PART 3

Central Artery/Tunnel Project: Precast/Prestressed Structures Span the Big Dig

Keith Donington, P.E.
Senior Bridge Engineer
Parsons Brinckerhoff Quade & Douglas, Inc.
Boston, Massachusetts

Precast, prestressed concrete is used at many locations for a multitude of functions throughout the multi-billion dollar Central Artery/Tunnel Project in Boston, Massachusetts. This article describes two bridges and a marine pier where precast, prestressed concrete was selected as the ideal material to span these structures.

Paul Towell, P.E.
Senior Bridge Engineer
Parsons Brinckerhoff Quade & Douglas, Inc.
Boston, Massachusetts

Vijay Chandra, P.E.
Senior Vice President
Parsons Brinckerhoff Quade & Douglas, Inc.
New York, New York

The Broadway and Dorchester Avenue Bridges are local street bridges located in South Boston, Massachusetts, that utilize butted box beam construction, while the Spectacle Island Pier in Boston Harbor uses butted double "T" beams. The latter two structures are located in a marine environment where corrosion resistance and inherent low-predicted maintenance costs were major factors in selecting precast, prestressed concrete construction. This article discusses the design-construction highlights of these three structures.

BROADWAY BRIDGE

The Broadway Bridge (see Fig. 1) is a nine-span continuous structure that carries local traffic to South Boston over Amtrak railway tracks, a Massachusetts Bay Transportation Authority railroad yard, and the Fort Point Channel. The new structure opened to traffic in January 1999. It replaced an existing historic, but obsolete, swing bridge on an alignment south of the old alignment.

The 760 ft long x 75 ft wide (230 x 23 m) structure provides two travel lanes in each direction and two sidewalks. The substructure comprises multi-column cast-in-place

Fig. 1. Completed view of the Broadway Bridge, Boston, Massachusetts.

concrete bents supported on 14 in. (0.36 m) square precast, prestressed concrete piles, except for certain supports founded on 3 and 4 ft (0.9 and 1.2 m) diameter drilled shafts where space limitations prohibited the use of driven piles with a typical footing.

The superstructure is comprised of precast, prestressed concrete butted box beams with a 5 in. (125 mm) cast-in-place concrete wearing course. This topping is reinforced with steel mesh and additional reinforcing bars over the piers to provide continuity for live loads.

Spans vary between 56 and 105 ft (17 and 32 m). A typical span has sixteen 48 in. wide x 42 in. deep (1.2 x 1.1 m), concrete box beams placed side-by-side with a mortar joint between the beams. For the spans over the railroad tracks, 33 in. (0.8 m) deep concrete beams were used.

Transverse prestressing strand ties, at the ends and quarter points of the span, provide nominal transverse precompression of the mortar joints. To provide a classic appearance, precast concrete light supports topped with double luminaires line both sides of the bridge, as well as an architecturally enhanced steel railing system. The total cost of this bridge was $8 million.

DORCHESTER AVENUE BRIDGE

The Dorchester Avenue Bridge (see Fig. 2) is an eight-span structure crossing Fort Point Channel, providing access to Boston's main post office. The new structure replaces an existing structure on an alignment east of the old alignment. The 550 ft (167 m) long bridge varies in width from 73 to 135 ft (22 to 41 m), providing two travel lanes in each direction and two sidewalks. Piers are skewed at 45 degrees. The total cost of this bridge was $7.2 million.

The bridge is very unusual in several aspects; for example, several bridge columns are located above the walls of the I-90 immersed tube tunnel. The first concrete immersed tube sections were floated out from the casting basin in January 2000 to rest on drilled shafts that have been installed in bedrock.

Other bridge columns located away from the tunnel are 4 ft (1.2 m) in diameter, supported on 6 ft (1.8 m) diameter single drilled shafts. Oval-shaped columns supported on the immersed tubes are all 2.7 ft x 4 ft (0.8 x 1.2 m). Furthermore, to accommodate an S-curve alignment at the south end of the bridge, the superstructure almost doubles in width to 135 ft (41 m). The excess deck area created by the 45-degree skew and S-curve is architecturally treated and will be landscaped due to its function as a pedestrian outlook to the channel.

