UHPC used in first-in-nation application in South Dakota

The Steel District is a new riverfront destination designed for Sioux Falls, S.Dak., residents and guests. It features select retail, entertainment, and hospitality catering to the lifestyles of the visitors.

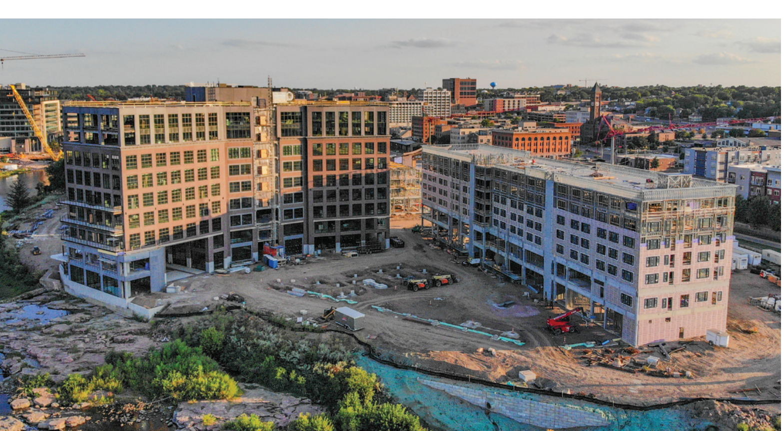
What is unique about the office facility in the Steel District is that it is built using precast ultra-high-performance concrete (UHPC) beams, provided by Gage Brothers of Sioux Falls, making it the first office building in the nation to use UHPC in this way.

UHPC is composed of a proprietary blend of components specifically combined to create the unique properties required. Structural steel fibers are used to virtually eliminate the need for reinforcing bar while increasing flexural strength.

There are several benefits to UHPC, including enlarged clear span capabilities. It has reduced construction time, uses less material, increases interior design flexibility, increases building durability and strength, and is more sustainable, with less ecological impact.

Engineers and architects can use UHPC to optimize their building's complete framing system to reduce the number of pieces and columns in interior spaces. Building owners enjoy the flexibility of renting to a larger customer base with the increased space design options. UHPC also creates open floor layouts, eliminating the need to design around beams that disrupt team collaboration. In addition, because there are fewer precast concrete pieces to work with, developers and general contractors enjoy faster building erection time lines and fewer workforce demands.

The new office facility in the Sioux Falls, S.Dak., riverfront Steel District was built using precast ultra-high-performance concrete (UHPC) beams, making it the first office building in the nation to use UHPC in this way. Courtesy of e.construct.USA, LLC.



The beams and hollow-core slabs are fully erected before the topping is placed for the new Steel District office building in Sioux Falls. Courtesy of e.construct.USA, LLC.

On this project, builders were able to meet design requests. "The developer wanted to keep floor heights the same, so this challenged us to find a way to run the mechanical, plumbing, and HVAC through the beams," says Joe Bunkers, president of Gage Brothers. "We created boxed-out sections, or holes, to allow them to cross through our beam instead of passing under our beam. We also encased these openings with concrete to maintain fire resistance."

In terms of production challenges, there were two. "First, UHPC takes materials we don't use for our traditional concrete production," Bunkers says. "We didn't have the infrastructure to buy in bulk and run it out of silos. Instead, we purchased everything preweighed in super sacks." Mixing concrete when dumping out of super sacks takes time and is not particularly efficient. "As a result, we essentially just powered through this," he says. The second production challenge was the time between batches. Having one mixer with a 2 yd (1.5 m^3) capacity made it difficult to keep up with pouring. "We ultimately switched to producing several two-yard batches and feeding them into a ready-mix truck for delivery," he says. "We would fill both trucks and then could dump in one continuous pour."

—William Atkinson

Precast concrete takes Baltimore utility over water

Baltimore Gas and Electric (BGE), a Maryland-based electric utility, owns and operates a high-voltage transmission grid. One important component of that grid is the Francis Scott Key Bridge in Baltimore, Md., where underwater lines were installed in the 1970s about 10 to 15 ft (3 to 5 m) below the riverbed. The 2.5 mi (4 km) long Key Bridge portion of the line has been in service for more than 50 years and displayed signs of deterioration. Because this section is critical for the resilience of the grid system, BGE planned to replace it.

