# New Potomac River Crossing Replaces 82-Year-Old Structure

by Ken Butler, AECOM

The new Nice-Middleton Bridge project is a $463 million design-build project that replaces a 1.9-mile-long, two-lane bridge over the Potomac River between Maryland and Virginia. The project is one of the Maryland Transportation Authority's (MDTA's) largest transportation initiatives to date. MDTA elected to use the design-build delivery method to take advantage of significant time savings and design innovation. The project was awarded in January 2020, design was completed in 11 months, and construction was completed in 30 months.

Like its predecessor, which opened in 1940, the new Nice-Middleton Bridge is 1.9 miles long; however, the new bridge provides four lanes of travel. With 59 spans, the 61-ft-wide structure was designed to cost effectively and aesthetically balance the number of spans against the number and heights of the supporting piers and foundations. The sleek new river crossing gradually ascends from the Maryland shore, rising 135 ft above the Potomac River to allow passage of tall vessels, and then descends to a level just above the water as it approaches the Virginia shoreline. The design leverages a combination of prestressed concrete girders in the low-level and high-level approach spans with haunched steel girders over the main channel. The substructure and foundations vary from precast concrete pile bents for the low-level spans to concrete columns and caps supported by waterline footings for the high-level and channel spans. Deep foundations consist of 36-in.-square prestressed concrete piles and 66-in.-diameter prestressed concrete cylinder piles

Designed and constructed in less than three years, the new Nice-Middleton Bridge over the Potomac River was opened to traffic on October 12, 2022. Photo: Skanska/Corman/McLean JV.

profile

**NICE-MIDDLETON BRIDGE** / NEWBURG, MARYLAND

**BRIDGE DESIGN ENGINEER:** AECOM, Richmond, Va.

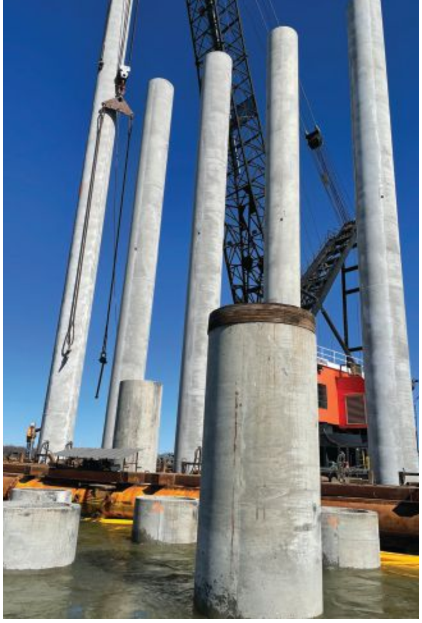
**OTHER CONSULTANTS:** Geotechnical engineering: Schnabel Engineering, Rockville, Md.; civil design: Wallace Montgomery & Associates, Hunt Valley, Md.; corrosion control plan: Siva Corrosion Services, West Chester, Pa.

**PRIME CONTRACTOR:** Skanska/Corman/McLean Joint Venture, Newburg, Md.

**CONCRETE SUPPLIER:** Chaney Enterprises, Gambrills, Md.

**PRECASTER:** Coastal Precast Systems, Cape Charles, Va.—a PCI-certified producer

The new concrete bridge (right), designed for a 100-year service life, will be more durable and require less maintenance than the previous steel structure (left). Photo: AECOM.



The main channel piers are supported by 66-in.-diameter prestressed concrete cylinder piles. Photo: AECOM.

driven to depths of up to 200 ft without splices. Most of the piles weigh more than 100 tons.

## Planning for Efficiency and Durability

A simple, repetitive concrete design increased construction efficiency and reduced costs while promoting quality and durability. The design provides a 100-year service life by leveraging strategies such as minimizing the number of deck joints, using drainage details that reduce exposure to salt-laden water, using custom-designed high-performance concrete, using precast concrete components as much as possible, and selectively using corrosion-resistant reinforcing steel.

The use of concrete for the foundations, substructure, and superstructure components was key to providing the most economical and durable bridge. The greatest economy in design and construction is attained by making the structure as simple as possible, with duplication of spans, superstructure, substructure, and foundations. With this type of design, every aspect of the project, including shop drawings, fabrication, and erection, becomes less time consuming and costly. Repetition also results in higher quality.

