EXCURSIONS

THE STORM-SURGE BARRIER IN THE OOSTERSCHELDE

RIJKSWATERSTAAT DELTADIENST[1]

THE DELTA PROJECT

Since 1954 large civil-engineering projects have been constructed along the whole Dutch coast. The Delta project in the SW part is designed on one hand to protect the low-lying polders against high river and sea levels, and on the other hand to achieve the requested separation of fresh and salt water in this country. The work is carried out to accomplish the Delta Act, which was adopted by the Parliament after the disastrous flood of 1953.

Included in the delta project are four large dams in the estuaries between the Westerschelde and the Rotterdamse Waterweg. At the present time three dams, namely those in the Veerse Gat, the Brouwershavense Gat and the Haringvliet have been completed, whilst the closing of the Oosterschelde must be completed in 1985. Figure 1 shows the topographic situation of the site.

WORK HARBOURS

The project in the estuary of the Oosterschelde (Eastern Scheldt) started in 1967. First two harbours with quays, jetties and construction areas were built; work harbour Schelphoek (1967) on the coast of Schouwen and work harbour Sophia (1968) on the coast of Noord-Beveland. In these harbours, the required materials for the construction of the dam delivered by trucks and ships are stored and transshipped. During bad weather work ships like dredgers, floating cranes and pontoons find shelter here.

In these harbours are also made the mattresses which will protect the bottom of the Oosterschelde against the scouring action of the water along the base of the dam. The construction areas of the Schelphoek are in use for 'the development and testing of new work methods and materials'. Meanwhile Schelphoek has become the parking place of the Delta project where no longer used equipment is awaiting a future destination.

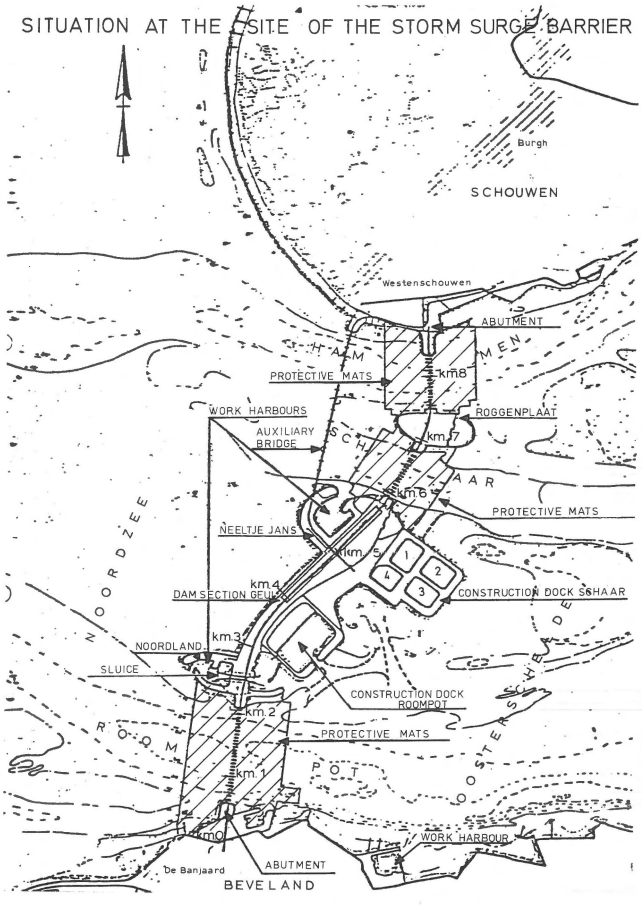


Fig. 1
Geographical situation of the Oosterschelde storm-surge barrier site.

[1] Rijkswaterstaat,Deltadienst, ZIERIKZEE, The Netherlands.

CONSTRUCTION ISLANDS AND ABUTMENTS

In 1968 the actual construction of the 9 km long Oosterschelde dam started. On the higher parts of the Oosterschelde bottom were built successively the three construction islands Roggenplaat (1969), Neeltje Jans (1970) and Noordland (1971), the dam section Geul between Neeltje Jans and Noordland (1972) and the abutments Noord-Beveland (1972) and Schouwen (1973). At the end of 1973 some 5 km of dam had been completed of which about 2 km at the final level of 11.5 m above chart datum. According to the plans, the remaining three deep channels (Hammen, Schaar and Roompot) should have been dammed between 1974 and 1980 with quarry-stone, slags, concrete blocks, gravel and sand.

