CERES-PARAGON CONTAINER TERMINAL IN THE PORT OF AMSTERDAM DESIGN AND REALISATION OF A HIGH-PRODUCTIVITY TERMINAL

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Abstract

In 2001 the realisation of the new CERES-Paragon Terminal was finished after 2 years of intensive work on design, construction and installation. The terminal, designed to handle the new generation of Jumbo-vessels with capacities of 6,000 TEU and more, has a so-called Indented Berth, allowing (un)loading operations on both sides of the ship. A total of 9 ship-to-shore container cranes will increase the berth transfer capacity to 300 moves/hr, thus keeping the in-port time of even the largest ships within 24 hrs. The total capacity of the terminal is about 1 million TEU/year in the first phase, with expansion possibilities to double that figure in the future.

The terminal layout has been developed by means of computer simulations of the logistic process. This included the complex traffic between the aprons on both sides of the Indented Berth and the stacking areas, and the connection to truck, rail and barge transport, all of which are provided on the terminal. The design of the Indented Berth required hydraulic and nautical studies to determine the overall dimensions and test the viability of the berthing process in terms of safety and time duration. The final design was tested by pilots in a Real Time Simulator of MARIN the Netherlands, proving that the manoeuvre was safe, even under quite adverse weather conditions.

The paper describes the results of these studies and presents some innovative design features, including the structural design of the quay walls on both sides of the Indented Berth.

1.0 Introduction

Since years the Port of Amsterdam (APA) is the fastest growing port in the Hamburg-Le Havre range. The throughput mainly consists of various types of bulk (coal, iron ore, agribulk, neobulk) cocoa and mineral oil products, while the container traffic was far below the normal percentage for a major commercial port in this region. There was no logistic nor operational reason for the absence of substantial container traffic in the Amsterdam Port. Also the access by sea is good and an additional large sea lock in IJmuiden is in the design stage.

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In 1996 Ceres Inc. from Wheehawken (USA) and APA, on behalf of the Amsterdam Municipality, decided to develop a new container terminal along the Amerikahaven/ Noordzeekanaal. Ceres is the operator of the terminal and the tenant of the site, owned by APA.

The layout was developed, based on general plans prepared by JWD in close co-operation with Ceres and APA (see Figure 1). The terminal has a surface area of about 54ha, designed to handle 950,000 TEU/annum. It has 2 berths along the Amerikahaven (635m quay length) and a 400m long Indented Berth, allowing shiphandling from 2 sides, thus achieving a berth productivity up to 300 moves/hr. Furthermore the landside handling includes truck facilities, a rail terminal and a reservation for a future barge terminal, each having excellent connections to the European road- rail- and IWT network.

Based on the required throughput, the layout and the hourly production of the ship-to-shore cranes, straddle carries were selected for container handling on the terminal. The 9 ship-to-shore cranes, made by ZPMC, can handle 22 TEU wide container ships, with an outreach of 61.0m (54,75 in over water), a backreach of 15.24m and a liftheight of 36m. The railgauge is 30.48m. The 39 straddle carries (made by Nelcon/Kalmar) are 1 over 3.

