

Aarhus, DENMARK

Extension of CT East



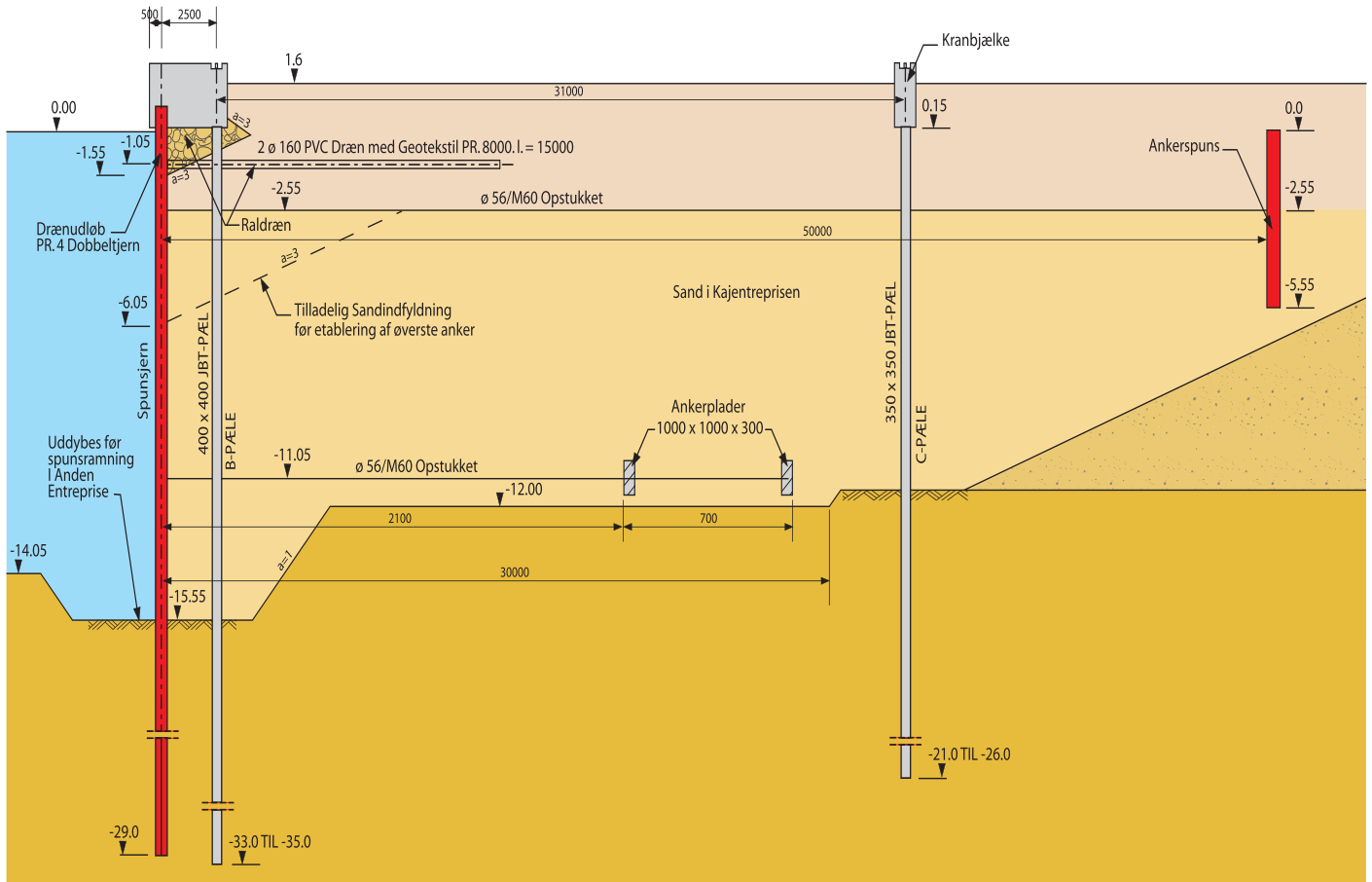
Aarhus is Denmark's major container port

Aarhus is located on the east coast of Jutland, Denmark's peninsula north of Germany. The town with its 300,000 inhabitants is home to the country's largest container port handling almost 500,000 TEU each year. Covering a land area of 227 hectares, the port offers a total quay length of 13.5 km. Aarhus has a market share of 63% of the total number of containers handled by Danish ports.

