Bridging Innovation and Practicality: The Schuylkill Banks Christian to Crescent Cable-Stayed Bridge

by Trevor Kirkpatrick and
Joel Cummings, AECOM

A view of the graceful S-curve alignment of the Christian to Cresent Bridge, with the Philadelphia, Pa., skyline in the background. Photo: Michael Worthington, Jr.; Worthington Images.

The Schuylkill Banks Christian to Crescent Bridge in Philadelphia, Pa., is a striking example of the integration of precast concrete U-beams into a complex pedestrian bridge structure. In this project, precast concrete U-beams were selected for four key reasons: U-beams can span long distances with limited permanent and temporary supports; construction would be fast and efficient; the structure would have long-term durability with minimal maintenance; and the U-beams would give stakeholders the needed flexibility to meet structural and aesthetic design goals. Each of these aspects played a role in the success of this bridge.

About the Bridge

The new, 650-ft-long Christian to Crescent Bridge is a cable-stayed structure that links Philadelphia's Center City section of the Schuylkill River Trail with the Grays Ferry Crescent segment of the trail. The elegant and practical bridge design features precast concrete U-beams made integral with two cast-in-place towers that rise 139 ft above the deck. Each of the towers anchors 28 wire-rope cables supporting the superstructure. The cables are 2¾-in.-diameter ASTM A586 galvanized structural strand with Class A coating

profile

CHRISTIAN TO CRESCENT BRIDGE / PHILADELPHIA, PENNSYLVANIA

BRIDGE DESIGN ENGINEER: AECOM, Tampa, Fla.

BRIDGE ARCHITECT: Bradley Touchstone, AECOM, Tampa, Fla.

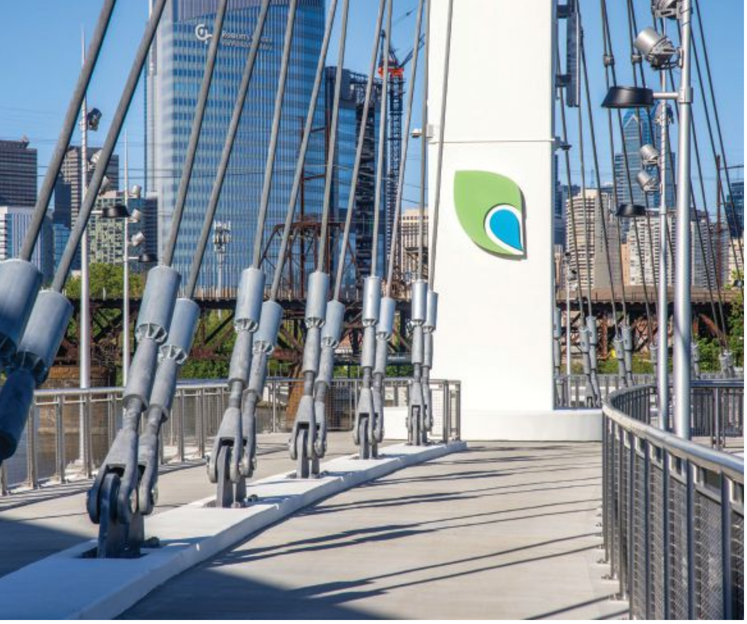
OTHER CONSULTANTS: Construction management and inspection: Pennsylvania Department of Transportation; Urban Engineers, Philadelphia, Pa.; TRC, Philadelphia, Pa.; City of Philadelphia; construction engineer: Janssen & Spaans Engineering, Indianapolis, Ind.

PRIME CONTRACTOR: PKF-Mark III, Newtown, Pa.

CONCRETE SUPPLIER: Silvi Materials, Philadelphia, Pa.

PRECASTER: The Fort Miller Co. Inc., Greenwich, N.Y.—a PCI-certified producer

POST-TENSIONING SUPPLIER: DYWIDAG-Systems International, Bolingbrook, Ill.



The center-cable arrangement with streamlined pin-and-clevis cable anchors supports the superstructure. Photo: Michael Worthington, Jr.; Worthington Images.

