'CHANNEL' BRIDGE IMPROVES CLEARANCE

by Matt Card, Purcell Associates
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This rendering of the DCR design shows the cross section of the precast concrete segmental "channel" bridge. Rendering: IBT.

Precast segmental concrete design offers thinner cross section

A precast concrete "channel" bridge offers significant opportunities for expanding the capabilities of post-tensioned segmental construction. The potential can be seen in the DCR Access Road Bridge over Route 24 in Randolph, Mass. The project will improve clearance for the heavily traveled road below, complement the scenic areas surrounding it, and reuse existing materials to reduce waste and lower costs.

The project is located in the Blue Hills Reservation area, surrounded by land owned by the state Department of Conservation and Recreation (DCR). The existing bridge, built in 1958, consisted of a 247-ft-long, four-span steel I-girder structure supporting a 7.5-in.-thick concrete deck and an asphalt wearing surface. The substructure featured two concrete stub-type abutments supported on steel piles and three reinforced concrete piers supported on spread footings.

Partly due to its low 14 ft 3 in. vertical clearance, the existing bridge had become structurally deficient. In fact, the steel I-girders had repeatedly been hit by trucks driving below on Route 24. Officials at the Massachusetts Department of Transportation (MassDOT) wanted to increase the vertical clearance without having to perform extensive roadway work either underneath the bridge or at the abutments. Raising the profile of the approach roads at the abutments was not an option because of the scenic location, landscaping surrounding the site, and transitions to extensive woods and horse paths used by horse-rental farms on both sides.

MassDOT officials also wanted to create a design that would blend with the scenic surroundings and minimize long-term maintenance needs.

To reach those goals, MassDOT engineers selected the precast concrete "channel" bridge concept with post-tensioned, segmental construction. In addition to meeting the immediate goals, it will provide long-term durability through a minimum service life of 75 years.

Edge Beams Serve Two Roles

The channel cross section features a precast concrete superstructure with an unusual U-shaped design. It consists of two edge beams that function as the main load-carrying elements, with the roadway slab supported between them. The two edge beams serve a second purpose by acting as traffic barriers.

During erection, top flanges on the outside of the edge beams temporarily support the segments on erection beams that span between the abutments and piers. This system eliminates the need for a below-deck support system, minimizing vertical-clearance needs and construction time while reducing life-cycle costs.

The DCR Bridge is 248-ft-long, comprising two 124 ft spans. The two-span continuous precast segmental concrete structure will increase vertical clearance over Route 24 by more than 2 ft to 16 ft 5 in. The substructure consists of two new, reinforced concrete stub-type abutments

profile

DCR ACCESS ROAD BRIDGE OVER ROUTE 24 / RANDOLPH, MASSACHUSETTS

ENGINEER OF RECORD: Purcell Associates, Boston, Mass.

SUPERSTRUCTURE ENGINEER: International Bridge Technologies Inc., San Diego, Calif.

CONSTRUCTION ENGINEER: FINLEY Engineering Group Inc., Tallahassee, Fla.

PRIME CONTRACTOR: R. Zoppo Corp., Sloughton, Mass.

PRECASTER: Unistress Corp., Pittsfield, Mass., a PCI-certified producer

The new precast concrete channel bridge (bottom rendering) and the original steel I-girder bridge (top photo) and are shown for comparison. The new channel bridge provides more than 2 ft of additional clearance. Illustration: IBT.

The original steel bridge's I-girders were removed and then reused as temporary erection beams to support the precast concrete channel segments during erection. Photo: Purcell Associates.

supported on steel piles and a new center pier consisting of two 59-in.-diameter, reinforced concrete columns supported on a common concrete spread footing. The specified concrete compressive strength for the substructure was 4350 psi. Utilizing only a center pier, the DCR Bridge eliminates the need for side piers at each outside roadway edge. This adds safety for highway users, and also reduces material cost and construction time.

The new superstructure is 29.7 ft wide and 5.38 ft deep. Each edge beam is fully post-tensioned using one 12-strand tendon, one 15-strand tendon, and two 19-strand tendons. All tendons use 0.6-in.-diameter strands. Fourteen additional longitudinal tendons are provided in the deck slab, using flat 4-strand tendons of 0.6-in.-diameter strands. Transversely, the structure is fully post-tensioned before erection using flat 4-strand tendons. All non-prestressed reinforcing steel is epoxy-coated.