The intention was to place the slags and the stones with dumping barges, the concrete blocks with cableways, the gravel with trailer dredgers and the sand with cuttersuction and trailer dredgers. Earlier (in 1971) the use of helicopters for placing the concrete blocks had been considered. After carrying out transport and dump tests at the end of 1971 and the beginning of 1972 with the assistance of a helicopter from the American army and with concrete blocks left from the closing of the Brouwershavense Gat, it was decided not to investigate this method any more.

The construction islands and abutments, too, got work harbours from where the floating equipment can do its work in the channels. The islands and abutments were built large enough to accommodate stations of the cableways, and also to yield storage facilities for the concrete blocks. The size of the construction island Roggenplaat was based on the initial plan to build the sluice there, which would be needed for the desalination and further control of the quality and quantity of the fresh Oosterschelde water. Later it was decided to build this sluice on the work island Noordland, where in 1973 a construction pit was excavated for this purpose.

COMPLETE CLOSURE

Aiming at a complete closure of the Oosterschelde in 1973 a start was made with the placing of the scour protection mats (extensive carpets) in the three remaining channels. These mats would be needed during the further construction of the dam to prevent scouring of the sea bed and to keep the erosion (which was expected at each side of the concrete block dam) far enough away from the dam.

At first the protective mats were made of mattresses, consisting of filtercloth and wood, ballasted with dumpstone. Later mattresses with fixed ballast were used: in the Hammen and the Schaar van Roggenplaat mattresses of stone-asphalt, which are made on the floating asphaltship Jan Heymans, and in the Roompot the concrete-block mattresses which are made in the production plant at the work harbour Sophia.

In 1973 and 1974 the 13 towers for the cableways, with which the concrete blocks would be dumped, were installed in the three channels by means of a lifting platform.

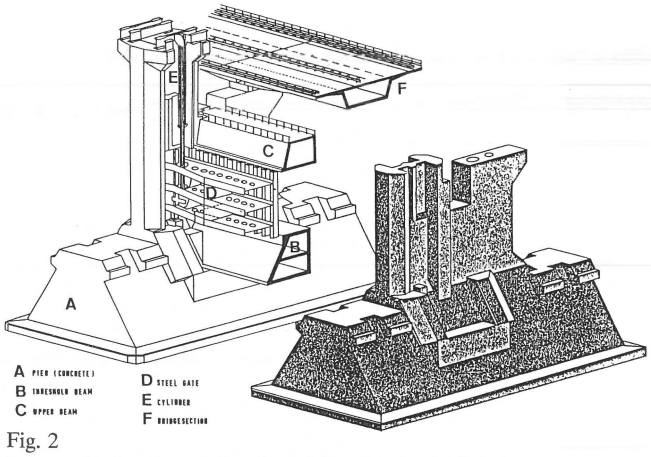


Fig. 2
Schematic drawing of the closeable gates in the barrier.

DISCUSSIONS ABOUT SAFETY AND ENVIRONMENT

In the meantime, at the beginning of the seventies, intense discussions arose on the plans of closing of the Oosterschelde. Supporters of the complete closure underlined the promised delta safety for the areas around the Oosterschelde. Opponents wanted to realize this delta safety by improving the existing dykes, so that in this way, in the open Oosterschelde, the existing saline tidal environment and the shellfish culture could be maintained.

A committee installed by the Minister of Public Works should advise the minister on the question, whether and how the Deltaplan could or must be adapted and whether and how the Delta Act must be revised.

Report about the storm-surge barrier

The committee concluded in its report on March 1st, 1974, that the safety and the environment in the Oosterschelde would be served best if the Oosterschelde be made closeable with a storm-surge barrier. According to this plan, open concrete-block dams would have to be installed in the channels of Hammen, Schaar van Roggenplaat and Roompot first. They should be impervious enough to lower the storm-surge level at the head of the Oosterschelde estuary by about 70 cm and porous enough to allow tidal movement at the Yerseke mussel banks.

The concrete-block dams would be built by using the cableways; for the largest concrete blocks (of about 40 ton), the ships were to be used which had been employed earlier especially for the same purpose during the construction of the piers at Hook of Holland.