The bridge features a streamlined, curved precast concrete spliced U-beam superstructure with cables in a basketweave pattern. Photo: Michael Worthington, Jr.; Worthington Images.

inner wires and Class C coating outer wires. The curved, spliced, precast and post-tensioned concrete U-beams are integrated with a cast-in-place 25-ft-wide bridge deck with circular overlooks at each tower. The deck thickness varies from 9 in. at the fascias to 11¼ in. at the bridge centerline. Above the deck, the towers taper in two directions, adding dimension and interest. The cables are arranged in a distinctive basketweave pattern and are anchored with elegant pin and clevis anchors for a streamlined look. The towers are founded on nine 6-ft-diameter steel-encased caissons that extend 60 ft below the bottom of the footing, including 20 ft of rock socket.

The Schuylkill River Trail is a planned 130-mile-long, off-road recreational trail and greenway that extends along the river from Schuylkill County, Pa., to the confluence of the Schuylkill and Delaware Rivers. The new pedestrian bridge, which is part of the trail, was completed in May 2025, closing the last remaining gap in the 4 miles of trail on the east side of the river and transforming how people move throughout the city.

Integrating Architectural and Structural Form with Community Needs

More than just crossings, bridges are community landmarks that reflect shared values and aspirations. By using precast concrete U-beams, the project team for the Christian to Crescent Bridge integrated thoughtful structural innovations to create a highly functional and visually distinctive bridge that enhances the Schuylkill River Trail experience for pedestrians and cyclists.

Reinforcement and the draped post-tensioning ducts for one of the U-beam segments are set up at the precast concrete manufacturing facility. Photo: Fort Miller Precast.

CITY OF PHILADELPHIA/SCHUYLKILL RIVER DEVELOPMENT CORPORATION, OWNER

OTHER MATERIAL SUPPLIERS: Precast concrete transport: Carver Companies, Albany, N.Y.; concrete formwork: Doka (custom tower form and deck overhang); EFCO (deck overlook support and end diaphragms); reinforcement fabricators: Re-Steel Supply, Eddystone, Pa.; Men of Steel, Bensalem, Pa. (prefabricated drilled shaft cages); bearings: RJ Watson, Alden, N.Y.

BRIDGE DESCRIPTION: 1800-ft-long pedestrian bridge structure, including a 650-ft-long cable-stayed bridge with a basketweave cable pattern on an S-curve alignment with a curved, precast concrete, post-tensioned U-beam superstructure

STRUCTURAL COMPONENTS: 84-in.-deep, curved, spliced, and post-tensioned precast concrete U-beams with a variable thickness (9 to 11¼ in.) cast-in-place concrete deck; 72-in.-diameter drilled shafts; cast-in-place concrete footings and towers

BRIDGE CONSTRUCTION COST: $48 million total project cost; $22 million for the cable-stayed bridge (approximately $1300/ft^2)

AWARDS: PCI Bridge Award; 2025 PTI Award of Merit Bridges Category

A precast concrete U-beam segment is transported to the dock facility in Albany, N.Y., before being shipped by barge to the project site. Photo: Fort Miller Precast.

The project team developed the concept through careful planning and in close collaboration with the City of Philadelphia and the Schuylkill River Development Corporation. The initial effort began with a 2016 feasibility study that explored four bridge types and recommended a straight alignment. Ultimately, the alignment was adjusted to incorporate a graceful 950-ft-radius reverse curve to avoid obstructions along the river. This practical and aesthetic decision led to the selection of a cable-stayed bridge with precast concrete U-beams.

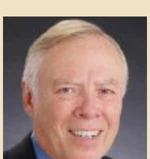
After the bridge type was established, precast concrete U-beams became a central element in achieving the objective of providing a landmark structure to connect the communities. Unlike cast-in-place alternatives, precast concrete U-beams could be fabricated in long sections off site. In addition, erection required fewer temporary piers than would be used for a cast-in-place structure, thereby reducing the impact of construction on the community. Equally important, the use of precast concrete U-beams provided a clean, streamlined appearance, free of bolted splices or segment joints that might distract from the bridge's elegant silhouette. The U-beams also paired well with steel cable anchors cast into concrete diaphragms.