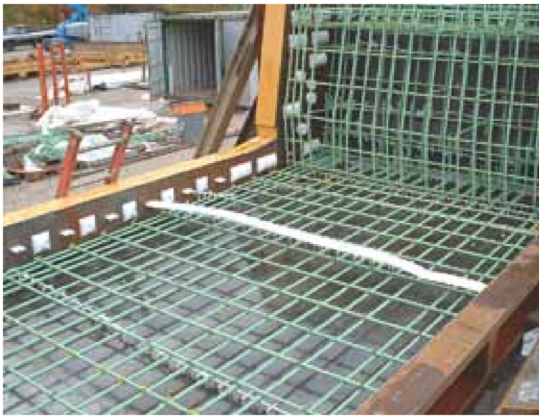
Purcell Associates served as the engineer of record on the project and designed the substructure elements. The firm subcontracted the superstructure design to International Bridge Technologies (IBT), which has experience with the channel concept. It was originally created and patented by the innovative bridge engineer Jean Muller, whose firm designed two such bridges in upstate New York in the 1990s and others in Europe. Daniel Tassin, IBT's technical director, worked with Muller for many years.

Superstructure Construction

A total of 31 precast concrete channel segments were match-cast for the project with concrete having a specified compressive strength of 6500 psi. Typical segments were 8.2 ft long, with the two abutment segments being 5.1 ft long.

To avoid deflection issues resulting from unequal weight distribution, all of the segments were placed onto the erection beams prior to their actual assembly. This erection took 4 days. Then, groups of two to four segments were assembled incrementally using epoxy joints and post-tensioning bars, starting from the center of the bridge and moving towards the abutments in a balanced sequence. Each group of segments was assembled in a 1-day shift resulting in a total time of 10 days. Once all of the segments were assembled, the permanent post-tensioning was stressed in the edge beams and deck slab, and the temporary steel erection beams were removed.

When the erection of the superstructure



The precaster purchased relatively simple specialized forms to cast the channel segments shown here during set-up for casting the first non-match-cast segment. Photo: IBT.

The channel design eliminates the need for a below-deck support system.

SEGMENTAL, POST-TENSIONED CHANNEL BRIDGE / MASSACHUSETTS DEPARTMENT OF TRANSPORTATION, OWNER

POST-TENSIONING MATERIALS: VStructural LLC, Hanover, Md.

PRECAST CONCRETE FORMWORK: EFCO Corp., Des Moines, Iowa

BRIDGE DESCRIPTION: 248-ft-long, precast concrete, post-tensioned segmental channel bridge, 29.7 ft wide and 5.38 ft deep, comprising 31 segments, typically 8.2 ft long

BRIDGE CONSTRUCTION COST: $3.86 million

The 8.2-ft-long, U-shaped segments feature a top flange on the outside of the edge beams that temporarily support the segments on erection beams. This approach eliminates the need for a below-deck support system. Photo: IBT.

Eliminating piers at the roadway edge increased driver safety while reducing material costs and construction time.

segments was completed, contractors finished casting the abutments and wingwalls and added the riding surface. It consists of a waterproof membrane covered with a binder coat and a final 3-in.-to 4-in.-thick asphalt wearing surface. The bridge's channel shape provides a 4-ft-high concrete parapet railing along both sides of the bridge, to which a Type II Modified Protective Screen was mounted on each of the parapets.

Timber guard railing and posts will be added within the project limits at all four corners of the bridge for traffic safety. The guardrail has a special steel backing for added strength and safety. The final step is to complete all surrounding incidental landscaping.

The bridge is scheduled to open in October 2010. To date, nothing out of the ordinary has arisen in the project, which is notable since the channel concept is being used for the first time in several years.

The channel design results in a sleek, low-profile appearance that provides functional clearance benefits while keeping it unobtrusive in scenic areas. Best of all, it minimizes long-term maintenance needs that will improve safety of construction crews and users while reducing costs over its service life.

Matt Card is a project manager at Purcell Associates in Boston, Mass., and Thomas Cyran is a bridge engineer with International Bridge Technologies in San Diego, Calif.

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Segment groups were assembled incrementally in a balanced sequence on each side.

Groups of two to four segments were assembled incrementally, using post-tensioning bars. Once all 31 segments were placed, they were permanently post-tensioned together into one secure unit, and the temporary erection beams were removed. Photo: IBT.

Sustainable Considerations

Minimizing waste and remaining environmentally aware were key goals of the project, and this resulted in an innovative reuse of materials. The steel I-girders of the existing bridge were reused as erection beams, thus serving as the needed temporary shoring while the segments were being erected. Upon completion of segment erection, the steel I-girders were removed and recycled.

The existing bridge piles were retained where possible and interspersed with new ones. To minimize excavation needs along the highway, the center pier's footings were retained. The contractor removed the existing material to the footing and started there with new concrete. The new center pier was designed for additional loads that were needed to support the weight of the concrete components that replaced the lighter steel components of the existing bridge.

Owners, contractors, and engineers are constantly looking for ways to reduce their projects' carbon footprints while ensuring long durability, speed of construction, and maximum aesthetics. The channel design provides a new alternative for achieving these goals. The design encourages the recycling of components from the old structure, which helps reduce construction costs and the impact on the environment.