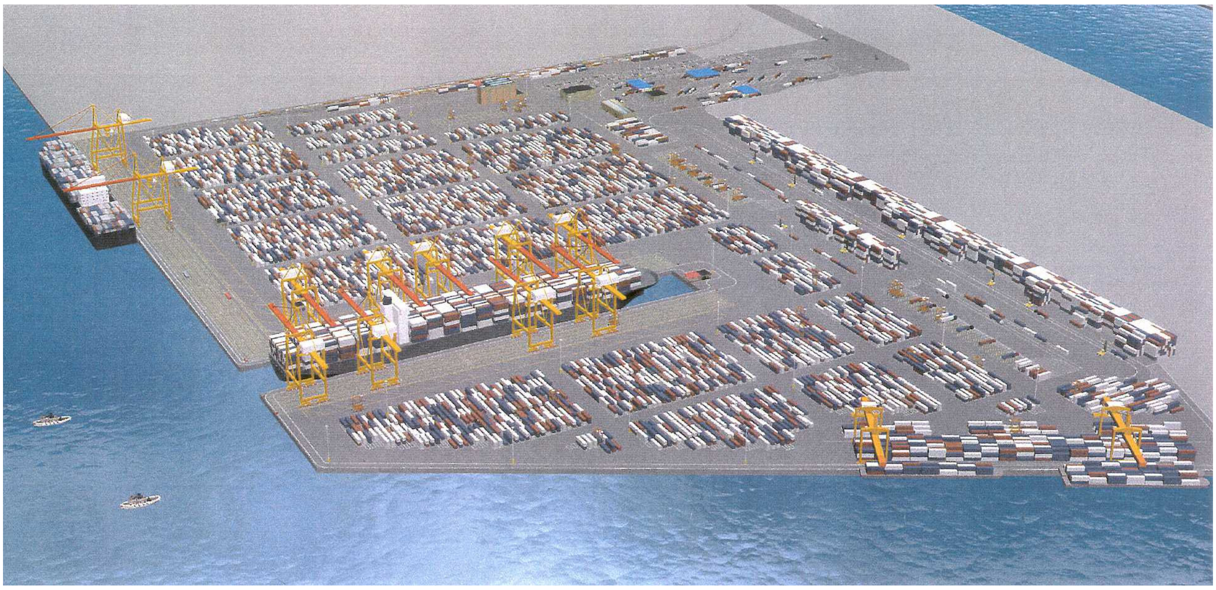

Figure 1. Layout of the Terminal with Indented Berth.

In the Lease Agreement between APA and Ceres it was agreed that APA would develop the civil engineering infrastructure of the terminal, and that APA and Ceres would jointly purchase the cranes and the terminal equipment. Ceres then leases the terminal infrastructure and the APA equipment.

The concept of the Indented Berth (IB) is new and required extensive nautical and hydraulic studies in support of the design process. Other innovative elements of the projects were the connection of the rail track along the Amerikahaven with that along the IB, and the solution chosen for the landside crane rail. Finally the project organisation is worth mentioning, because of close interaction between APA, the engineer and the contractor. These aspects are presented in the following sections.

2.0 Innovative Design Aspects

2.1 The Indented Berth

Hydraulic and Nautical Studies

The IB has been designed for a ship with the following dimensions: L = 380m, B = 56.3m, D = 15m, based on the assumed development of ship design for capacities of 9,000 TEU and above (see Figure 2). The feasibility of manoeuvring such large ships into the relative narrow basin under the influence of wind (waves and currents are negligible in the Amerikahaven and the port has no tide) had to be demonstrated and operational limits determined. Moreover the water movement around the ship, during entry and departure, would necessitate a bottom protection or a very large underkeel clearance.