The center-cable arrangement required a torsionally rigid superstructure to support loading demands. To address this challenge, the design combined curved, spliced, post-tensioned precast concrete U-beams with a cast-in-place composite concrete deck. Together, these elements create a closed cross section that efficiently resists torsional forces generated by the curved geometry while maintaining durability, safety, and constructability within a highly constrained urban environment. The result is a smooth, modern structure that fits comfortably into the urban landscape and serves as a civic destination.

Advancing Curved U-Beam Technology

The curved precast concrete U-beams used in the Christian to Crescent Bridge exemplify the advances in technology developed over the years. Curved precast concrete U-beams were initially developed by the Colorado prestressed concrete industry during the 1990s, and their use has since expanded across the United States. A collaboration of designers, contractors, and owners developed PCI's *Guide Document for the Design of Curved, Spliced Precast Concrete U-Beam Bridges*.[1]

The U-beam section on the Christian to Crescent Bridge followed the web and top flange proportions recommended in PCI's guide document, but the bottom flange was widened to suit the project's unique needs, and embedded couplers



AESTHETICS **COMMENTARY**

by Frederick Gottemoeller

When it is completed, the Schuylkill River Trail will extend from Tuscarora Springs in Schuylkill County some 120 miles until it joins the Delaware River in Philadelphia's Center City, providing recreational opportunities and pedestrian and bicycle routes in the communities through which the river passes. For most of its length, the trail winds its way through the woods along the riverbanks. But the design challenges are very different in the urbanized sections of the valley, and most different of all in downtown Philadelphia.

In Center City, the riverbanks are already occupied by highways, railroads, and power lines. Therefore, most of the trail's Christian to Crescent section must be over water. (Unlike most river bridges, this one runs parallel to the riverbanks.) Notably, the highways, railroads, and power lines have ramps, bridges, and pylons that not only occupy the riverbank space but also conceal the river itself from the surrounding city. In this setting, the design challenge was twofold: to provide a physical passage along the river and to create a visual symbol that says "Hey, I am here."

To provide physical passage, it made economic sense to minimize the number of foundations in the water, a decision that suggested the use of long spans. Long spans inspired the vision of a cable-stayed structural system that would give the bridge tall vertical elements capable of visually competing with the confining ramps, bridges, and pylons. These aspects of the design were all just applied common sense.

The art of the design is evident in the unique basketweave pattern of the stays. The pattern's peaked profile stands out among its visual competition and inserts a memorable shape into the scene. (The redundant stay pattern also reduces the load per stay, allowing the use of less-expensive, standard wire rope cables and fittings.) The art is also found in the vertically tapered, dramatically truncated towers and in the gradual reversed curves of the bridge's alignment, which, as pedestrians move along the bridge, slowly sweeps their gaze across their surroundings.

Another innovative aspect of the design is the application of a spliced, precast concrete U-beam. To river users, the bridge presents as an enclosed, light-colored element, with no visible hollows or recesses to accumulate dirt, debris, or pigeons.

The result is a memorable urban landmark that fits its environment, is a pleasure to use, and attracts people and activity to the riverfront.

A barge-mounted marine salvage crane with a crawler assist crane is used to lift the U-beam segments onto temporary falsework. Photo: Pennsylvania Department of Transportation.

U-beam segments sit on temporary falsework after the deck is placed but before cables are tensioned. Photo: AECOM.

