

# Prøvestenen, Copenhagen, DENMARK

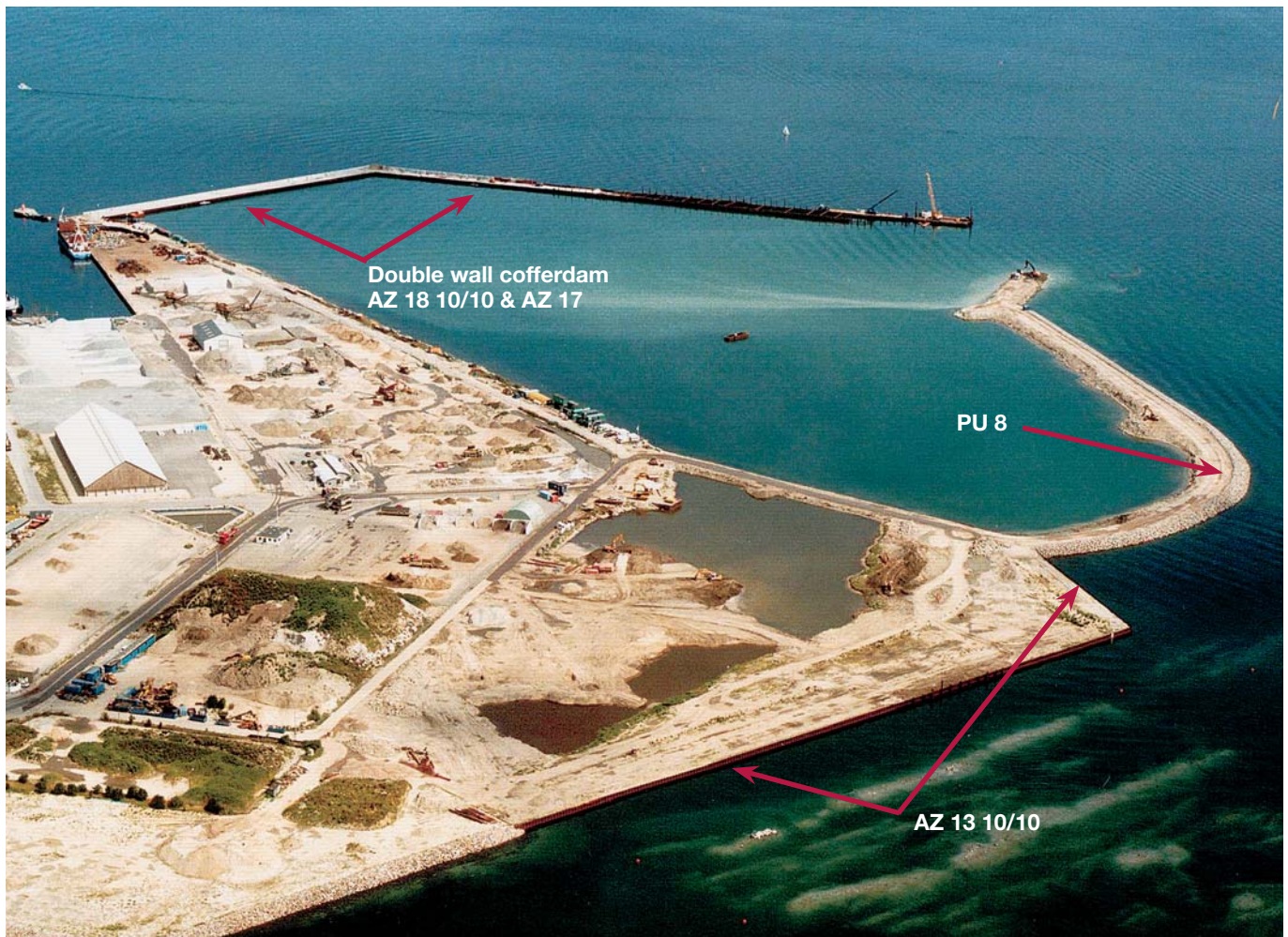
## Construction of a new harbour & soil enclosure