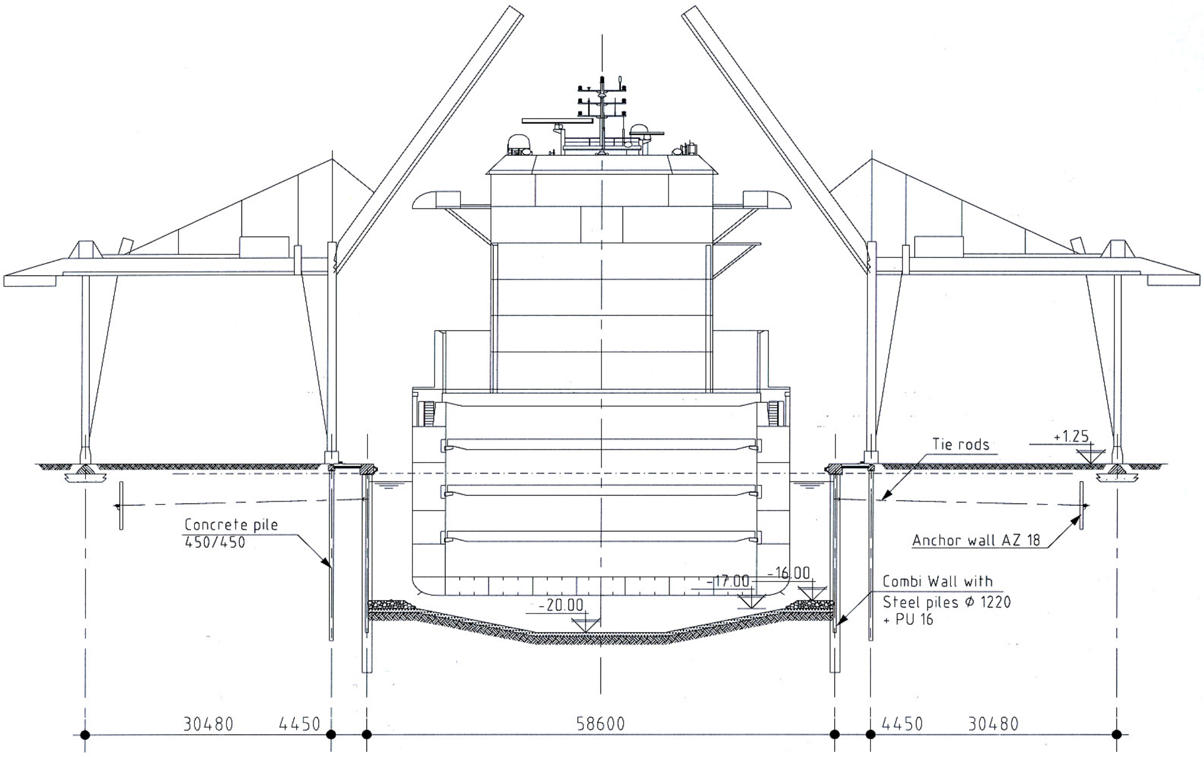

Figure 2. Cross-section Indented Berth.

To address these design aspects hydraulic and nautical studies were carried out in close collaboration between Royal Haskoning[4] and MARIN / MSCN, both in the Netherlands.

The hydraulic studies comprised numerical simulation of the berthing and deberthing process, using the fully 3-dimensionsal finite element model FINEL, developed by Svašek. For different width and depth combinations of the IB and different speeds of entry/departure the flow pattern around and the hydraulic loads on the vessel were computed. As a result of these computations a width between the quay walls on both sides of the IB of 57m was selected. At a standard speed of 0.5m/s (keeping the duration of the entire manoeuvre within 15 min) the longitudinal loads on the vessel were 300kN and maximum return flow velocities of 1.0m/s were encountered (see Figure 3).

[4] more specific the Hydraulic Engineering group, previously working under the name Svašek Consultants.