During the proposal phase, MDTA provided engineering data and comprehensive performance specifications, as well as other pertinent information regarding the design. This

Installation of 741 prestressed concrete piles (36 in. square) and 80 prestressed concrete cylinder piles (66 in. diameter) was accomplished in 18 months. The piles were cast full length and delivered by barge directly from the precaster. Photo: Skanska/Corman/McLean Joint Venture.

## MARYLAND TRANSPORTATION AUTHORITY, OWNER

**OTHER MATERIAL SUPPLIERS:** Expansion joints (modular joints and strip seals): Watson Bowman, Amherst, N.Y.; disc bearings: RJ Watson, Alden, N.Y.; elastomeric bearings: Cosmec/Dynamic Rubber, Athens, Tex.

**BRIDGE DESCRIPTION:** 1.9-mile-long, 61-ft-wide bridge with 56 prestressed concrete girder approach spans and 3 steel girder navigational channel spans

**STRUCTURAL COMPONENTS:** One hundred sixty-two 79-in.-deep, prestressed Maryland precast concrete economical fabrication (PCEF) girders, two hundred three 95-in.-deep Maryland PCEF prestressed concrete girders, seven hundred forty-one 36-in.-square prestressed concrete piles, eighty prestressed concrete 66-in.-diameter cylinder piles, and an 8½-in.-thick cast-in-place concrete deck reinforced with low-chromium reinforcing steel. The substructure and foundations vary from precast concrete pile bents for the low-level spans to concrete columns and caps supported by waterline footings for the high-level and channel spans.

Precast concrete “bathtubs” were an innovative detail developed by the contractor. They created a dry work space and were also used as sacrificial forms for the waterline footings. Photo: AECOM.

information allowed the design-build team to make key decisions in their proposal and before beginning final design-build, which greatly reduced the risk of unforeseen circumstances. To construct a bridge in this aggressive marine environment, it was critical that the team understood the river mechanics, subsurface conditions, climate, and exposure conditions as they relate to durability. The level of development accomplished during the proposal phase facilitated starting construction as quickly as possible after project award. Pile driving commenced six months after project award.

## Low-Level Approach Spans

The low-level approach spans extend 3975 ft from the Virginia shoreline. The typical span length is 150 ft, with a typical five-span expansion unit of 750 ft. The minimum low-chord elevation is set to account for the 100-year flood elevation and wave action. The superstructure consists of six lines of prestressed, 79-in.-deep Maryland precast concrete economical fabrication (PCEF) girders spaced at 10 ft 7 in. centers, and an 8½-in.-thick cast-in-place (CIP) reinforced concrete deck, which includes a ½-in. integral wearing surface and a silane sealer. Three alternative technical concepts were accepted by MDTA: the use of 0.6-in.-diameter prestressing strands in the girders, increased concrete strength for the prestressed concrete girders, and galvanized steel intermediate diaphragms between the prestressed concrete girders. The design concrete compressive strength of the girders is 10,000 psi. Low-chromium carbon steel reinforcement was used in the deck and barriers, and the deck concrete includes synthetic fibers to reduce cracking for added corrosion protection.

The 95-in.-deep, prestressed Maryland precast concrete economical fabrication girders were fabricated with 10,000-psi self-consolidating concrete and sixty 0.6-in.-diameter strands in each girder. The use of the 10,000-psi concrete and the 0.6-in.-diameter strand was part of an alternative technical concept submitted by the design-build team and accepted by the Maryland Transportation Authority. Photo: AECOM.

