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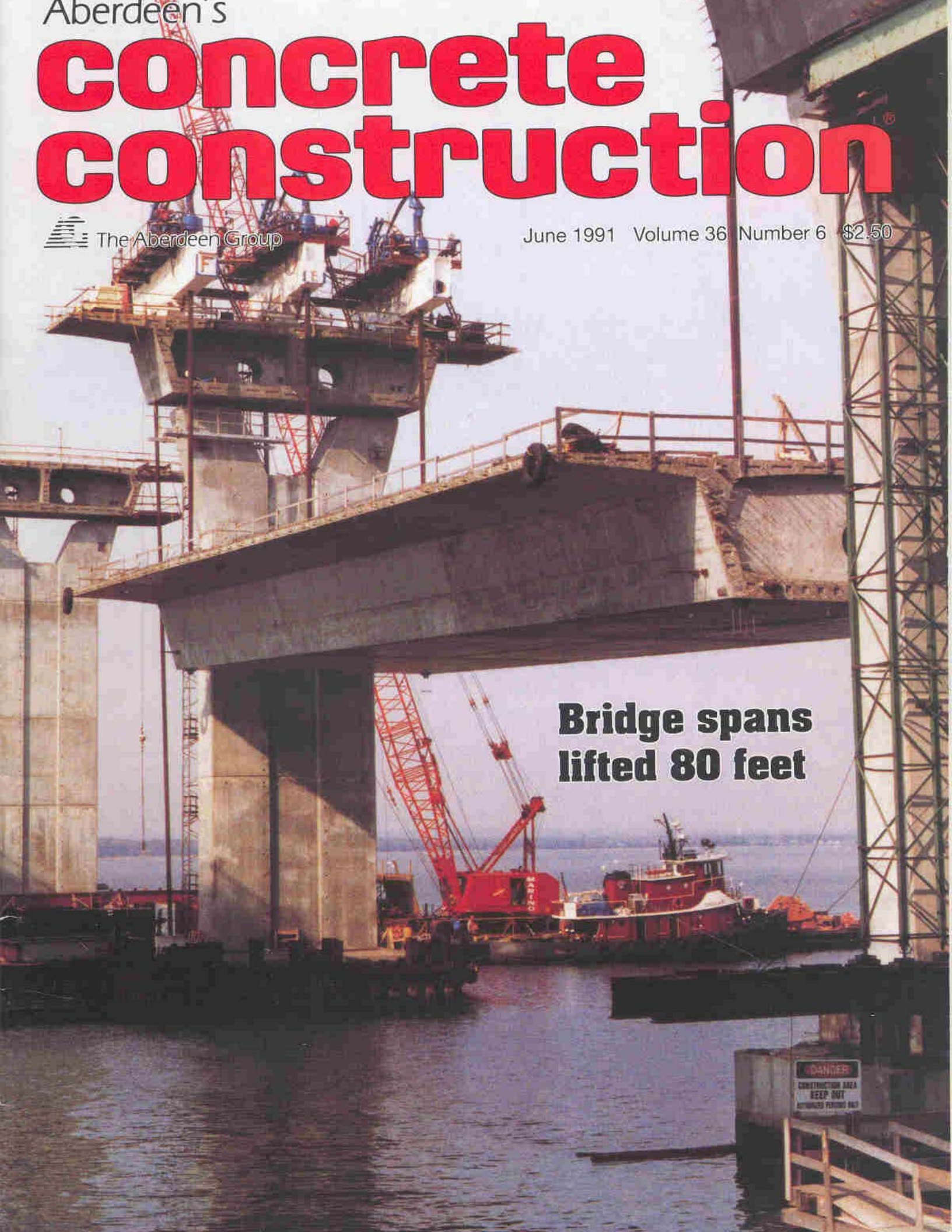
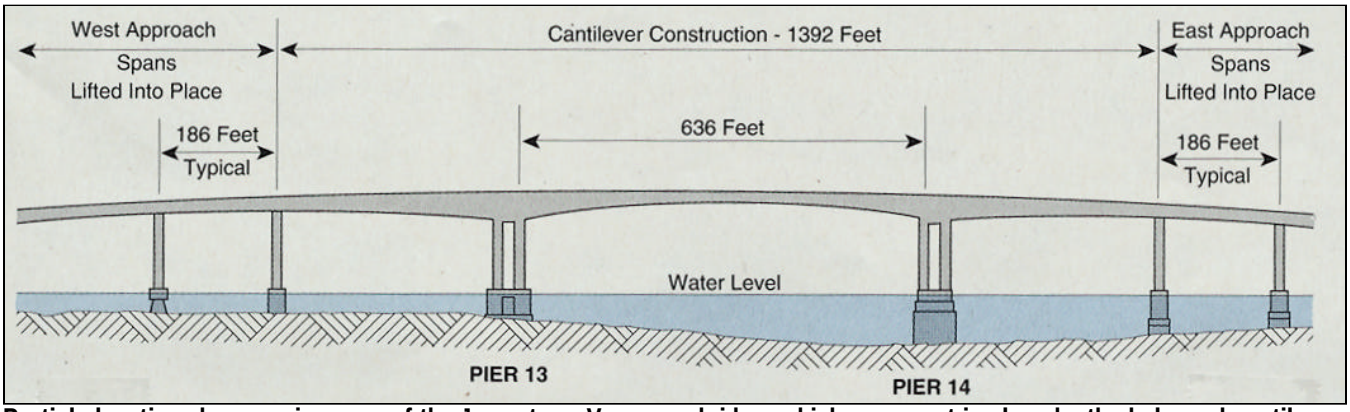


