Widening of an Existing Concrete Girder Railway Bridge with an Asymmetric Steel Section for an Additional Track

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Summary

The railway line between Bruges and the Zeebrugge at the Belgian coast will be expanded with a third track on one side of the bridge. The railway tracks cross the Bevrijdingslaan, one of the major entrances to the historic city centre of Bruges. The existing bridge has a rather functional outlook: it's a concrete box girder bridge with a three span continuous superstructure. The two box girders, which are post-tensioned, carry two tracks. For architectural reasons, a fully integrated design solution is chosen for the widening of the bridge, without structurally influencing the superstructure of the existing bridge. A new asymmetrical steel caisson structure is built adjacent to the existing bridge. The new bridge structure will be continuous over both piers as well. The necessary parapets are part of the bridge and the bridge design also incorporates an acoustic screen and a service pad on the other side of the existing concrete bridge. The new steel caisson has a curved design, which is repeated in the acoustic screen ensuring that the unity between all bridge components is highlighted. This is further realised by integrating the existing piers into the design of the new piers resulting in a more uniform design concept. Due to het incorporating of the old piers into the new piers, the horizontal resistance of the bridge is different, resulting in a redistribution of the horizontal forces. Since the complete structure must be in accordance with the present codes for the railways. Especially, these codes are severe to horizontal movements and forces. Furthermore, the curvature of the bridge is continued into the piers, which ensures not only the unity in design between old and new, but also works as a portal function, creating and inviting entrance to the historic city of Bruges. The objective of a fully integrated design is achieved, creating a portal to the historical city of Bruges.

Keywords: Continuous steel caisson bridge, pier strengthening, integrated bridge design, bridge widening.

1. Design of the bridge

Nowadays, more attention is given to the integration of a new engineering structure into the environment from the start of the design phase. Therefore, a holistic design approach was chosen for the necessary widening of the existing bridge crossing the Bevrijdingslaan. During the entire design process, special attention was given to the actual function of the bridge. The bridge does not only fulfil a transportation function, being part of an important railway connection to the Belgian coast and the Port of Zeebrugge, it also bridges one of the major entrances of the city of Bruges, making the bridge an important landmark for the city. In addition, the bridge has a road safety is one of the obvious ways to clarify to car drivers that they are entering the city. To cover all of these functions of the bridge, an asymmetrical steel caisson structure is built, adjacent to the existing structure, an architectural impression of which is given in figure 1

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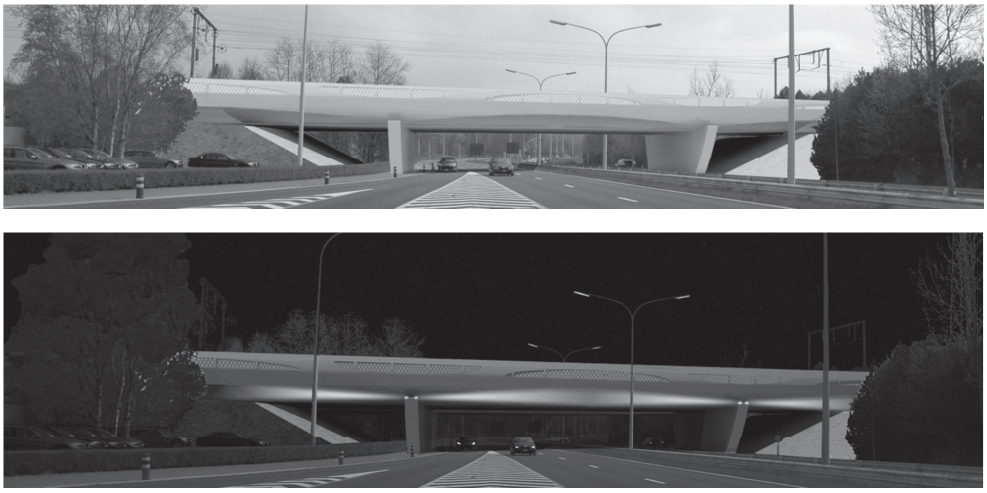

Fig. 1: Visualisation of the new Bevrijdingslaan Bridge by day (above) and by night (below)

2. Concept

The calculation of the new foundations is based on the assumption that the existing dead load is carried by the existing foundations, while that the strengthening of the existing piers will be responsible for carrying all new dead loads, as well as all of the live loads on the entire bridge (new and existing parts of the bridge). In other words, the vertical load acting on the new parts of the pier structure include the dead load of the new superstructure, the live load of the trains on all three tracks as well as the dead load of the new parts of the pier structure itself. Only the main horizontal loads, being the braking forces on the existing bridge, are taken by the piers, since they are equipped with bearing systems allowing for longitudinal movements. The horizontal forces of the new track are thus redirected to the abutment. The dead load of the piers is diminished as much as possible by using neoprene blocks to fill up the between the separate columns of the existing pier.

The superstructure, being a steel caisson, is a very light structure when compared with the concrete box girder of the existing decks of the bridge. In the preferred design situation, the bridge would consist of a three span continuous superstructure with the length of the mid span equalling about two thirds of the total length of the bridge deck. As this is not the case in the existing parts of the bridge and due to the lightness of the superstructure of the new additional bridge deck, upwards acting reactions appear on the supports above the abutments. As a first part of the solution, some of the steel section of the bridge superstructure, such as the diaphragms and the transversal stiffeners were designed heavier, but this still was not sufficient enough to remedy this unbalance in the reactions resulting in a possible uplifting at the abutments. A final solution for this problem included installing a concrete layer in the steel caisson close to the abutments in order to create additional downforce to prevent uplifting.

3. Conclusion

The objective of a fully integrated design for this expansion of the old Bevrijdingslaan Bridge is achieved, functioning as a portal to the historical city of Bruges. The existing two track bridge is widened with a third track. This is realised by constructing a steel caisson adjacent to the existing bridge. The paper describes how the new bridge and the existing bridge are incorporated into a new structure.This paper also gives an overview of the design considerations of this particular bridge, taking into account the existing boundary conditions, and the corresponding solutions in the final design. The new bridge is almost completely separate from the existing bridge, although they share the same piers and are visually a monolithic construction. This mainly necessitates a strengthening of the existing pier foundations.