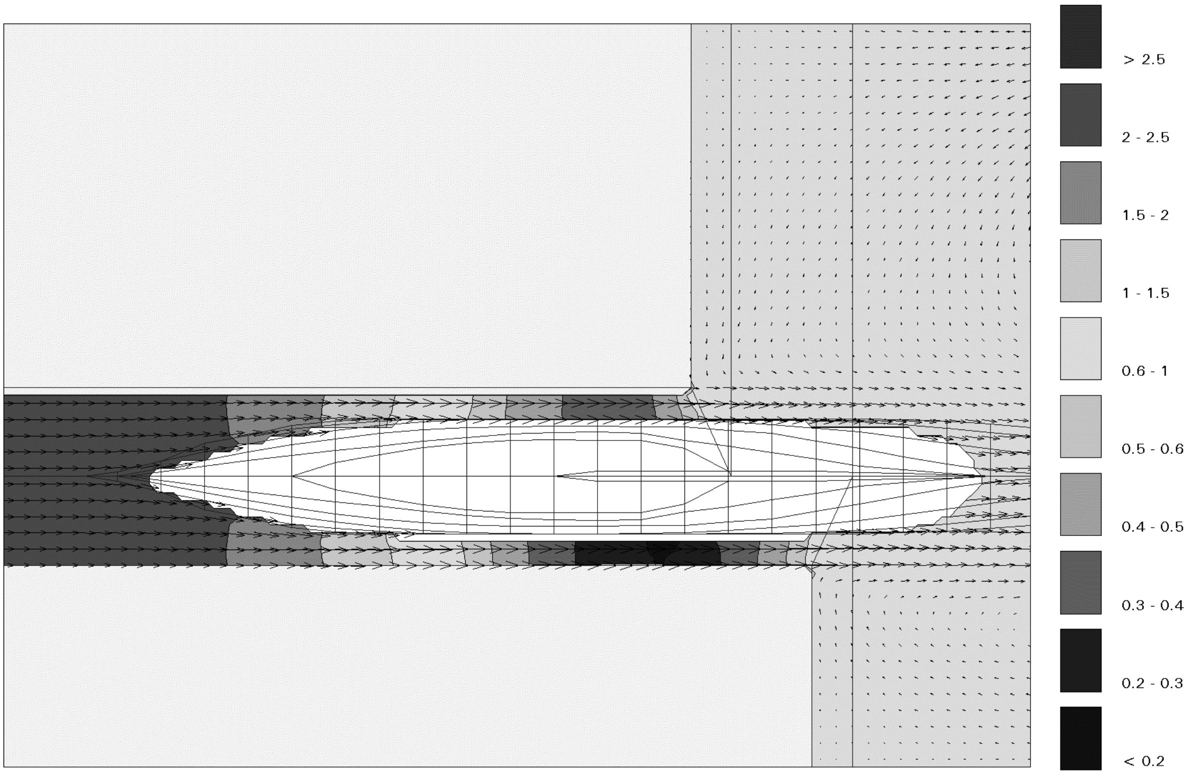

Figure 3. Water Levels and Flow Velocities During Berthing Manoeuvre.

After nautical desk study by Royal Haskoning, involving all parties in the Port of Amsterdam engaged with the handling of ships, such as the harbour masters office, linesmen, tug boat operators and pilots, a number of critical manoeuvres was simulated in the Real Time Simulator of MARIN, providing a full bridge view. The external forces on the vessel came from the FINEL computations, mentioned before, and from hand calculations of wind force. The simulations were partly carried out by the Amsterdam Northsea Channel pilots, which in the near future will also receive training on the RTS in handling the actual vessels calling at the terminal. Figure 4 gives the plotted result of a berthing manoeuvre under design wind speed of BF 7 (in gusts). It was concluded that under these conditions the arrival and departure manoeuvres could safely be made with the assistance of 3 tugs with 50-ton bollard pull. During moderate wind, up to BF5, two tugs are sufficient.