Bridge spans lifted 80 feet

Bridge spans lifted 80 feet from barge

Box girder structure combines precast with cast-in-place concrete



Partial elevation shows main spans of the Jamestown-Verrazano bridge, which were cast in place by the balanced cantilever method. Approach spans were precast and lifted into place.

BY M. K. HURD

Working from a barge in Narragansett Bay contractors lifted the first 2,400-ton precast bridge span into position on the Jamestown-Verrazano Bridge late in 1990. With this development the long-delayed bridge job swung into high gear while progress continued on the cast-in-place part of the bridge. The lifting operation will be repeated 15 times before the bridge's scheduled completion in 1992.

The four-lane bridge, with an overall length of 1.4 miles, crosses part of Narragansett Bay, linking North Kingstown and Jamestown, Rhode Island. The main structure of the bridge is nearly 5,000 feet long, with a trestle-supported approach on the west making up the remaining length. The double-cell box girder used for both the high-level approach spans and the main structure varies in depth from 10 feet to 32 feet, 9 inches. The three main spans are being cast in place using balanced cantilever construction and the high level precast approach spans are lifted into place (see drawing). Navigation clearance at the center of the main span is 135 feet above the high water level.

The high level approaches were initially designed by T. Y. Lin International, San Francisco, to be built in place using an underslung truss to support the formwork. The main spans were to be built by the balanced cantilever method. When the work was first bid in 1984, VSL Corp. of San Jose, California, proposed an alternative segmental precast construction method that promised considerable reduction in construction time.

Under construction options in the specifications, VSL redesigned the high-level approach spans to permit span-by-span erection with VSL equipment. Their proposal was to precast the 15-foot pier segments and the 167-foot span segments offsite, then barge them in, erect, and tie them together with post-tensioning. They also proposed a redesign of the main span to permit use of existing form travelers for the balanced cantilever construction. Original construction joint spacing was too large for the available travelers.

Project rebid

The project came to an abrupt halt in 1987 when the general contractor learned that the west approach piles had to be driven, not the 90 feet originally planned, but up to 180 feet, to gain the desired resistance. Unable to negotiate an agreement for the added cost of pile driving, the Rhode Island Department of Transportation and the contractor terminated the contract by mutual agreement. New bids, taken in 1988, resulted in a contract awarded to Atkinson-Kiewit, a joint venture of Guy F. Atkinson, South, San Francisco; and Kiewit Eastern, Scarborough, Massachusetts. The new contractors elected to follow the VSL redesign which provided the option of casting pier segments of the approach spans—l5-foot-long segments of the box girder supported directly on the piers—in place.

Balanced cantilever construction on main span

The contractor first cast two pier tables—38-foot-long segments of the bridge girder supported directly on the main span Piers 13 and 14—as takeoff points for the balanced cantilever construction of the highest bridge spans. With pier tables in place, cantilevering formwork could be supported from the pier to begin segmental casting of the main span.

Working in balanced fashion in both directions from each pier table, short segments of the girder are cast using traveling forms, then post-tensioned back to the main pier. The casting and subsequent post-tensioning are repeated until a span is completed. Balanced cantilever construction requires at least two form travelers, which may cost $750,000 each, or closer to $1 million if formwork is included. The original design had construction joint spacing too large to work with then-available VSL form travelers, thus the redesign for reasons of construction economy.

Cantilever construction for the Jamestown-Verrazano bridge is done in a three-phase pour for each segment. The bottom slab of the girder is cast first and becomes the base for casting the web members in a second stage, followed by casting of the deck slab to complete the box. After the concrete gains sufficient strength, each segment is post-tensioned back to the previous construction and the forms advance to make another segment. The segments range from 11 1/2 to 16 feet long. Finally at the bridge center, where the cantilevers approach close to each other, jacking adjustments are made and a closure section is cast before full post-tensioning continuity is established.

