

SR 520 Evergreen Point Floating Bridge Low-Rise Superstructure

Precast concrete, ribbed-slab segments

by David B. Birrcher and Christopher M. Hall,
International Bridge Technologies Inc.

Aerial view of state route (SR) 520 Evergreen Point Floating Bridge Low-Rise Superstructure under construction. Photo: KGM.

The state route (SR) 520 Evergreen Point Floating Bridge and Landings project is an 8643-ft-long project crossing Lake Washington near Seattle, Wash. The floating bridge portion—the Evergreen Point Floating Bridge—is 7710 ft long, making it the longest floating bridge in the world. It replaces the old SR 520 floating bridge that was opened to traffic in 1963 and that currently holds the record as the longest floating bridge. The Washington State Department of Transportation determined that the old bridge needed to be replaced to improve traffic congestion, maintenance access, and bridge performance under extreme events such as windstorms.

Structure Types

The project consists of four different structure types supported on floating concrete pontoons or traditional fixed

foundations. At the eastern end of the project, a concrete, cast-in-place segmental twin box-girder bridge is supported on spread footings. The twin box-girder bridge is 627-ft-long with a main span of 320 ft. A 190-ft-long transition span connects the box-girder bridge to the floating bridge. At the western end of the project, another 190-ft-long transition span connects the floating bridge to the west-approach structure. The west approach is part of a different contract. The transition spans and their pinned connections accommodate differential displacements and the associated rotations between the floating bridge and the fixed approach structures due to changes in the level of Lake Washington.

The support structure for the Evergreen Point Floating Bridge consists of 77 concrete pontoons joined together

and anchored to the lake bed with large steel cables. For 1150 ft at the east end, and for 880 ft at the west end, reinforced concrete columns and bent caps are rigidly attached to the pontoons. They support simple-span, prestressed concrete girders with an 8-in.-thick, cast-in-place concrete deck. The typical span is 90 ft. These two regions of the floating bridge are referred to as the “high-rises.” The east high-rise accommodates a 5% grade; the west high-rise accommodates a 3% grade.

Between the eastern and western high-rise regions is a 5580-ft-long “low-rise” portion of the project. The low-rise consists of a precast concrete, segmental, ribbed-slab superstructure supported on circular columns that are rigidly connected to the pontoons. The low-rise has a straight plan alignment

profile

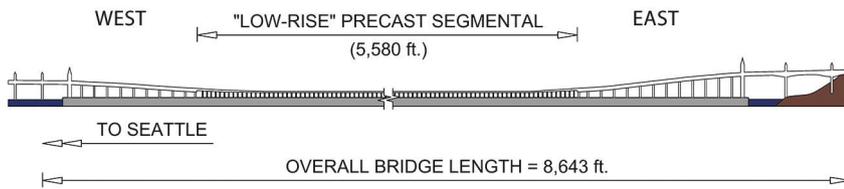
SR 520 EVERGREEN POINT FLOATING BRIDGE LOW-RISE SUPERSTRUCTURE / SEATTLE AND MEDINA, WASHINGTON

BRIDGE DESIGN ENGINEER: International Bridge Technologies Inc., San Diego, Calif.

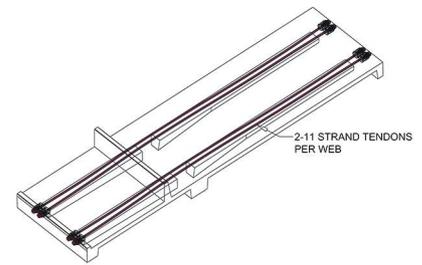
PRIME CONTRACTOR: Kiewit, General Construction, Manson Construction (KGM)—a joint venture, Federal Way, Wash.

PRIME CONSULTANT: KPFF and BergerABAM, partners as the prime engineering team, Seattle, Wash.

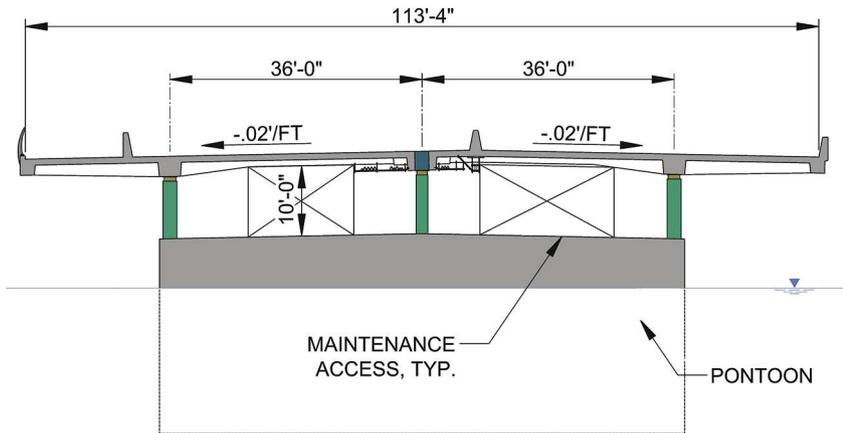
POST-TENSIONING CONTRACTOR: Schwager Davis Inc., San Jose, Calif.



