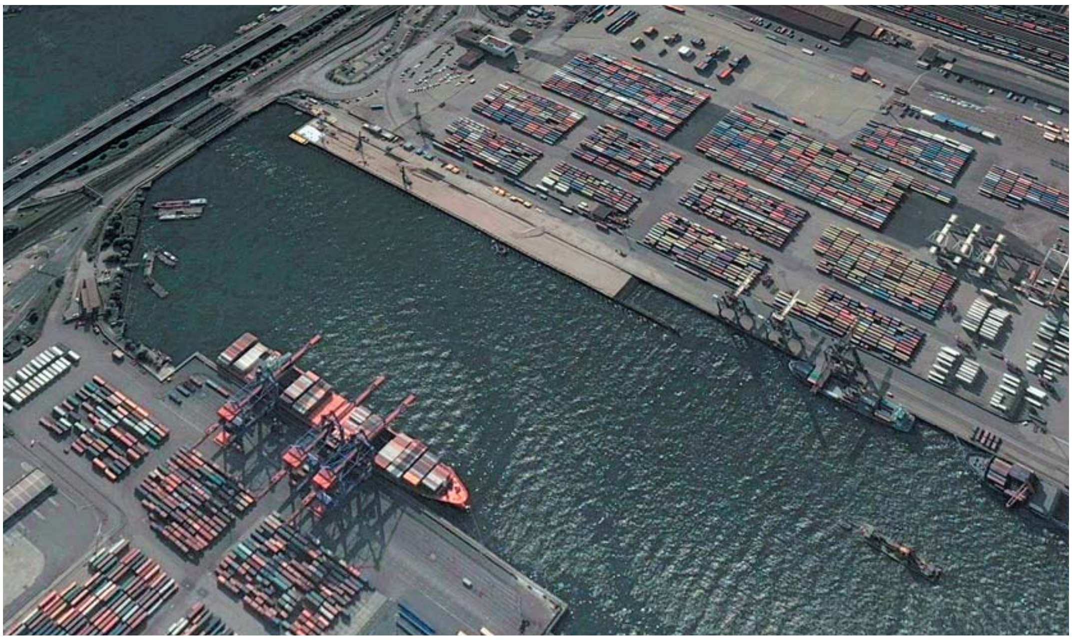
Hamburg, GERMANY

Predöhlkai extension project – Berth 1

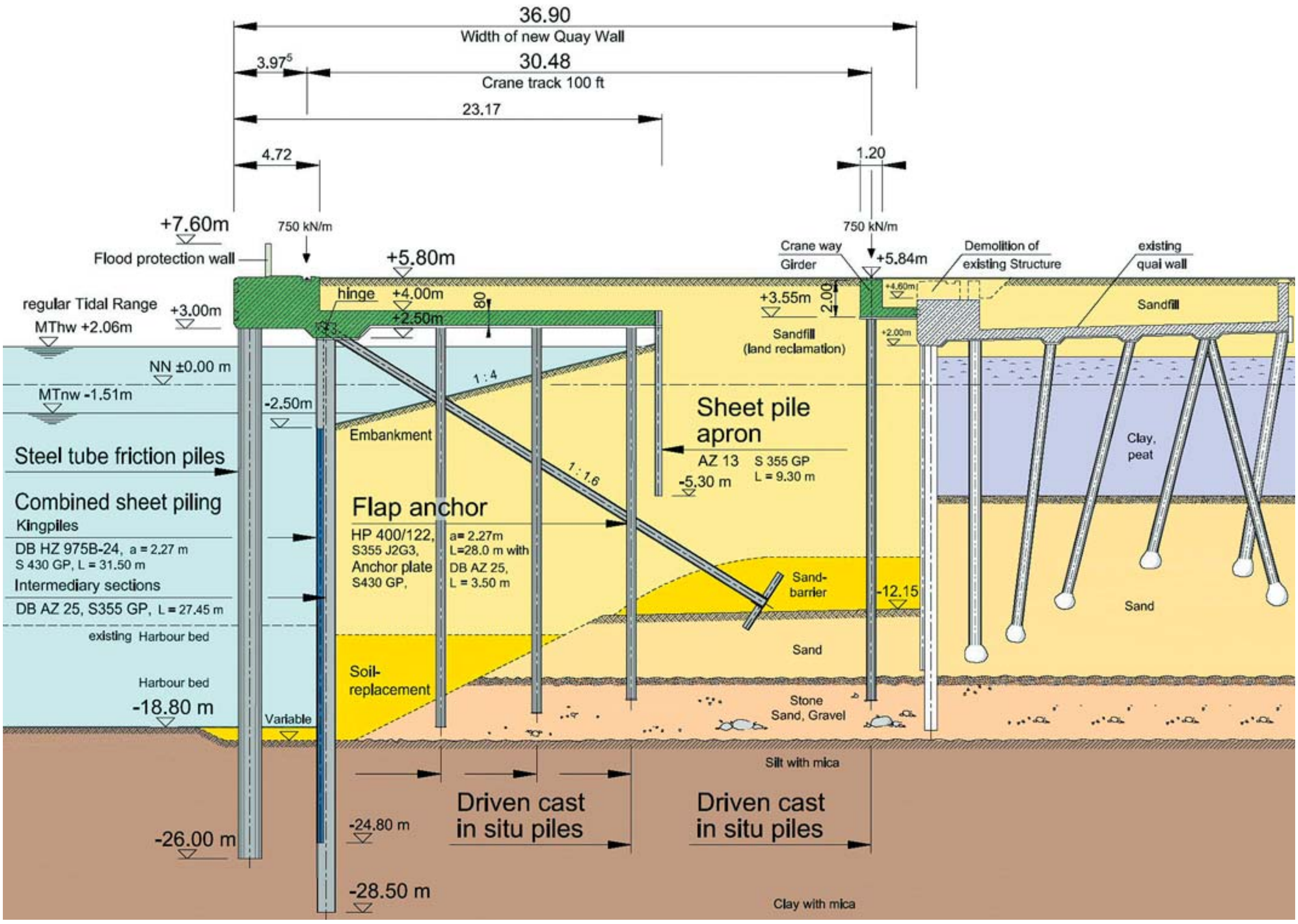
As one of the world's most important ports, Hamburg will handle an expected 14 million TEU by 2010. This represents a major rise from today's 8.5 million TEU container handling capacity. The European mega-port is currently confronted with a 15% yearly rise in container volume and close to 10% growth for total cargo throughput. It was therefore decided to increase the investment funds to approximately 1,000 million euros for enlargement of the following four facilities:

- **Burchardkai Container Terminal:**
  Current quay length: 2,850 m. Current quay depth: 16.5 m.
  Increase of capacity from 2.6 million TEU to 5 million TEU by area modification and modernisation of the storage system.
- **Altenwerder Container Terminal:**
  Current quay length: 1,400 m. Current quay depth: 16.7 m.
  It is planned to increase the capacity of the new container terminal built with steel sheet piles from 1.9 to 3 million TEU.
- **Tollerort Container Terminal:**
  Current quay length: 395 m.
  The expansion of the handling area will increase the container handling capacity by 0.8 million TEU to reach over 2 million TEU by 2011.
- **Eurogate Container Terminal – Predöhlkai:**
  Current quay length: 2,100 m. Current quay depth: 18.8 m.