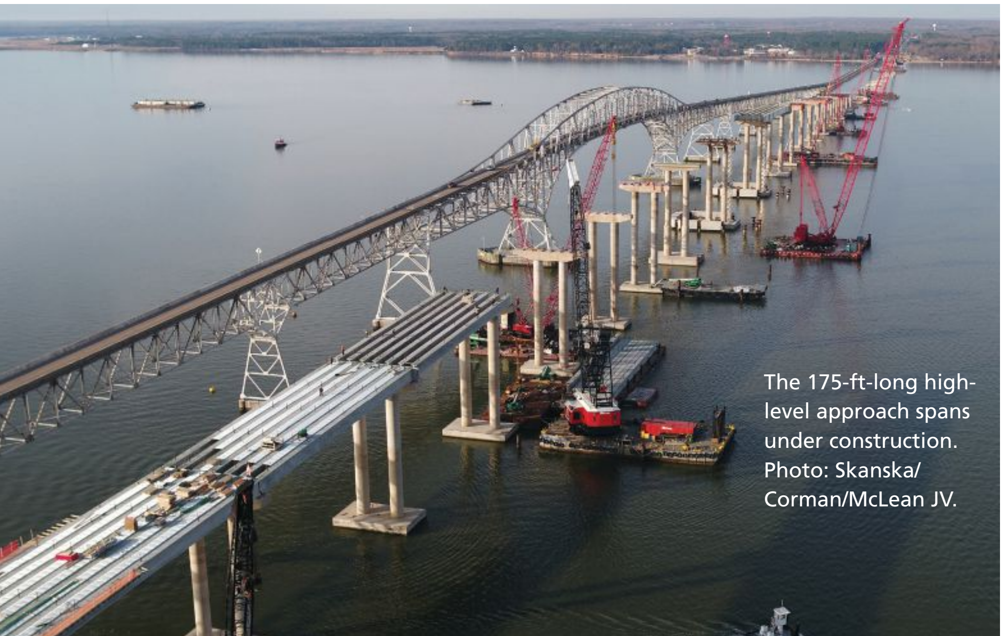
The precast concrete girder anchorage zones were designed in accordance with the strut-and-tie procedure provided by the Virginia Transportation Research Council (VTRC)[1] and checked against the American Association of State Highway and Transportation Officials’ *AASHTO LRFD Bridge Design Specifications*.[2] The VTRC procedure specified more reinforcement—approximately 350 lb of additional reinforcement per girder—than what would be required to strictly meet AASHTO requirements. With the additional reinforcement, no cracks were observed in the end anchorage zones of the girders.

Drainage was accommodated using MDTA-approved slotted barrier scuppers. The details for expansion joints at piers use drainage details developed by Virginia Department of Transportation and precast concrete troughs.[3]

The substructure consists of pile bents composed of concrete bent caps supported by 36-in.-square prestressed concrete piles. The typical pile bent includes six piles, each fitted with an 8-ft-long fiberglass protective jacket.

## High-Level Approach Spans

The high-level approach spans begin where the height of the pile bent reaches approximately 25 ft. The high-level approach spans are almost symmetrical about the centerline of the navigation channel spans, with lengths of 2446 and 2625 ft on the Maryland and Virginia approaches, respectively. The total length of the high-level approach spans is 5071 ft, including twenty-eight 175-ft-long



The 175-ft-long high-level approach spans under construction. Photo: Skanska/Corman/McLean JV.

Virginia Department of Transportation drainage trough details were used at the piers where there were expansion joints. Minimizing the number of deck joints and using drainage details that reduce bridge components' exposure to salt-laden water are two of the strategies used on this project to provide the structure with a 100-year service life. Photo: AECOM.

spans. To minimize the number of expansion joints (seven total), the typical expansion unit is 875 ft long, comprising five continuous spans. The high-level approach superstructure consists of seven lines of prestressed 95-in.-deep Maryland PCEF girders spaced at 8 ft 11 in. centers, and the same deck details as the low-level approach spans.

