PROJECT

Atkinson Boulevard Over CSXT Railroad and Interstate 64

Concrete provides economic and durable new east-west link

by Timothy Beavers, Caroline Hemp, and Jeremy Schlussel, Whitman, Requardt & Associates LLP

Since the mid-1980s, the comprehensive plan for Newport News, Va., included a new four-lane east-west connector between Warwick Boulevard and Jefferson Avenue to address future needs for cross-peninsula traffic movements. This new roadway would be required to span the CSX Transportation (CSXT) railroad and Interstate 64 (I-64) and traverse a large, forested area with wetlands throughout. To bring this road to fruition, numerous alignment studies were performed to determine the most appropriate corridor that would have the least environmental impact while also providing an economic and durable connection. Key goals were to reduce the roadway's impact on wetlands, limit long-term maintenance and construction costs, constrain superstructure depths, and keep fills to a minimum. The decisions resulting from these goals led to the creation of the longest continuous, prestressed concrete bulb-tee beam bridge in Virginia. Owing to the hard work of the city staff managing the design and construction, the designer's attention to detail, and the contractor's proactive planning and collaboration, this new, vital transportation link was successfully completed, and a grand opening was held on December 8, 2020. The bridge was funded through the Virginia Department of Transportation (VDOT) with city, state, and federal funding contributions.

Project Description

The bridge is 1742 ft 6 in. long with a 27.5-degree skew and an out-to-out width of 75 ft that carries four travel

A train passes under a beam that had just been placed over the busy CSX Transportation railroad line. A chain hold-down at the beam end on the pier provided positive restraint. Photo: Whitman, Requardt & Associates.

profile

ATKINSON BOULEVARD OVER CSXT RAILROAD AND INTERSTATE 64 /
NEWPORT NEWS, VIRGINIA

BRIDGE DESIGN ENGINEER: Whitman, Requardt & Associates LLP, Richmond, Va.

OTHER CONSULTANT: Surveyor: Precision Measurements Inc., Newport News, Va.

PRIME CONTRACTOR: Joint venture of Bryant Contracting Inc., Toano, Va. (bridge), and Basic Construction Company LLC, Newport News, Va. (roadway)

PRECASTER: Coastal Precast Systems, Chesapeake, Va.—a PCI-certified producer

Aerial view of the Atkinson Boulevard Bridge looking east. Photo: New Media Systems and Whitman, Requardt & Associates.

Lightweight concrete being placed in the deck. VDOT Class III (stainless steel) reinforcement was used in the concrete deck and barriers. Photo: Whitman, Requardt & Associates.

lanes and a shared-use path. The superstructure cross section consists of eight 85-in.-deep prestressed lightweight concrete bulb-tee beams spaced at 9 ft 11 in. with a composite 8½-in.-thick lightweight concrete deck. The lightweight concrete specified for both the beams and concrete deck had a 120 lb/ft^3 maximum density. The bridge consists of 12 spans made continuous for live load. The bridge substructure elements use normalweight concrete and feature two "Virginia abutments" to account for expansion and contraction. The 11 cap-and-column concrete piers reach up to 40 ft tall, and the two piers adjacent to the CSXT railroad were designed with a crash wall. The substructure is supported by 520 plumb 16-in.-square prestressed concrete piles totaling over 27,000 linear ft. In addition, the approach roadway is supported by mechanically stabilized earth (MSE) walls totaling 1274 ft in length.

Why Concrete?

The goal of the bridge design was to create an economical, durable, resilient, and low-maintenance bridge structure. During the initial study phase, three major design concepts were developed: a fully continuous concrete superstructure, a fully continuous long-span (180 ft minimum) structural steel superstructure, and a two-bridge solution with one bridge crossing over the CSXT railroad and the other crossing I-64 east- and westbound, connected by a nearly 50-ft-tall and approximately 900-ft-long MSE wall. At the time of the study in 2015, structural steel was in high demand, resulting in reduced availability and premium cost. The two-bridge option was deemed not viable because of the poor soil conditions at the MSE infill location and the associated impacts. After review with the city and permitting agencies, the fully continuous prestressed concrete bulb-tee beam bridge was chosen.

