Kaohsiung, TAIWAN

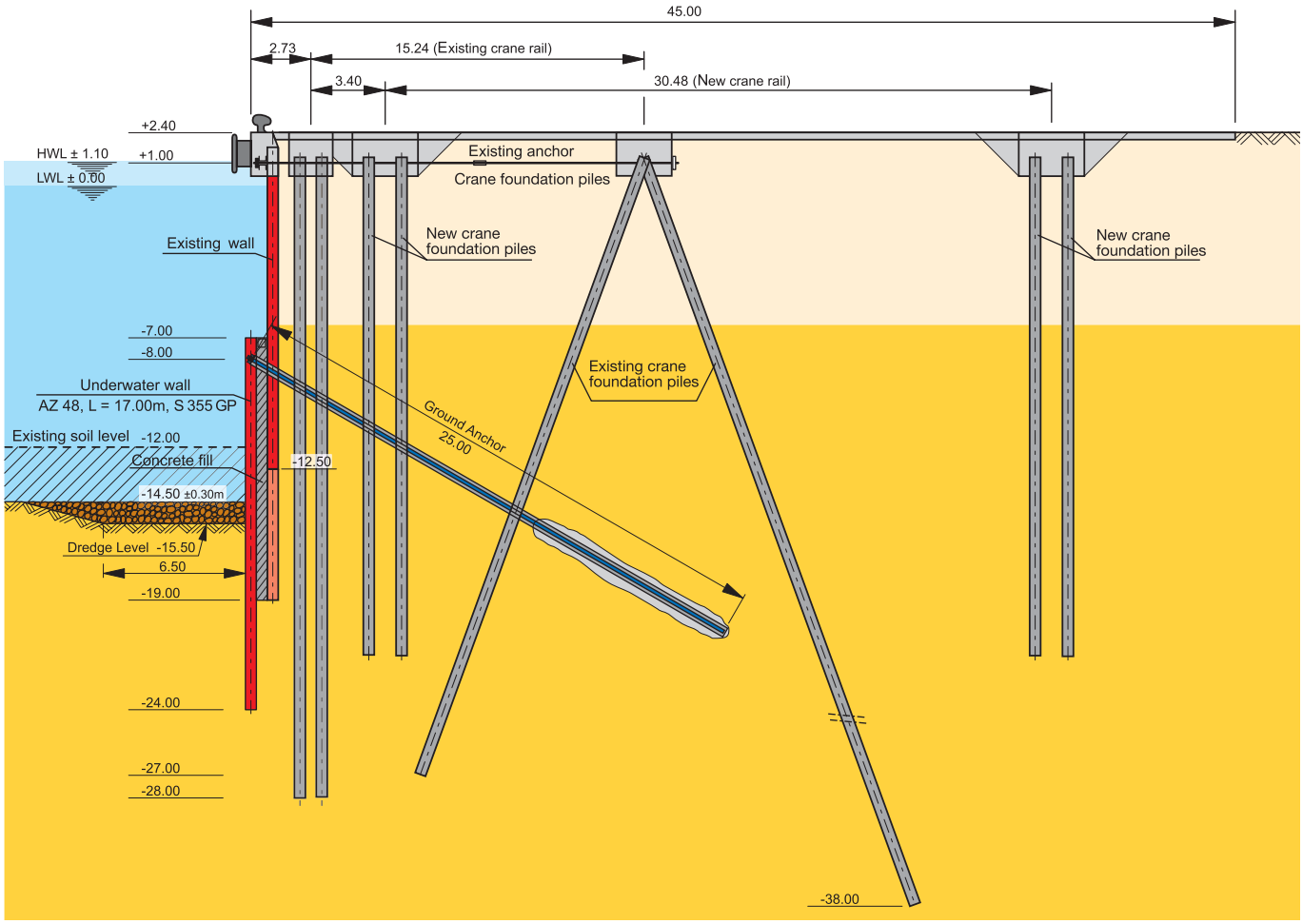
Deepening of Berths 65 and 66

There are currently seven international harbours in Taiwan playing important roles in economic development: Keelung, Kaohsiung, Hualien, Taichung, Suao, Anping, and Taipei. The port of Kaohsiung is Taiwan's leading international commercial port with Anping serving as its auxiliary harbour.