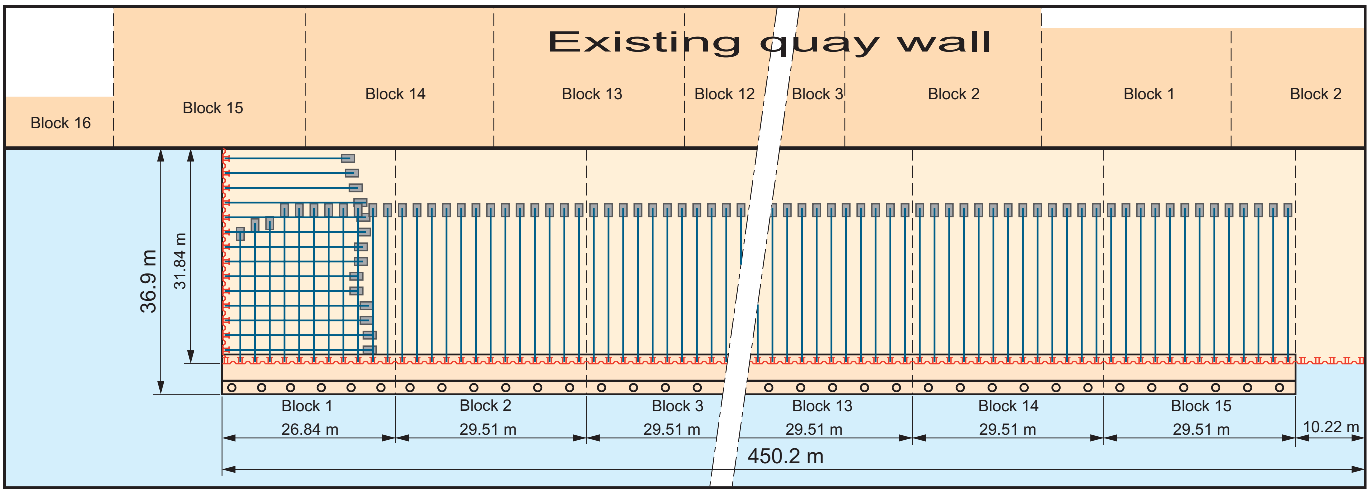
The extension of Berth 1 has just been completed; the development of Berth 2 to 3 is currently under way. The extension programme is scheduled for completion by 2008 and will extend the entire Predöhlkai quay length by 1,035 m.



By 2010 the Predöhlkai quay will be able to handle more than four million TEU per year

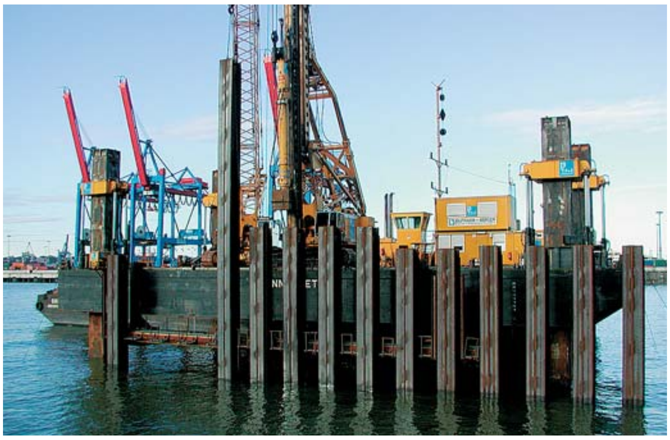


The quay wall consists of a high-strength HZ 975 B - 24 / AZ 25 sheet pile solution



Berth 1 is 450.2 m long and is 18.8 m deep

The new sheet pile wall of Berth 1 was placed 36.9 m in front of the old quay wall


The steel sheet pile wall was installed with the help of a jack-up platform


A template guides the head of the double HZ king piles


The pile toe was guided by a special sledge


Installation proceeded smoothly as a result of two-level-guidance

There are further plans for a westward expansion towards the river Elbe that will increase capacity from 2.6 to over 4 million TEU by 2010. The Eurogate project budget is 350 million euros.

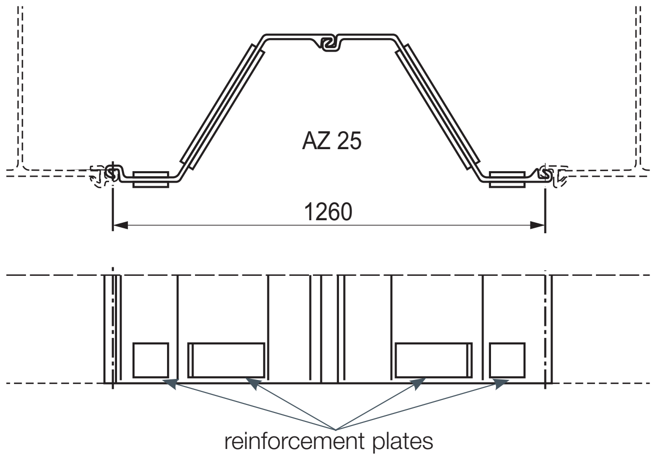
The Eurogate Terminal was officially reopened in November 2005 when the first part of the modernisation programme was completed, after a construction time of 18 months. Boasting some of the biggest container cranes in Europe, the terminal is now ready to handle the world's largest container vessels. The modernisation of the 450-m-long Berth 1 included the construction of a new 24.6-m-high quay wall placed 37 m in front of the existing quay wall. Construction of the sheet pile wall was subdivided into 29.51-m-long sections. The first construction unit at the east end of the quay was 26.84 m long and was connected to the old construction at right angles. The western end of the quay is temporarily connected to Berth 2 which is currently being extended. The temporary wall used a combined sheet pile solution.

