks residents and visitors.

"The bridge will improve access to jobs, health care, education and recreation for the community, while also benefitting local tourism and feeding a robust economy," Amico said. "Despite the many challenges of such a unique and complex site, once completed, this impressive structure will provide NCDOT, local residents and innumerable vacationers with a safe, durable crossing for the next century." PS

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