The port is ideally located in relation to the home market – not far from the centres of consumption and production in Denmark. Nature has provided the port of Aarhus with a range of significant advantages, for example a natural water depth to match the requirements of large, ocean-going container ships. In addition, there are no natural hindrances such as large waves and winter ice that can hamper vessels calling at the port. Apart from the sea-port, Aarhus has major shipbuilding and petroleum-refining industries; other manufacturing activities include machinery, transportation equipment, processed food and beer.



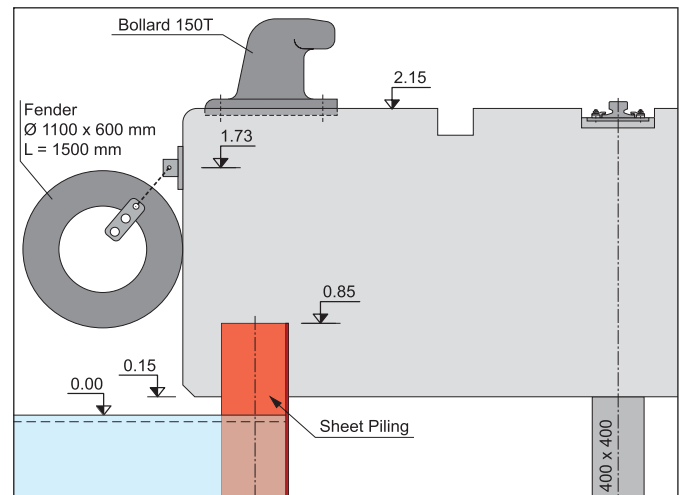
The extension project will increase the annual cargo-handling capacity to 20 million metric tons



Two levels of tie rods were chosen due to poor soil conditions leading to the positive side-effect of reducing maximum bending moments. A combined wall system was thus unnecessary. The underwater installation of tie rods by divers was a complex task however

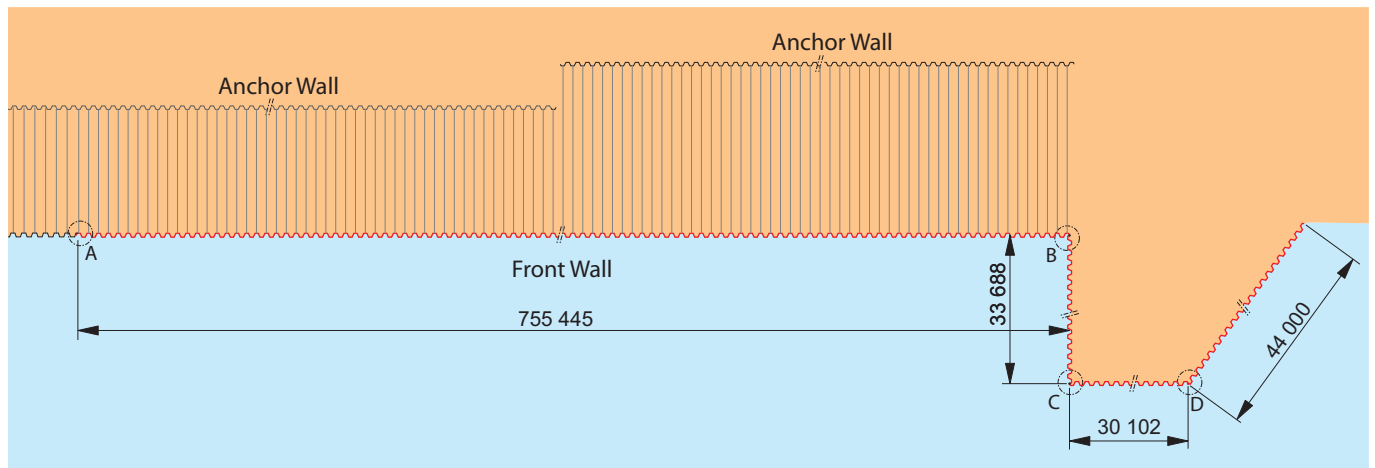


Some 3.5 Mm³ of sand were placed behind the sheet pile wall to create the new CT East