The entire Predöhlkai quay wall (Berth 1-3) in Waltershofer Hafen harbour will be built by placing a new offset sheet pile wall in front of the existing (sheet pile) quay wall. The Hamburg Port Authority has been using this method for numerous modernisation projects. The method, known as the "Hamburg solution", comprises a row of tubular fender piles and a half-open main sheet pile wall topped with a concrete capping beam and a flood protection wall. All installation works will be carried out from a jack-up platform. The sheet piles and anchors will be brought to the site by barge.

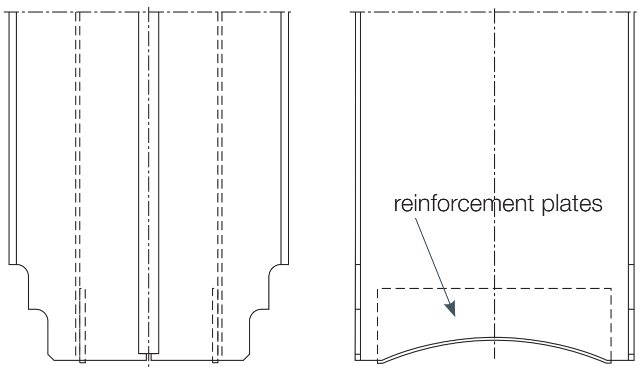
The soil investigations were completed prior to the start of the construction works. They showed that driving obstacles such as large stones are to be expected beneath the present harbour bed. It was therefore decided to replace the in situ soil layer: the sand was dredged, sieved and dumped. This proved to be a good idea as stones with a diameter more than 63 mm were extracted. At greater depths very hard silt and clay layers made driving extremely difficult but not impossible.

A high-strength combined steel sheet pile wall (HZ 975 B - 24/AZ 25) was chosen as a soil retaining structure. The main elements are double HZ 975 B king piles in a high steel grade. The double king piles at 2.27 m intervals were driven to depths ranging from 28.5 m to 29.5 m with a hydraulic hammer. Driving proceeded smoothly in the first sections with the IHC S-90 hydraulic hammer. From section 4 onwards, the cohesive values of the lower silt and clay layers proved to be too high for the hammer to drive the piles to the design depth. It was therefore decided to use an IHC S-280 hammer, the heaviest driving gear ever to

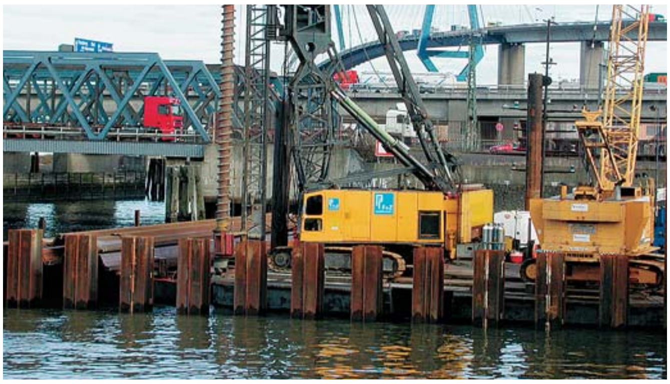
A crane lifted the sheet piles into the template



The toe of the double AZ pile was reinforced with 15-mm-thick steel plates



The web and flanges of the king piles were cut to facilitate penetration into the hard soil