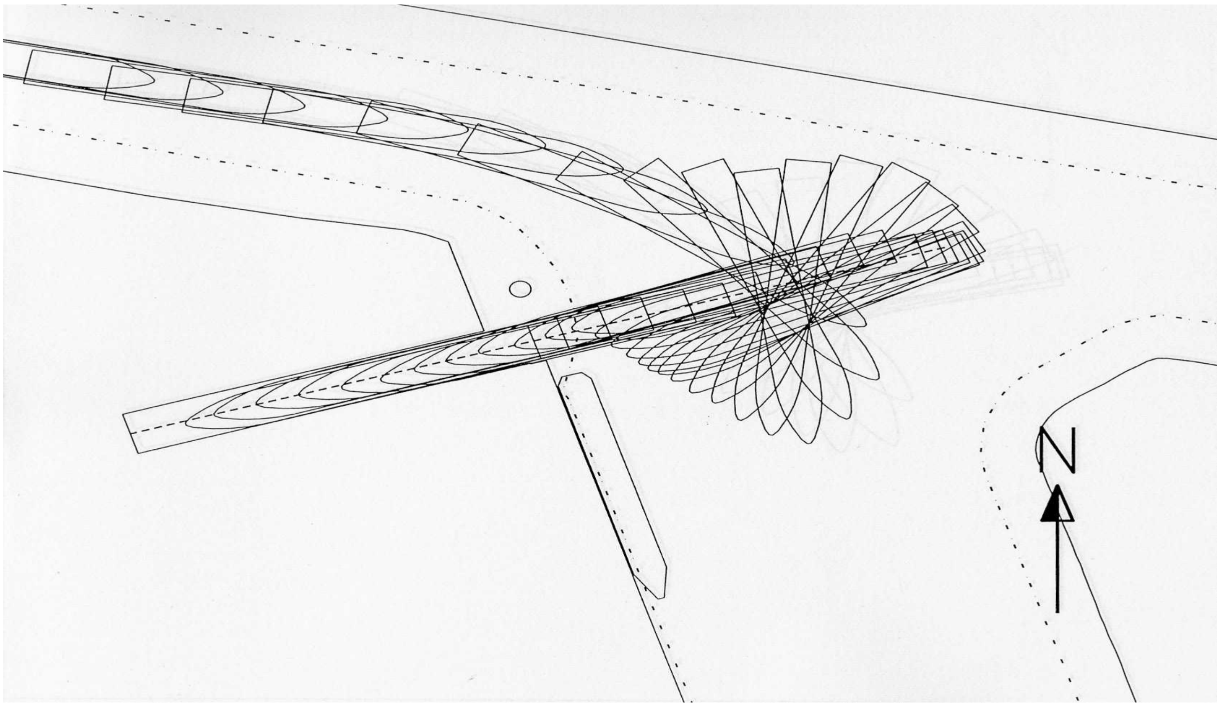

Figure 4. Berthing Manoeuvre on Real Time Simulations.

An important factor in the manoeuvre, which should be safe even when the vessel is subject to strong lateral wind, is the way the bow is controlled. Initially a hauling device was developed to pull the vessel in, while at the same time providing this lateral control (in addition to the force generated by the bow thrusters). Based on the fact that the present generation of Post-Panamax vessels still leaves sufficient space in the IB for a tug to pass, this hauling device has not been included in the quay presently constructed. It will be possible however to add this hauling system at a later stage, when the ships would become too wide to let a tug pass.

Based on these studies the definitive dimensions of the IB were established at a length of 400m, a width of 57m and a depth of NAP –18.0m (NAP being the reference level, the average water level in the port area amounts to NAP –0.4m).

Bottom protection

Based on the results of hydraulic computations the need for a bottom protection was investigated. Several options were examined, such as:

- the provisions of a system of ducts parallel to the IB with openings in the quay wall, to reduce the flow velocities;
- a solution, whereby only a strip along the IB quay walls would be protected, leaving the middle part to erode to a new "equilibrium depth".

The first solution proved to be uneconomic, whereas the second solution would create such depth, that the stability of the side protection could not be guaranteed. Consequently the bottom protection was designed across the entire width of the IB with a 0.5m layer of 10-60kg stones. Along the quay walls additionally 60-300kg stones are placed over a width of 5m in order to provide additional safety and taking into account the combined effect of back flow and flow due to the bow thrusters. Figure 5 gives a cross section of the bottom protection.