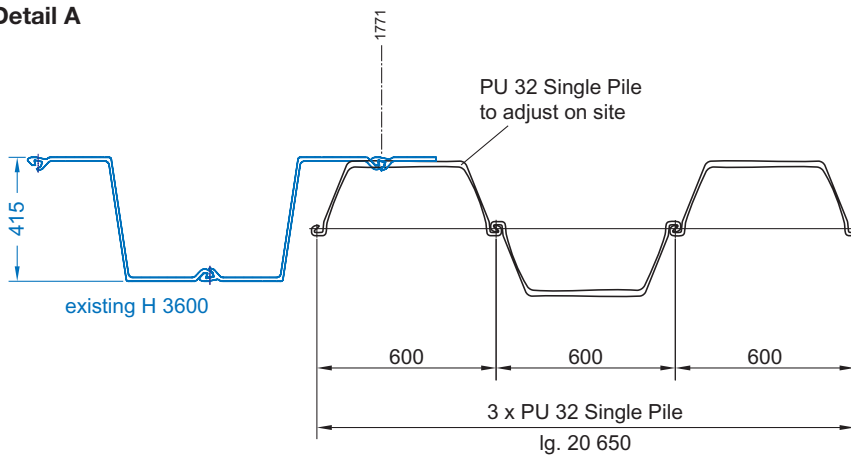
Concrete capping beam showing fender, bollard, crane rail and top of sheet pile

The all-purpose port has its own towage, pilot and mooring service which is available 24 hours a day, 365 days a year. Approximately 8,000 ships including some 25 cruise ships dock annually at the port of Aarhus carrying a total of 10 million metric tons of goods. Almost 5 million metric tons of cargo are handled via the two container terminals North and East and via the ferry services. The turnover of oil products amounts to almost 2 million metric tons. The last 3 million metric tons include bulk cargo such as animal feed and coal.



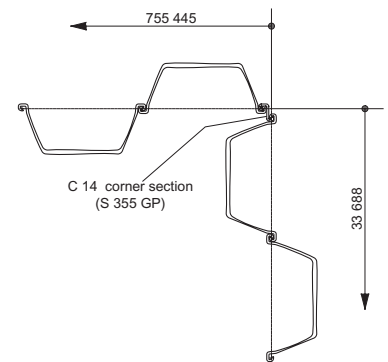
Layout of the new sheet pile quay wall of Container Terminal East

Detail A

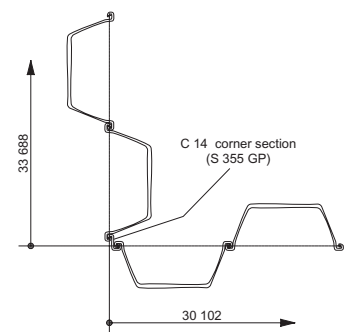


The existing sheet piles were connected to the new PU 32 sheet piles by a single pile that was adjusted on site

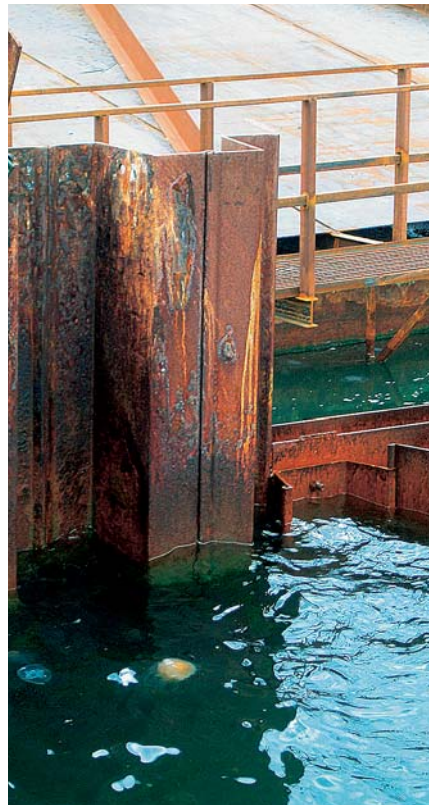
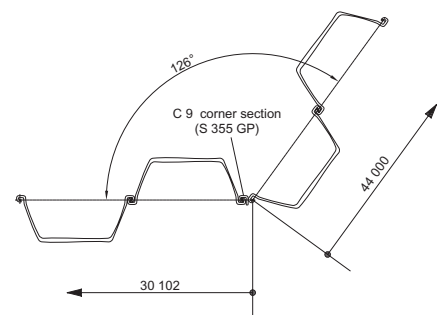
Corner detail B



