Durable embassy uses precast UHPC to copy tribal patterns

Serving as a lasting symbol of the United States' commitment to Mozambique, the new embassy in Maputo is a safe, secure, and resilient building that is as functional as it is aesthetically pleasing. Situated on a 10-acre (4 ha) site adjacent to the Indian Ocean, the stunning 360,000 ft^2 (33,400 m^2) facility features an outer layer constructed with precast ultra-high-performance concrete (UHPC). This outer layer ties into local culture through a meticulously designed veil reminiscent of the wood carvings of the indigenous Makonde tribe.

Due to the embassy's location along the Mozambique Channel, the engineering and architecture teams sought a building material resilient enough to fend off harsh coastal conditions, including salt water and potential seismic events. Bomb blast requirements were also a consideration, further leading the design team to select precast concrete and UHPC, which is generally known for its high-strength properties, for the work.

Beni Kohen, project and business development manager for Fibrobeton, which work with general contractor Pernix LLC, says that UHPC played a crucial role in the project by offering exception durability.

"This material allowed for thinner cross sections and more elegant forms without sacrificing the ability to withstand extreme weather conditions in the area, such as hurricane-force winds," he says. "Additionally, using UHPC was instrumental in achieving the project's stringent security requirements."

Beyond strength and durability, UHPC also plays a major role in the building's energy efficiency through the reduction of solar heat gain. This, combined with other sustainable features such as LED lighting, low-flow plumbing fixtures, and solar water heating systems, enabled the embassy to achieve LEED gold certification in 2022.

More than 1229 fins varying in height from 13 to 26 ft (4 to 8 m) were installed on the project. The fins encompass 330 different shapes and account for 97,000 ft^3 (9000 m^2) of UHPC. The fin system provides several additional advantages to the building and its occupants by mitigating direct sunlight, eliminating glare, maximizing interior daylight, and providing unobstructed views.

"Using UHPC helped make the embassy's intricate design possible," Kohen says. "We were able to highlight local cultural elements without compromising on the project's functional requirements."

The new Maputo embassy reflects U.S. ideals, principles, and technical innovation. Thanks to the use of precast concrete and UHPC, the embassy offers a mix of resilience and beauty with a structure that serves as a lasting symbol of excellence for all parties involved.

Ultimately, the completed project also provides jobs for local workers, along with a larger regional presence for the U.S. Agency for International Development, Centers for Disease Control and Prevention, and other diplomatic missions of the U.S. State Department.

—Mason Nichols

The new U.S. embassy in Maputo, Mozambique, uses precast ultra-high-performance concrete to meet durability and blast resistance requirements. Courtesy of Pernix Federal LLC.

Many of the larger components for the new Earl C. Davis Memorial Bridge connecting Straits, N.C., with Harkers Island, N.C., were delivered by barge. Courtesy of Balfour Beatty Infrastructure Inc.

Replacement bridge uses CFCC, GFRP for durability

The North Carolina Department of Transportation replaced the Earl C. Davis Memorial Bridge (bridge number 73) and bridge number 96, both of which connect the town of Straits, N.C., on the mainland to Harkers Island, N.C., with a new structure. The bridges were each more than 50 years old and were due for replacement. The new bridge is designed to provide better access to and from the island in emergencies and during hurricane evacuations.

Work began in fall 2021 and ended in winter 2023. The new bridge is primarily made using carbon-fiber- and glass-fiber-reinforced concrete, making it the first structure in the state to use the material. The material is used to combat corrosion in coastal environments, meaning the bridge will need less maintenance.

Coastal Precast Systems of Chesapeake, Va., was selected for the precast concrete portion of the project, and Balfour Beatty Infrastructure Inc. was the general contractor. "We were chosen due to our extensive experience and expertise in prestressed concrete, particularly in using CFCC [carbon-fiber-composite cable] strands," says Bert Richardson, project manager for Coastal Precast. "We also possess considerable experience in shipping these specialized prestressed products."

Coastal Precast provided two hundred and twelve 24 in. (600 mm) concrete square piles varying in length from 75 to 130 ft (23 to 40 m) and two hundred and sixty-seven 12 in. (300 mm) concrete sheet piles with 28 different mark numbers, including three specialized corners from its Chesapeake, Va., plant; forty-four 72 in. (1800 mm) Florida I-beam (FIB) girders that are 130 ft long and weigh 72 tons (65 tonnes) and fifteen 78 in. (2000 mm) FIB girders, the largest at 164 ft (50 m) and weighing 94 tons (85 tonnes) from its Cape Charles, Va., plant; and fifty-six 54 in. (1400 mm) FIB girders that are roughly 100 ft (30 m) long and weigh 50 tons (45 tonnes) from its Wilmington, N.C., plant.

Richardson says that the design of the prestressed concrete square piles and FIB girders required using CFCC strand and glass-fiber-reinforced polymer. "This presented unique challenges due to the differences compared to traditional steel strands," he says. "We addressed these challenges through specialized training provided by Tokyo Rope. Adjustments had to be made in our standard processes to accommodate the Hoyer effect, as CFCC reacts differently from steel strands."

During production, it was critical to ensure that steel and CFCC strands were spliced correctly. This required specialized equipment and a daily inspection process to ensure safety. "We implemented rigorous quality and safety control measures and modified some of our conventional procedures to effectively use the CFCC strands, ensuring all specifications were met without compromise," Richardson says.

Delivery of the precast concrete pieces, especially the large girders shipped by barge, required meticulous planning because tides affected barge accessibility. "We shipped several of the large 72 in. girders from the Cape Charles plant to the jobsite by truck. Due to their size, we were required to travel at night when there was less traffic," Richardson says.

The Chesapeake Bay Bridge-Tunnel (CBBT) had to stop traffic to allow the girders to travel through them. The CBBT says that the girders for this project were the largest and heaviest to ever cross the tunnel. Since the girders traveled through multiple cities and jurisdictions, several permits and specific travel times were required, making the delivery particularly challenging and taking multiple days. "The roads near the jobsite were difficult to navigate and required us to use specialized steerable six-axle trailers and certified escorts to stop traffic as the trucks navigated sharp corners on narrow back roads," Richardson says.

The installation of concrete piles and girders went smoothly without any problems. "However, the concrete sheet piles were slightly more challenging," he says. "The specialized corner pieces tended to camber, which made the tongue and groove keyways extremely tight. Overall, the project was a success, and the contractor finished the project about a year early."
—William Atkinson