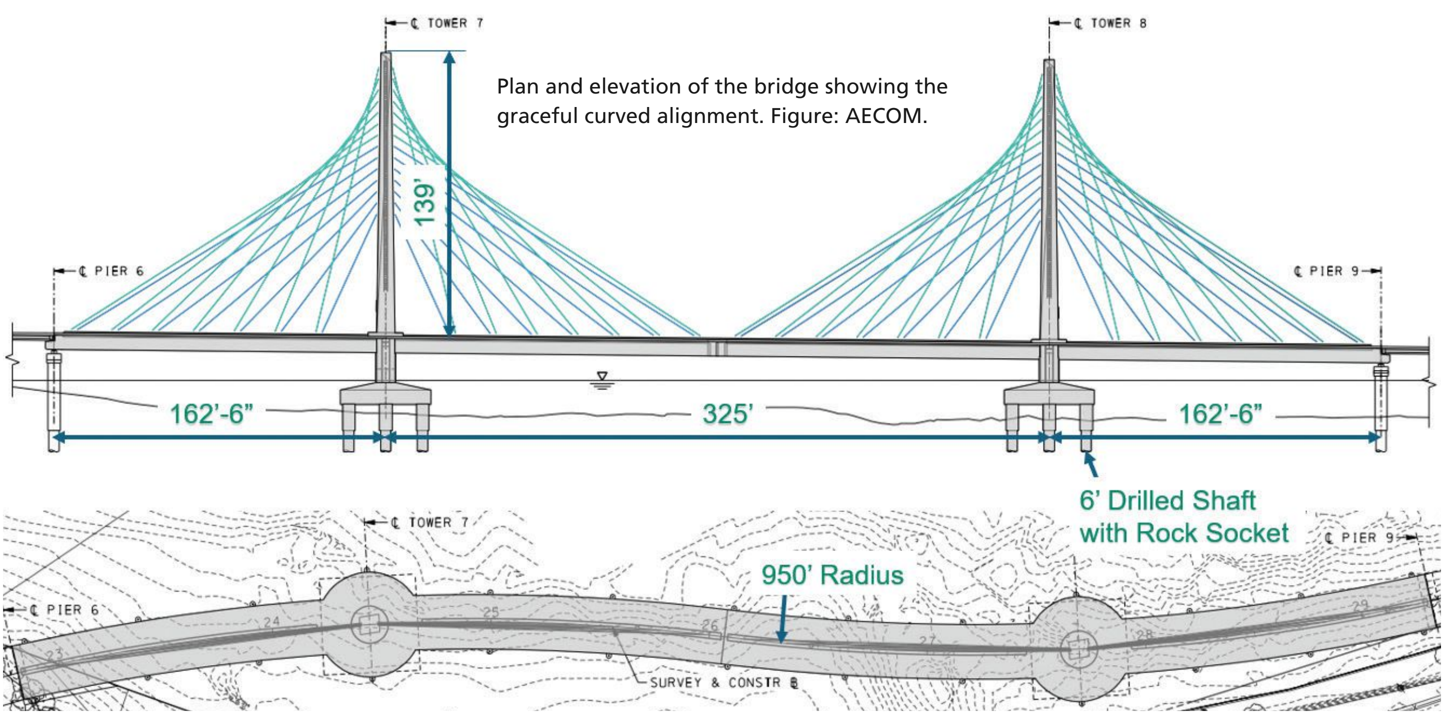
View of the basketweave pattern of the center stay cables shortly after the cables were tensioned. Photo: Pennsylvania Department of Transportation.

and shear keys were incorporated to accommodate cast-in-place diaphragms. The bridge has a cast-in-place lid slab—a small portion of the deck that spans between the precast concrete webs—which increased torsional stiffness 50 times compared with the open precast concrete section and allowed the girders to function as a composite closed section before post-tensioning and concrete deck placement.

The U-beam design used 7-strand tendons that were installed in the casting yard and tensioned before the U-beams were shipped. The rest of the 12- and 15-strand continuity tendons were installed and tensioned after diaphragms, closure joints, and the lid slab were placed, but before the remainder of the cast-in-place concrete deck was placed. The design concrete strength for the precast concrete U-beams at transfer was 6.8 ksi, and the 28-day design concrete strength was 8 ksi.

Reducing Costs and Maintenance

Costs and long-term maintenance are always top of mind when planning major bridge projects. The Christian to Crescent Bridge is a great example of



Plan and elevation of the bridge showing the graceful curved alignment. Figure: AECOM.

how careful design decisions can help reduce future costs.

