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1. Houston Ship Channel Bridge (Texas, USA)

Owner:	*Texas Turnpike Authority*
General Consultant:	*Howard Needles Tammen & Bergendoff (HNTB)*
Section Engineers:	*North Approach Spans – Bernard Johnson Inc.* *Main Spans – HNTB* *South Approach Spans – Turner, Collie & Braden, Inc.*
Contractors:	*North Approach Spans – Gardner/B/H Constructors* *Main Spans – Williams Brothers Constr. Co.* *South Approach High Spans – Williams Brothers Constr. Co.* *South Approach Low Spans – Austin Bridge Company*
Construction Time:	*32 Months*
Service Date:	*1982*

General

In Houston, Texas, the need for an outer circumferential highway route was apparent as early as 1953. A formal plan providing for a 141-km-long road encircling the central business district of the city was approved in 1954. Since then, many important sections of this project have been completed.

One of the most critical and expensive links in the system is a 6.8-km-long section that includes a high-level bridge over the ship channel. In 1976, the Texas Turnpike Authority was requested to study the financial feasibility of their constructing this section as a toll facility. A detailed traffic revenue analysis and engineering design report was completed in May 1978 by the Authority's general engineering consultant, Howard Needles Tammen & Bergendoff (HNTB) and traffic engineering consultant, Wilbur Smith. These reports confirmed that the project was feasible, and in July 1978 a $102 million bond issue was sold to finance the total project.

HNTB studied seven different alternatives for the main spans across the ship channel as follows:

1. Concrete box girder
2. Steel orthotropic box girder
3. Steel girder with diagonal struts
4. Steel thru truss
5. A cable-stayed girder
6. Steel tied arch
7. Steel half-thru tied arch

Preliminary designs and cost estimates were prepared for all seven types. The selected alternate, concrete box girder, was considered aesthetically superior and of least overall cost with low maintenance. Also, this alternative could easily be constructed without the use of falsework in the channel, which was a requirement.

Main Spans – Superstructure

The Houston Ship Channel bridge has the longest prestressed segmental concrete box girder in the United States. Its main span of 229 m surpasses the 195 m span of the Parrotts Ferry Bridge in California. In addition, there are two side spans of 114 m, which, together with the 229 m main span,

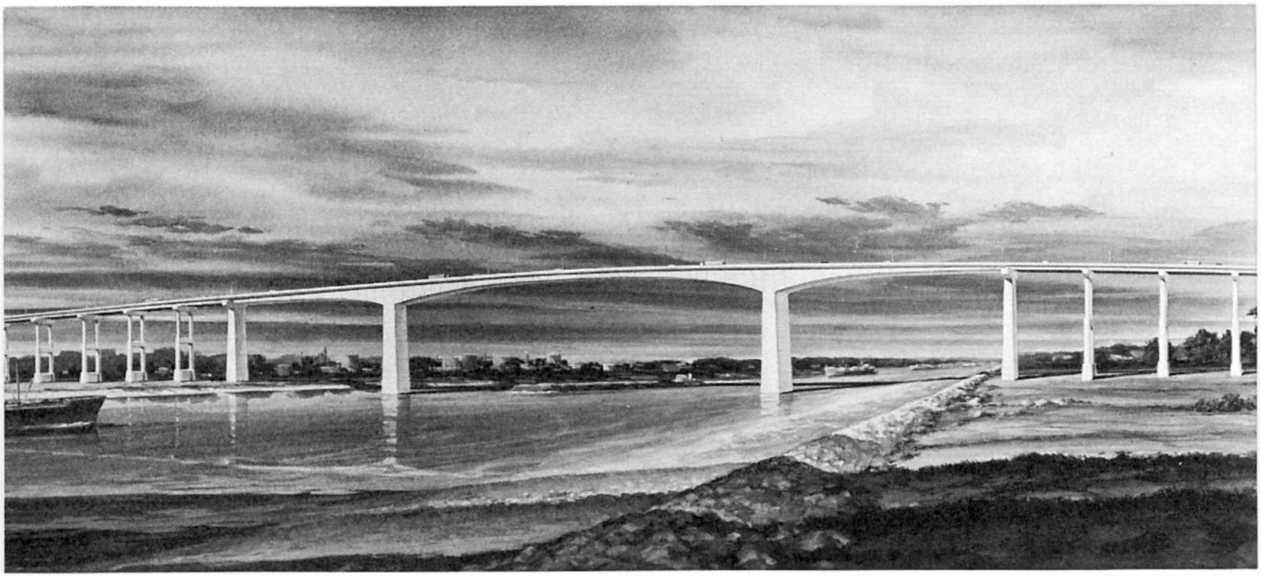

Fig. 1 Rendering of completed structure

form a three-span continuous unit. The two-cell box girder carries four lanes of traffic within a total width of 18.1 m and has a depth which varies from 14.5 m at the piers to 4.6 m at the center of the span. Balanced cantilever construction was utilized with cast-in-place segments that varied in length from 2.4 m to 4.6 m, depending on the depth of girder.