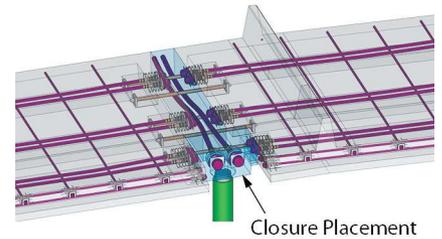
Schematic elevation of the Evergreen Point Floating Bridge and Landings project. Figure: International Bridge Technologies Inc.



Typical precast concrete, ribbed-slab segment showing transverse post-tensioning in ribs. Figure: International Bridge Technologies Inc.



Typical section of low-rise precast concrete ribbed-slab superstructure. Figure: International Bridge Technologies Inc.



Post-tensioning details in segments and longitudinal closure near expansion joint. Figure: International Bridge Technologies Inc.

and a flat profile for the majority of its length. It accommodates a variable grade where it transitions to the high-rise to the east and to the west. The deck has a crown with a $\pm 2\%$ cross slope. The superstructure of the low-rise is the primary focus of this article.

Design Features

The width of the low-rise deck is 113 ft 4 in. to accommodate four traffic lanes, two high-occupancy vehicle lanes, 10- and 4-ft-wide shoulders in each direction, and a 14-ft-wide pedestrian/bike path. Semicircular overlooks called belvederes are positioned adjacent to the pedestrian/bike path at three locations along the low-rise region. The width of the supporting pontoons is

75 ft, which necessitated the use of large cantilever overhangs. Available column locations were further restricted by the cellular structure and ballast requirements of the pontoons.

In addition, 10 ft of vertical clearance between the underside of the bridge and the top of the pontoon was required for maintenance access. The clearance requirement was compounded by a fixed vertical profile that limits the overall height of the low-rise portion of the bridge. The structure is designed to be widened in the future to accommodate two additional mass transit lanes along the centerline of the bridge. Structural modifications to the existing bridge would be limited

to the outer portions of the structure, including supplemental pontoons, supporting frames, and the widened superstructure.

A low-profile, precast concrete segmental ribbed-slab concept was developed to address the project requirements. Variable-depth transverse ribs run the full width of the bridge and are optimized to increase the vertical clearance between the pontoon and the bridge soffit. The ribs are spaced at 7 ft 6 in. and frame into longitudinal beams that are located along each of the three column lines and at each edge of the bridge. A 10-in.-thick slab spans between the transverse ribs and the longitudinal beams.

Three lines of columns are spaced transversely across the width of the pontoon at 36 ft on center.

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION, OWNER

BEARING SUPPLIER: Scougal Rubber Corporation, Seattle, Wash.

EXPANSION JOINT SUPPLIER: Mageba USA, San Jose, Calif.

BRIDGE DESCRIPTION: The low-rise portion of this bridge consists of a precast concrete segmental ribbed-slab superstructure on circular columns supported by floating concrete pontoons.

STRUCTURAL COMPONENTS: 776 precast concrete, ribbed-slab segments



Setting of typical 15-ft-long north segment on falsework. Photo: KGM.

Longitudinally, the columns have a 30 ft typical spacing, except near the expansion joints where the spacing is reduced. Steel-reinforced elastomeric bearings are grouted directly between the longitudinal beams and the circular columns. No substructure cross beams are needed. The relative flexibility of the bearings limit the longitudinal and transverse forces that are transferred from the superstructure to the columns and to the pontoons. Further, varying the stiffness of the bearings provided a means to concentrate loads where desired in the pontoons. Twenty percent of the bearings have a steel pintle that positively connects the ribbed-slab segment to the column.

The ribbed-slab superstructure was divided into approximately 56-ft-wide north and south precast concrete segments that were joined together by a 2-ft-wide longitudinal closure strip. To achieve a 360-ft distance between expansion joints, 23 typical segments that were 15 ft long and two expansion-joint segments that were 7 ft 3 in. long were utilized. This arrangement was repeated 14 times. Where the low-rise region transitioned to the high-rise region, the number of typical segments was reduced to achieve smaller distances between expansion joints, which were spaced at 225 ft to the west and 315 ft to the east. In total, 776 precast concrete segments were used. The epoxied joints between segments were located at the quarter-span to reduce stresses at the joints.

The ribbed-slab segments were post-tensioned in both directions. Each transverse rib in the typical 15-ft-long segment had two 11-strand tendons. The ribs in the expansion joint segments had two 12-strand tendons and two 4-strand tendons. Across the longitudinal closure strip, two 1¾-in.-diameter post-tensioning bars were stressed at each transverse rib.

Longitudinal tendons ran the entire length between expansion joints (typically 360 ft). Sixteen four-strand tendons with a straight profile were distributed within the 10-in.-thick slab. In the beams running above the outer column lines, two 25-strand tendons with a variable profile were provided. In the beam running above the center column line, two 27-strand tendons were provided.