Once the fully continuous concrete superstructure had been selected, the goal was to ensure that the final layout would span the CSXT right-of-way and

The bridge has two "Virginia abutments" that allow for contraction and expansion while protecting the beam ends and bearings with a concrete end diaphragm. Roadway drainage is collected in the concrete trough and directed away from the bridge structure. Photo: Whitman, Requardt & Associates.

CITY OF NEWPORT NEWS, VIRGINIA, OWNER

OTHER MATERIAL SUPPLIERS: Lightweight aggregate: Carolina Stalite Company, Gold Hill, N.C.; stainless steel reinforcement: Transcon Supply, Harrisonburg, Va.; elastomeric bearings: Cosmec Inc./Dynamic Rubber, Athens, Tex.; mechanically stabilized earth walls: Reinforced Earth Company, Reston, Va.

BRIDGE DESCRIPTION: A 1742-ft 6-in.-long, 12-span, fully continuous (joints only at abutments) prestressed lightweight concrete bulb-tee beam bridge

STRUCTURAL COMPONENTS: All spans used eight lines of prestressed lightweight concrete 85-in.-deep bulb-tee beams up to 156 ft long with an 8½-in.-thick cast-in-place lightweight concrete deck with lightweight concrete end diaphragms and continuity diaphragms; cast-in-place concrete pier caps, columns, and footings; and 16-in.-square prestressed concrete piles

BRIDGE CONSTRUCTION COST: \$22.7 million (\$173.70/ft^2)

allow for future widening of I-64. The designers optimized the layout over the CSXT railrod and I-64 east- and westbound to lay out three spans that were geometrically similar. Lightweight concrete was selected during the early part of the final design efforts. The use of lightweight concrete deck and girders allowed the designer to remove a beam line while keeping the same 85-in. beam depth, and to reduce substructure loads to help optimize the length of the numerous prestressed concrete friction piles. The optimized spans measured 156 ft 2 in. from centerline of pier to centerline of pier. The remaining nine spans were chosen as an economic balance between number of piers and the span limitations of the 85-in. bulb-tee beams. With the use of concrete elements and standard detailing, the bridge-only costs proved to be very economical, with an as-bid price of approximately $175 per square foot of bridge deck.

Technical Design Details and Unique Features

While this project was designed and constructed for the City of Newport News Department of Engineering, standard VDOT details were used extensively to help keep construction costs down and to reduce future maintenance costs. Although the bridge used standard elements, the design decisions behind the scenes were anything but standard.

The prestressed concrete beams were designed within VDOT standards, including the use of 8000-psi lightweight concrete. However, the fully continuous design had to take into account special detailing for creep, shrinkage, and thermal effects; the detailing of the continuity diaphragms; the design and detailing of the 192 elastomeric bearings; stresses during shipping and handling; and the effects of camber.

One challenge was how to account for the creep, shrinkage, and thermal effects in this long, skewed, continuous (joints only at abutments) bridge. To understand the behavior of the bridge, a detailed analysis was performed using a combination of hand computations and finite element models (using LARSA-4D software) to better predict thermal centers and long-term creep and shrinkage behavior. The results showed total movement of approximately 6.75 in. at the abutment joints in the final condition. These results provided guidance for the design of the bearing system and for decisions about which substructure elements were to be fixed or expansion. After reviewing bearing types, reinforced elastomeric bearings were selected as the most economical choice. They were designed to be fully fixed at the three middle piers, with the remaining pier bearings designed as expansion bearings using sliding plates over elastomeric pads. To account for the transverse and longitudinal movements, the interior four beam lines used anchor bolts guided with elongated slots in the sole plates, whereas the exterior two beam lines of each side used sliding bearings without any anchor bolts. This concept allows the bridge to expand and contract as specified by the American Association of State and Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*,[1] while still providing positive connection through a combination of the anchor bolts and dowels at the fixed continuity diaphragms.

