The bridge over the Canandaigua Outlet in New York replaces a steel bridge with a precast concrete single-span bridge that used ultra-high-performance concrete to connect beams longitudinally and to speed construction. Photos: New York State DOT.

UHPC JOINT PROVIDES NEW SOLUTION

New York State's first application of deck bulb-tee girders results from new joint design

by Craig A. Shutt

The bridge consists of eight precast concrete deck bulb-tee girders that were erected to close tolerances despite a variety of logistical needs.

To complete a bridge superstructure replacement project on a tight deadline, officials at the New York State Department of Transportation (NYSDOT) decided to take a new design approach: precast concrete deck bulb-tee girders. To overcome durability concerns that had kept them from using deck bulb-tee girders in the past, they customized the bulb tees to create joints between the girders that would be filled with ultra-high-performance concrete (UHPC), optimizing the system. The result was a satisfactory design with a significantly shorter construction time and will be used in additional applications.

"This was the first time any of us—designers, contractors, or precasters—had used this approach in New York State," explains Mathew Royce, an engineer in the Structures Division at NYSDOT. Royce had attended sessions at bridge conventions discussing the technique. Bill Adams, vice president and project manager for the general contractor, also had researched the technique prior to bidding, talking with Washington DOT officials and contractors who had experience with constructing such bridges.

The goal was to replace the superstructure on a former steel jack-arch bridge that spans the Canandaigua Outlet creek while retaining most of the cast-in-place abutments. The new bridge consists of a single-span, 87 ft 5 in. long and 42 ft 9 in. wide, comprising eight precast concrete deck bulb-tee girders that are 41 in. deep. The interior girders have a top flange 4 ft 10 in. wide while the width of the exterior girders' top flange is 5 ft 1 in. The flange is 6 in. deep at the edges. This top flange and the joint design represented the innovative aspect of this bridge technique for the project, Royce explains.

"We were familiar with the deck bulb tee, but we were concerned about the longitudinal joint and its ability to stand up over a long time period with heavy traffic," he says. "We had seen it used in low-traffic applications, but this bridge already has fairly high usage, and we wanted to prepare for the future when the usage increases further. We didn't

profile

ROUTE 31 BRIDGE OVER CANANDAIGUA OUTLET / VILLAGE OF LYONS, WAYNE COUNTY, NEW YORK

ENGINEER: New York State Department of Transportation, Albany, N.Y.

PRIME CONTRACTOR: Ramsey Construction Inc., Lakeville, N.Y.

CONTRACTOR'S ENGINEERING CONSULTANT: Erdman Anthony and Associates Inc., Rochester, N.Y.

PRECASTER: Northeast Prestressed Products LLC, Cressona, Pa., (formally Schuylkill Products Inc.) a PCI-certified producer

ULTRA-HIGH-PERFORMANCE CONCRETE SUPPLIER: Lafarge North America, Calgary, AB, Canada

The 6-in. wide joints were created by extending epoxy-coated reinforcing bars 4 in. or 6 in. from the edge of each flange, offset longitudinally so they would not meet each other, and filling the joints with ultra-high-performance concrete.

want to have to worry about increasing inspection or maintenance costs to avoid worries about leaks or corrosion."

This concern was exacerbated by the short period of time available for the closure, he notes. A maximum of 3 months was available, due to scheduling of an annual fall festival, for which the bridge had to be accessible to handle the heavy traffic of additional visitors to the area.

Test Beams Fabricated

Prior to beginning construction, the designers and contractor worked with the precaster to test several designs in the precaster's yard to ensure a proper joint fit, according to Troy M. Jenkins, the precaster's chief engineer. "We decided to pre-erect the beams in our yard to ensure everything would fit correctly." "In addition, the field installation has been instrumented with strain gauges," Royce notes. "They will give us more valuable information about the material's performance under different conditions.

The girders are set with a 6-in.-wide joint between the top flanges. The joint tapers to 9 in. wide at mid-depth. Two layers of epoxy-coated reinforcement extend from each girder flange and lap within the joint. No. 6 bars just above mid-depth lap 6 in. and No. 4 bars just below mid-depth lap 4 in. That's more than adequate to ensure the bars are fully developed in the ultra-high-performance concrete, Royce explains. The UHPC concrete, manufactured by LaFarge North America, allowed the joint to be narrowed and also sped up the curing process, he notes.

"It's a very high-end concrete with very high-strength capabilities, and it will resist scaling, freeze-thaw deterioration, and cracking due to the high steel fiber content," Royce says. "But the key for us was not the added strength the UHPC could provide but the speed with which we could complete the closure. The shorter length of reinforcing bar that we could use let us create a narrower joint that could be completed in less time."

The precaster's prior tests had showed that, with heat curing, the UHPC concrete could achieve a compressive strength of 33 ksi. In the field, without heat curing, it could reach 22 to 24 ksi, with an initial strength of 14 ksi after 4 days. "The girder concrete provides 10 ksi, so the joint will be stronger than the concrete beam," Royce notes.

Stability of the beams during construction was provided by bolting the beams down to the abutments. The upper part of the beam-end tie downs consist of an approximately 1-ft-square steel plate with a no. 6 all-thread bar protruding down on a slight angle. It connects through the beam flange to an anchor below in the end abutment.

