Bridge over the Eastern Scheldt

by Ben C. Gerwick, Jr.

SYNOPSIS

The Bridge over the Eastern Scheldt in The Netherlands is an outstanding example of long-span bridge construction in precast prestressed concrete. The bridge scheme consists of very large prestressed cylinder piles, precast pier elements post-tensioned together, and precast superstructure elements erected and post-tensioned to form a double-cantilever system. Individual elements weigh as much as 600 tons. The methods of fabrication, transportation, erection, jointing, and stressing are described.

This bridge illustrates a principle: bridge spans in the range of 200 to 500 feet belong to prestressed concrete. The *how* and *what* are in process of development and evolution. Here is the longest bridge in Europe, one of the few bridges in the world which must really pay its way in a short span of years—and one for which prestressed concrete was the only proper solution.

Techniques will evolve. This project utilizes the advantages of large capacity equipment, heavy segmental units, repetitive construction. I believe there were modifications of the scheme which might have reduced plant investment—but the good features far outweigh the negative ones. The basic facts on the Oosterschelde Bridge (Fig. 1) are as follows:

1. The bridge is part of the great Delta Works Scheme which will eventually close the mouths of the many rivers and estuaries southwest of Rotterdam, thus protecting the coast line against disastrous flooding and also protecting against salinization of ground water. Since the Delta Works won't be completed and continuous until 1978 and since the Southwestern part of the country is growing and industrializing rapidly, a connecting bridge that could be financed and paid for by tolls in 12 to 15 years was needed now, in 1966. Thereafter, it will still be a vital roadway but not the only one.

2. The bridge is 16,000 ft. long, composed of 55 spans of 300 ft. each. The cost was 65,000,000 Hfl = $16,000,000. A vertical clearance of 50 ft. for vessels was specified. The roadway width is 35 ft.

3. The design of spans was dic-

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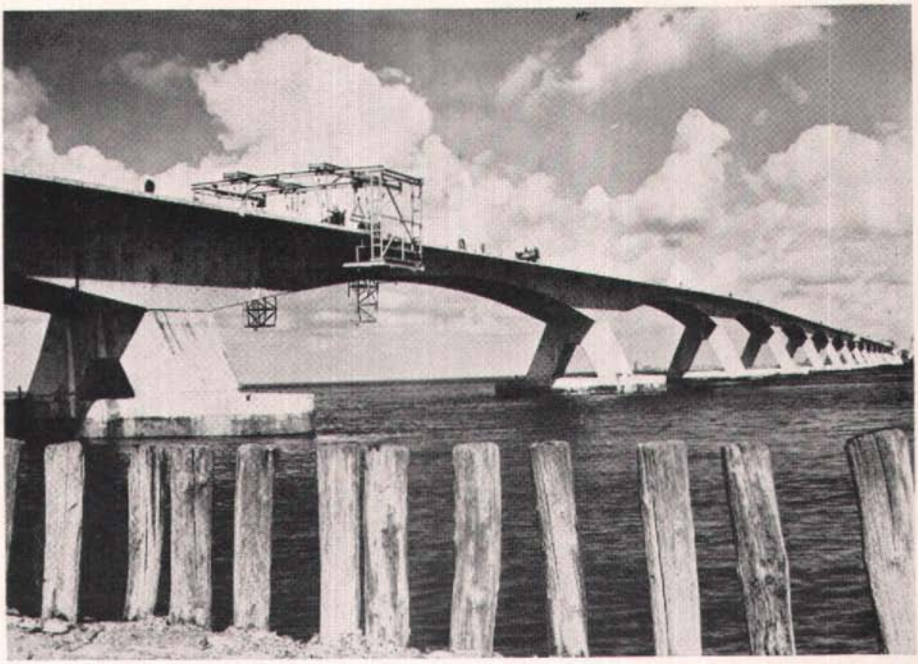

Fig. 1—This massive bridge is entirely comprised of prefabricated elements joined together by prestressing.

Fig. 2—Overall view of precasting facility for the Oosterschelde Bridge

tated by foundations, ice, and economy. Water is up to 100 ft. deep. Below, lie recent, loose sands, then firm sands. Cylinder piles were selected, 3 per pier. Piles will have their tips filled with concrete. The remainder will be left unfilled, but arrangements have been made to fill with sand later if vibration is noted.