The construction of these concrete-block dams should be completed at about the same time (1978) as the original de-

sign. After this first stage, which was a temporary solution, the second stage would be the following: the construction of a storm-surge barrier in a construction pit on the work island between the Roompot and the Schaar van Roggenplaat, this on the islands Noordland, Neeltje Jans and the connecting dyke section Geul. The storm-surge barrier was envisaged as a complex of closeable tunnels situated below the low-water level. After the completion of the storm-surge barrier the third stage would be the final closing of the concrete-block dam.

The storm-surge barrier, including two compartment dams in the eastern part of the Oosterschelde, could, according to estimates, be completed by about 1990.

Prefabrication

Following the report, the contractors consortium Dijksbouw Oosterschelde and Rijkswaterstaat suggested other technical possibilities for the storm-surge barrier, in this case based on three conditions laid down by the government:
(1) the technical feasability;
(2) the year of completion (1985);
(3) the financial limit.

That is why designs were made for an – in fact triple – storm-surge barrier in each of the remaining channels Hammen, Schaar van Roggenplaat and Roompot. They all had one purpose in common: the prefabrication of the storm-surge barrier, in order to carry out the work on dry land, because in the channels construction docks could not be made. Construction docks would have closed the estuary temporarily to the disadvantage of the environmental circumstances. It also seemed obvious to reduce the 'offshore' activities to a minimum.

Successively storm-surge barriers were designed with closeable caissons on a threshold, caissons on a driven foundation and with piers on a driven foundation.

THE CHOSEN DESIGNS

Finally there has been chosen for a storm-surge barrier consisting of monolithic piers and a sill construction of quarry stone, heightened further with threshold beams (Fig. 2). The piers, the sill and the beams together form the frames in which steel sliding gates can be raised or lowered. During normal weather conditions the gates are kept raised so that the water, important for the saline tidal environment, can pass through the barrier. During storms the gates will be lowered. In this way the coastal defence line, requested by the Delta Act to protect the terrestrial environment against floods, can be achieved. The size of the total opening through which the water flows is on the one hand related to the requirement that the tidal amplitude remains as large as possible, and on the other hand to the condition of the government to keep the cost of the barrier within the required financial limit. The size of the opening is therefore based on an average tidal amplitude at Yerseke of 2.70 m.

In order to achieve this amplitude an effective opening of 14,000 m^2 is necessary. The design of the storm-surge barrier results in a total length of over 2800 m and 63 closeable openings. A total of 66 reinforced concrete piers have to be placed in the three channels: in the Hammen 16, in the Schaar van Roggenplaat 17, and in the Roompot 33. These piers have a baseplate of 25 × 50 m, the heights vary between 35 and 45 m. The maximum weight is 16000 ton. The centre line distance between the piers is 45 m. The raising of the bottom in the 63 openings with a sill and threshold beams is designed in such a way that below chart datum (N.A.P.) the required flow opening remains.

The sill will be built as a filter construction with layers of stony material such as gravel, phosphor slags and quarry stone. In order to withstand the passing currents, heavier materials are used in each higher layer. On each side of the sill the existing scour protection will be extended: in the Hammen and in the Roompot to 650 m and in the Schaar van Roggenplaat to 550 m from the barrier. The protection next to the sill will be strengthened with asphalt and quarry stone. To close the gates of the storm-surge barrier, normally in a raised position, they will be lowered between the piers into the threshold beam and against the upper supporting beam.

During storm the water is retained by the gates and upper beams; from the threshold beam to 1.20 m + by the gates, and from 1.20 m + to 5.80 m + by the upper beams. The threshold and upper beams are made of reinforced concrete, the gates of steel.

All the gates are more than 42 m wide and 5.40 m thick. Depending on the level of the sill between the piers, the heights vary between 5.90 and 11.90 m. The weights lie between 300 and 525 ton. They comprise a framework, water returning plating and end supports. These last mentioned parts bear against the piers. The plating fitted to the Oosterschelde side is not flat but a so-called shell plating. The slide doors will probably be driven hydraulicly. For each gate two hydraulic cylinders are required. So, to close the 63 openings, at a forecasted storm, 126 cylinders are required. The time needed for closing will be about one hour. The required power of about 5000 to 6000 KVA will be supplied by an own diesel power station.

Across the storm-surge barrier a road for public traffic (motorway) and a road for service traffic are planned. Therefore bridge sections will be placed over the piers for a traffic road with a width of 11.92 m and for a service road with a width of 10.10 m. These sections are reinforced-concrete box beams. The driving equipment for the gates will be installed in the traffic beams. The level of the traffic deck will be at 12 m above N.A.P. A lock with harbours will be built. The lock will measure 100 × 16 × 7 m and is required for the passage of floating construction equipment during the construction of the storm-surge barrier. This lock should be completed by the summer of 1982.