The double-wall cofferdam was installed in open water

Prøvestenen is located in the Danish capital in Copenhagen, whose name historically means “the merchants’ harbour”. The entire Öresund region has always been the obvious connection between Sweden and Denmark as well as between the Baltic Sea region and Western Europe, where a steady increase in cargo volume is anticipated. The region where the famous Öresund Bridge was built is an established logistics centre which includes Copenhagen Malmö Port (CMP). Created in 2001, the two harbours of Copenhagen Malmö Port are 26 kilometres apart. CMP’s vision is to become the leading harbour in the region. The port currently offers a maximum water depth of 13.5 m, a combined quay length of 16.5 km including two container and ten ferry terminals as well as oil tanks with a volume of two million cubic metres.

CMP is the biggest dry-bulk harbour in the region and will enhance its position with investments in docking facilities.

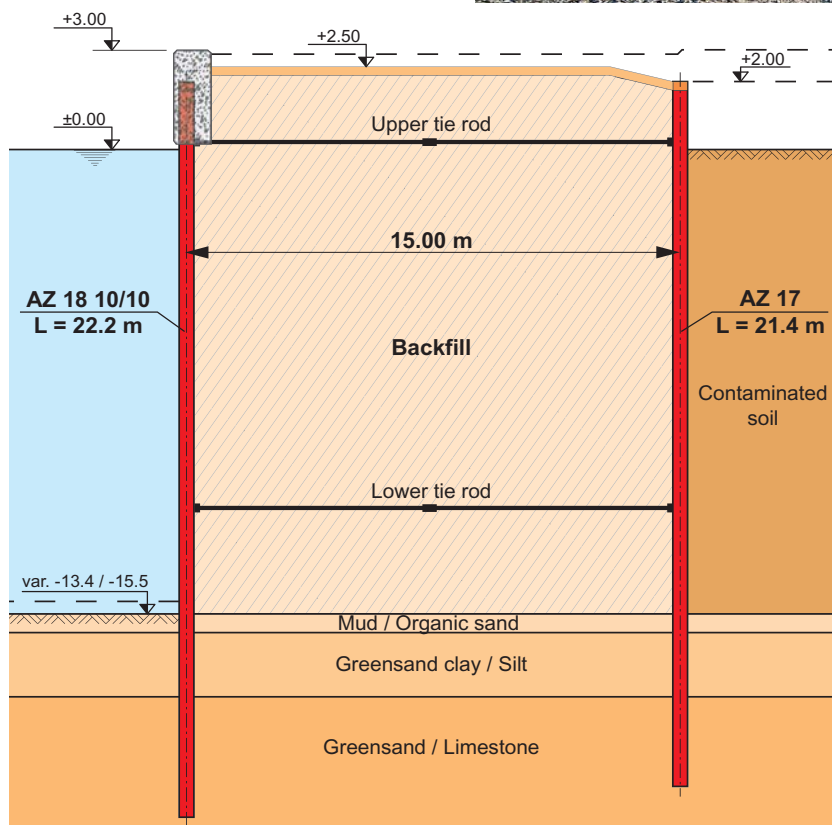


Different types of steel sheet piles were used for the cofferdam that functioned as a soil enclosure and harbour wall





The sheet pile cofferdam forms an impervious barrier for the contaminated soil



The cofferdam consists of AZ 18 10/10 sheet piles on the water side and AZ 17 sections on the land side

A development company owned by Port of Copenhagen and the Copenhagen municipality was established in 2001. It was to invest €8 million in the development of Prøvestenen over a 5-year period. The so-called “Fuel Island Prøvestenen” also plays an important role for the local petroleum industry. Construction of the new dry-bulk area in the southern part of Prøvestenen started in May 2002, including a 650-metre quay that will expand the bulk area by 180,000 m<sup>2</sup>.

