Hamburg, GERMANY

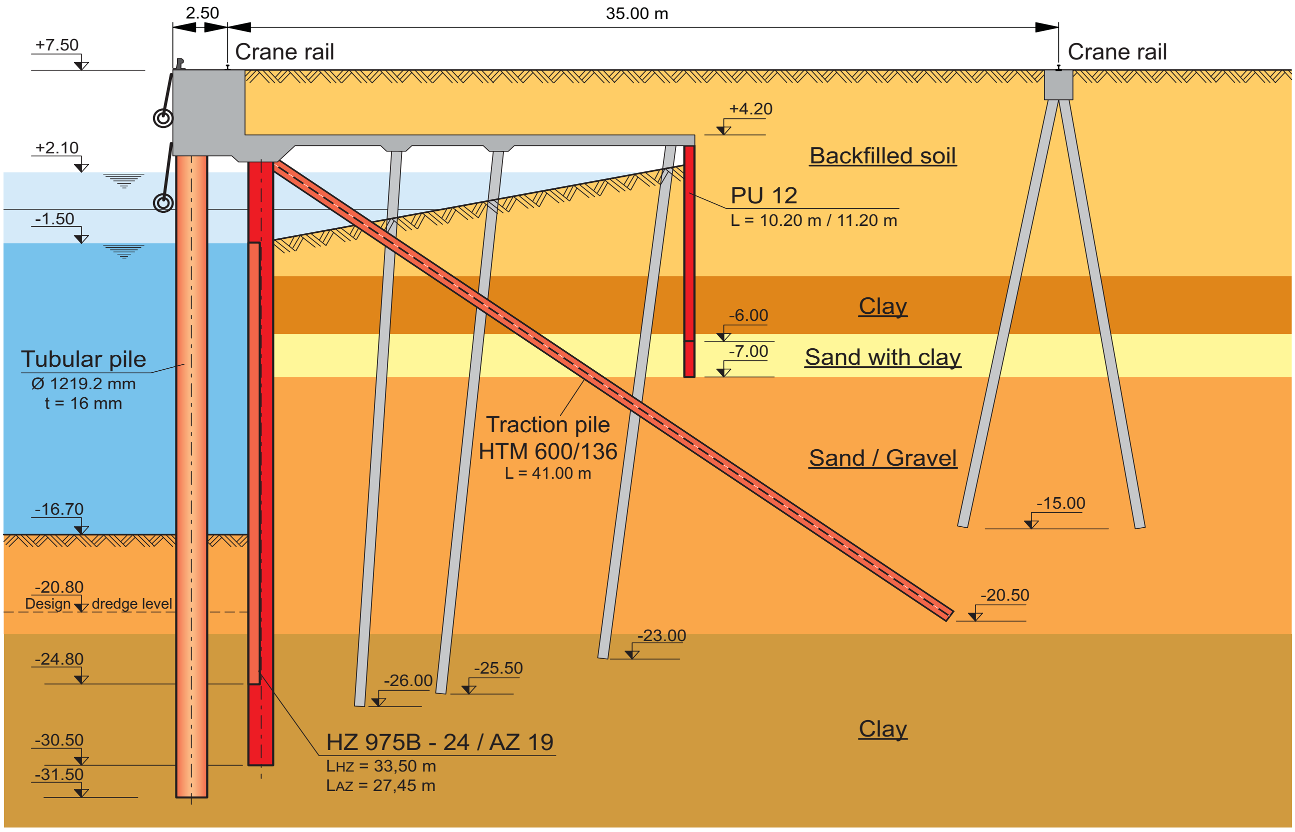
Altenwerder Container Terminal

Hamburg, Germany's largest seaport, is also Europe's second largest container port and is among the top ten ports in the world. Due to the predicted increase of harbour transhipments, the port decided to annex the 250-hectare site of the former fishing village of Altenwerder in 1990. A new container terminal with state-of the-art technology was to guarantee maximum efficiency in the handling of containers by 2003. The Altenwerder Container Terminal was designed to handle 1.9 million TEU per year.

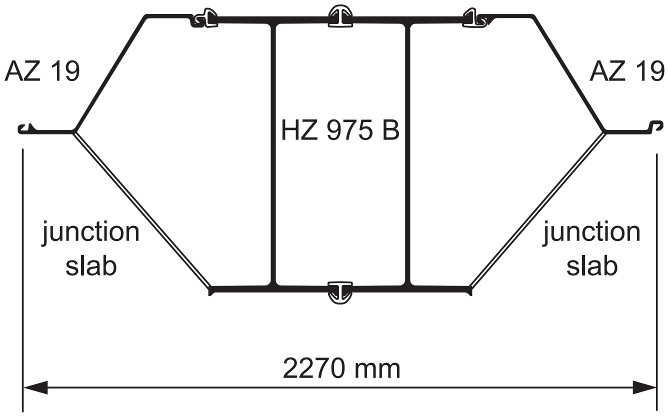
The elevation of the top platform of the container terminal had to be incorporated into the port's flood protection scheme. For this reason the ground level of the Altenwerder site was raised to +7.50 m to allow continued operation despite frequent local floods. The dyke running directly along the waterway was relocated behind the site to make way for the new terminal. The next step consisted in deepening the shipping channel to permit even the largest container vessels to access their berths in all weather and river conditions.

Following EU-wide tendering, the construction of the first section of the quay wall began in April 1999. Apart from predominantly economic factors, the essential criterion for contract award was the construction time. The decision eventually fell in favour of Arcelor's HZ/AZ system, the most cost-effective solution. The expansion of the port calls for construction of four large container-vessel berths with a total quay length of 1,400 m and a water depth of 16.70 m.