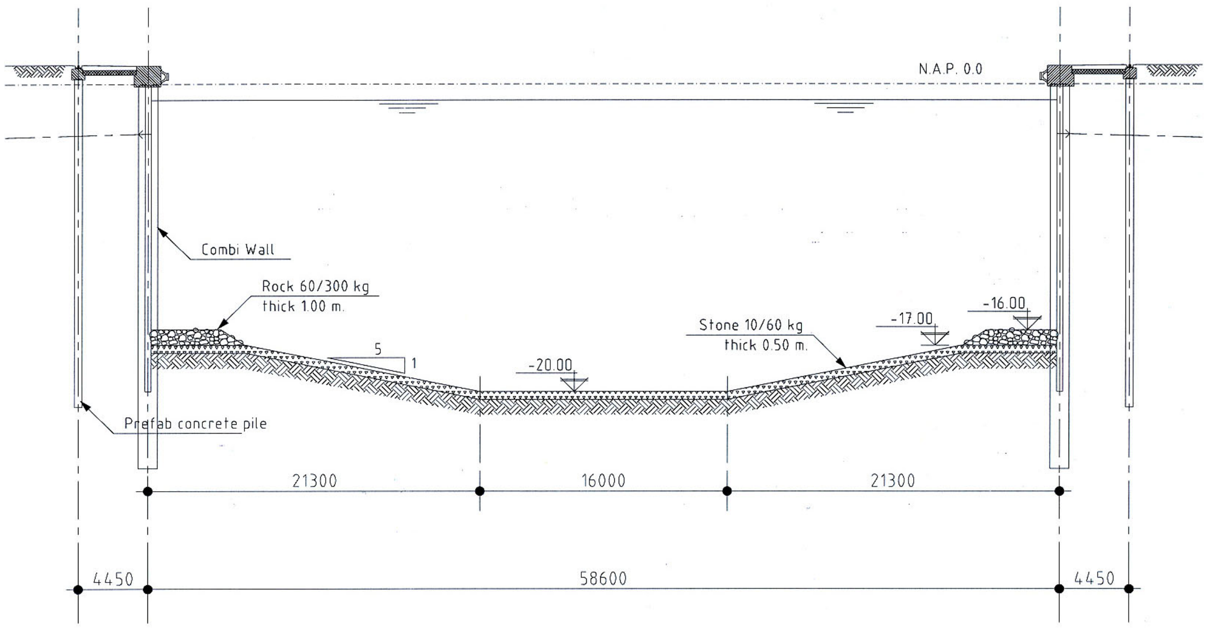

Figure 5. Bottom Protection Indented Berth.

2.2 Rail Track

The ship-to-shore cranes measure 40m height, have a boom length of 62.0m to span the IB completely and are travelling on rails having a gauge of 30.48m. They are expensive elements in the overall terminal investment and optimum utilisation is of high importance. Exchange of cranes between the IB and the conventional quays was therefore a logical requirement. In consultation with APA and Ceres it was decided to achieve this flexibility by connecting the rail tracks along the IB and along the conventional quay by a bend. Switching systems are included however at the two tangent points in order to allow the cranes to service the full length of both quays (see Figure 6).

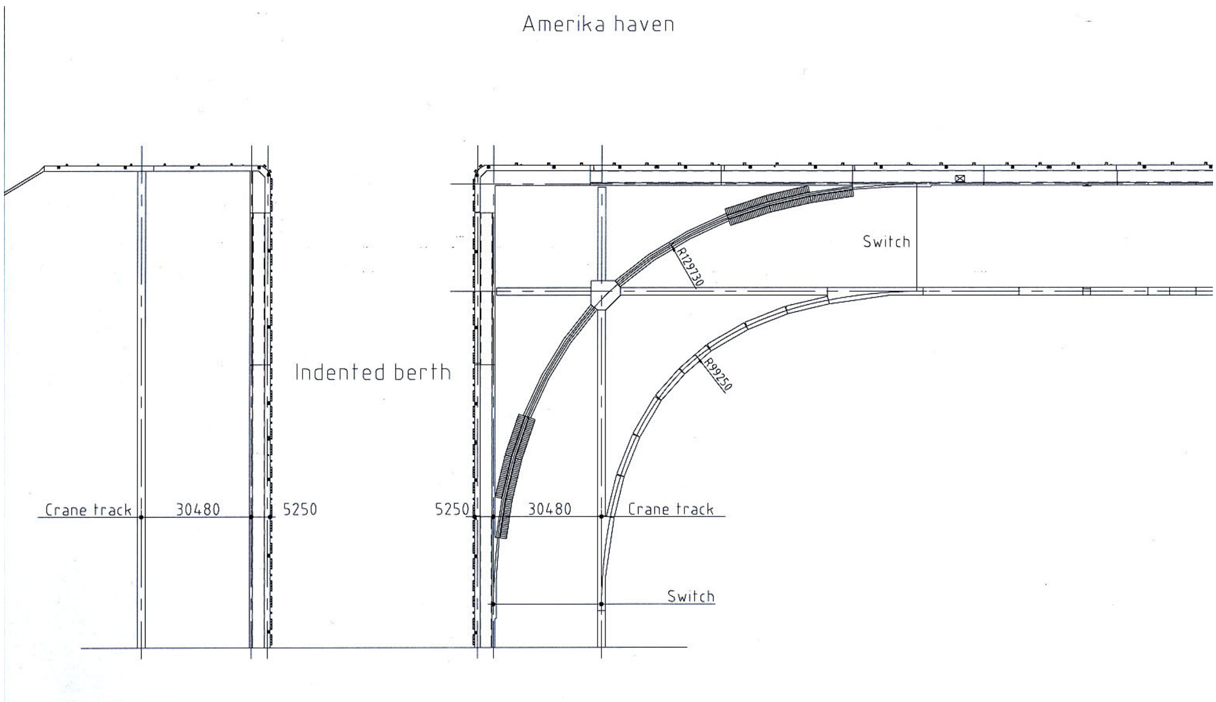

Figure 6. Rail Track Junction.