VSL Corp./Michael Veegh

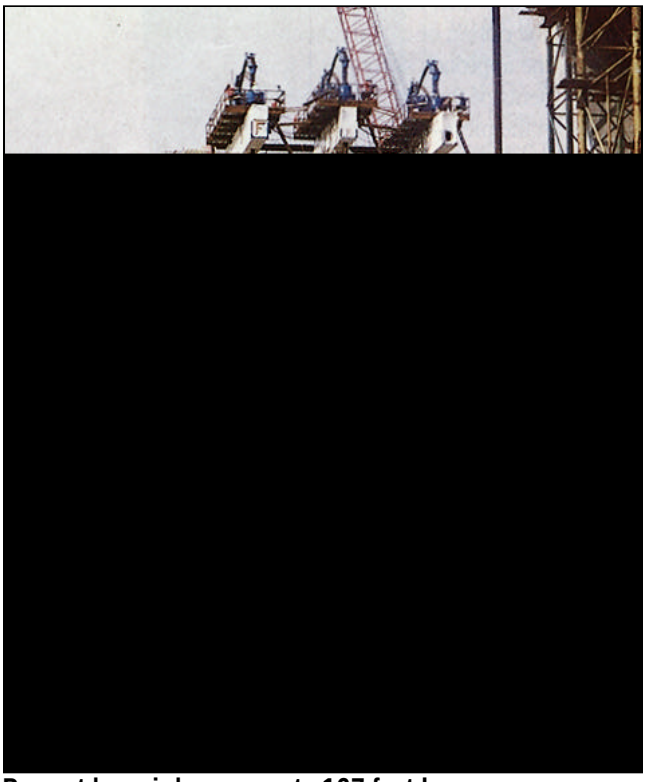
Six 1,000-ton jacks mounted on steel box beams atop the pier segment of the bridge provide lifting power at each end of the 2,400-ton precast girder.

Casting pier segments for the approach spans

The contractor chose to cast the pier segments of the approach spans in place. These 15-foot-long segments weigh 711,000 pounds. Atkinson-Kiewit first sets up the forms on a jig on a barge, places the steel and post-tensioning hardware, and lifts the entire 65-ton unit of formwork and reinforcement into place on the pier cap. The assembly of form and reinforcement is tied down and adjusted for elevation and alignment before concreting. The pour then can be made in a single working day.

Casting the approach span segments

Typical approach spans are 186 feet center to center—made up of precast span units 167 feet long, plus the cast-in-place pier segments, with 2-foot closure pours on each side of the pier segments. The double-cell box girder spans are precast at a yard about 5 miles from the bridge site for barging to their final location. The 167-foot spans are cast in six stages using formwork covering one-third of the length of the segment. After the bottom slab is cast for the first third of the segment, it moves along a runway to the next position where top forms (for webs and deck) are brought into position, partially supported on the bottom slab. While concrete is being placed in these forms, a second segment of the bottom slab is being cast at the first position. When the concrete has cured sufficiently, the



VSL Corp./Jamestown Verrazzano

Precast box girder segments 167 feet long were transported 5 miles by barge to the Jamestown-Verrazano bridge site in Rhode Island, then lifted into place.

segment again advances on the runway and the process is repeated. The form advance and concreting continue until the entire segment is complete.

Each segment continues from the casting area on the same runway, which takes it to the barge for transport to the site. The

barge—sized by Atkinson-Kiewit to 146 feet so it would fit between the piers—is ballasted to slide in under the horizontal ways of the casting site at low tide. Then it is deballasted to rise with the tide and a framework protruding above the barge deck lifts the 2,400-ton span off the ways for the 5-mile trip to the bridge.

Segment erection

To raise the spans into position, three steel box beams are set on top of each pier to support the 1,000-ton jacks, six at each end of the span. Tendons from reels on the beams pass through the jacks down to the lifting wells in the 167x72-foot segment. Crews maintain radio communication to synchronize operation of the jacks that pull the tendons. Again the tide helps transfer the load. The tendons are connected just before high tide, and lifting begins as the tide falls, maintaining tension in the tendons.

After the segment is raised to desired elevation and leveled, workers put blocks in the 2-foot gaps between pier segments and span segments, then apply 10% of the post-tensioning force to stabilize the span. The closure pieces are then formed and poured. After curing of the closure joints, the continuity post-tensioning is stressed, the lifting cables are released, and the lifting system advances for use on the next span.

The first span segment was lifted November 3, 1990, at speeds of 7 to 9 feet per hour while the crews learned to use the equipment. As experience grows, the lifting rate is expected to reach 15 feet per hour. A total of 15 such spans, including two side spans for the main cantilever portion of the bridge, will be positioned by lifting during the next 12 months while work proceeds to complete the main span. A latex-modified concrete overlay is planned as the traffic surface for the completed bridge.

Acknowledgment

Thanks to Michael Veegh, division engineer for VSL Corp., and Karen Cormier, project engineer for T. Y. Lin International Inc., for providing information on which this article was based.

Credits

Owner: State of Rhode Island, Department of Transportation

Designer: T. Y. Lin International Inc.

General contractor: Atkinson-Kiewit

Subcontractor and post-tensioning supplier: VSL Corp.

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