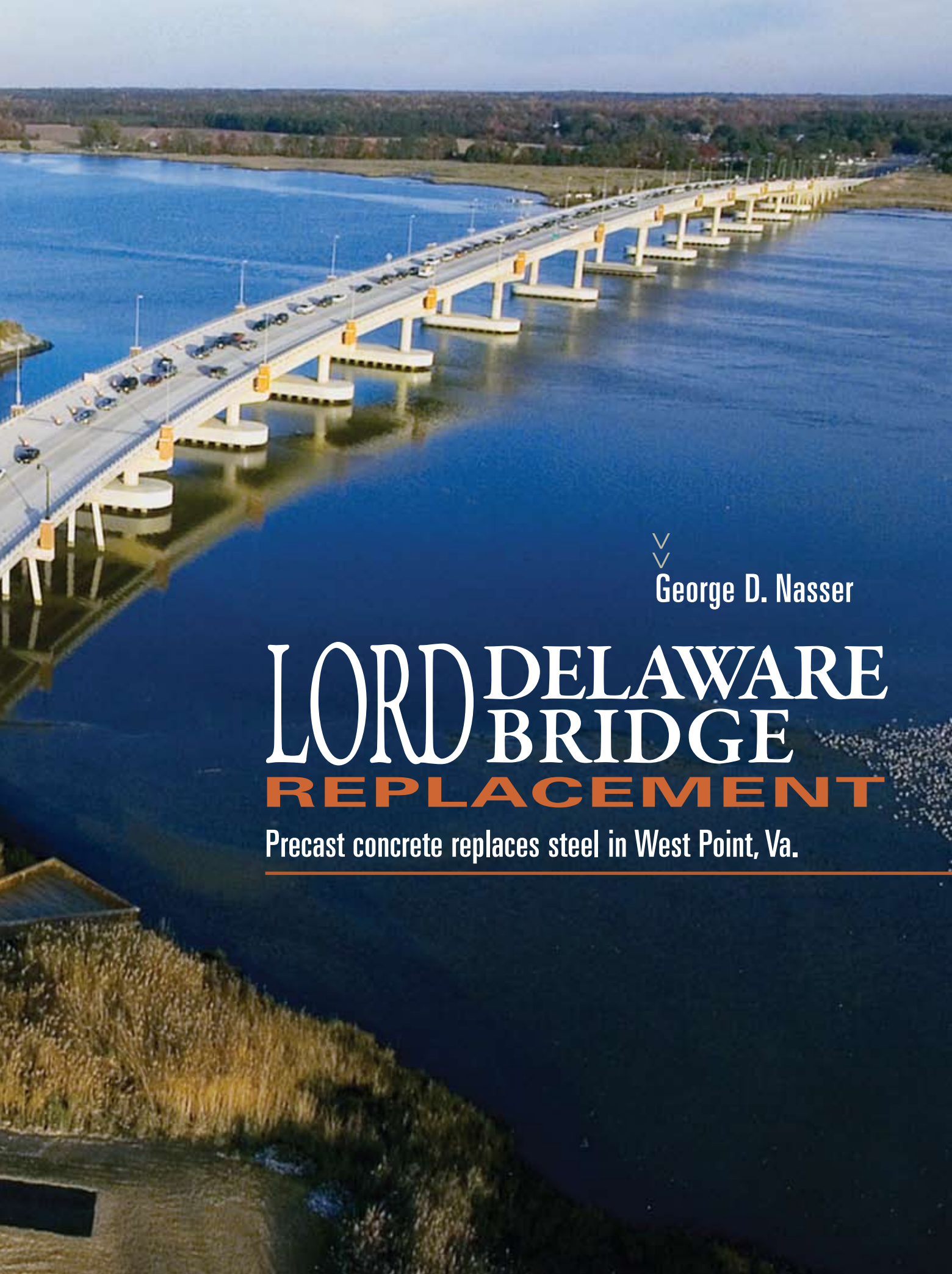

George D. Nasser

LORD DELAWARE BRIDGE REPLACEMENT

Precast concrete replaces steel in West Point, Va.

Adjacent to the historic town of West Point, Va., the prestigious new Lord Delaware Bridge carries highway traffic on Route 33 over the Mattaponi River. When the owner decided to replace an obsolete, two-lane, swing-span, steel bascule bridge constructed in 1945, the design team chose spliced bulb-T girders made of lightweight, high-performance precast, prestressed concrete for the main spans.