4. The superstructure was chosen as double cantilevers rather than cantilever-suspended spans. This throws most of the moment and concrete to the piers, eliminating dead weight of concrete at center of spans. The only problems are transfer of shear and preservation of riding surface. The solution is provided by special shock absorbers at the joints at span centers, which transmit horizontal and vertical shear. They do not shorten under short time loading, but do adjust to long time temperature shortening and lengthening.

Prefabrication to highest degree was necessary because of time, scarcity of labor, and exposed location. Because piles would be large and heavy, it was decided to make all pier and superstructure elements also large and heavy, i.e. in the range of 400 to 600 tons.

Initially, the Oosterschelde will be open to the sea and exposed to swift currents, deep water, and a medium ice pressure. Later, in 1978, when the mouth is dammed, the lake will be fresh, so there will be more ice; the current will be slower, so there will be more pressure; but depth and thus exposed length of piles can be reduced by sand fill around piers.

For the superstructure a box section was selected for maximum

Fig. 3—A prestressed cylinder pile, 14 ft. in diameter and 120 ft. in length, being loaded out from casting yard

efficiency for torsion and bending. Longitudinal prestress consists of Freyssinet cables in the deck, except for a few in the bottom near the center of the span to take care of moment reversal.

MANUFACTURE

The prefabrication site is served by 2-300 ton gantry cranes with a span of 200 ft. (Fig. 2). It is a specially built yard near one end of the bridge with complete facilities for manufacturing and loading the precast elements.

Cylinder piles are 14 ft. in diameter, with 14 in. thick walls. They are cast vertically in 20 ft. lengths, then turned on a turning frame to horizontal. There they are set on straps to reduce point bearing pressure, and sections are aligned to produce pile of desired length, up to 165 ft. Joints are concreted, then the cylinder pile is post-tensioned. The entire pile is lifted by the two cranes and set on similar straps between two barges (Fig. 3).

A steel shoe is attached in the yard, as well as a temporary steel driving helmet.

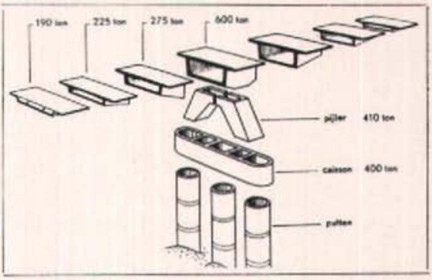

Fig. 4—Elements of the Oosterschelde Bridge

Meanwhile, also at the yard, a caisson, or pier cap is cast, and post-tensioned circumferentially and vertically. The remaining pier column sections are cast with provision for site post-tensioning to tie all of the pier together.

The superstructure elements consist of one hammerhead segment, and two each of three progressively smaller segments; thus seven superstructure segments make up one double-cantilever span of 300 ft. (Fig. 4).