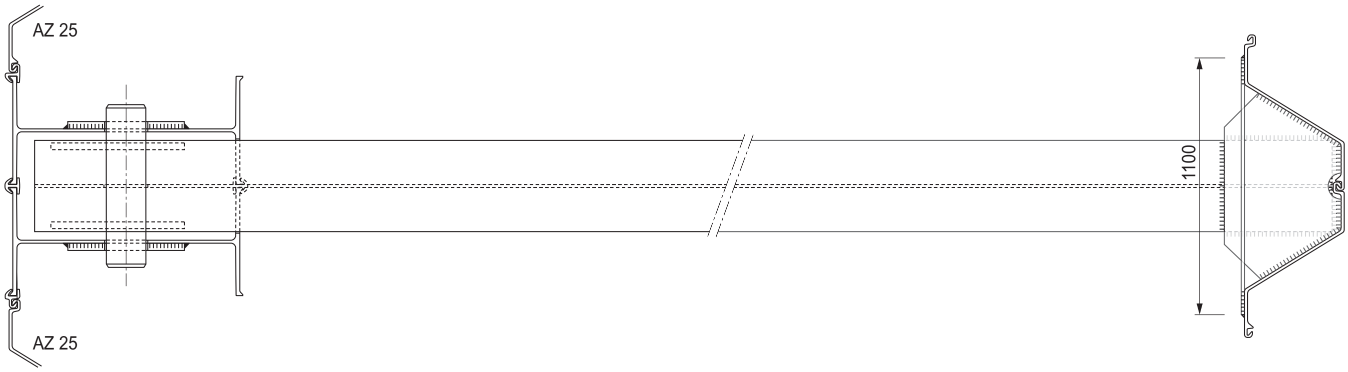
Because of the extreme soil conditions, pre-drilling was necessary to facilitate installation of the AZ piles

be used in the port of Hamburg, delivering an energy of 280 kNm per blow with its 13.5-ton ram.

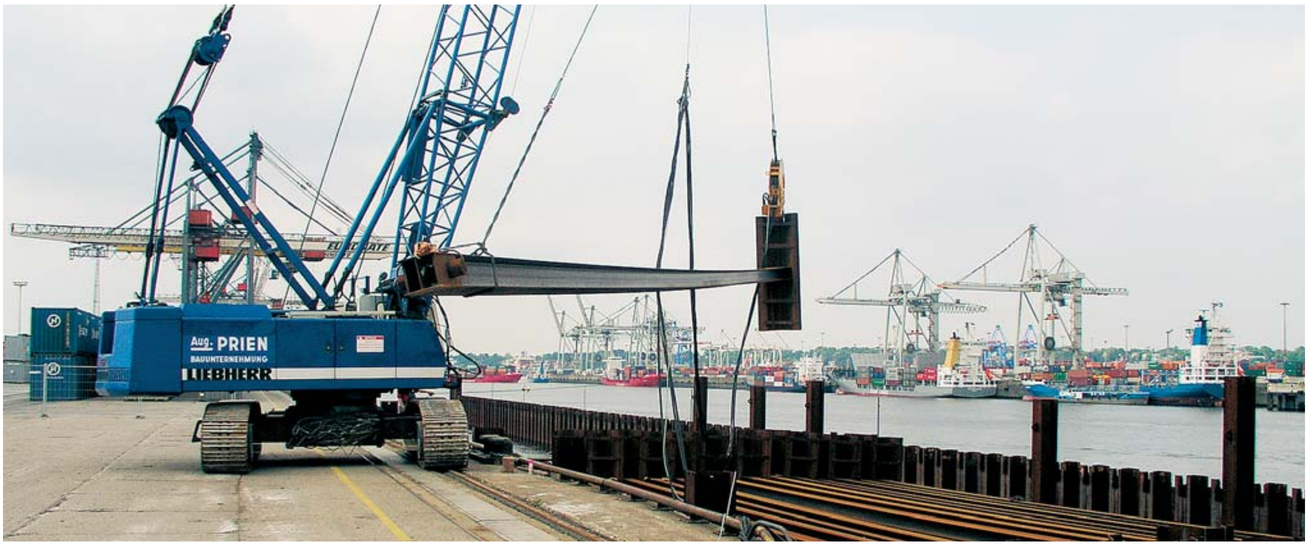
Arcelor recommends installing combined walls with the "Pilgrim Step" driving method using a template with two guiding levels. The contractor chose an alternative method: a single template attached to a jack-up platform guides the top of the piles. The second guiding level is provided by a sledge that ensures the correct predefined distance between the king piles. Even though the "Pilgrim Step" driving method was not applied, the installation results were excellent.