Above **This view shows the approach of the Lord Delaware Bridge.** Photo courtesy of Crow's Nest Photography.

Previous page **The Lord Delaware Bridge is located near West Point, Va.** Photo courtesy of Crow's Nest Photography.

Project details

Construction of the new bridge began in the summer of 2004 and was completed—on time and within budget—in August 2006. The 3545-ft-long (1080 m) precast, prestressed concrete structure is part of a larger project that replaces two existing two-lane, movable bridges with modern four-lane structures.

The Lord Delaware Bridge was designed by Parsons Brinkerhoff (PB), the engineer of record and a firm with a long history of designing bridges. Strong input was provided by the Virginia Department of Transportation (VDOT). The contractor was McLean Contracting Co. Two precasters were involved in the project. The primary precaster was Bayshore Concrete Products Corp., which supplied a majority of the products. The other precaster was Standard Concrete Products, which supplied the spliced bulb-T girders for the main spans of the bridge.

Team members

Owner:
Virginia Department of Transportation, Central Office, Richmond, Va.

Engineer of record:
Parsons Brinkerhoff, Norfolk, Va.

Contractor:
McLean Contracting Co., Glen Burnie, Md.

Precasters:
Bayshore Concrete Products Corp., Cape Charles, Va.
Standard Concrete Products, Savannah, Ga.

Design challenges

VDOT had several design requirements for the structure of the new Lord Delaware Bridge, including being sensitive to the environmental requirements of the site, keeping the navigation channel open, and being economical. All of these challenges were met with the new structure.

The first challenge was the sensitive environmental site. Construction had to be done in the Chesapeake Bay watershed. The bridge site is in the midst of open marshlands fed by seawater. This required minimal disturbance to wildlife and their natural habitat. Also, an extensive public involvement process was used to develop aesthetic treatments for the project, such as historically themed lighting on brick pilasters, extensive decorative planters, and brick sidewalks. Because of these environmental restrictions, it was important to maximize span length in order to minimize disturbances by the foundation.

A major feature of the bridge is the fixed main span unit, which provides a 55-ft-high (17 m) × 212-ft-wide (65 m) navigation channel. The project specifications stipulated that a navigable channel be provided that had a 55 ft height clearance (U.S. Coast Guard requirements) and was at least 200 ft wide. The navigable channel was required to be vessel collision proof, which meant that the abutments, piers, and footings had to withstand vessel impact. A vessel-collision analysis was conducted to show the statistical probability of a failure occurring due to a vessel colliding with a pile cap or pier.

The final major challenge facing the design team was to develop a structural scheme that was functional, efficient, and economical but that also fulfilled the aesthetic and environmental requirements. In the initial design phase, both a concrete and a steel solution were considered. For the shorter spans over the salt marsh, only precast concrete members were considered due to their performance over short spans.

It soon became apparent that a concrete solution would better meet the environmental requirements of the site. Standardized precast, prestressed concrete members with the possibility of long spans and a cost-effective foundation, coupled with a fast construction period, proved important factors in promoting a concrete solution. The decision to use concrete was further reinforced when durability and maintenance costs were considered.