Walls are stressed vertically with unbonded bars, and laterally with

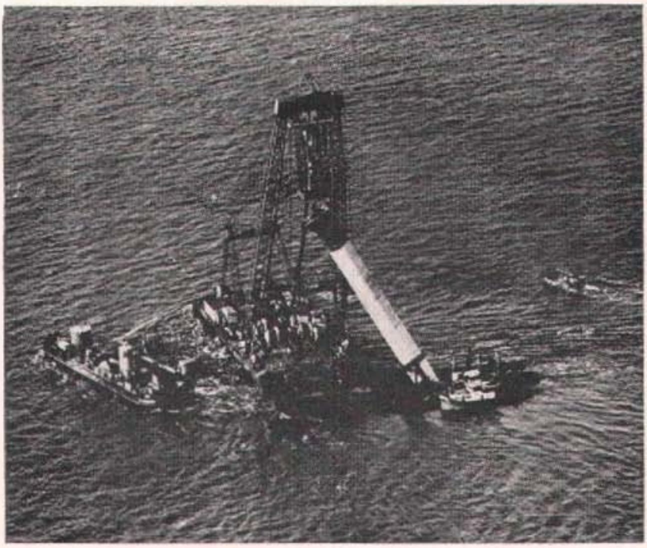

Fig. 5—Lifting a prestressed cylinder pile into position

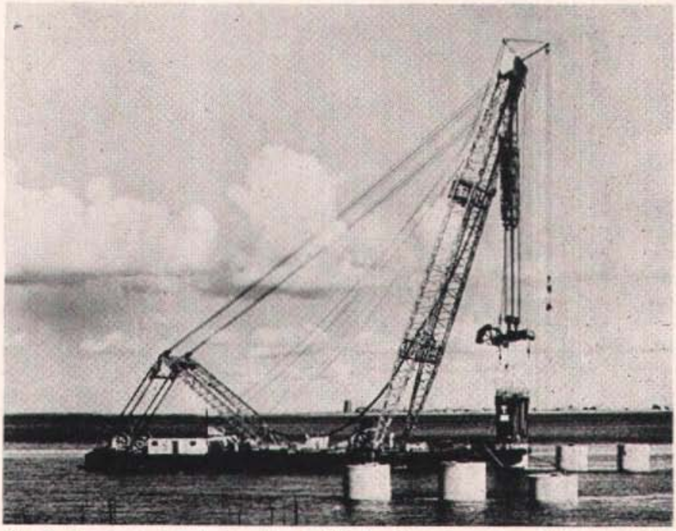

Fig. 6—Prestressed cylinder piles 14 ft. in diameter are sunk by dredging and weighting

Freyssinet tendons.

TRANSPORT AND ERECTION

The cylinder piles weigh from 300 to 550 tons, the hammerhead segment, 600 tons. Other elements of the pier are in the 400 ton range. The superstructure elements weigh from 190 to 275 tons.

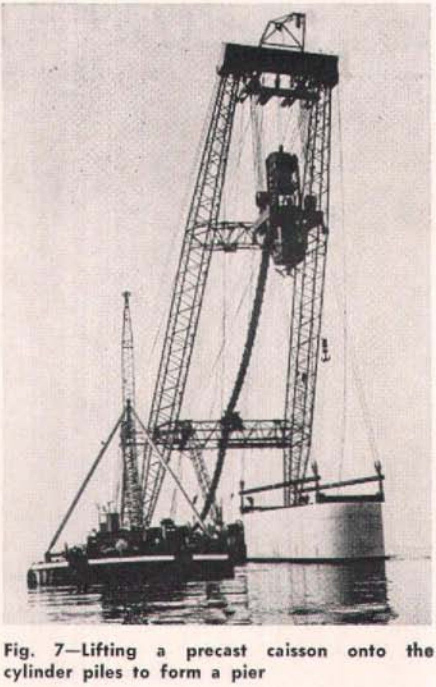

Fig. 7—Lifting a precast caisson onto the cylinder piles to form a pier

All elements were lifted by the use of prestressed lifting bars.

Piles were moved to the site suspended by slings between two barges. A 600-ton shear-leg derrick picked a pile up from one end, rotating the cylinder pile to the vertical and setting it accurately in position on the bottom (Fig. 5). The derrick then suspended a small dredge ladder inside the cylinder pile which cut and pumped the sand out (Fig. 6). The cylinder pile sank as a caisson. As it neared grade, the derrick barge hooked onto the pile and raised its bow up, thus adding 500 tons effective weight to aid sinking. Water level was kept slightly higher inside than outside in order to prevent boiling.

Once founded, the base of the pile was filled with gravel. Then grout was pumped in to form an intruded concrete.

After a bent of 3 piles was driven, a caisson pier cap was lifted by the derrick and set over the piles (Fig 7). Juncture to the piles was made

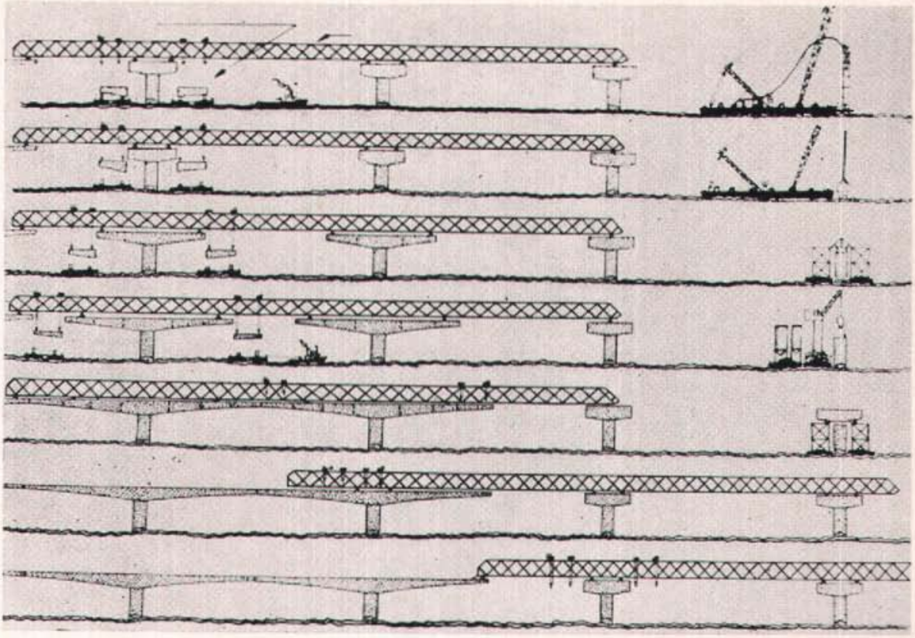

Fig. 8—Schematic erection scheme for Oosterschelde Bridge

by concreting.

