Structural assessment of an existing concrete cantilever bridge: The Hartelbridge

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Summary

In this paper the assessment of the cantilever part of the Hartel bridge is presented based on the guidelines given in Eurocode together with Dutch additions and modifications for existing structures. Attention is paid to the safety levels, traffic load, archival research and inspection of the bridge condition as well as the applied structural models and calculations. The outcome of the assessment reflects that the safety against shear failure is not sufficient, therefore it is advised to strengthen the bridge by external prestressing inside the box girder. Key points and challenges of possible measures are discussed.

Keywords: Assessment, existing structure, bridge, post-tensioning, shear, structural reliability, strengthening

1. Introduction

The Hartel bridge is located in the Netherlands close to the port of Rotterdam and is part of the N218 motorway. This bridge was constructed in 1967 and spans (besides a sluice) a primary and a secondary canal. The main crossing has a separate bridge for each direction both with a width of 8,25 m. The main bridge is the concrete cantilever bridge with a total length of 248 m, a main span of 114m and two equal side spans of 67m. These cantilever bridges form the scope of this paper.

This cantilever bridge was the first to be built in the Netherlands according to cantilevering construction method with precast segmental elements with glued joints. The bridge is post tensioned with cantilever prestress and with continuity prestress. See figures 1 and 2 for en longitudinal section and a typical cross section.

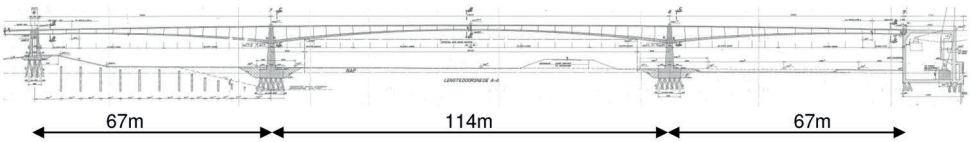

Fig. 1: A longitudinal section of the Hartel bridge

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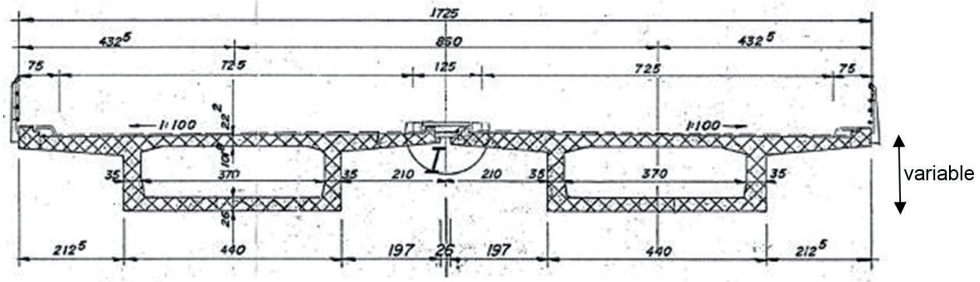

Fig. 2: A typical cross section of the Hartel bridge (dimensions in cm)

The Province of South Holland, being the owner and manager of the bridge, has the intention to increase the capacity for road traffic. The concern is that the structure may not meet the minimum structural safety requirements. Therefore a structural assessment has been carried out.

2. Method of assessment

The applied method is based on the Eurocode together with the Dutch NEN 8700-series, containing additions and modifications that take into account the fact that for existing structures a lower safety level is acceptable compared to a new structure. Archival research is carried out, leading to the determination of the internal forces due to the actual prestress, the creep effects and the construction method. Tests were carried out to determine the actual concrete strength. In the assessment of the slender cantilever bridge the main structural behaviour is an important element. Therefore a beam model is used (a) to verify the results obtained from the original calculations for the prestress, creep and construction method, and (b) to calculate the effect of own weight without creep effects as well as the effect of live load on the internal forces. Outside the model all these effects are combined.

3. Strengthening

In order to make the bridge satisfy the above mentioned critical points it is advised to the client to strengthen the bridge by application of external prestressing inside the box girder. A critical detail is the introduction of the prestress forces into the existing webs of the box girder. In the anchorage zone there are a lot of existing tendons inside the web, also the internal height inside the girder is limited. Special measures are proposed.

4. Conclusions

The Eurocodes combined with the additional Dutch regulations have proven to be an appropriate basis for the assessment of the structural safety of the Hartel bridge. It appears that the present bridge does not satisfy the necessary safety level, even with a traffic reduction by means of a traffic sign of 50 ton restriction; as could be expected the shear strength is not sufficient. Also in terms of serviceability the bridge does not satisfy, because at some joints between precast segments theoretically gaps may occur leading to a reduction of durability and fatigue resistance. Therefore a strengthening by means of application of external prestressing inside the box girder is advised to the client. This makes the bridge satisfy the above mentioned critical points, besides it offers an opportunity to improve the whole bridge substantially, providing it with a certain amount of robustness to cope with expected and unexpected developments and future events in material degradation and traffic increase.