Corner detail C



Corner detail D



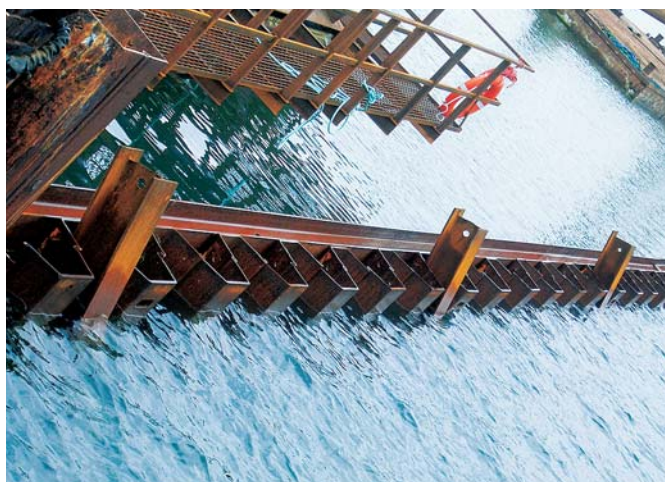
Detail A: End of capping beam of the old CT East. The existing sheet piles of CT East continued a few metres beyond the capping beam.



The construction equipment was mounted on barges to build the quay wall



The new quay wall was temporarily fixed with inclined piles



A steel beam was fixed to the main wall as waling

The Port of Aarhus is a municipal autonomous port led by a Board of Governors of seven members with the Mayor of Aarhus as chairman. Ocean-going container ships call at the port to load cargo arriving via smaller feeder ships from countries located around the Baltic Sea. The relatively new EU membership of the Baltic states will result in a market increase in the volume of exports and imports in coming years. The port has already established a position for itself as an important Baltic hub. Regular services have been established to other large European and Asian ports. Numerous road and rail connections in addition to modern computer management systems that control reception, delivery and storage of containers mark the efficiency of the Port of Aarhus.

Due to ever increasing trading volume, there is already significant pressure on the European highway network and on the West European container ports. To relieve traffic problems, the EU has declared that sea transport must be promoted. Being close to the new markets around the Baltic Sea, the Port of Aarhus is a solution for fast and efficient cargo transportation avoiding the congested road networks.

The Port of Aarhus is investing its financial profits in the maintenance of the port infrastructure and the development of harbour facilities to make space for even more vessels. In 1995 the port reached its maximum capacities and a programme for extension of the existing quays was decided. Expansion began in 1998 and will be spread out over 25 years. When the extension operation is completed, the port area will have doubled. The annual cargo-handling

Port of Aarhus, DENMARK



Storage area for sheet piles



Barge-mounted crane for installation of sheet piles



The sheet piles and the beams were transported to the installation site by barge

capacity will increase to approximately 20 million metric tons. The projected maximum water depth is 15.5 m alongside the quays. The budget for the expansion project is estimated to exceed 250 million euros.

The two existing container terminals in the Port of Aarhus are Denmark's largest and busiest offering a water depth of up to 14 m. Each year, 1,500 ships call at Container Terminal North and at the new Container Terminal East to load and unload approximately 500,000 containers. Container Terminal North is equipped with five gantry container cranes, each with a lifting capacity of up to 40 metric tons, while Container Terminal East is equipped with 3 post-Panamax cranes with a lifting capacity of up to 90 metric tons. Each crane can lift an average of 35 containers per hour. The terminals have room for container ships or roll-on/roll-off ships. The terminals are complemented by modern facilities for cooling and refrigerating containers.

The existing part of Container Terminal East came into use by APM Terminals in April 2001. CT East currently offers a quay length of 500 m, a water depth of 14 m and has a storage area of 200,000 square metres that can accommodate up to 6,400 containers. It is equipped with Ro/Ro facilities, railway tracks, office and warehouse facilities and repair and service companies. Efficient cargo handling is assured by straddle carriers, reach stackers and trucks in cooperation with computer reporting and logistics systems.

The projected new quay will add almost 300,000 square metres of harbour area to the existing terminal. The budget for the expansion of CT East designed to accommodate container vessels carrying up to 7,000 TEU was limited to 65 million euros.

For the extension of the terminal, the sheet pile wall of the existing part of the terminal will be prolonged to reach a total quay length of 1,300 m. The new structure is planned as a multiuse terminal. An anchored wall consisting of Arcelor's PU sheet piles was chosen by NIRAS Portconsult and by the technical department of the port. NIRAS Portconsult is a Danish consulting company carrying out assignments worldwide in the fields of port planning and engineering as well as in soil engineering.