Upper elements of the pier were transported by two barges joined by rigid truss work at one end. This double barge, of U shape, straddled the pier and lowered each element in turn into position, using jacks. The spaces were then concreted and the whole pier subsequently stressed together.

The hammerhead segment was set in much the same way, taking advantage of a lowering tide for setting. The segment was initially set onto temporary rubber bumpers, and final adjustment to exact position was by jacking.

The superstructure elements were all set from a travelling steel falsework bridge that extended over two and one-half spans at a time (Fig. 8). Elements were brought in under it by barge, then hoisted in symetrical order about each pier (Fig. 9). The joints were concreted, and the primary stressing done before the next series was hoisted.

Joints in the superstructure were 16 in. wide. The faces of the precast elements were serrated, for shear keys.

A typical cycle for two spans of superstructure, involving the raising, concreting, and stressing of 12 elements, was 3 weeks.

In total, the bridge consumed 170,000 cu. yds. of concrete. About 85% of this was precast. 3300 tons of prestressing steel were used, employing three different systems. The bridge is being completed ahead of schedule.

The cost per square foot was not cheap by our standards, being approximately $30 per sq. ft., but considering that this includes design and financing as well as construction, and considering the exposed location, the

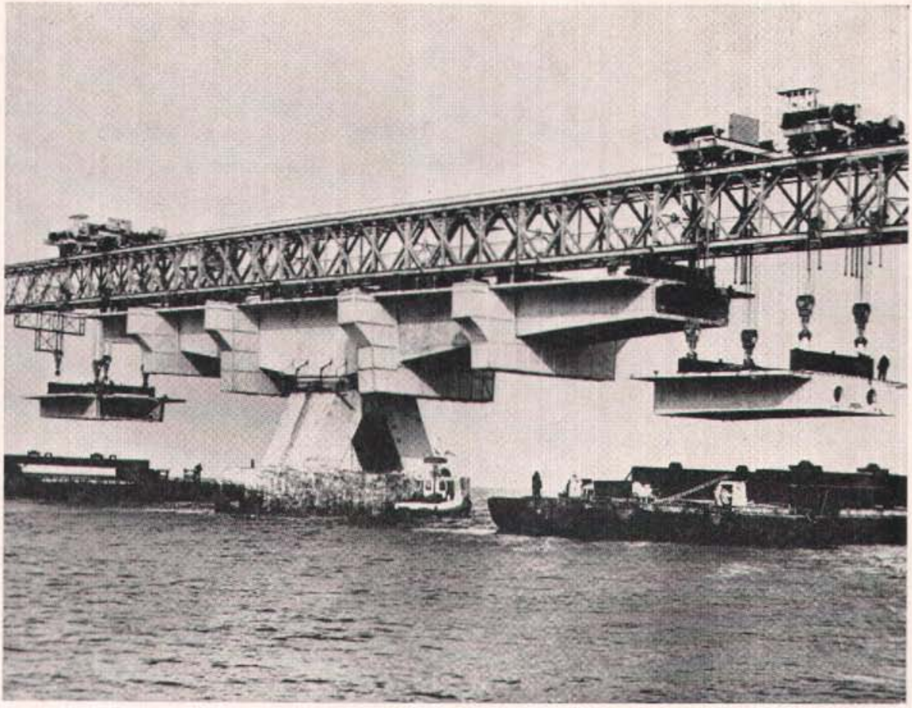

Fig. 9—Overhead falsework truss is used to erect the precast superstructure elements

ice and water depth and span lengths, this longest bridge in Europe is indeed a notable achievement, made practicable and feasible through the bold application of prestressed concrete.

The design and construction of the bridge was performed by N. V. Amsterdamsche Ballast Maatschappij and van Hattum en Blankevoort N. V. working together in Combinatie Brug Oosterschelde.

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