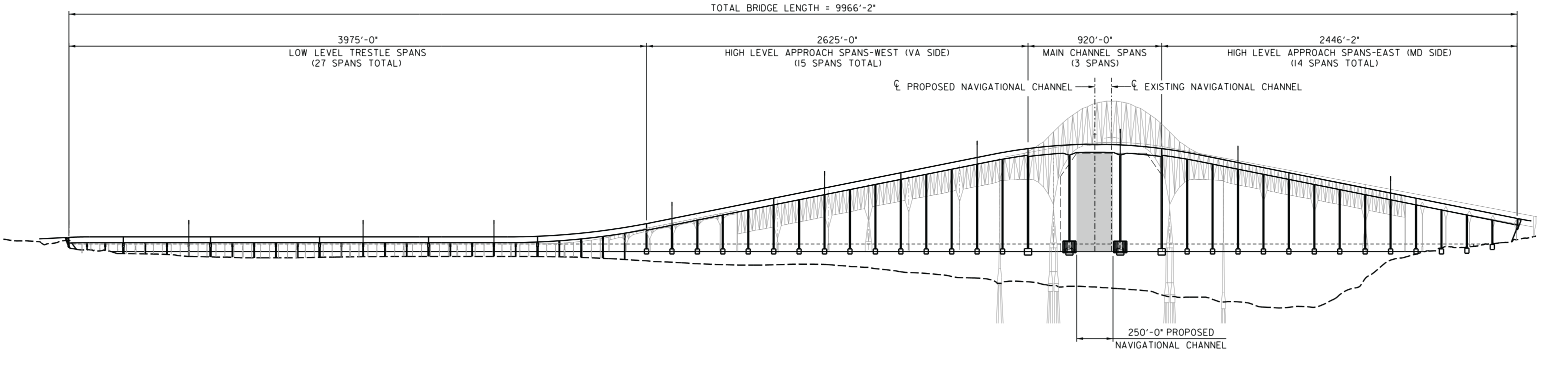
The substructure foundations consist of waterline footings supported by 36-in.-square prestressed concrete piles. The number of piles in each footing varies depending on pier height and vessel-collision requirements. The piles are designed for nominal bearing resistances up to 1086 kip. The concrete for the prestressed concrete piles is self-consolidating concrete with a 28-day design compressive strength of 7000 psi. The 36-in.-square piles contain thirty-two 0.6-in.-diameter seven-wire, low-relaxation steel prestressing strands with an ultimate tensile strength of 270 ksi. The spiral ties in the piles are hot-dipped galvanized steel. The ground conditions include a soft-clay alluvium at both approaches. The depths of the combined water and very soft soils range from 70 to 150 ft. Foundations were driven below the soft alluvium to the dense sand and gravel of the Aquia Formation to ensure axial capacity and lateral stability, and meet long-term settlement criteria.

The footings and pile layouts were designed for repetition to facilitate construction and maintain visual consistency and aesthetics. All footings are 28.5 ft wide longitudinally; waterline footings were constructed with precast concrete tubs. The tubs are sacrificial—designed for a minimum life expectancy of 75 years—and the bottom of each tub is about 2 ft below mean low water elevation.

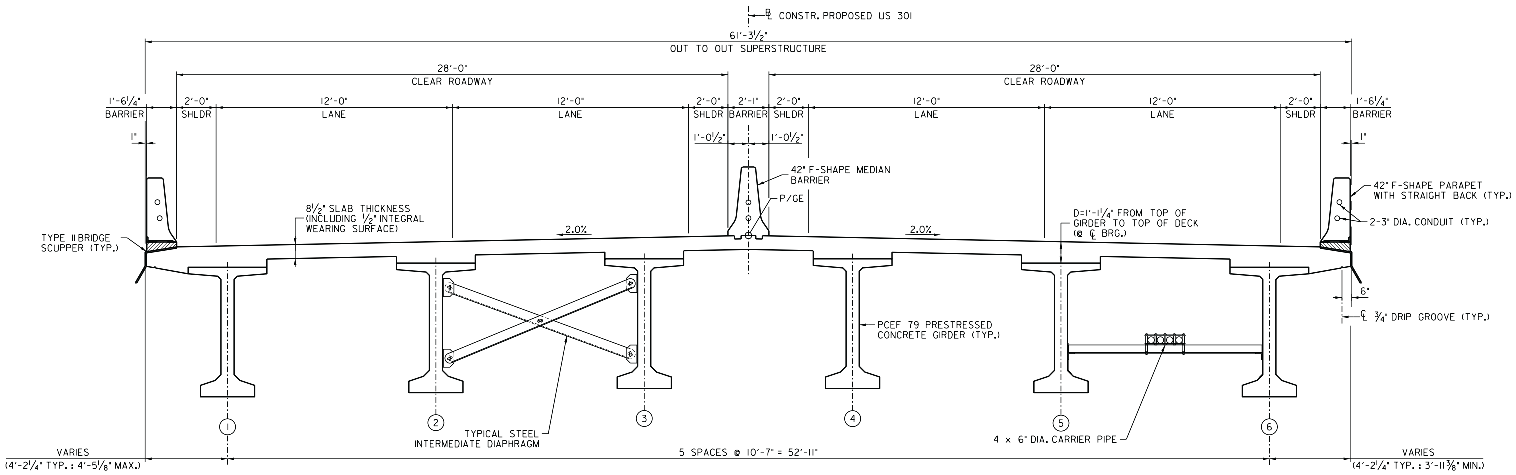
The substructure piers consist of CIP reinforced concrete circular columns with diameters of 6 ft 6 in., 7 ft 6 in., or 8 ft 6 in., depending on pier height. Traditional cantilever CIP concrete pier caps are used.