From the outset, the project team set out to minimize future maintenance needs, which guided the selection of the bridge's structural system. While steel tub girders offer some of the same constructability advantages as precast concrete U-beams, they require regular repainting to prevent corrosion, which would be an especially challenging and expensive task given the bridge's location over the Schuylkill River. In addition, steel structures often require detailed, "arms-length" inspections at welds and connections.

Another option was segmental cast-in-place concrete, which offered some advantages in reducing temporary supports in the river. However, this system came with higher costs and required specialized contractors, which could limit competition during bidding.

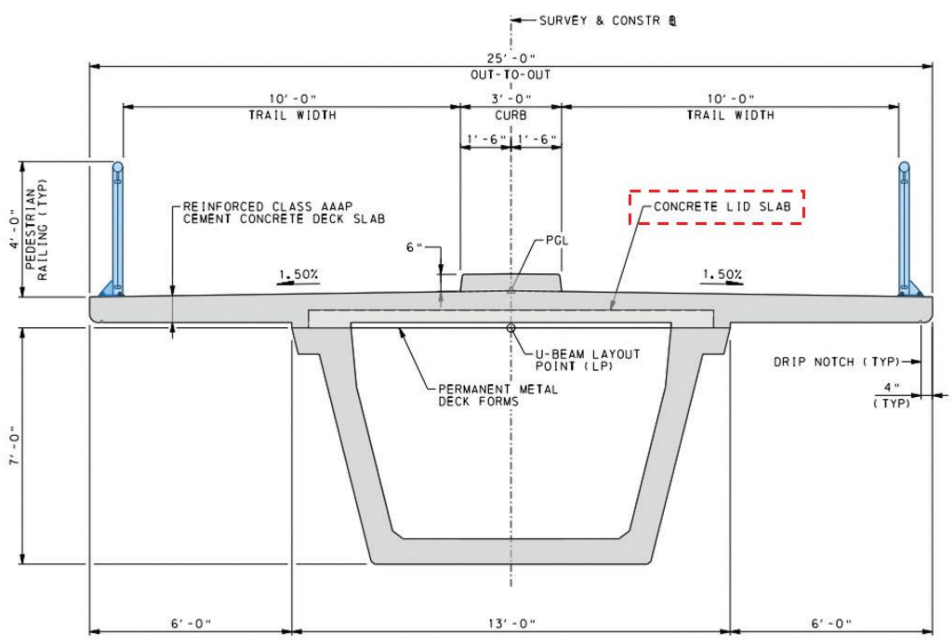
Ultimately, precast concrete U-beams stood out as the best fit for the project. They combined durability with cost-efficiency, and would have lower long-term maintenance needs than the other alternatives. Precast concrete offers resistance to weathering and corrosion when protected from the elements. To further protect critical components, the design included stainless steel reinforcement in the deck, reducing the likelihood that the deck would need to be replaced in the years ahead. All exposed steel elements, such as cable connections, plates, and anchors, were galvanized or stainless steel to help guard against corrosion.

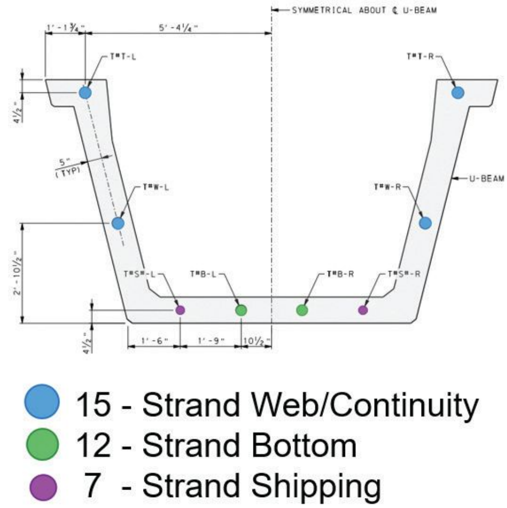
Accessibility for inspections was also a priority. The bridge incorporates deck-level access openings and built-in ladder and rope access systems, making it easier for maintenance teams to carry out routine inspections safely and efficiently without using heavy equipment.