The project specifications allowed the successful contractor a number of construction options, provided they were indicated and a redesign submitted with the bid proposal. The contractor took advantage of a number of options including the substitution of 41.4 MPa concrete in lieu of 34.5 MPa, which allowed the use of thinner structural elements. For the contractor's proposed erection scheme, the concrete also had to achieve a strength of 27.6 MPa in 40 hours. In addition, the contractor received approval to use sloping exterior webs to reduce the bottom slab width and the length of the cantilever at the roadway level. The contract price for the main spans, including the four supporting piers, was $19.6 million.

Main Spans — Substructure

The bridge is constructed in an area that has experienced as much as 2.8 m of subsidence over the past 75 years. While the rate of subsidence has decreased, it is expected that the bridge will experience 230 mm of subsidence during its life, 90 mm of which will occur during construction.

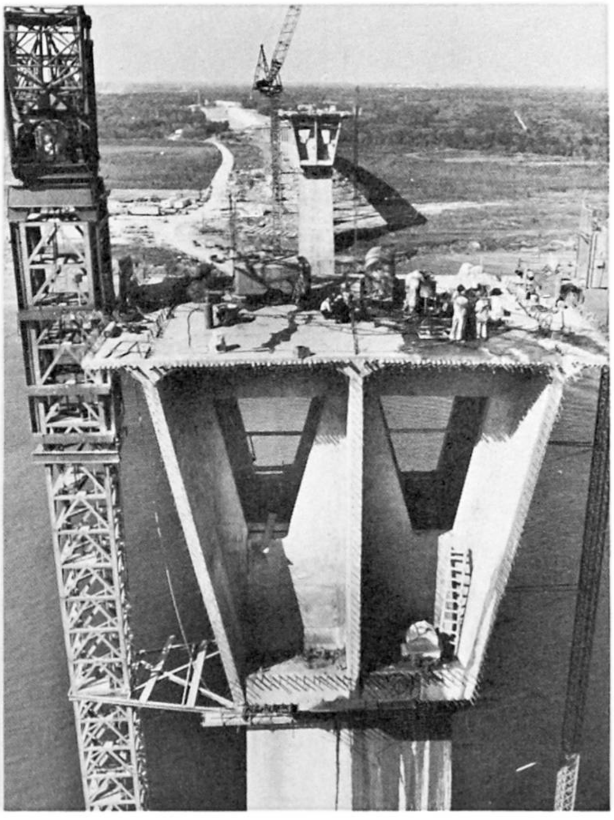

Fig. 2 Construction. Cross section at pier

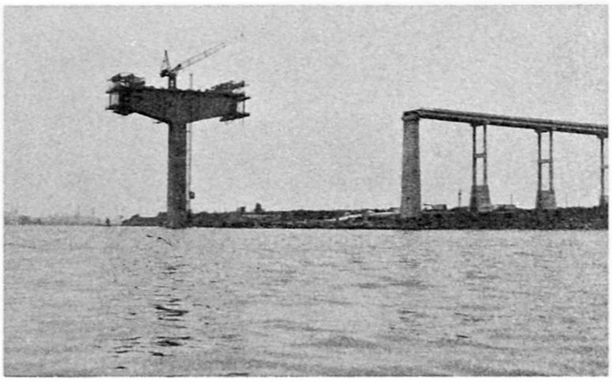

Fig. 3 August, 1981 Stage of construction

In constructing the hollow concrete main piers, the contractor utilized 37.9 MPa concrete in lieu of 24.8 MPa originally called for on the plans. This allowed the wall thickness of the piers to be reduced from 0.6 m to 0.4 m, which led to problems with concrete placement. In fact, the first placement was badly honeycombed. To eliminate this problem, external vibrators on the forms were used to supplement the high-cycle internal vibrators.

The footings of the main channel piers measure 24.7 m x 22.9 m x 4.6 m. Each footing is supported by 255 open-ended 0.6-m-diameter steel pipe piles with a wall thickness of 13 mm. The pile design load is 1.25 MN and the length of pile is 26 m. To determine the capacity of the piles a test load was placed on one of the piles, and it was found that the pile could support 3.1 MN before soil failure occurred.

Approaches

Three different alternatives were studied for the approach spans as follows:

1. Simple span prestressed concrete I-beams
2. Continuous span concrete box girders
3. Continuous span welded steel plate girders

The precast prestressed concrete I-beams with simple span lengths of 28.7 m and 36.6 m were used due to their being most economical for the approach spans. In addition, this structure type utilizing simple spans is best suited for the site since differential settlement between adjacent piers will not induce stresses in the superstructure.

Substructure elements for the simple spans consist of two or three column bents. For the piers with heights in excess of 18 m an intermediate strut is used between the columns. A 0.6-m-thick pedestal wall is added between the columns above the footings for piers with heights in excess of 30 m. The columns are supported on individual footings except for the piers with pedestal walls, where continuous footings are used. Piles are used as a support for all the footings.

The total length of the approaches is 2.75 km with a construction bid price of $26.1 million.

(Gerard F. Fox)