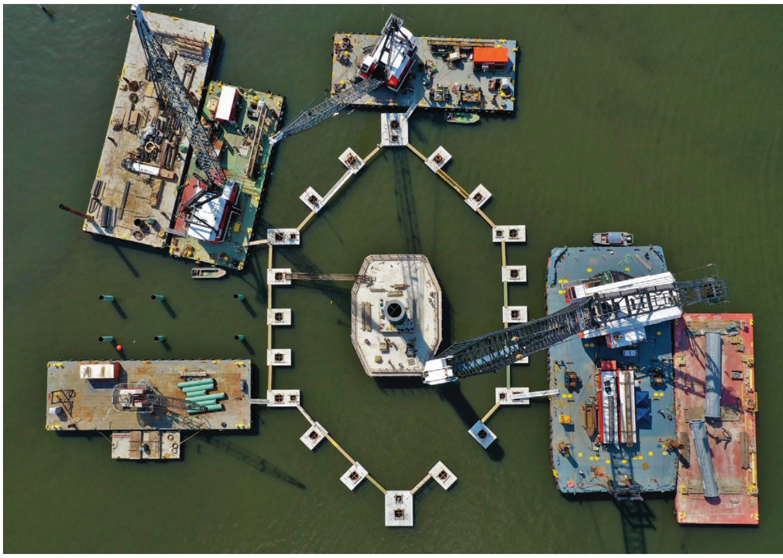
Although various alternatives were analyzed, taking into consideration cost, design complexity, environmental impact, stakeholder preferences, permitting complications, and interruption of shipping, the project team selected overhead lines incorporating tall towers in the river.

Compared with the underwater option, which would have required jet plowing submarine cable through the river bottom, the overhead option was more environmentally sound. In addition, installing underground cables would have cost about twice as much as the overhead project.

The final design was completed at the end of 2019 and includes a total of eight towers, with heights between 160 and 400 ft (42 and 122 m). The towers in the water required independent vessel collision protection structures to prevent ships from striking the towers or their foundations. The protection structures have a continuous concrete ring around each foundation, the largest being 14 ft (4.3 m) wide, 7 ft (2.1 m) deep, and 633 ft (193 m) long.

Both the foundation and protection structures are composed of layers of precast and cast-in-place (CIP) concrete supported by steel pipe piles. Precast concrete was incorporated into the earliest design concepts and was a dominant technology in all overwater construction, reducing the construction time of the in-water structures, increasing the design life of the reinforcement, reducing the amount of CIP concrete formwork, and improving the accuracy of perimeter fender bolt placement. With so much work to be performed in an accelerated construction schedule, using precast concrete was the most effective method to achieve on-time completion of the project.

Overlapping precast concrete components in place atop steel piles simplified the formwork required for constructing a continuous concrete ring surrounding each in-water electrical transmission tower. Courtesy of McKissack & McKissack.



Using precast concrete reduced the construction time of the in-water tower protective structures, reduced the amount of CIP concrete formwork, and improved the accuracy of perimeter fender bolt placement. Courtesy of McKissack & McKissack.

All concrete components directly above open water were designed and detailed as precast concrete, requiring only narrow CIP closure pours between precast concrete planks.

The precast concrete configuration consists of precast concrete caps installed on top of the piles, with precast concrete planks spanning between the caps to form a continuous precast concrete working surface over the water. A total of 62 panels and 67 pile caps—weighing from 8 to 47 tons (7 to 43 tonnes)—were used for the project.

The contractor's substitution of a single monolithic precast concrete foundation piece at three of the towers required a 164 ton (149 tonne) square precast concrete pile cap. Marine concrete was used to provide a 75-year design service life.

"To accelerate construction, precast pieces were redesigned to minimize the amount of forming required for the cast-in-place operation," says Bert Richardson, project manager for Coastal Precast Systems of Chesapeake, Va., the precaster selected for the project. "Because smaller pile caps were redesigned into a single pile cap that weighed over 160 tons, care had to be taken to ensure that concrete curing temperatures did not exceed specifications."

The project is located in the Patapsco River, so all the precast concrete was barged to the jobsite. "This allowed us to make larger pieces that sped up construction," Richardson says. "Job specifications required preassembly of the precast before shipping. Because storage space was limited in the casting yard, we erected the pieces on the barge and shipped it to the jobsite mock erected."

—William Atkinson