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Public involvement

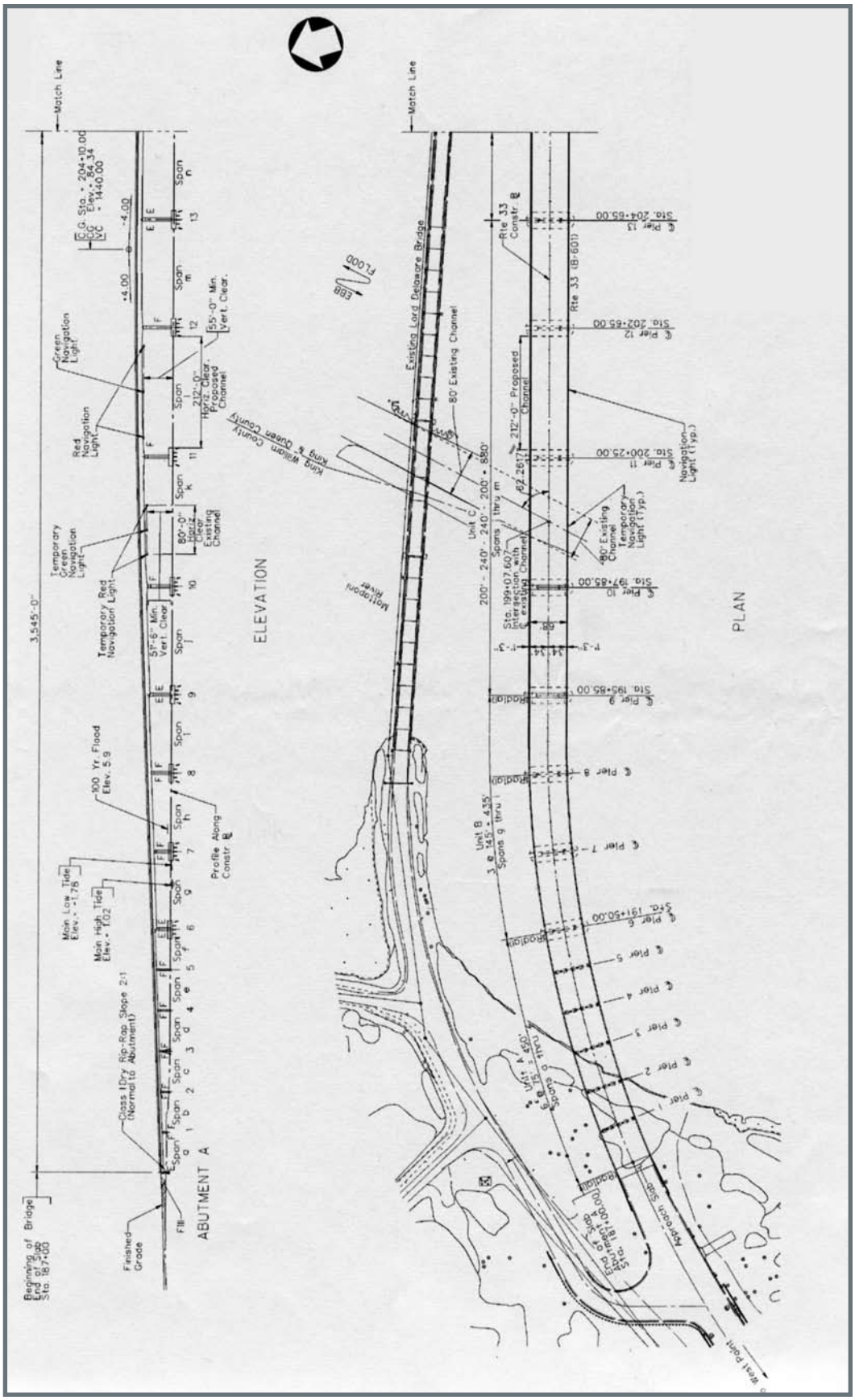
The comprehensive public involvement program for the design of the Lord Delaware Bridge included formal hearings, an informational meeting, numerous informal meetings with special interest groups, and a website. Several subalternative designs were developed to accommodate citizen input, including adding intersections, aesthetic treatments, and roundabouts. Additional design work included the development of computer-enhanced renderings of potential project impacts to the town of West Point, Va.

Close work with the community and the Virginia Department of Transportation enabled the project team to craft a context-sensitive solution to widening the roadways through town, as well as aesthetic treatments of the bridge and other amenities, such as the addition of a bikeway and scenic overlook.