The deep-water port of Kaohsiung is the marine transit hub for East Asia and South Taiwan. Featuring a natural harbour and two access channels with depths of 11 and 16 metres, the 2,683-hectare port is capable of handling up to 100,000-DWT vessels. Kaohsiung currently has five container terminals and a total of 118 berths – including 26 container berths – which can accommodate 6,000-TEU post-Panamax container ships. Handling over 70% of Taiwan's container traffic and 60% of the country's total international trade volume, the harbour has been the world's third largest container port for many years, with a container throughput of 10 million TEU in 2006. Plans have been made to benefit from geographical advantages and nearby software and hardware facilities to speed up the development of Kaohsiung Harbour. To respond to the development of large vessels and to maximise the harbour's efficiency, several container wharves have been

Kaohsiung features 5 container terminals and 118 berths

Handling 10 million TEU per year, Kaohsiung is one of the largest harbours in the world



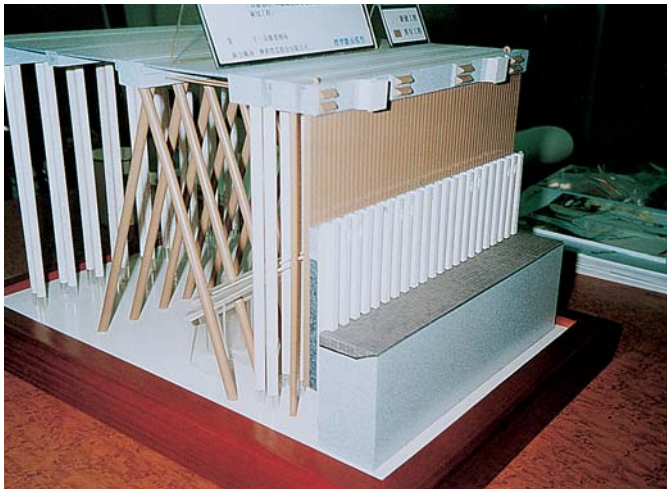
The most economical deepening solution involved installation of an underwater sheet pile wall forward of the quay

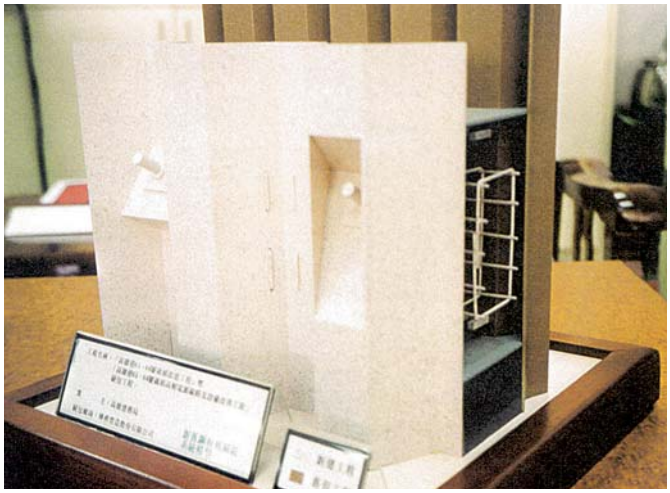
The existing structures were left in place

deepened, including the existing berths 65 (length: 244 m) and 66 (length: 440 m) that have been be rebuilt as container wharves.

Berths 65 and 66 are part of the Container Terminal No. 2. Due to the scheduled deepening from 12 to 14.50 metres, the existing quays had to be redesigned. The quay walls of the existing Berths 65 and 66 consist of a combined sheet pile wall featuring box piles as king elements and 500-mm U-piles as intermediary elements. The king elements (L = 20.5 m) and the intermediary elements (L = 13 m) are made of FSP VL sheet piles.

The Kaohsiung Harbour authorities disregarded the original concrete tender solution of the redesign because it exceeded the budget by 70%. It was therefore decided to opt for a high-strength steel sheet pile solution to deepen the quays. The new underwater sheet pile wall was to be placed in front of the toe of the existing quay wall.





