PROJECT

# INTERSTATE 91 BRATTLEBORO BRIDGE— A GATEWAY TO NATURE IN CONCRETE

by Garrett Hoffman, FIGG

Construction of the Interstate 91 (I-91) Brattleboro Bridge Project in Brattleboro, Vt., replaced twin existing bridges over the West River with a new long-span landmark bridge. The best value-selected, design-build project was designed by the team for the Vermont Agency of Transportation (VTrans). The new gateway bridge features a 1036-ft-long arching concrete bridge soaring 90 ft above the West River and built using balanced-cantilever construction. Two piers flank the river banks to support the three-span (263-515-258 ft) bridge.

## Vermont's Bridge to Nature

It was important to VTrans and the surrounding communities that the new bridge serve as an icon and a gateway to Vermont. The bridge construction also needed to have minimal impact on the traveling public using the bridge, as well as those traveling under the bridge: vehicles on Vermont Route 30 (VT 30) (a major route for ski resorts), kayakers on the beautiful West River, and hikers on the West River Trail.

The design-build team was excited about the challenge of designing and constructing a beautiful, signature structure that represents Vermont. Overlooking the West River and mountainous valley, this bridge features viewing platforms for pedestrians, hikers, and visitors. True to its theme, "A Bridge to Nature," every detail of the uniquely shaped superstructure, including its piers, viewing platforms, and railings, complements Vermont's natural landscape. The piers feature Vermont-inspired stone-formed and stained concrete that blends with the local environment. A visual quality advisory team consisting of representatives from VTrans, the local aesthetic committee, and the bridge designer selected eco-friendly concrete stain colors, platform railing designs, and other aesthetic details.

The focal points of the bridge are the quad-wall piers, which emerge from the ground in sweeping organic forms and support the arching concrete spans. Each quad-wall pier is comprised of four concrete columns that individually curve outward in two directions, creating a symmetrical pattern. The three-dimensional (3-D) design and detailing of the columns resulted in a varying cross section and complex reinforcing steel configurations.

The designer, contractor, reinforcing steel fabricator, and formwork provider held workshops to ensure that all details were considered and to provide the most efficient design. The quad-wall system of the piers provides stability, and allowed the bridge superstructure to be built from above using balanced-cantilever segmental construction without temporary falsework in the river. This scheme minimized the impact of the project on the West River and West River Trail.

Every detail of the uniquely shaped superstructure complements the natural Vermont landscape. Each quad-wall pier is comprised of four concrete columns that curve outward in two directions, symbolizing stone trees emerging from the ground and supporting the arching concrete spans. All Photos: FIGG.

## profile

**INTERSTATE 91 BRATTLEBORO BRIDGE** / BRATTLEBORO, VERMONT

**BRIDGE DESIGN ENGINEER:** FIGG Bridge Engineers Inc., Exton, Pa.

**ROADWAY/GENERAL CIVIL ENGINEER:** Sebago Technics Inc., South Portland, Maine

**PRIME CONTRACTOR:** PCL Civil Constructors Inc., Raleigh, N.C.

**POST-TENSIONING CONTRACTOR:** DSI, Freedom, Pa.

The new gateway bridge in Brattleboro, Vt., carries Interstate 91 over the West River, Vermont Route 30, and the West River Trail. Located in southern Vermont, the bridge provides a visual "gateway" to the state's mountains, valleys, and rivers.

Using self-advancing formwork (form travelers), 16-ft-long segments of the bridge were cast-in-place, alternating from one side of the pier to the other, until each cantilever arm reached 252 ft. When the cantilever arms on adjacent piers were complete, a small closure segment was cast to connect the two cantilever arms and form the span. Surveying and geometry control were a full-time endeavor to ensure that the two cantilevers would meet at a precise, midair target. Prior to casting the closure segment, the two cantilevers were longitudinally jacked apart to mitigate long-term creep and shrinkage effects on the relatively stiff quad-wall pier system.

## Segmental Superstructure

To support the 104-ft-wide bridge deck carrying two lanes of traffic in each direction, a two-cell, three-web trapezoidal box girder was used. The use of a single bridge instead of twin bridges eliminated a major traffic shift and crossover section and improved mobility during construction. A variable-depth profile was used for structural efficiency and provided a natural aesthetic as the bridge spans the valley. With a depth of 12 ft 7 in. at midspan and 30 ft 7 in. at the piers, the segments were large relative to the human scale. The biggest segments contain 221 $yd^3$ of concrete and took 6 hours to cast. Another unique feature of the box-girder section is the vaulted-bottom soffit that runs the full length of the underside of the bridge. This 20-ft-wide, 4-ft-deep, barrel-like shape adds dimension to the soffit, which would otherwise have a flat 55-ft-wide surface.