After the beams were set, a jacking system was used to even out the camber between the beams, so they were as level as possible for the waterproofing membrane and overlay.

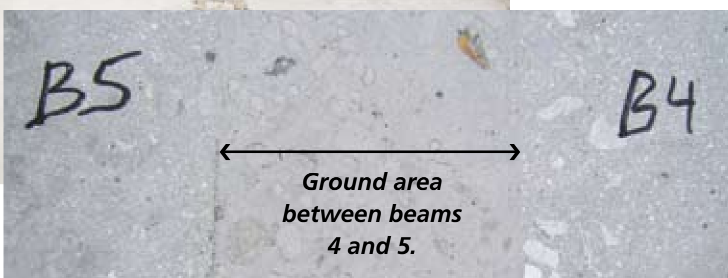
'The key for us was not the added strength the UHPC could provide but the speed with which we could complete the closure.'

SINGLE-SPAN PRECAST CONCRETE DECK BULB-TEE BRIDGE / NEW YORK STATE DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Single span, precast concrete deck bulb-tee bridge consisting of eight girders 87 ft 5 in. long, 41 in. deep with a 58-in.- or 61-in.-wide top flange. Joints between the flanges contain a short lap length that was filled with ultra-high-performance concrete.

BRIDGE CONSTRUCTION COST: $1.3 million

The joints were overfilled to account for some settling in the UHPC mix. The excess was ground off later.



Ground area between beams 4 and 5.

The designers worked with the precaster to create a staggered plan so the bars protruding from adjacent flanges didn't meet in the middle, Royce says. "Each side was adjusted accordingly so the bars land between two bars from the other side." Epoxy-coated reinforcement for the concrete vehicle barrier was cast into one of the fascia beams at the plant. A bolted steel rail was used for the other barrier.

Camber Adjustment Required

A detailed erection plan was prepared by the contractor's engineering firm to show the specified crane locations, beam tie-downs at end abutments, top-flange blocking, and transverse stabilization during construction.

A key challenge came from the need for the contractor, engineer, and precaster to recalculate and adjust pedestal elevations and process this information to field crews so they could place pedestal concrete 3 days before beam erection. "This schedule left no time or margin for error," says Adams. To ensure accuracy, the team followed specific measures to control camber growth while the beams were in storage, as that time delay could affect the tolerances in the specifications.

The beams were preloaded with concrete weights at the fabricator's plant. The precaster shot camber elevations just before the beams were loaded with weights to determine a base line. Three days prior to shipping and erecting the beams, the concrete weights were removed and camber elevations were shot again. These data showed that all of the pedestal elevations had to be adjusted.

"We had to place the pedestal high-early strength concrete by noon that day to achieve the needed strength in the 72-hour curing time before the beams arrived," Adams explains. The process went like clockwork, and the beams were hoisted into place on schedule. "It was nerve racking to await the concrete cylinder breaks on the pedestal concrete," he says. "But we had confidence the concrete would achieve strength because test-batching the previous week had delivered the required strength."

Once all eight girders were in place, their camber was adjusted to keep them level at midspan so a thin spray-applied waterproofing membrane and wearing overlay could be provided later without adding depth to the profile. "It required some adjustment, and we didn't have a lot of room to play with since the overlay was very thin—2 in. at midspan," Royce explains.

The contractor's Adams agreed. "Designing the camber leveling beam and jacking system so the girders could be aligned to the required tolerance was the most challenging part of the entire project," he says. The contractor worked closely with their engineering consultant to create the camber-beam jacking system." The crew used this beam to lift or push each girder into vertical alignment within 3 mm ($^1\!/_8$ in.) tolerance. Then the diaphragms were cast with high-performance concrete and the beam tie downs and top-flange blocking were removed.

The joints were overfilled by a few millimeters to ensure they would be level when settling was completed, Royce notes. Once the material settled, any remainder was ground off. "It required some grinding, but took less than a day to complete" Adams says.

The project was completed on budget and a few days ahead of schedule, Royce reports. "Everyone was very happy with the results. The design and the overall application of the concrete joints worked very well." As a result of this success—and the on-going tests being conducted on load conditions, Royce expects the design will be used more often in the state.

"In the near future, I can see it being used for specialty applications such as this one, certainly," he says. "And as more opportunities arise, especially where the need is very high for rapid construction, I expect we'll be using it more often overall, because of its effectiveness. This approach eliminates any concerns about joint conditions, while giving us the speed of construction that we needed. That gives us the potential to use it in more situations like this."

As a first-time use, he notes, costs were somewhat higher as expected, due to the learning curve associated with the new techniques. "The steep learning curve will be reduced as we become more familiar with it and contractors learn about it," he says. "Plus, we eliminate the costs associated with later inspections and maintenance, which become significant, so the long-term value is higher."

Adams agrees that more projects would benefit. "I can see it being used in applications with the right conditions, because it does expedite projects," he says. Already, the state has begun work on another project in which these bulb-tee girders and UHPC joints are being considered, Royce adds. "It's a slight variation from this first project, but it's similar, and we think this approach will work very well."

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