When the expansion of Prøvestenen was completed in 2004, the dry-bulk activities in the other port areas were scaled down and moved to the new area where the water depth of 13.5 m

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The PU 8 piles were driven into a berm by an excavator-mounted vibratory hammer

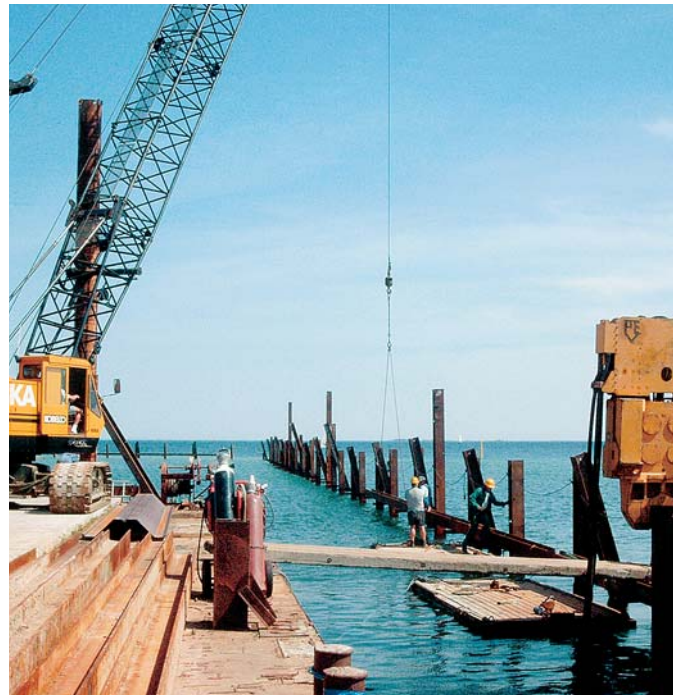


Several barges facilitated the installation of the two cofferdam walls

can accommodate large vessels. The reclaimed area on which the Prøvestenen project was built is located close to the Öresund bridge linking Denmark and Sweden.

The harbour was not the main reason for building the cofferdam in Prøvestenen. The structure was primarily designed as a dumping place for contaminated soil. As a side effect the impervious sheet pile cofferdam forms a quay wall that will serve as a temporary docking place to relieve congestion from nearby ports.

Different types of sheet piles were used for the construction. The total amount of sheet piles was delivered to Prøvestenen in batches, in accordance with the needs at the construction site. Deliveries took place from 2001 until 2003, either by ship or by truck from the mills in Luxembourg.



The crane, vibratory hammer and sheet piles were loaded on a barge

The water at the south side of the reclaimed area is shallower (design water depth = 4 m). Therefore 9.4-m-long AZ 13 10/10 sheet piles were sufficient for this side of the new quay. The AZ 13 10/10 wall was tied back to concrete anchor plates. A berm was built up along the other part of the south quay. PU 8 sheet piles were driven into this berm with an excavator-mounted vibratory hammer.



The depth of Öresund Sound on the north side of the quay varies between 13.4 and 15.5 m. A double-wall cofferdam was chosen for this part of the construction. The cofferdam is made up of two sheet pile walls 15 m apart.

The wall facing the Öresund Sound consists of AZ 18 10/10 sections in S 390 GP steel grade with a length of 22.2 m and a section modulus of 1,870 cm<sup>3</sup>/m. The wall facing the reclaimed area comprises 21.4-m-long AZ 17 sections made of steel with a yield strength of 355 N/mm<sup>2</sup> and a section modulus of 1,665 cm<sup>3</sup>/m. The installation of these sheet piles in open water took place with the help of a vibratory hammer that was mounted on a barge. Z-type sheet piles were chosen for the deep-water side of the Prøvestenen quay because of their more



**Horizontal beams were used as a driving template**



**Top steel tie rods of the cofferdam**



**The conventional top tie-rod system includes a waling**



**Model of the lower off-centre tie rod**



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**Workshop installation of the waterswelling sealing system**

economic section-modulus-to-weight ratio compared to U-type sheet piles.