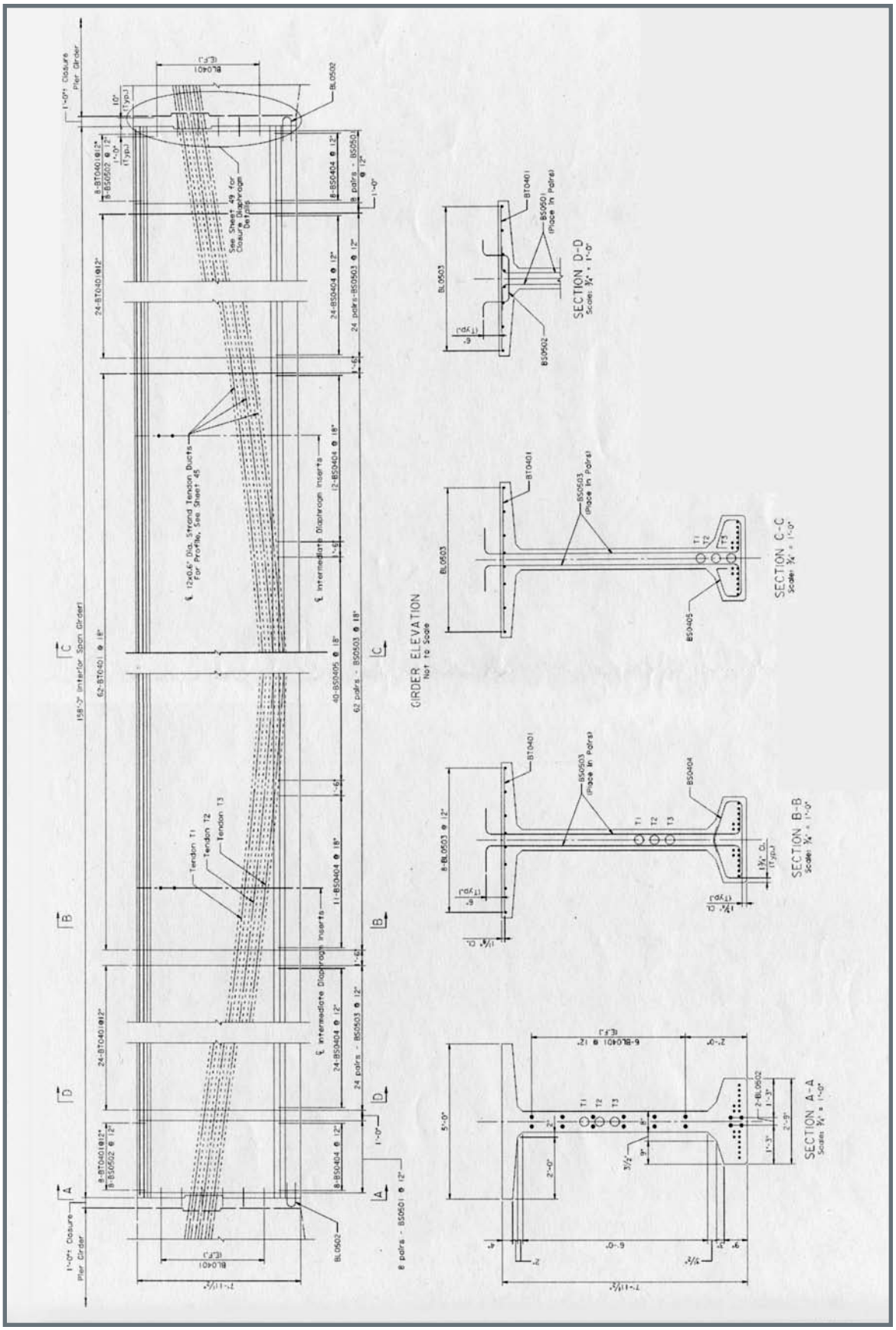
Geometry of Lord Delaware Bridge

Overall length	3545 ft
Overall width	68 ft (face-to-face of curb)
Total area of deck	241,060 ft^2
Six spans	75 ft long
Three spans	145 ft long
Two spans	200-240-240-200 ft
Five spans	90 ft
Six spans	75 ft
Radius of horizontal curve	2000 ft
Predominant grade	4%
Number of lanes	4
Number of shoulders	2

Note: 1 ft = 0.3048 m; 1 ft^2 = 0.093 m^2.



These drawings show the plan and elevation for the Lord Delaware Bridge. Figure courtesy of Parsons Brinkerhoff.



Details are shown for the elevation and cross sections of the bulb-T girders used in the Lord Delaware Bridge. Figure courtesy of Parsons Brinkerhoff.

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Environmental solutions

>> The design team prepared several wetland impact studies for environmental permitting of the bridge substructures and developed and monitored a remediation program to restore wetlands disturbed during the soil-boring activities. To reduce settlements for fills placed in the marshes, pile-supported and lightweight fill embankments were used in different areas of the project.

The crossing was hydraulically analyzed for scour effects for both 100-year and 500-year return-period flood events. This work included building a mesh model of significant portions of the river, as well as calibrating the model tidal effects.

The Coast Guard's navigable-channel specifications required vessel-collision analysis—statistical probability of collapse investigation as well as the design of the pier pile caps for vessel-collision loading.

