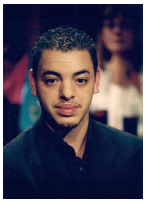
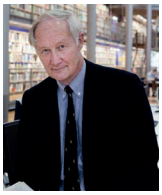
Upgrading techniques for quay walls

Mohamed DOUAIRI
Delft University of Technology,
Delft, Netherlands
douairi@gmail.com



Mohamed, born 1976, is a Master student civil engineering at Delft University of Technology

Jarit DE GIJT
Ass. Professor
Delft University and senior consultant, Engineering Dept., Municipality of Rotterdam, Netherlands
jg.degijt@rotterdam.nl



Jarit , born 1947, is Assistant Professor since 2004 at Delft University of Technology

Summary

The rapid expansion of trade has led to fast growth of handling of goods in many ports. The ports are the catalysts of trade development and this will result in large future effects.
The on-going increase of ship numbers and sizes will challenge ports in every aspect. The ports have to adapt to the upcoming changes by increasing capacity in every dimension.
Quay walls are one of the most essential components of port infrastructure and with growing volumes of cargo and increasing vessel size; the demand on these structures is increasing. Efficient transfer at the quay wall interface is required for the commercial and operational success of any terminal or port. This paper comprises many options for creating extra depth in front of quay walls. Not all presented options have been used in practice.

Keywords: quay wall, anchors, ports, walls, upgrading

1. Introduction

Rotterdam is no exception in the trend that can be seen around the world. In the port of Rotterdam there is a trend to move these mooring arrangements towards the sea, where the draughts are deeper. The functionality of those quays outdate in less time than they are designed for. The need for larger depths and vessels is one of the reasons that leads to build 'Maasvlakte 2'.

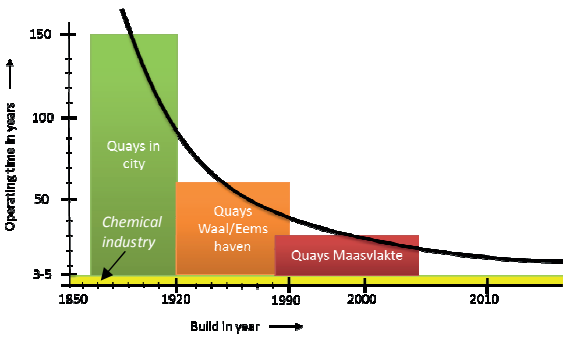


Figure 1: Service life of quay walls in Rotterdam

The question arises, how to deal with these changes. The complete demolition of an existing quay wall structure and replacing by a structure with a larger height is often not possible due the high costs and / or environmental boundaries. The deepening and upgrading of the existing quay walls is the next option, which means that the existing quay walls will have to retain more soil then they actually designed for. Berthing bigger ships means also that the quay wall has to sustain increased external forces. Constructive adjustments have to be made to the quay walls, to provide sufficient strength and stability.

https://doi.org/10.2749/222137813806474192

2. Upgrading techniques sheet wall quays

This problem leads to higher retaining height than the facilities are designed for. As a first approach to this problem conceptual solutions are presented. To ensure sufficient stability and strength the following general formula can be applied:

$$SF = \frac{F_{Resisting}}{F_{Driving}} \geq 1 \quad (1)$$

Assuming that the value of SF (Safety factor) has to remain approximately the same (same level of safety, see equation 1). There are three possibilities to achieve this (see figure 2).

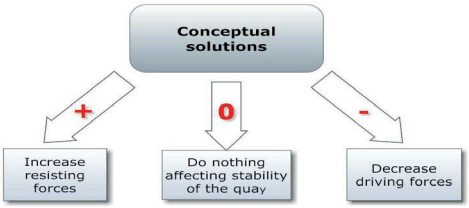


Figure 2: Conceptual solutions

3. Conclusions

- By excavating the harbour bed (increase the retaining height), the decisive mechanism is the internal (strength of material) and external moment stability. These values increase to the third power of the ratio H/L (height/total length of the quay). This means that the costs will also increase at higher order.
- Increasing retaining height and the design surcharge is double trouble. This will lead to extensive upgrade of the quay wall. A thought-out of the goal of upgrading is recommended.
- The extra anchorage is technically and from cost-aspect the most feasible solution. This is not surprising as it the only the solution that effectively reduces the span of the quay wall.
- With additional measures for the strength (bending moments) of the quay wall, using heavy material on passive side as a measure upgrading the quay-wall is a feasible technical solution. Further research with more advanced models is needed. Because of the weight of the material, this leads to reduce the scour problem at the quay.
- Solution with concrete floor and inclined piles as a solution to reduce the span of the quay-wall is technically feasible solution. The solutions will also serve scour protection. The construction costs of this solution are higher than other proposed solutions.
- Sheet-walls are more flexible for upgrading than a diaphragm wall. This because of the diaphragm wall is not homogenous over the total length. Upgrading such a quay wall needs to be taken into account in the design (as done for the Euromax).
- This study comprised many options for creating extra depth in front of quay walls of which not all have been used in practice. Options 2, 12, 14 and 18 are applied regularly in practice.