Both HZ king piles and AZ intermediary piles were reinforced at the toe to cope with the hard soil. The webs of the HZ 975 double king piles were provided with 15 mm reinforcement plates and a concave cutout. The stepped cutouts of the flanges additionally reduced the driving resistance. Both sides of the AZ 25 double piles were reinforced with 15 mm steel plates. They were driven to a depth of 24.8 m in between the HZ king piles installed previously. Due to the difficult driving conditions it was decided to loosen the soil by pre-drilling to facilitate the installation of the lighter intermediary sections. A vibratory hammer was used to drive the AZ sheet piles until refusal, and an impact hammer then drove them to the design depth. The top part of every second AZ intermediary pile was cut to allow a wave chamber to form by natural erosion of the soil underneath the superstructure. The top 2.5 m of the interlocks of the concerned AZ piles concerned was cut off at the mill. This reduced welding torch cutting on site to a minimum.

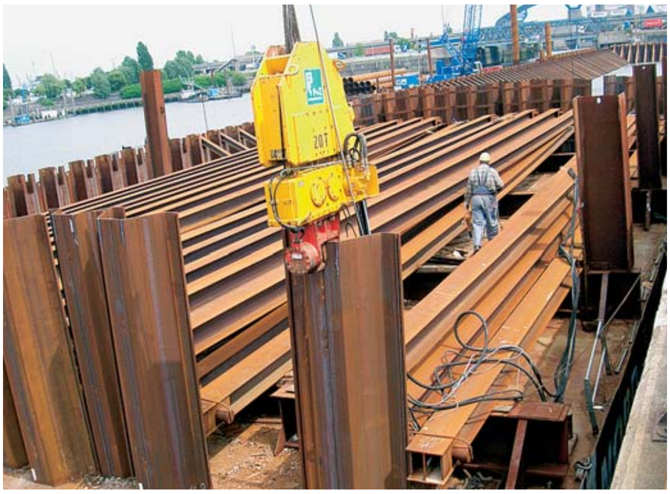
The ingenious anchor system of Predöhlkai quay consists of pivoted 28 to 34-metre HP bearing piles attached to short double AZ sheet piles. This system is not only able to take high traction forces, but it can also be installed where very difficult driving conditions are to be expected. The preassembled anchors made up of HP 400/122 piles (steel grade S 355 J2G3) and stiffened AZ 25 double piles (steel grade S 430 GP) were delivered to the construction site by barge.



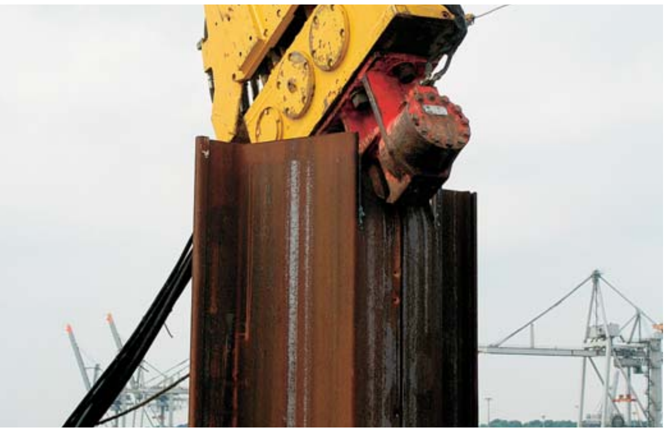
Pivoted tension piles welded to AZ 25 sheet piles acted as anchors



A crane lifted the preassembled anchors into position


The vibratory hammer was attached to the sheet piles prior to installation of the anchors.