CONSTRUCTION DOCK

March 1st, 1979 is the starting date for the construction of the piers. They will be built in the construction dock Schaar, the most northerly of the two construction docks, sited on the work island Neeltje Jans. In view of a storm-surge barrier consisting of caissons these docks were already under construction in 1976.

The construction dock Schaar in fact is a polder which is kept dry by a deep-well system. It has a total area of 800 × 1200 m^2 and a depth of 15 m. At present the dock is being excavated to that level. The sand released by the excavation will be used for the dykes, which divide the construction dock into four compartments. After the piers in a compartment are completed, the compartment will be flooded.

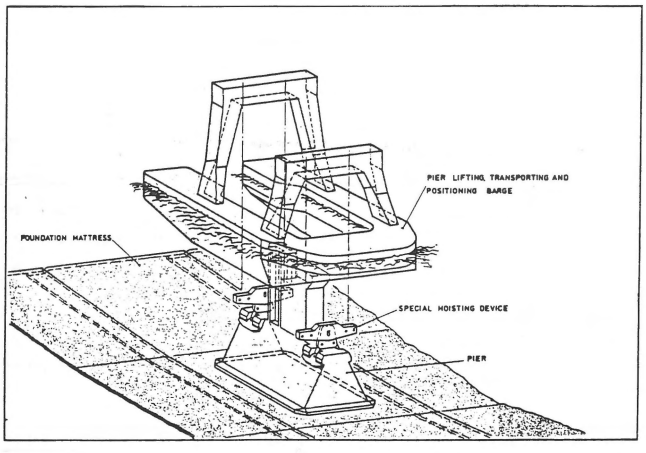
By means of a special ship the columns will be transported one by one to the channels where they will be sunk onto the foundation bed. The foundation layer will then already have been improved by means of soil replacement and compaction with vibrators mounted on a special ship.

Deep-well system and power plant

The construction pit will be kept dry by a deep-well system of 320 underwater pumps: 296 to a depth of about 30 m (capacity 25 to 35 m^3/h) and 24 to a depth of 69 m (capacity of 500 m^3/h). The required power is drawn from an electric power-plant on the work island Neeltje Jans. The power plant has an output of 1200 KVA, a capacity which is sufficient to provide a city of 30,000 inhabitants with power.

Of the total output 4800 KVA is available for the deep-well system and 7200 KVA for the equipment for the production of concrete and asphalt, lighting etc. The 1200 KVA is produced by 15 units of 800 KVA each. Those 15 power units are split up into 2 stations: 6 units for the plant for the deep-well system and 9 units for the service power on the construction areas and in the dock.

Fig. 3
Lifting barge



CONSTRUCTION METHODS

For the concrete production a mixing plant and jetty are required. The average capacity of the plant will be 120 m^3/h. The concrete will be transported from the plant to the site by truck mixers. The sills will be built with floating equipment.

The scour-protection mattresses are made in the plant at the Sophia harbour and by a special pontoon lowered to the bottom. The placing of the asphalt will be carried out by the floating asphalt plant Jan Heijmans. After the piers have been placed in position and the sills are complete, the traffic beams, the gates, the threshold beams and upper beams will be successively installed. These parts of the storm-surge barrier are transported by ships and installed on their position by floating cranes and other floating equipment.

TEMPORARY BRIDGE CONNECTION

For the construction of the storm-surge barrier a great labour force will be needed. The expectation is that during the period from half 1980 to half 1982 approximately 1100 people will be employed on the work island. In order to transport these people and the required materials to and from the construction island, a bridge connection has been built (1978) between Schouwen and the work island. This steel bridge is over 2800 m long and has 20 spans of 145 m. The bridge, 13 m above datum and with an effective width of 7 m, is supported by 19 pillars. For some of these pillars the steel casing piles from the cableway which were driven in 1973 and extracted in 1976/1977, were used.

The bridge joins the construction islands at the westerly pier of the work harbour which was built in 1978 on the seaward side of the work island Neeltje Jans.

COSTS

According to the calculations (based on the price level of April 1st, 1978) the storm-surge barrier in the Oosterschelde will cost Hfl. (Dutch guilders) 3.32 × 10^9.

Fig. 4
Compacting barge