In addition to typical strip-seal expansion joints, steel beams were positioned across the joint to provide displacement and rotational continuity. A steel beam and saddle bearing assembly that permitted longitudinal movement was designed in the cantilever overhangs to link vertical displacements. At the centerline of the bridge, a steel beam was detailed to control transverse displacements across the expansion joint.

At the roadway surface, the segments were detailed with 3 in. of clear cover above epoxy-coated, top-



Epoxy-joining of a typical 15-ft-long north segment. Photo: International Bridge Technologies Inc.

mat reinforcement. A portion of the clear cover (½ in.) was allocated for grinding and texturing. No additional overlay was applied, although the design can accommodate one in the future if needed. The ribbed-slab segment concrete had a 28-day design compressive strength of 6.5 ksi and very low permeability.

Construction

The precast concrete segments were match-cast at a nearby site in Kenmore, Wash. The segments were steam-cured overnight and were advanced to the match-cast position the next morning to achieve a 24-hour casting cycle. One casting bed was used for the north segments, and a second casting bed was used for the south segments. The traffic and pedestrian barriers were cast integrally with the segments, but with a ½-in. gap between the barriers at the segment joints. After match casting, the segments were lifted off the formwork and were post-tensioned transversely. The typical 15-ft-long segments weighed approximately 100 tons.

On site, the pontoons were floated and anchored into position. The columns were cast, and falsework was installed between the column lines. The precast concrete ribbed-slab segments were shipped in by barge from Kenmore and were erected onto the falsework with a large barge-mounted crane. The segments were placed on polytetrafluoroethylene pads on the falsework that allowed them to be easily manipulated. Epoxy was applied to the match-cast joints, and the segments were joined via temporary post-tensioning bars mounted to the



View of completed precast concrete ribbed-slab structure from the top of the pontoon. Photo: International Bridge Technologies Inc.

top of the deck with temporary steel brackets. The north and south segments were epoxy-joined independently. There were five locations across the 56-ft-wide

segment where the temporary post-tensioning was applied. On a typical setting day, eight precast concrete segments were erected. A maximum of

18 segments were erected in 1 day. All 776 segments were erected within 11½ months.

After the segments were epoxy-joined, reinforcement and post-tensioning was placed within the longitudinal closure strip and concrete for the closure was cast. Transverse post-tensioning bars were stressed across the longitudinal closure strip after the concrete reached sufficient strength. Then, the longitudinal post-tensioning tendons were stressed, and the elastomeric bearings were grouted. After the grout reached sufficient strength, the falsework was removed and the superstructure was self-supporting.

The SR 520 Evergreen Point Floating Bridge is scheduled to open to traffic in April 2016. 

David B. Birrcher is a bridge engineer and Christopher M. Hall is a principal engineer at International Bridge Technologies Inc. in San Diego, Calif.

AESTHETICS COMMENTARY

by Frederick Gottemoeller



It may seem odd to focus a discussion of bridge aesthetics on a structure that will only be seen by the occasional Washington State Department of Transportation maintenance worker. What makes it worthwhile in this case is that the structural innovations pioneered here create a unique and attractive bridge that would not be out of place in any park or urban area. The innovations were obviously inspired by the specialized requirements of the SR 520 Evergreen Point Floating Bridge, but the result is a lightweight and economical structure that would apply to any viaduct situation allowing modest spans and modest vertical clearances, especially where accelerated construction is a goal.

Its economy is based on a repeating precast concrete module that combines the longitudinal spanning element, the transversely spanning element, the deck, and the transverse column brace, all in one precast concrete piece. This module can be manufactured off site and quickly erected. This contrasts with the usual precast concrete bridge where only the longitudinal spanning element (I-girder, bulb tee, and others) is manufactured and the transverse spanning element/column brace (pier cap) and the deck are cast in place in separate, time-consuming field operations.

This manufactured module also supplies the aesthetic benefits. First of all, over most of its width it is thinner than the typical girder/deck combination. This allows more clearance and light below, a lower overall structure, or some combination of the two. The deepening of the transverse ribs at the longitudinal beams creates an element of visual interest and demonstrates the flow of forces in the structure. The elimination of a visible pier cap/column brace eliminates the transverse visual element that restricts longitudinal views underneath a typical viaduct and makes the space below seem much more constricted than it need be. Finally, and perhaps most importantly, the ribs themselves create a pattern on the “ceiling” of the space underneath the viaduct that recalls the coffered ceilings of traditional monumental buildings. One can imagine lighting elements along the longitudinal beams washing the underside of the deck between the ribs. Rather than being feared as an ominous source of bats and pigeon droppings, as it is in so many urban viaducts, the ceiling would be welcomed as the source of light for the whole area under the bridge.

The space under viaducts has often been considered “left-over” space. In recent years, with the growing public interest in urban living and making cities more livable, there has been new interest in taking advantage of the space under viaducts, and not just for organized parking. Parks and playgrounds and farmers’ markets are all uses that are now occurring under viaducts. It is time to consider what contributions the structure itself can make to the attractiveness of those spaces.