The tie rod consists of a 28 m steel bar, 56 or 63 mm in diameter



Reinforced concrete deadmen 1,000 x 1,000 x 300 mm



The crane lifted the tie rod together with the deadmen into position at a depth of eleven metres

Due to poor soil conditions, it was necessary to install two levels of tie rods for the construction of the new quay. To limit the weight and thus the costs of the steel solution, a high-strength steel grade with yield strength of 430 N/mm² was chosen. PU 32 profiles were used for the main wall, PU 22 profiles for the anchor wall. The soil conditions vary considerably along the quay wall comprising weak to stiff clay layers. The sheet pile solution was adapted to these changing conditions: the length of the PU 32 sheet piles of the main wall of the terminal varied from 20.65 to 31 m. The sheet piles were vibratory driven and temporarily fixed with inclined beams by Danish contractor MT Højgaard. The next step consisted in backfilling the area behind the PU 32 wall to -12 m with sand brought in by a dredger from the Bay of Aarhus. The lower tie rod was then installed on top of the backfilled sand at a depth of eleven metres. The tie rod consists of a 28 m steel bar with a diameter of 56 or 63 mm, depending on the soil characteristics present. Two reinforced concrete deadmen, one at the end of the tie rod, the second 7 m from the end, transfer the anchor's traction forces into the backfilled soil. A crane lifted the tie rods with the two 300-mm-thick concrete plates from a barge and lowered them to the design depth. Divers fixed the tie rods to the main sheet pile wall. A hole to fit the tie rod was burnt in the sheet piles prior to installation to facilitate the underwater works.

The dredger then backfilled the area behind the front sheet pile wall until a water depth of three metres was reached. The 1,200-mm-wide PU 22 double piles of the anchor wall were installed with a vibratory hammer. The upper tie rod connects both sheet pile walls at a depth of -2.55 m. All top tie rods have a diameter of 56 mm and are made of high-strength steel (yield strength: 460 N/mm²).

The first 450 m of the extension uses 20.65-m-long PU 32 double piles. The anchor wall made up of 7-m PU 22 profiles is placed 30 m behind the main wall. The next 345.6 m to the corner of the structure consists of PU 32 profiles with lengths of 25.65, 29.65 or 31 m depending on soil conditions. At a distance of 50 m, 5.5-m-long PU 22 profiles anchored the structure. A corner at the west end of the quay wall was designed to accommodate Ro/Ro vessels.



Nearly 4,000 metric tons of PU 32 profiles in different lengths had to be installed to complete the 1,170 m main wall



Sand was pumped from a dredger to refill the area behind the sheet pile wall



Large areas had to be backfilled to complete the new CT

Owner:

Port of Aarhus, Denmark

Designer:

Technical Department of the Port of Aarhus
and NIRAS Portconsult

Contractor:

MT Højgaard, Denmark

Steel grade:

S 430 GP

Sheet piles:

3,930 t PU 32 double piles
690 t PU 22 double piles

Total quantity of sheet piles:

4,620 metric tons

The foundation for the crane rails was separated from the quay-wall structure because of poor soil conditions. The Port of Aarhus purchased five super-post-Panamax cranes with an outreach of 60 m to serve even the largest container vessels. The loads of the crane rails are carried by reinforced concrete piles with a sectional area of 400 x 400 mm. Due to the enormous loads of super-post-Panamax cranes, the piles were driven as much as 35 m into the weak soil.

The Port of Aarhus has long and very satisfying experience with cathodic protection systems. Several steel sheet pile quays in Aarhus are considerably more than 50 years old. The anodes protecting those structures have been replaced every five to eight years. The port authorities decided to rely



Existing part of Container Terminal East



The new terminal will feature super-post-Panamax cranes and a water depth of 15.5 m



on sacrificial zinc anodes as corrosion protection for the new quay. The expected lifetime of the new structure exceeds 50 years. Visual inspections by divers are scheduled every two years to check the actual condition of the anodes.

Although the tidal variations in the Port of Aarhus are in the range of only one metre, a drainage system consisting of rocks was installed behind the main wall. This system reduces the water pressure on the sheet pile wall and allows a more economical section to be chosen. A concrete platform overlying a layer of compacted sand and stones mixed with cement was installed on top of the backfilled sand behind the PU 32 quay wall. Asphalt finishing was not suitable as there are severe risks of the material being damaged, especially in warm weather conditions. A slope of 0.5% ensures rainwater drains from the container handling area. Completion of the new terminal currently under construction is scheduled for mid 2007. ■

The port's long-term extension plan is situated on the right side of the white line. The red line marks the new port area which was finished in 2001.