Design solution

PB, working closely with VDOT, came up with an elegant solution. By using lightweight, high-performance concrete, newly developed spliced bulb-T girders were able to attain spans up to 240 ft (73 m). In particular, the 145-ft-long (44 m) precast concrete economical fabrication (PCEF) bulb-T girders and spliced girders in the two 200-240-240-200 ft (61-73-73-61 m) units are all-lightweight concrete as well as the cast-in-place concrete deck in these three units. This scheme greatly reduced the number of footings and piles, while also diminishing the environmental impact and increasing vehicular capacity from two lanes to four lanes. A major feature of the bridge is the fixed main-span unit that provides a 55-ft-high (17 m) × 212-ft-wide (65 m) navigation channel.

The lightweight concrete was derived from expanded shale aggregate produced by Carolina Stalite Co. The density of the concrete is 125 lb/ft^3 (2000 kg/m^3), with a specified compressive strength of 8000 psi (55 MPa).

In addition to the bulb-T girder superstructure components, precast concrete piles, footings, abutments, and wingwalls were used. The specified compressive strength of the piles was 6000 psi (40 MPa).

Precast concrete piles enabled trestle-type bents to be used for most of the low-level span, eliminating costly and environmentally destructive pile caps in the marsh. Precast concrete piles were also used under the larger footings in the river, with the footings cast just above the water level to eliminate the need for cofferdams.

Precast concrete meets project requirements

The selection of precast, prestressed concrete for this project was a cost-effective solution that will minimize future maintenance expenditures. Already, the bridge has fulfilled the public's transportation needs of increased traffic capacity. With its aesthetic charm, the bridge (along with the recently completed bridge over the Pamunkey River) has become an attractive landmark.

The total cost of the project was $37.6 million. The bridge cost $31.2 million, and the cost per deck area of the bridge was $129/ft^2 ($1400/m^2).

The Lord Delaware Bridge was officially opened on July 29, 2006, during a ribbon-cutting ceremony headed by former Virginia governor A. Linwood Holton Jr.

In March 2007, the Virginia Chapter of the American Concrete Institute honored the Lord Delaware project team, including the contractors, lead designers, and consultant project managers, with the Commonwealth Award for construction quality. This award recognizes a project team whose work exemplifies the best in construction quality and management practices.

Project highlights

Several important accomplishments were achieved on this project:

- This structure is the first high-performance, lightweight, precast concrete, spliced bulb-T girder bridge designed and bid in Virginia.
- The use of high-strength, lightweight, precast concrete spliced girders with haunched sections allowed spans of up to 240 ft (73 m) and also reduced their weight. This allowed for more economical foundations because the number of footings and piles was minimized.
- The bridge used water-level footings on river piers, provided for ship collision protection, and eliminated cofferdams in the water and all of the environmental disruption that they entail.
- To mitigate potential settlements, precast concrete piles were driven to support geotextile-fabric-reinforced embankments at compressible soil areas off the east end of the bridge.
- A formerly overgrown portion of the site was enhanced with a bike and hiking trail that includes scenic overlooks in the marsh and provides an off-road connection between an existing bike trail and downtown West Point. Bike-friendly rails were also added to the bridge.

This aerial photo was shot during construction of the Lord Delaware Bridge. To the right of the bridge is the old, obsolete steel bascule bridge.
Photo courtesy of Crow's Nest Photography.

About the author

George Nasser is editor emeritus of the *PCI Journal*. Nasser has written multiple articles and technical papers for the precast, prestressed concrete industry. A well-respected expert in the precast concrete industry, he was editor of the *PCI Journal* for over 30 years. He is a PCI fellow and was named a Titan of the industry in 2004.

Synopsis

This 3545-ft-long (1080 m) precast, prestressed concrete river crossing with main spans up to 240 ft (73 m) replaces an obsolete, two-lane, movable bascule bridge. The new bridge features spliced bulb-T girders for the main spans using lightweight, high-performance precast concrete.

Keywords

Bridge, bulb T, environmentally sensitive site, girder, high-performance concrete, lightweight concrete, precast concrete, spliced bulb T, spliced girder.

Reader comments

Please address any reader comments to *PCI Journal* editor-in-chief Emily Lorenz at elorenz@pci.org, or Precast/Prestressed Concrete Institute, c/o *PCI Journal*, 209 W. Jackson Blvd., Suite 500, Chicago, IL 60606.