The entire anchorage system was lowered to the harbour bed with the vibratory hammer


Two slots prevented jamming of the vibratory hammer


At an angle of 32°, the vibratory hammer was switched on to securely position the anchor

A 170-mm-diameter pin forms the pivot of the anchor system

Each HZ double king pile was fitted with an HP 400 x 122 tension pile

The corner anchors had to be installed with great care as they crossed each other on different levels

Steel tubes take vertical loads and minimise scouring

The 3.5 m AZ 25 piles transfer tensile forces into the backfilled soil

A crane lifted the anchor into a horizontal position behind the quay wall. A joint connection attached the pivoted system to the wall. The vibratory hammer was attached to the anchor piles before the system was lowered to the harbour bed. Once the anchor reached an angle of 32°, the vibratory hammer was switched on to drive the sheet pile into the soil to ensure it did not move during backfilling. To facilitate installation of the anchors and to prevent jamming of the vibratory hammer, the top of the AZ piles was provided with two slots. The inclined anchor system functioned perfectly even in the east corner of the quay wall where the anchors of the main wall and side wall crossed each other.

To minimise scouring problems caused by ships' propellers, 1,220-mm-diameter steel tubes were placed in front of the quay wall. The entire area behind the new quay wall was backfilled with sand in later construction stages. The river sand from the Elbe River delivered by dredgers was piled up behind the main wall, securing the anchor system in position and allowing the concrete works on the top of the quay wall to be built in the dry.

The vertical loads of Predöhlkai Berth 1 are partly carried by steel systems – tubes and sheet pile wall – and partly by concrete piles towards the back of the quay. Three rows of concrete piles with diameters of 510 mm take the loads of the concrete superstructure. The superstructure fulfils a load relieving function, allowing economical design of the front sheet pile wall. AZ 13 10/10 sheet piles in steel grade S 355 GP were driven to -5.3 m at the back end of the concrete superstructure. These sheet piles have a soil retaining function. A row of concrete piles carries the loads of the rear crane rail situated just in front of the former quay wall.

The load-relieving concrete superstructure installed at elevation +3 m provides for economical design of the combined sheet pile wall

- **Phase 1:**

An excavator mounted on a jack-up barge dredged the stony soil layer and placed it on a sieve. The sieved sand was transferred by conveyer belt onto a barge.

- **Phase 2:**

The barge was towed above the future location of the new sheet pile wall where it released the sand.

- **Phase 3:**

The HZ king piles were driven from the platform using a crane-mounted hydraulic hammer. The IHC S-90 hammer drove the piles to a depth of approximately 22 m. If extremely difficult driving conditions were expected, pre-drilling to a diameter of 360 mm was carried out. An IHC S-280 hydrohammer was used to drive the king piles to the final depth.

- **Phase 4:**

The soil was pre-drilled (diameter 600 mm) prior to installation of the intermediary AZ 25 sheet piles with a hydraulic-hammer.

- **Phase 5:**

The anchor was first lifted from a barge with a crane and placed in the joint connection, then vibrated into the harbour floor before placement of the backfill material. The steel scour-protection tubes were also installed during phase 5.

- **Phase 6:**

A hopper dredger carried river sand to backfill the area between the new and old quay walls.