The two walls are held together by two layers of tie rods. The top layer was installed the traditional way with a waling made of double U beams held in place by supporting brackets. The U beams were supplied in 12-metre lengths and joint together with waling joints and screws on site. The lower tie rod had to be installed underwater by divers. The conventional central attachment of the tie rod implied that the holes through which the tie rods pass had to be burnt through the middle interlock of the AZ sections. Furthermore a special supporting plate to bridge the central Larssen interlock is needed. In order not to lose the economic advantage of the AZ sheet piles, Arcelor worked out a means of installing the tie rods next to the central interlocks. The principle of this solution combines the static advantages of the AZ piles with the simple anchoring of U-shaped sheet piles. Off-centre attachment of the tie rods means that ordinary supporting plates are sufficient and that the more difficult boring through the middle interlock does not have to be carried out by the divers. Both material and installation costs are thus considerably reduced.



**Most of the sheet piles were brought to Prøvestenen by ship**

**Owner:**

Udviklingsselskabet Prøvestenen

**Contractor:**

Skanska

**Consulting engineer:**

Moe & Brodsgaard a/s

**Sheet pile systems:**

PU 8, AZ 13 10/10, AZ 17, AZ 18 10/10

**Steel grade:**

AZ 18 10/10 in S 390 GP, all other sheet piles in S 355 GP

**Total quantity of sheet piles:**

4,500 metric tons



**The cofferdam was filled with dredged sand**

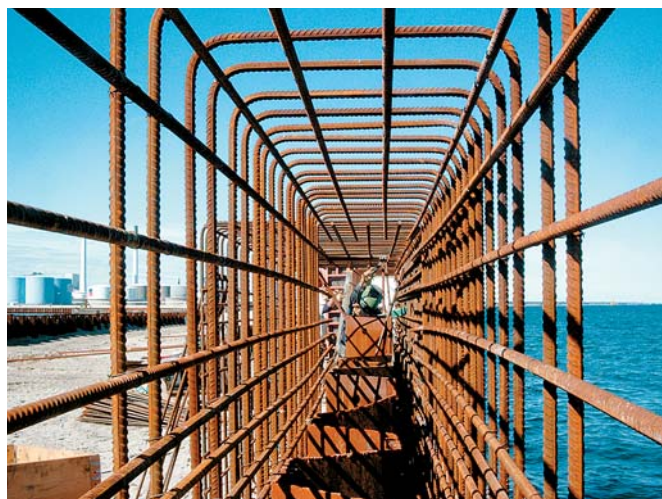




**The structure is also an enclosure for dumping soil**



**A capping beam fitted with fenders and bollards was placed on top of the sheet piles to finish off the construction**



**Reinforcement bars of the capping beam**



**Formwork for the concrete capping beam**

The installation of a double-wall cofferdam implies the filling of the inner wall area with dredged material. The interlocks of the AZ 18 10/10 front wall were sealed. There are several systems available from Arcelor to ensure the watertightness of Larssen interlocks. The simplest system, a bituminous filler, was rejected in this case due to the fact that the nearby petrochemical facilities may have a negative impact on the durability of the bituminous filling system. As contaminated soil was used as backfill material behind the double-wall cofferdam, the sheet pile walls had to form an impervious enclosure to protect the waters of the Öresund region.

The contractor for the Prøvestenen project decided to use a waterswelling product – the Roxan sealing system. Roxan is a urethane prepolymer with waterswelling properties that increases its volume by 100% when in contact with water. The product starts to expand in water after a contact time of two hours and reaches its maximum volume after 24 hours of exposure. It can resist water pressures of up to 25 m. The system possesses excellent durability for each type of environment. Arcelor supplied the sheet piles together with the sealing system in the interlock. The Roxan system is preferably installed in a workshop with special tools under clean and dry conditions. ■