3.0 Design Details

In additional to the more innovative aspects presented above the “conventional” design elements are treated here to complete the picture.

IB quay wall

The terminal area has an elevation of NAP +1.25m. The average water level in NAP –0.4m. As mentioned before the minimum water depth in front of the quay wall is 17.5m. The retaining height amounts to approximately 19m. The quay wall is designed for a live load of 40kN/m2.

The quay wall has been designed as a combi-wall with 1220mm steel tubular piles (wall thickness in average 13.5mm and steel quality X 65) at 3.17m centre-to-centre distance. Between the piles 3 sheetpiles are placed. On top of the retaining wall a concrete beam is provided, to which the bollards and fenders are mounted. As shown in Figure 7 the retaining wall reached to NAP –26.50m. To achieve overall stability anchor rods are provided at each tubular pile, tying the retaining wall to an anchor wall.

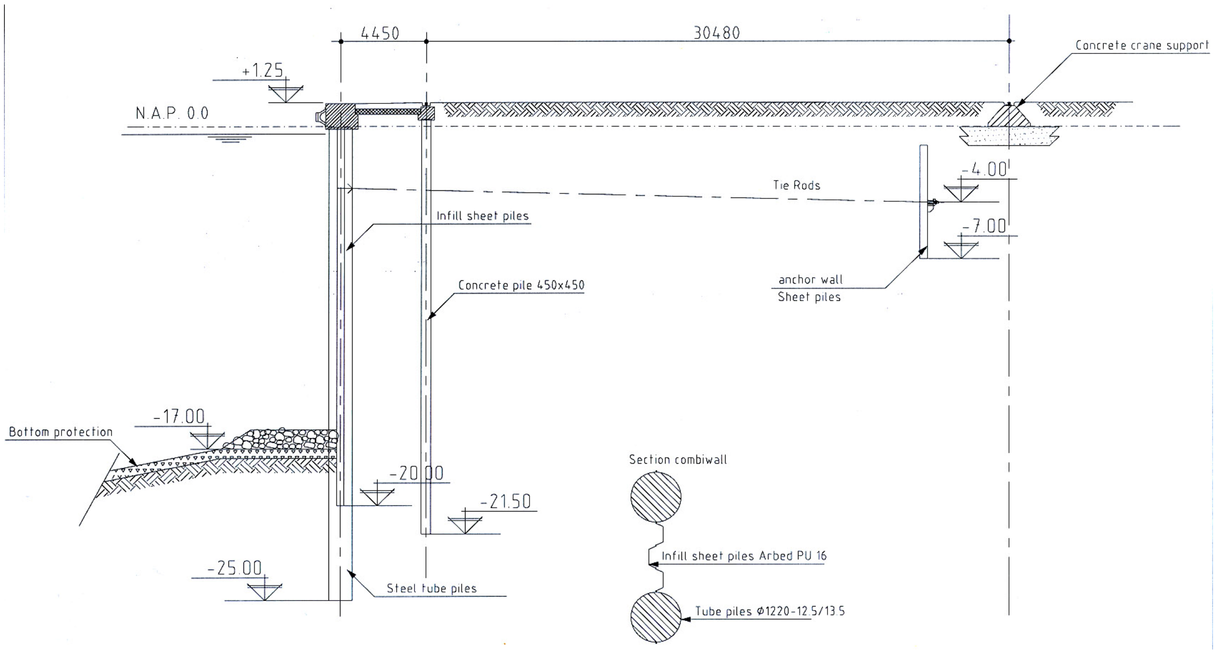

Figure 7. Quaywall Indented Berth.