The long spans in this structure are connected by concrete continuity diaphragms that were designed to accommodate the differential temperature deformations in the superstructure cross section along with composite dead-load and live-load moments. To account for positive moments at the continuity diaphragms due to differential thermal gradients, the continuity diaphragms were designed based on research sponsored by the Virginia Transportation Research Council.[2] Based on this design methodology, additional bottom-flange continuity reinforcing steel was combined with bent-up strands to provide a more durable and resilient connection.

Experience, a review of available research, and a review of the assumed travel route to the project site indicated that stability and stresses during shipping and handling were significant concerns for prestressed concrete beams of the length and depth specified for this project. The bridge design engineer performed design checks for the lifting, handling, and shipping stresses for the long prestressed concrete beams using guidance from VDOT and a draft (at the time of design) of PCI's *Recommended Practice for Lateral Stability of Precast, Prestressed Concrete Bridge Girders*.[3] Notes were added to the plans to inform the contractor about the design assumptions that were used.

In addition to the shipping and handling stresses, there were also concerns about how to account for camber in the long-span prestressed concrete beams. Recent research into camber prediction showed that if a time-dependent method were used for this analysis, it would provide a better prediction of the final cambers.[4–6] After the project was awarded, the contractor and fabricator worked directly with the design engineer to estimate the predicted camber of the beams based on the age of the beam at the time of erection according to the proposed project schedule. The contractor provided the beam production schedule along with the erection schedule, allowing

View of a typical pier near the middle of the bridge showing prestressed concrete beams before deck placement. The 12-span structure has 11 five-column concrete piers that reach up to 40 ft tall. The piers are supported by 520 plumb 16-in.-square prestressed concrete piles totaling over 27,000 linear feet. Photo: Whitman, Requardt & Associates.

Dual crane setting operation for the 85-in.-deep, 156-ft 2-in.-long prestressed lightweight concrete bulb-tee beams spanning over the CSX Transportation railroad. Clips on the beam web were for crossframes and utility hangers for conduits.. Photo: Whitman, Requardt & Associates.

the designer to provide adjusted pier and abutment seat elevations as a construction revision. While all beams had to meet a minimum of 90 days of age before the continuity diaphragm was placed, some beams were not scheduled to be erected until almost a year after casting.

The planning and collaboration among the designer, contractor, and fabricator were beneficial to the successful installation of the prestressed lightweight concrete beams and, ultimately, the reinforced concrete deck. The recalculated cambers based on the time-dependent method were used to adjust the beam seat elevations and predicted the actual cambers well enough to avoid any areas of deck thinning throughout the bridge.

Durability and Resiliency Considerations

The Atkinson Boulevard Bridge is the largest bridge in overall deck area in the city's inventory, over 70% larger than the next largest bridge. Therefore, durability of materials and the extensive use of jointless detailing were critical to provide a low-maintenance and resilient bridge structure. The superstructure materials were chosen to increase the durability of the bridge, and, following VDOT guidance, a combination of approved corrosion-resistant reinforcing steels were selected. VDOT Class I (low-carbon chromium) reinforcement was used in the substructure and prestressed concrete beams (for reinforcement that projects out of the beam) and VDOT Class III (stainless steel) reinforcement was used in the concrete deck.

View of 155-ft-long, 85-in.-deep prestressed concrete bulb-tee beams during the setting operation. Beam camber was a major concern due to the long times between beam production and erection. This concern was mitigated using time-dependent methods to recalculate the predicted camber and adjust the substructure seat elevations. As a result of the contractor and fabricator working directly with the design engineer, the camber predictions were a good estimate of the actual field-measured camber. Photo: Whitman, Requardt & Associates.

Conclusion

The decision to use concrete for the entire project provided the City of Newport News with a long-service-life, low-maintenance bridge. The use of lightweight concrete reduced both pile lengths and the total number of piles required. In addition, lightweight concrete also helped advance the design of the prestressed concrete beams by reducing the number of strands, which helped control camber growth. Lightweight concrete was the go-to option given these design benefits coupled with increased durability at minimal additional cost.

References

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