Casco Bay Bridge

Portland, Maine

Jurors Comments

Innovative...unique trunnion strut, graceful lines and aesthetic pier shape...excellent presentation to make a moveable bridge aesthetically appealing.

The Fore River is an important navigable waterway serving both commercial shipping and recreational boating activities of the Portland-South Portland area. The old movable bridge spanning the navigation channel was a two leaf Sherzer rolling bascule type providing a channel clearance of only 98' horizontally and less than 24' above mean high water vertically when the bridge was closed. The draw span provided a narrow entryway with less than 5' side clearances, at times, for large tankers and cargo ships to delivering oil and cargo to the terminals located in the upper Fore River. The bridge is also an integral part of the area's transportation network with over 30,000 vehicles per day traveling between the two cities.

Public debate about replacing the old bridge started as far back as 1951. Numerous studies were conducted to evaluate the deteriorating structural condition of the old bridge and to determine the feasibility of rebuilding or replacing it, including the possibility of a tunnel crossing. Other studies focused on navigational needs and potential navigation improvements that would be provided by a bridge replacement.

It was not until 1987 that a plan to replace the old bridge was accepted by local, state and federal officials, clearing the way for the design and construction of the Casco Bay Bridge.

The Casco Bay Bridge is the Maine Department of Transportation's largest bridge construction project to date. The 4,748' long structure includes a mid-level movable bascule span over the navigational channel of the Fore River that flows into Casco Bay. The span is one of the largest of its type in North America and it is a trunnion bascule with a center-to-center trunnion distance of 285.5'. The new span has a horizontal channel clearance width of 60 m (196.85'), over 100' wider than the old movable span, making the passage through the bridge safer for navigation. The new span is also higher providing 65' of vertical clearance at the center of the channel, with the bridge in the closed position, thus decreasing the number of openings of the span and reducing delays to bridge users.

Bascule Span Design

The design of the bascule span incorporates the state-of-the art in bridge design and construction for structural, mechanical and electrical systems and conforms to both AASHTO's, *Standard Specifications for Movable Highway Bridges*, and *Standard Specifications for Highway Bridges*, 15th Edition, using a design live load of HS25 and alternate military loading. The specifications are supplemented by the latest industry standards applicable to each individual discipline.

ASTM A709, Grade 36 and Grade 50 painted structural steel, was used for the bascule superstructure. Due to the size of the bascule leaves and the need for counterbalancing, it was beneficial to provide an efficient structure which minimizes the weight of the leaves where feasible to achieve an economical design. The reduced mass of the leaves also results in cost-effective design of the support system, balance system and drive system. Still, for the bascule leaves strength design is not always the controlling factor. Live load deflection of the cantilevered leaves at mid-span had to be controlled to minimize any potential problems with the span locks. Parabolic-shaped steel I-girders were chosen to conform to the moment envelope of the cantilevered leaves for efficient distribution of materials and ease of fabrication. Similarly, the full-depth floor beams were configured as trusses with readily available rolled shape members designed to have adequate load carrying capacity as well as to provide torsional rigidity for the entire movable leaf during span operation. The floor beams support the galvanized stringers, open grid decking, steel barriers and steel sidewalks.

Unique Features

Each bascule leaf is counterweighted with a concrete-filled steel box at the heel end between the pair of I-girders. The box is 16' × 19' × 30' and is formed with 3/4" stiffened steel plates. Due to the size of the counterweight, and the 78 degree angle of opening needed for the bascule leaf, a sizable clear space had to be provided between the support columns to allow for the movement of the counterweight. The conventional bascule bridge pivot consists of a trunnion shaft through the girder web with support bearings on each side of the web. This arrangement was not feasible for this structure. An innovative concept was advanced to solve this problem and was accomplished by the use of the trunnion strut. A stiff space truss (referred to as the trunnion strut) spans between each pair of support girders. At each end of the strut a trunnion shaft penetrates the main girder web to engage the strut in order to transfer the load of the bascule leaf to the supporting trunnion bearing. The single bearing at each girder is supported by an exterior column. This arrangement opened up an uninterrupted space between supports for the movement of the counterweight. A large percentage of the steel used for the strut is distributed to the corners for efficient use of material to provide a very stiff element with constant section property in any orientation. The required stiffness is used to control the deflection in order that camber and load distribution will not be a problem, thus controlling the alignment of the bearings.

