Evaluation of the remaining lifetime of the piers of the railway bridge crossing the Little Belt, Denmark

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Summary

The bridge was constructed in the 1930s and is approximately 1.2 km long, and is the only railway connection between the western and the eastern part of Denmark.

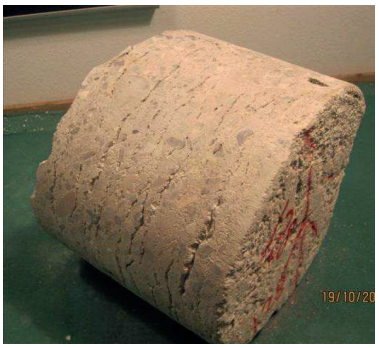
The preliminary investigations of the 4 main concrete piers situated in seawater indicated that severe degradation of the concrete was occurring. A detailed investigation of the concrete in the piers confirmed extensive cracking due to mixed design of the concrete made with reactive aggregates from a local source.

Additionally, numerous samples were collected and tests carried out, including: Measuring the compressive of the strength on samples with severe cracking. The results concluded that the current strength of the structure was sufficient to achieve the necessary load bearing capacity.

Keywords: Bridge structure, alkali silica reactions, load bearing capacity, remaining lifetime, rehabilitation strategies.

1. Introduction

Fig. 1: Overview of the railway bridge across Little Belt, the only railway link between the western and the eastern part of Denmark. The 4 main piers are situated in seawater, 60 m from the seabed.



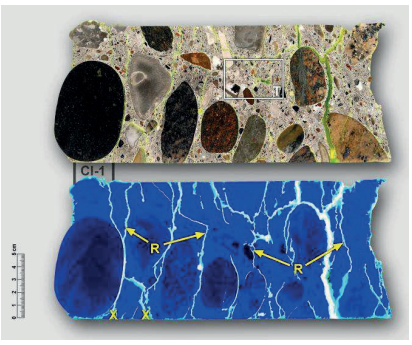


Fig. 2: Sample and test results from the mass concrete near the inner side, showing that the cracks are mainly vertical.

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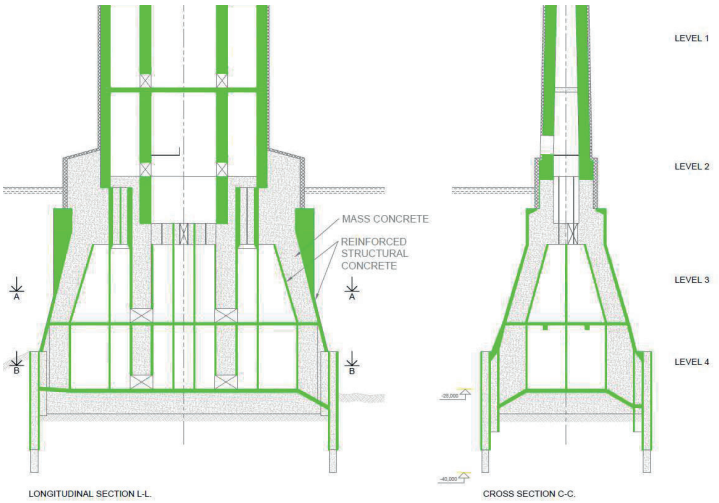
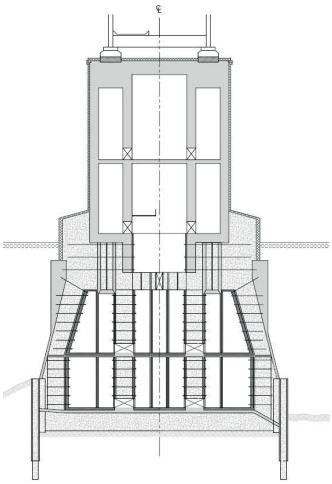


Fig. 3: Vertical sections of the piers. The reinforced concrete is highlighted in green signature, and the mass concrete are marked in grey. The inner parts of the piers are hollow, thus making it possible to inspect the internal sections of the piers from top to bottom.

Based on the conclusion from this study, it is expected that a rehabilitation of the piers will be necessary in 20 to 60 years. The timing will be confirmed based on the planned monitoring. The magnitude of the rehabilitation work expected includes the following activities:

New reinforced concrete walls to be constructed on the internal sides of the existing walls in the cells at the lower level (level 3 and 4). The new walls shall be designed to take over the load bearing capacity from the existing structure, leaving the existing structure to disintegrate due to the alkali-silica-reactions.



The concrete in the existing walls will be kept in place with numerous long anchors, drilled through the mass concrete and anchored into the new walls.

New reinforced concrete slabs in the lower level and between the levels will be constructed in order to replace the existing deck slabs, which will provide the stability of the piers.

If the disintegration of the outside walls is deemed beyond acceptable, an intermediate sheet pile wall will be constructed, surrounding the pillar. Behind the sheet pile wall, a reinforced concrete wall will be constructed on the outside of the existing structure. The new external concrete wall will be connected to the new internal concrete wall with anchors through the mass concrete.

Fig. 4: Rehabilitation of the pillar includes construction of new reinforced concrete walls on the internal sides of the walls to be attached to the existing structures with anchors through the mass concrete.

2. Discussion

The results of the inspections demonstrated that the concrete is deteriorating because of alkali-silica-reactions in the concrete aggregate. The results of the investigations indicated that the deterioration process is slow and that the structural residual load bearing capacity is acceptable. The development of the deterioration will be monitored, and a monitoring program has been prepared in order to determine when the rehabilitation will be required. The conclusion of the study shows that there is no need for rehabilitation at least for the next two decades.