- **Phase 7:**

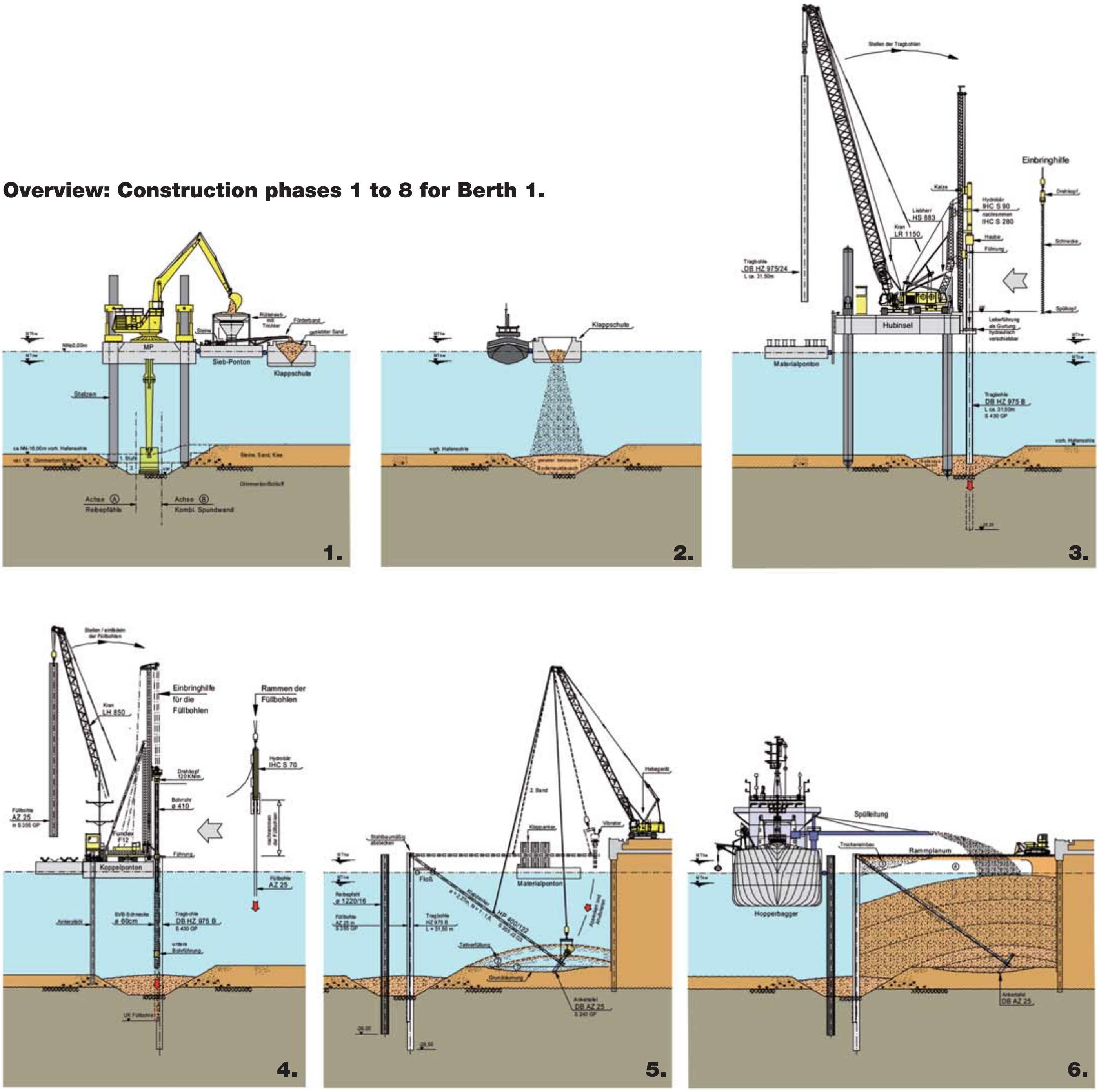
The 510-mm-diameter concrete piles and the AZ 13 10/10 rear sheet pile wall were installed. Each concrete pile has a maximum bearing capacity of 2,500 kN.

- **Phase 8:**

The reinforced concrete superstructure was installed. “Windows” were cut from the lower side of the superstructure down to -2.5 m into the AZ piles to allow the wave chamber to form. ■

The structural elements of the quay comprise sheet piles, steel tubes, tension anchors, concrete columns, and the load relieving-superstructure

Overview: Construction phases 1 to 8 for Berth 1.



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

Designer:
- KMT Ingenieurgesellschaft mbH, Hamburg
- Hochtief Construction AG, Hamburg
- F + Z Baugesellschaft mbH, Hamburg

Contractor:
- Hochtief Construction AG, Hamburg
- F + Z Baugesellschaft mbH, Hamburg
- Aug. Prien Bauunternehmung, Hamburg

Steel grade:
S 430 GP, S 355 GP

Sheet piles:
HZ 975 B – 24 / AZ 25
3,740 t HZ 975 B - 1,470 t AZ 25 &
AZ 13/10/10 - 910 t HP 400/122 anchors

Total quantity of sheet piles:
6,120 metric tons