The sizeable 1500 ton dead load per bascule leaf required support bearings capable of supporting very heavy loads while limiting the size of the trunnion bearings. Special maintenance free spherical plain bearings with sliding contact surface combination of steel and special bronze was specified. The sliding layer is composed of discs of bronze material inserted in recesses milled into the inner steel spherical convex surface. The special bearings, specifically manufactured in the United States for this project, are capable of supporting very heavy radial loads and axial loads. These may be the only bearings of this type used for bridge application in this country.

Foundation and Substructure

Although alternate 7' diameter drilled shafts and H-pile foundations were designed for this bridge, the contractor selected the later for construction. High bending capability required for the H-pile foundation resulted in the specification of A572 high strength HP14 × 117 steel piles, reinforced with cover plates near the tops of the piles. A total of 231 piles were utilized for each bascule pier. A critical length of embedment of the H-piles was required to develop sufficient anchorage of the piles against lateral loads. Difficult pile driving conditions were anticipated in the glacial till material, based on available geotechnical information, but did not present any significant problems during construction.

A pair of unique, reinforced concrete piers were designed to emphasize the entrance to the harbor. The fully

screened and enclosed piers were desirable due to their ability to protect the bridge's operating machinery from the weather, as well as keeping out birds. The shape of the pier tops is more or less defined by the arc of travel of the counterweight within when the leaves open or close. The reduced width of the lower portion of the mid-level bridge piers also resulted in a savings of material.

Pier Protection

A pier protection system consisting of four cellular sheet pile dolphin and fenders demarcating the boundaries of the channel was designed to prevent, or at least minimize, any damage to the bridge piers due to vessel impact.

Concrete from the old bridge was recycled by processing the demolished concrete into a consistent gradation and used as granular fill for the cellular sheet-pile dolphins.

Clusters of 36" diameter fusion-bonded epoxy coated steel pipe piles and wales consisting of W24 × 117 rolled beams form the protective fender system along each edge of the channel. The wales were faced with ultra high molecular weight (UHMW) polyethylene rubbing strips for decrease vessel impact force due to the very low coefficient of friction. The UHMW material was also selected for its durability and resistance to deterioration.

Efficient energy absorbing kinematic rubber fenders were introduced at the pier locations to provide the minimum offset of the fender, and maximize the channel width opening to satisfy the navigational clearance requirements of the U.S. Coast Guard.

Electrical/Mechanical

The state-of-the-art electrical system includes automatic control which is performed by the programmable logic controller (PLC) for sequencing of the various operating steps required by the movable span. Solid state speed controls are also used to provide a higher degree of accuracy in bridge movement.

The bridge drive machinery uses a single enclosed drive arrangement for each leaf to enhance reliability and minimize maintenance. The main motors and motor brakes, including the auxiliary drive system, were pre-assembled on the drive unit in the manufacturer's facility in an attempt to provide more accurate alignment of the various components.

Unique "wet" type disc brakes were specified for the bridge machinery. These compact brakes provide an efficient braking system and also have excellent corrosion resistance.

Aesthetics

Special consideration was given to the visual impact of the bridge on the landscape of Portland Harbor. An aesthetic committee was established to provide input and guidance to finding a design that would complement its environment and serve as a new landmark for Portland Harbor. By taking advantage of the long curvilinear alignment of the new structure the design team endeavored to achieve the concept of a continuously flowing ribbon in space, punctuated only at the bascule span.

The treatment of the large bascule piers commanded the attention of two nationally renowned bridge architects. The upper section of each bascule pier above the shaft is shaped to conform to the enclosed space required to accommodate the movement of the counterweight as the span opens and closes. It also provides a protective enclosure for the trunnion bearings and the machinery which operates the span. The bascule span is viewed as an accent to the desired ribbon effect.

A special red color was selected for the paint on the structural steel girders to enhance their appearance and blend in with the red brick seen on many of Portland's waterfront buildings.

Project Team

Owner
State of Maine Department of Transportation

Designer
Modjeski and Masters, Inc.

Steel Fabricator
Tampa Steel Erecting Company

Steel Detailer
Tensor Engineering Co.

Steel Erector
Cianbro Corporation

General Contractors
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