Land side crane rail

For reasons of economics, construction sequence and operations the landside crane rail was not founded on piles, but mounted on a continuous beam on a spread foundation. The waterside rail is mounted on the quay wall structure, hence the two rails are not structurally connected. In order to guarantee the required rail gauge, the anchorage of the quay wall was given sufficient prestress load to keep the horizontal deformation within acceptable limits. And the vertical settlement of the landside crane rail was minimised by applying a soil improvement to a depth of approx. NAP -7.0m under the spread foundation. The operational advantage of this solution is that there will be no difference in settlement between the crane rail and the surrounding pavement, allowing unhampered passage of the straddle carriers.

For operations of the cranes the horizontal displacement of the crane rails is the most critical. Horizontal displacement calculations were performed with two different calculation programs (M-sheet and Plaxis). Based on these calculations a maximum relative displacement of the rails of 30mm is expected. Based on a theoretical rail gauge of 30.48 meters, the rails were constructed at a distance of 30.46 meters (an offset of 20mm). This allows a total relative displacement of 40mm, which is less than the maximum calculated displacement of 30mm. In the curve the offset during construction was 0 mm, because the calculated displacements are far less, due to the fact that the loads are determined by the travelling crane. The flanges of the crane wheels are machined in such a way, that they can accept a total displacement of 40mm.

In addition to these measures, the crane bogies are constructed in such way, that horizontal and vertical adjustments will be possible.

4.0 Project Implementation

According to the contract between APA and Ceres the project was to be completed within 24 months after approval by the City Council. A fast track approach was necessary to achieve this. A special Project Team was set up by APA, comprising technical, financial and legal specialists, to manage the overall project, including design, construction and procurement. Royal Haskoning was selected as prime consulting engineer, responsible for design, including the hydraulic and nautical studies, preparation of tender specifications and documents, selection of the contractor and technical supervision during construction. The tender procedure followed the European Commission rules, but was dovetailed into the design process in such way that there was hardly any discontinuity.

The selection of the contractor started only 4 months after the start of the design contract of Royal Haskoning. After a pre-selection procedure of 3 months, 5 (combinations of) contractors were invited to prepare their bids. After submitting their proposals and a period of negotiations with the 2 most economic proposals the letter of intend was signed 9 months of the start of the project. The construction period was only 14 months.

The construction contract was awarded to the combination ComPACT (comprising Van Oord ACZ, De Klerk Werkendam, Ooms Avenhorn, GTI and BemoRail).

It proved to be very successful that all partners had their own specialism and there were no discussions who was responsible or the various parts of the contract. The final contract value was approx. € 50 million, divided as follows over the key components of the contract.

- Quaywalls 34% of the costs
- Dredging and bottomprotection 8%
- Drainage and pavement 41%
- Powers supply and utilities 8%
- Crane rails and rail terminal 9%

In the contract between APA and ComPACT it was agreed, that ComPACT would take over the design responsibility in a D&C approach, based on the design and tender documents prepared by the Engineer. Royal Haskoning remained the consultant of APA and supervisor of the design and construction. The construction contract required detailed engineering of many components of the project. This was done in close co-operation with Project Team and Consulting Engineer, resulting in very short approval periods. In the tender documents a period of 6 weeks was mentioned, but due to the close co-operation it proved to be an average period of less than 5 days. The experience and flexibility of Contractor and Engineer were important elements to meet the required time schedule.

In the contract between APA and the Contractor it was stipulated that savings achieved in the detailed engineering would be shared between the two parties. This incentive proved to be effective and several percent of the contract sum could be saved.

Because the main aim of APA, the Contractor and the Engineer was to complete the terminal in time and in accordance with the conditions of the contract, it was decided to have day to day meetings between the supervisor of APA/ Royal Haskoning and the worksmanager of the Contractor over the progress of the work, to have design meetings between the Engineer of Royal Haskoning and the engineers of the partners of ComPACT and once every two weeks a coordination meeting between APA project manager, assisted by representatives of the Engineer and ComPACT project manager, together with representatives of the partners of ComPACT to approve the proposals from the design meetings, to discuss and if required adapt the planning and to decide on financial matters and approve the progress payment to the Contractor.

It proved to be a very effective organisation structure.

Keywords

Container terminal, container handling, hydraulic modelling, real time simulation, bottom protection, rail track bend, quay wall, design & construct.