Spans vary from 62 to 78.7 ft (19 to 24 m) and use a combination of 36 and 48 in. wide x 27 or 33 in. deep (0.9 and 1.2 x 0.7 or 0.8 m) precast, prestressed concrete box beams. The eight-span structure is made continuous for live loads over one two-span and two three-span units by reinforcing the 5 in. (125 mm) cast-in-place topping.

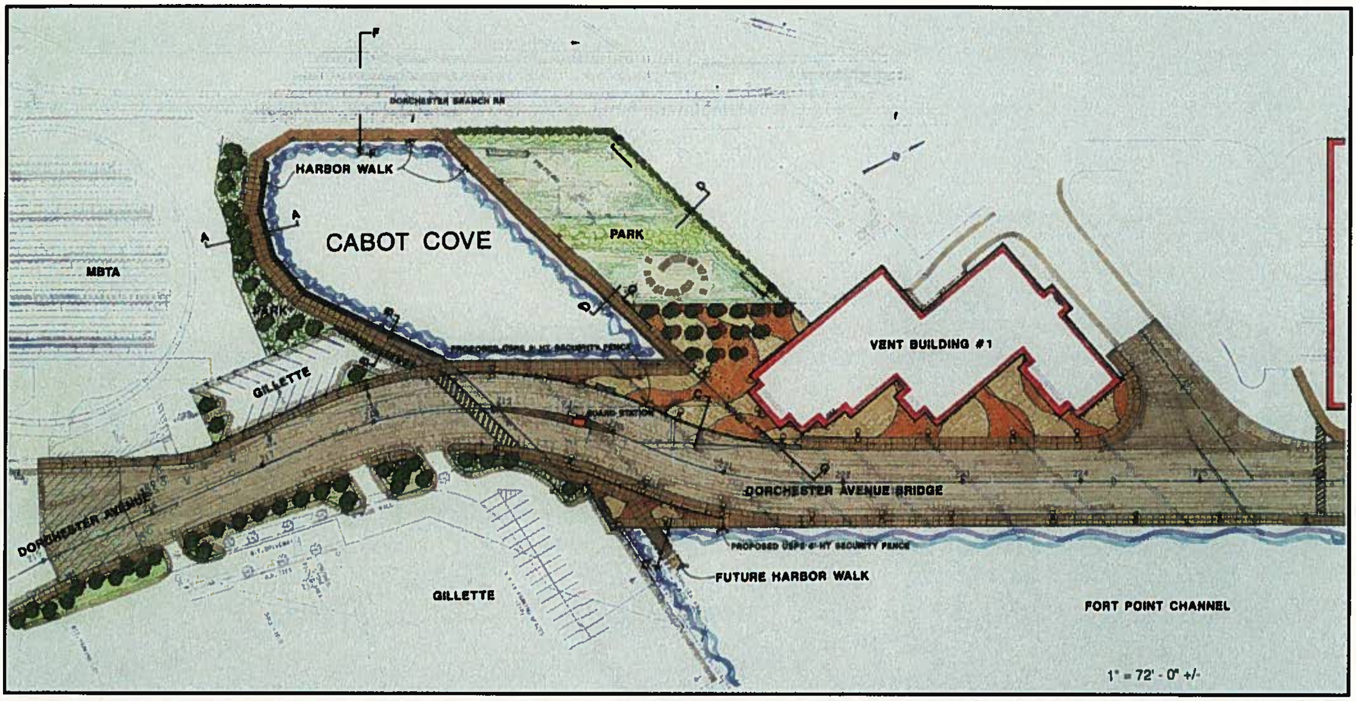

Fig. 2. Plan of Dorchester Avenue Bridge, Boston, Massachusetts.

The cross section of a typical span is comprised of fifteen 48 in. wide x 33 in. deep (1.2 x 0.8 m) box beams and four 36 in. wide x 33 in. deep (0.9 x 0.8 m) box beams placed side by side with transverse post-tensioning located at pier diaphragms and at quarter span points.

