Structural rehabilitation and lengthening of three 50 year old locks in Limburg, the Netherlands

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Summary

To meet rising demands for larger vessels and to limit waiting times at locks, Rijkswaterstaat has invested in the enlargement of three locks on the Julianakanaal in the south east of the Netherlands. The lengths of the locks have been increased from 142m to 225m, the structural safety of the existing lockchambers was raised and the mechanical and electrical fittings have been replaced. This has resulted in an increased canal freight capacity.
It became apparent that the locks could be overloaded due to the combined effects of soil pressure from the backfill and cyclic loads from temperature and water level changes inside the locks, this risk was to be mitigated.
This paper provides an overview of the design and build project "Sluizen Limburg" project that was undertaken for Rijkswaterstaat. The paper includes a discussion on the solution to the overloading of the chamber-walls and the analysis and rehabilitation of the existing structures.

Keywords: soil-densification, cyclic loading, reverse engineering, refurbishment, lengthening of locks, European directive on machinery, submerged concrete, combi-wall, proven safety.

Figure 1: Lengthened lock at Maasbracht

1. Introduction

The structural rehabilitation and lengthening of three locks was part of the deelproject "Maasroute", which focused specifically on the improvement of the Maasroute navigation route.

As the owner considers that every set of locks (Born, Maasbracht, Heel) is one single, complex machine in accordance with the European directive on machinery, any works on the locks were to comply with this directive.

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2. Lengthening of the locks

It was decided to lengthen the locks from the upstream side. This had an important consequence. As the channel bed in the upper harbour is higher than the ground water level, it was necessary to ensure that the channel bed was adequately waterproofed. The existing channel bed was waterproofed by means of an asphalt layer, which had to be removed or perforated without permitting leakage to the surroundings during construction. This was one of the first and most significant risks that were encountered during the project. Besides the waterway had to stay in function during the works through the adjacent lock.

2.1 Lengthening of the chamber

The design of the chamber lengthening was undertaken assuming back anchored combi-walls with a submerged reinforced concrete floor. It was a requirement that the chamber can be emptied periodically and thus is was necessary to provide an anchoring system to the floor.

2.2 Modification of the existing upper head

When lengthening the locks from the upper harbour, the upper head requires major modifications as the structural system changes significantly.The adequacy of the existing reinforcement to the floor and walls was checked and it was found in all cases that the concrete sections were sufficiently thick to withstand the increased loads associated with the structural modifications

3. Structural rehabilitation of the existing civil structure

Prior to the lengthening works, it became clear that the operational width of the locks had reduced due to an inward movement of the concrete walls.
Based on these measurements and a review of the original design calculations, an evaluation of the situation was made. It was concluded that the cyclic movements of the walls had caused the soil behind the walls to densify, which in turn resulted in increased soil pressures and thus a reduced residual wall capacity.

3.1 Solution

A solution was proposed, in which the ground behind the chamber walls would be excavated in order to reduce the ground pressure on them. The lock platform level was maintained through a precast concrete deck over the excavation, which was supported vertically by the chamber walls and by an anchored sheet pile wall that acts as a retaining wall to permit the excavation behind the walls.

4. Conclusions

Through using the concept of “proven safety” and modelling the soil densification by applying cyclic loading in the Plaxis model, with a calibration of the model, it was possible to demonstrate that sufficient safety existed to the structure without altering the existing chamber walls.