Port of Zeebrugge – Deepening of Container Handling Zeebrugge quay wall

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Summary

The Container Handling Zeebrugge quay wall was built in 1962-1970 and was designed for a water depth of 14m. The existing construction is of the “Danish type”, consisting of a concrete relieving floor on driven concrete piles and a steel sheet pile retaining wall. To make the quay accessible for container ships with a draught of up to 18 m a new front (combi-)wall will be erected. Behind the existing relieving floor new vertical tubular piles and MV piles driven at an angle of 50° to the horizontal will be installed. Cast in-situ and post-tensioned concrete beams with a slab on top will transfer the vertical loads to the front and rear tubular piles and transmit the horizontal forces to the MV piles. The corrosion rate of the existing sheet piles has been investigated allowing a structural verification and because of geometrical restrictions the results of a pile test were integrated in the design and this made it possible to reduce the number of piles.

Keywords: container terminal; quay wall; combined wall; MV-piles; pile test; post-tensioning; corrosion; quay deepening; quay renovation

1. Introduction

Zeebrugge, or Bruges by the Sea, is a young seaport with modern port equipment suitable for the largest ships. The CHZ quay wall was built between 1962 and 1970 and had a length of 600m. To be prepared for future evolution in container traffic the port authority decided to deepen the existing quay wall up to 19m water depth. A stringent renovation is necessary with a new structure bridging over the existing one. Possible vertical and horizontal loads are also increased.

2. Design of new quay wall

2.1 Initial Design

To increase the dredging depth a new front (combi-)wall will be erected. Behind the existing relieving floor new vertical tubular piles and MV piles driven in at an angle of 50° to the horizontal will be installed. Cast in-situ and post-tensioned concrete beams with a slab on top will transfer the loads to the front and rear tubular piles and carry the horizontal forces to the MV piles.

It was intended to keep the existing crane rails and to keep the retaining function of the existing sheet pile wall. To re-use the existing wall its corrosion rate was investigated. A concrete plug cast below water to connect the existing and new retaining wall and a cathodic protection to prevent further corrosion were necessary to assign a long term function to the 40 year old wall. The inclined MV-piles could only be placed in between the piles of the separate rear crane rail foundation. In this way the number op piles was limited. The design load is based on an in-situ test.

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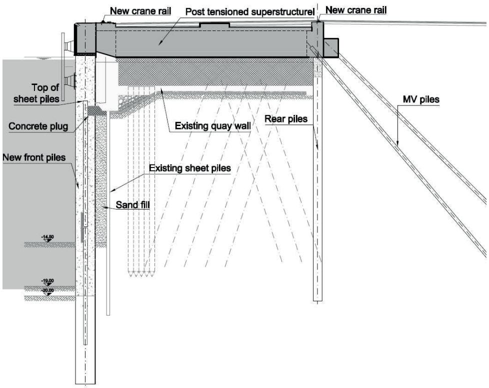

Fig. 1: Typical cross section quay wall

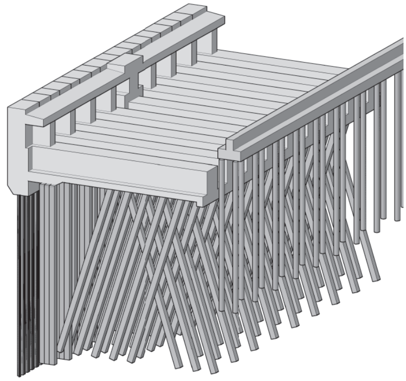

Fig. 2: 3D-figure of existing quay wall with all the piles and separate rear crane rail

2.2 New Design

During execution and more precisely during the installation by vibration of the vertical rear and front piles a horizontal displacement and a settlement occurred in a certain zone. It was no longer a safe solution to rely on the existing sheet pile wall. In addition the damage on the existing foundations of the crane rail was an opportunity to integrate both rails on the new structure. This is of great importance for the terminal and also reduces the risk on differential subsidence.
The length of the sheet-piles between the tubular piles of the combi-wall has been increased to protect the existing wall. The new and existing structure were designed in an integrated Plaxis model. The existing quay wall was verified, in particular for forces coming from the displacements that can occur during dredging.

2.3 Pile test

The resistance of the piles was calculated in several ways. The goal of the test was to load one pile to 7300kN, twice the load we expected on the pile. No significant displacements were observed. In the compacted sand layers in Zeebrugge much higher loads are possible than predicted.

3. Conclusions

Container traffic is booming. Ports have to adapt their infrastructure and have to anticipate on future developments. The Port of Zeebrugge will be ready to receive container ships with a draught of up to 18m, where today's maximum draught is 15,5m.
The port authority decided to deepen and renovate the existing CHZ quay wall that dates from the late sixties. To extend the lifetime of the construction several investigations and assessments were necessary. Corrosion rates have to be investigated and the contribution to the overall stability has to be minimized. Supports can be added and future loads should be prevented. Geometrical restrictions determine and limit the overall dimensions. In this particular case the number of MV tension piles was restricted. A pile load test indicated that design loads could be much higher than indicated by the prevailing standards.
Damage during execution turned out to be an opportunity to tilt the renovation to a higher level by integrating the crane rails in the new construction and by protecting the existing wall in a better way.