The new Altenwerder CT will handle 1.9 million TEU per year



With a quay-wall height of more than 24 m, the new container terminal can receive super-post-Panamax class vessels



The double king piles and the intermediary piles were delivered to the site as joined elements

Tubes placed in front of the sheet pile wall act as fenders

The basic features of the cross-section include the following elements:

- Low-level superstructure slab with pile foundation (to reduce soil pressure)
- Sheet pile wall set back by 4 m (to minimise scouring)
- Open cross-section (to reduce water pressure)
- Anchor piles (to provide stable anchorage and minimise deformation)
- Soil replacement (ice-age rock strata with boulders)
- Crane track on separate foundation (to reduce surcharges).

The difficult subsoil of the harbour floor in front of the quay wall bears the imprint of the ice age, with changing characteristics resulting in different design scenarios. A clay layer containing huge boulders had a major impact on the choice of installation method.

The unconventional installation method called for replacement of the soil layers above El. -25.3 m instead of driving the sheet piles through the different layers of sand, gravel, pebbles and boulders. The steel elements were placed and driven to final depth in a 1.20-m-wide bentonite-supported trench. Cement was added to the suspension to prevent flushing out of the prevalent extremely fine sand particles. The required vibration energy was considerably reduced by choosing this alternative installation method which implied a much lower likelihood of possible negative impacts on existing structures nearby.

The 47-m tailor-made HTM 600/136 anchor piles were driven with a hydraulic impact hammer

The low-level superstructure slab is placed on top of the two sheet pile walls, steel tension piles, fender tubes & concrete piles

The quay wall of the first construction phase is 955 m long. It comprises two 350-m berths for container vessels and a 100-m feeder-vessel berth. Altenwerder boasts the highest quay wall in Germany with a top level at +7.50 m and a water depth of 16.70 m. The heart of the quay's cross-section is the HZ/AZ combined sheet pile system.

The container terminal's HZ/AZ system features double HZ 975 B king piles in steel grade S 390 GP with a length of up to 33.40 m as structural elements resisting both horizontal soil and water loads as well as vertical foundation loads. Additional plates were welded onto the king pile's toe in order to further increase their loadbearing capacity. The 27.45-m intermediary piles (AZ 19, steel grade S 240 GP) hold back the soil and distribute the loads into the king piles.

The elastic section modulus of the combined wall is 10,330 cm^3/m. The HZ king piles and the AZ intermediary piles were joined together in the mill. The large resulting system width of 2,270 mm is of great benefit in terms of installation speed. Openings in the intermediary elements allow sand to be flushed out from below the quay platform. Arcelor delivered all the piles just in time, thus minimising the required storage space.

The joined sheet pile elements each weigh approximately 22 t. They were threaded into the interlock of the previously installed pile and driven to design depth with an impact hammer. Excavation for the bentonite-filled trench and installation of the piles were carried out block by block. A loading trial on a separate king pile at the beginning of the construction works confirmed that the required load bearing capacities were achieved.

The joined sheet pile elements where delivered just in time

Owner:
Freie und Hansestadt Hamburg, Hamburg Port Authority (HPA)

Contractor:
Hochtief AQ, NL Tief- und Ingenieurbau Nord, Fr. Hoist GmbH & Co.

Sheet piles:
8,500 t double HZ 975 B king piles, steel grade S 390 GP, L = 32.60 m - 33.40 m

1,500 t AZ 19 intermediate piles, steel grade S 240 GP, L = 27.45 m

1,120 t PU 12 sheet piling apron, steel grade 355 GP, L = 11.20 m

Bearing piles:
2,300 t HTM 600/136 anchor pile, L = 45.5 – 47.2 m, steel grade S 355 J2G3

Total quantity of sheet piles:
11,120 metric tons (sheet piles)

Due to difficult soil conditions, and as a means of reducing vibration, the sheet piles where driven in a bentonite-supported trench

A sheet pile wall finishes off the terminal at both ends

After pouring, the concrete of the relieving platform was covered with a 3.3 m sand layer

The heavy sheet pile elements were driven to a depth of 30.5 m with an impact hammer

The relieving platform was founded on concrete cast-in-situ piles. Tensile forces were transferred to 47-m anchor piles fixed to the superstructure with disc anchors. The steel anchor piles were spliced on site and driven with a hydraulic impact hammer at an angle of 1:1.3 into the soil below the platform. Due to the substantial tensile forces prevailing, Arcelor supplied tailor-made HTM 600/136 sections. These piles are characterised by excellent durability due to low susceptibility to corrosion. Quay construction was completed with a rear sheet pile apron made of 11.2 m PU 12 sheet piles at the end of the relieving platform.

Tubular fenders were arranged below the head of the quay, in front of the sheet pile wall, at intervals of 3.59 m. The 30.8-m tubes were positioned by a crawler crane, vibrated with heavy vibratory hammers, then driven with an impact hammer to their final depth of 27.30 m. In order to increase the vertical bearing capacity, steel wings were welded onto the toes of the tubes. Other tubes were extended by up to four metres by on-site splicing. The water cushion between the tubes and the sheet piling reduces scouring at the base of the sheet piles caused by ships' propellers.

Construction works for the foundation (tubes, sheet piles and anchor piles) began in April 1999 and were completed by December 1999. The entire Altenwerder project was completed in spring 2001 using 16,500 metric tons of steel products supplied by Arcelor. ■