The sheet pile wall reached from -7 to -24 m and was anchored with inclined anchors

L-shaped plates were used to connect the sheet piles to the anchors

Owner:
Kaohsiung Harbour authorities

Designer & Contractor:
HWA CHI Construction

Sheet piles:
AZ 48

Pile length:
17 m

Steel grade:
S 355 GP

Total quantity of sheet piles:
2,690 metric tons

Due to the substantial water depth of the new structure and seismic loads with horizontal ground accelerations of 0.11 g above and 0.22 g below the water level, bending moments were very high. The allowable deformation of the underwater sheet pile wall was strictly limited. In order to allow safe docking of vessels at the two deepened berths, the harbour authorities had to limit deflections so that ships would not strike the new wall.

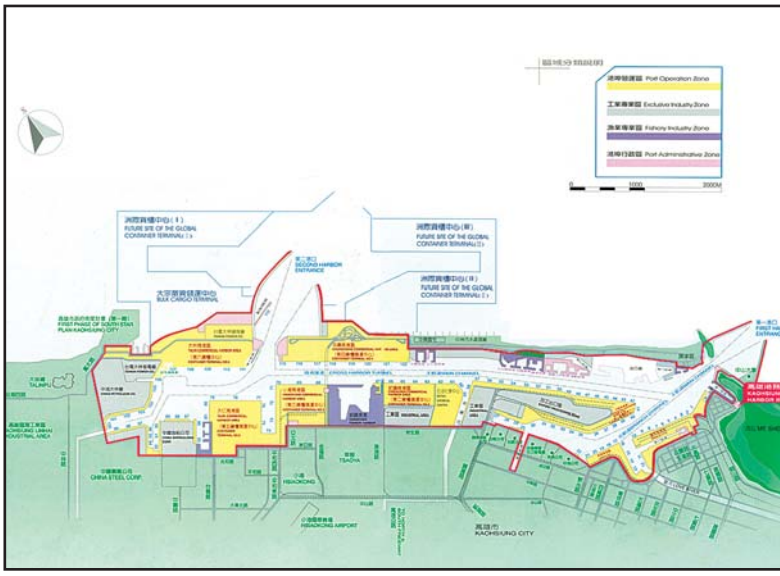
A design study carried out by the Arcelor's technical department showed a maximum moment of 1,014 kNm/m for the ultimate limit state and a maximum moment of 1,482 kNm/m for seismic conditions, assuming over-dredging of 1.0 m. These loads stretch conventional steel sheet piles to their limit: only Arcelor's AZ 48 with a section modulus of 4,800 cm^3/m is capable of handling these moments.

The renovation of the 650-m quay calls for underwater installation of the AZ 48 sheet pile wall in front of the existing FSP VL box pile wall. The 17-m AZ 48 piles were driven into the harbour bed until their head reached a depth of seven metres. Cement grout and concrete were injected between the new and existing sheet piles.

The deep excavation and seismic loads called for heavy-duty AZ 48 piles

The piles were driven hard alongside the existing berths

Belonging to CT 2, Berths 65 & 66 can handle vessels of up to 6,000 TEU



Kaohsiung Port is promoted as an Asian-Pacific transhipment centre

Due to static requirements and the restricted allowable deformations, the new wall had to be anchored. Pre-stressed grouting anchors attached to the head of the sheet piles ensured the stability of the AZ 48 wall. The anchors were attached to every third sheet pile: the distance between anchors is thus 3 x 0.58 m = 1.74 m. The grouting anchors had to carry high loads which had to be transferred into deeper soils with high load-bearing capacities. The contractor opted for inclined anchors, for which a special connection system was developed. L-shaped plates were welded into holes cut into the AZ 48 piles. The 25-m tie rods were connected to the L-shaped plates and were held back by a 10-m-long grout section. They were installed half a metre from the top of the underwater sheet pile wall, at -7.5 m, with an inclination of 30 degrees. A total of 373 tie rods were required to hold back the 650-m quay wall. Each of them has a working load of 660 kN and an ultimate load of 2,490 kN. Following installation of the anchored underwater steel sheet pile wall, the harbour bed was dredged to -14.5 m. Deflections remain well within the set limits and safe operation of container traffic can thus be guaranteed. ■