## Navigational Channel Spans

The navigational envelope of 250 ft horizontal and 135 ft vertical was maintained throughout construction by shifting the existing centerline of the channel 115 ft to the west (toward the Virginia shoreline).



The new Nice-Middleton Bridge gradually ascends from the Maryland shore (on the right), rising 135 ft above the Potomac River to allow passage of tall vessels, and then descends to a level just above the water as it approaches the Virginia shoreline (on the left). The design leverages a combination of prestressed concrete girders in the low-level and high-level approach spans. The old bridge is shown in gray. Figure: AECOM.



The superstructure for the low-level approach spans consists of six lines of prestressed, 79-in.-deep Maryland precast concrete economical fabrication girders spaced at 10 ft 7 in. centers, and an 8½-in.-thick cast-in-place reinforced concrete deck, which includes a ½-in.-thick integral wearing surface and a silane sealer. Figure: AECOM.

The substructure foundations for the four channel spans consist of waterline footings supported by 66-in.-diameter prestressed concrete cylinder piles. Each cylinder pile contains thirty-six 0.6-in.-diameter carbon-fiber-reinforced polymer (CFRP) prestressing strands with an ultimate tensile strength of 370 ksi. The spiral ties are CFRP with an ultimate tensile strength of 258 ksi. The substructure piers consist of CIP reinforced concrete circular columns with diameters of 10 ft 6 in. for the first 40 ft starting from the base of the column, and then transitioning to 8 ft 6 in. for the remainder of the pier height.

The impact criterion specified for vessel protection design is a 5000 deadweight tonnage design vessel at a speed of 8 knots. For the piers adjacent to the navigation channel, the perimeter fender system is designed to absorb the total kinetic energy of the design impact. The fender system consists of a precast concrete cap beam that surrounds the pier, supported by steel-pipe piles. The 200-ft-long steel piles supporting the cap are designed to absorb impact energy by ductile yielding at plastic hinges; one of these hinges forms beneath the cap whereas another forms deep underground. For the remaining piers within the design vessel impact zone, sufficient lateral capacity is accounted for in the substructure. For the rest of the piers falling outside of the impact zone, sufficient capacity is provided to sustain impact from a 200-ton barge drifting at 1.4 knots.

## Construction

The design-build team developed the construction approach for the project through a series of workshops and three-dimensional computer animation sequences. The team used the construction sequences, combined with cost- and schedule-benefit analyses, to validate the concept and virtually build the project in both three-dimensional and four-dimensional environments. This strategy enabled the team to optimize the design and construction approach, operational aspects, construction access, and land and marine construction activities, including construction over a navigable waterway and demolition of the existing bridge.

Key aspects of the project were construction access, staging, and logistics for deliveries and maneuvering the large marine fleet of equipment. The design-build team negotiated leases for parcels of land to stage materials and operate a project office. MDTA provided a 2.5-acre space adjacent to the existing bridge for the on-site batch plant. The closest ready-mixed concrete plant was located 30 minutes from the project. The on-site batch plant provided schedule and cost benefits and ensured quality.

Concrete from the on-site plant was transported from land to a set of transport barges via a conveyor system that included the redundancy of two belts. The barges, which each housed six agitators and were capable of transporting up to 90 yd$^3$ of concrete, were moved by tugboat to the point of placement. Concrete was then conveyed into a placement barge complete with a remixer and 140-ft-long placing boom that allowed placement of concrete at footings, columns, caps, and decks.

At the ribbon-cutting ceremony on October 12, 2022, Maryland governor Larry Hogan commented that the new bridge is "graceful in form and useful in function." The structure also has double the vehicle-carrying capacity of the bridge it replaced, and it has significantly improved safety for the traveling public.

## References

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2. American Association of State Highway and Transportation Officials (AASHTO). 2017. *AASHTO LRFD Bridge Design Specifications*, 8th ed. Washington, DC: AASHTO.

3. Virginia Department of Transportation (VDOT). 2020. "Pier Details General Guidelines and Type Selection Virginia Pier Cap." In *VDOT Manual of the Structure and Bridge Division: Part 02: Design Aids and Typical Details*. Richmond, VA: VDOT. https://www.virginiadot.org/business/resources/bridge/Manuals/Part2/Chapter15.pdf.

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