Maximizing Conventional Construction in Complex Structures

The Christian to Crescent Bridge is a clear example of how thoughtful design can deliver a distinctive structure while relying on conventional construction methods. The team prioritized—and maximized—the opportunity to develop an ambitious bridge design that could be built using conventional construction techniques, equipment, and workflows to maintain efficiency on a challenging site. The site was constrained due to an industrial docking facility, high-voltage electric lines, the narrow footprint against railroads along the shoreline, and vertical limitations because the structure passes underneath a rail bridge and the Schuylkill Expressway.

Superstructure cross section showing the 13-ft-wide U-beam and lid slab. Figure: AECOM.





Cross section of the U-beams showing layout of shipping and continuity post-tensioning. Figure: AECOM.

The cast-in-place concrete towers are 9 ft × 8 ft at the base and taper to 5 ft × 8 ft at the top. Intersecting triangular planes give the illusion of a rotating section. The towers were constructed using custom adjustable formwork in eight total lifts above the deck. Eight 1¾ in. vertical post-tensioning bars, offset from the center of gravity of the column, counteract the eccentric loading caused by the curved alignment. In other words, the cables pull the tower toward the center of the curve and the vertical post-tensioning pulls the tower back to near vertical.

Precast concrete curved U-beams were chosen as the main structural elements because they could handle the bridge's pronounced horizontal curve and because cranes and conventional lifting techniques could be used to erect them. These beams were fabricated offsite in upstate New York, transported by truck overland to a dock, and then delivered by barge to the project site. There was very little land access at the site due to the adjacent active rail lines, industrial facilities, and overhead power transmission lines. Delivery by rail was an alternative discussed during the design phase, but barges were ultimately chosen to simplify erection. This approach ensured that the precast concrete elements arrived ready to install without requiring complex formwork or specialized erection equipment.

Construction proceeded largely from barges on the river, minimizing disruption

Barge-mounted crawler assist crane lifts the U-beams from the transport barge. Photo: PKF-Mark III.

to adjacent properties and enabling work to proceed within the tight site constraints. To place the U-beams, the team sourced a unique marine salvage crane not commonly used for bridge construction and supplemented it with a crawler assist crane. This equipment, while specialized in capacity, still fit within the realm of conventional lifting operations rather than requiring custom gantries or launching trusses.

After the beams were set, the diaphragms and closure joints were placed, and then the lid slab was placed. After lid slab placement, 12- and 15-strand continuity tendons were placed and tensioned in one stage. This was followed by the concrete deck placement.

Contractors with expertise in cable-stayed bridges were engaged early in the design phase and returned during construction to oversee the installation of the bridge's distinctive cables. These cables, which contribute to the bridge's visually striking profile, were installed sequentially in pairs at each tower, progressing from the lowest to the highest positions. After all the cables were in place, each cable was carefully tensioned to a specified force to control stresses and maintain the intended geometry of the towers and the superstructure. As the cables were tensioned, the beams lifted off the falsework and into their final position.

By focusing on conventional construction methods, the Christian to Crescent Bridge proved that ambitious design does not have to come at the expense of practicality or efficiency.

Conclusion

The Christian to Crescent Bridge highlights how precast concrete U-beams can redefine what is possible in bridge construction. The curved, spliced U-beam superstructure achieved a graceful alignment while delivering the torsional stiffness needed for a central plane of support cables. Off-site fabrication in a controlled environment ensured consistent quality and efficient installation with conventional equipment.

This project demonstrates how these innovative components can unlock complex geometries and durable structures without requiring specialized methods or crews. From highways to pedestrian crossings, precast concrete U-beams are proving their value in creating bridges that are practical to build and inspiring to experience. Christian to Crescent Bridge stands as a testament to this approach—and serves as a model for what is next in modern infrastructure.

Reference

1. Precast/Prestressed Concrete Institute (PCI). 2020. *Guide Document for the Design of Curved, Spliced Precast Concrete U-Beam Bridges*. Chicago, IL: PCI. https://doi.org/10.15554/CB-03-20.

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Stainless steel reinforcement in the cast-in-place concrete deck. Photo: Pennsylvania Department of Transportation.