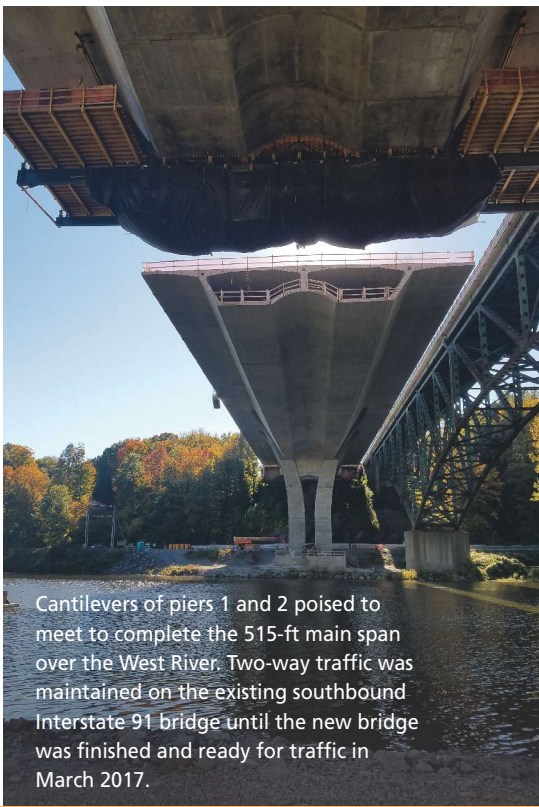
Continuous mild reinforcement through segment joints and a grouted post-tensioning system create continuity of the cast-in-place segments. Top slab tendons were used during cantilever construction, while bottom slab and external draped tendons provided continuity after span closures were cast. Transverse top slab tendons balanced the deck design. All tendons have multiple layers of corrosion protection, including a 2¼-in.-thick integral wearing surface, increased concrete cover, low-permeability concrete, plastic ducts, and grout.

## User Experience

Travelers along VT 30 experience this distinctive bridge from a side vantage point before they then travel under the bridge. They see the vaulted soffit stained with a blue color to mimic the sky. The arching, long span of the superstructure is half as deep as the former bridge and opens up the view of the landscape. To match the surrounding environment, a permanent concrete earth-toned stain was applied to all sides of the bridge superstructure. The piers were cast with a texture that simulates Vermont stone, which creates a dramatic look with different natural colors along the 60-ft-tall piers. The upper "fins" of the piers cradle the superstructure and were hand-sculpted using shotcrete to match the stone texture below.

## Community Involvement

The design-build team led monthly "trail talks" to give the community the opportunity to walk up the West River



Cantilevers of piers 1 and 2 poised to meet to complete the 515-ft main span over the West River. Two-way traffic was maintained on the existing southbound Interstate 91 bridge until the new bridge was finished and ready for traffic in March 2017.

### VERMONT AGENCY OF TRANSPORTATION, OWNER

**BRIDGE DESCRIPTION:** The new bridge is a 1036-ft-long three-span segmental cast-in-place concrete box girder bridge built utilizing balanced-cantilever methods with form travelers.

**STRUCTURAL COMPONENTS:** A single dual-cell segmental concrete box girder with transverse and longitudinal post-tensioning with an overall deck width of 105 ft.

Trail to the bridge with the team and learn about the design and construction of the monumental bridge.

The bridge designer also created 3-D-printed models of the bridge in snap-together pieces to make hands-on learning tools for student education programs at Brattleboro-area schools. During both design and construction, the design-build team visited several local schools to discuss the construction and engineering behind bridge building. Custom FIGG Bridge Boxes, which contain education tools to inspire and teach children about science and engineering, were part of the project activities.

On Saturday, March 4, 2017, more than 800 local residents and visitors took advantage of an opportunity to walk across the new bridge before it opened to traffic. Representatives from VTrans and the design-build team were on hand to answer questions as the public journeyed across the bridge. The bridge was dedicated on September 12, 2017.

## Durability

VTrans required a 100-year design life, but the bridge designers focused on providing a 150-year design life. Concrete segmental bridges as a structure type are inherently durable due to sustainable materials and the use of biaxially post-tensioned concrete. Concrete mixture proportions were designed for low permeability and the addition of calcium nitrite enhanced resistance to chloride penetration. Also, stainless-steel reinforcing bars were used in the bridge deck to enhance the deck life. Incorporation of durability into the initial design will ensure the least possible maintenance and cost over the life of the bridge.

## Conclusion

The design-build team provided creative solutions to the bridge challenges, including the use of balanced-cantilever construction, which eliminated the need for temporary falsework in the West River. Compared with its predecessor, the single bridge provides a smaller overall footprint. With fewer footings and abutments, it required less erosion control and had fewer areas of environmental impact during construction than the original bridge concept during the request-for-proposal phase. The single concrete bridge also provides ease of inspection inside the bridge, requiring less mobilization during future annual inspections. A best-value concrete segmental solution provided a one-of-a-kind gateway to nature in the beautiful state of Vermont.

Pedestrians enjoy the West River Trail and provide scale to the grand 60-ft-tall quad-wall piers of the bridge. The piers have a textured concrete surface inspired by the area's native stone. The barrel shape cast into the soffit is colored blue to match the sky.

Construction of Pier Table 1. Pier 1 soared 70 ft in the air while vehicular traffic was maintained on Route 30 and river remained open for recreational boating.

*Garrett Hoffman is the northeast regional director for FIGG in Exton, Pa.*

Balanced-cantilever construction allowed work to continue through the harsh Vermont winters. No temporary falsework was needed, which kept crews out of the water and allowed construction to continue on both sides of the river.