Neoprene bearings are provided under the ends of each beam and longitudinal restraint is provided at intermediate piers by extending the cast-in-place pier diaphragms into recesses cast into the piers. Lateral restraint is provided by shear blocks.

SPECTACLE ISLAND PIER

Spectacle Island is located in Boston Harbor and has been filled and reconfigured with 3.7 million cu yd (2.8 million m^3) of tunnel spoil from the Central Artery/Tunnel Project, becoming the highest point in Boston Harbor. The island is in the process of being transformed from a landfill wasteland to a public parkland as part of the project's extensive environmental mitigation program. A Visitors Center and 5 miles (8 km) of pathways will be constructed, and landscaping will include the planting of 28,000 trees and shrubs.

Fig. 3. The all-precast concrete Spectacle Island Pier, Boston, Massachusetts.

To provide access to the island, the Spectacle Island Pier (see Fig. 3) is a marine trestle type structure designed for the dual function of initially docking construction barges and, finally, as a public recreational boat dock after the island park has been completed. The structure is L-shaped, comprising a 500 ft long x 40 ft wide (152 x 12 m) trestle that extends out from the shore to a 270 ft long x 50 ft wide (82 x 15 m) boat dock.

As shown in Fig. 4, cast-in-place pier caps are supported by 14 in. (0.36 m) square prestressed concrete piles with an 80-ton capacity in compression and a 40-ton capacity in tension (for barge impact forces). The caps are made composite with the precast, prestressed concrete double-T superstructure, which has a 4 in. (100 mm) cast-in-place mesh reinforced topping. The beams are integral with the caps so as to raise the caps as far above high tide as possible.

Eight 6.25 ft (1.9 m) wide double-T beams are provided for the docking area. The stems vary from 6 in. (150 mm) at the bottom to 9 in. (230 mm) at the underside of the 4 in. (100 mm) thick top slab. The stems are prestressed using pairs of 0.5 in. (13 mm) diameter strands; the lower strands are debonded 8 ft (2.4 m) from the ends. For the trestle, a similar design uses six 6.7 ft (2 m) wide beams.

Originally, the pier was designed as an all timber structure. However, the contractor hired consulting engineers to completely redesign the structure in precast concrete as part of a value engineering proposal. The construction savings derived from switching from timber to precast construction totaled $285,000 for the $4 million structure.

To address corrosion concerns in a marine environment, the contractor hired a specialized corrosion consulting firm. Corrosion mitigation measures included using pozzolanic additives and epoxy coated reinforcing bars in all concrete, and calcium nitrate in the cast-in-place piers and superstructure. The maximum water-cementitious ratio was limited to 0.35 for the precast piles and 0.40 for the other concrete components.

Fig. 4. View of the precast, prestressed concrete double-T superstructure of the Spectacle Island Pier, Boston, Massachusetts.

ACKNOWLEDGMENTS

Client: Massachusetts Turnpike Authority, Boston, Massachusetts

Management Consultant: Bechtel/Parsons Brinckerhoff, Boston, Massachusetts

Section Design Consultants:

- Broadway Bridge, Maguire Harris/Lin Associates, Boston, Massachusetts
- Dorchester Avenue Bridge, Gannet Flemming, Boston, MA
- Spectacle Island Pier, Universal Engineering, Boston, Massachusetts

Contractors:

- Broadway Bridge, Keiwit/Cashman, Boston, Massachusetts
- Dorchester Avenue Bridge Modern Continental, Boston, Massachusetts
- Spectacle Island Pier, Cashman/Keiwit/Perini/Atkinson, Boston, Massachusetts

Precast Producers:

- Broadway Bridge, Northeast Concrete Products LLC, Plainville, Massachusetts
- Dorchester Avenue Bridge, Northeast Concrete Products LLC, Plainville, Massachusetts
- Spectacle Island Pier, Northeast Concrete Products LLC (piles), Plainville, Massachusetts
- Unistress Corporation (double T beams), Pittsfield, Massachusetts