Strengthening fly-over Rottepolder junction with external post-tensioning

Hans (J.C.) GALJAARD
Strategic Specialist
Volker InfraDesign bv
Woerden, the Netherlands
hgaljaard@volkerinfradesign.nl

Hans Galjaard, born 1956, received his civil engineering degree from Delft University of Technology. Before joining Volker InfraDesign he worked at Delft University of Technology as Assistant Professor Concrete Structures.

Andrew QUANSAH
Senior Structural Engineer
Ingenieursbureau Amsterdam
Amsterdam, the Netherlands
aquansah@iba.amsterdam.nl

Andrew Quansah, born 1960, received his civil engineering degree from Delft University of Technology. Before joining Ingenieursbureau Amsterdam he worked as Civil Engineer at Movares B.V.

Summary

The fly-over at the highway crossing Rottepolderplein in the A9 consists of two parallel viaducts. Each of them was designed for 3 driving lanes, but both have been used for 2 lanes only since its construction in the late 1970's. Due to increasing traffic an additional third and (during maintenance of the bridge for the other driving direction) a fourth lane was required. The deck slab was wide enough and reassessment showed that the deck slab, as well as the box-girders had sufficient bending capacity for the intended use. The shear capacity of the box-girders however was insufficient for an additional lane. This was primarily due to changes in the principles with respect to the detailing of the shear reinforcement since the construction. External post-tensioning has been applied to reduce the shear forces in the webs of the box-girders enabling a third, and if necessary fourth, lane.

Keywords: Lightweight concrete, external post-tensioning, shear capacity.

1. Introduction

Fig. 1: Fly-over Rottepolderplein

In the late 1970's the fly-over at the highway crossing Rottepolderplein near Schiphol has been constructed in lightweight concrete using the incremental launching method as two separate box-girders, see Fig.1. The box-girders have 11 spans of 41 m and 2 spans of 30,5 m, giving a total length of 512 m. The width of each deck slab is 16,55 m, at the time of construction intended for 3 driving lanes. Since its construction however 2 lanes were in use.

Before a third driving lane and occasionally during maintenance of the other fly-over even a fourth driving lane could be allowed the capacity of the structure had to be checked according to current design standards. The only inadequacy found during this reassessment was the way the shear reinforcement in the webs was detailed, see Fig. 2. This web reinforcement consisted of prefabri-

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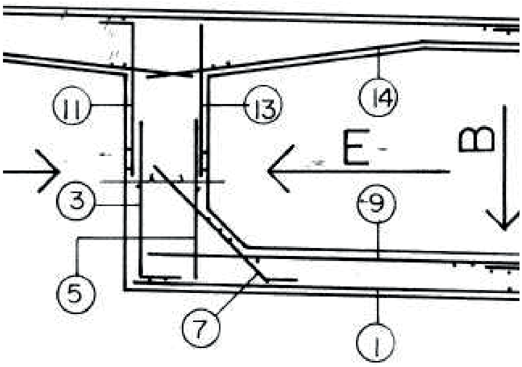

Fig. 2: Principal lay-out of existing reinforcement

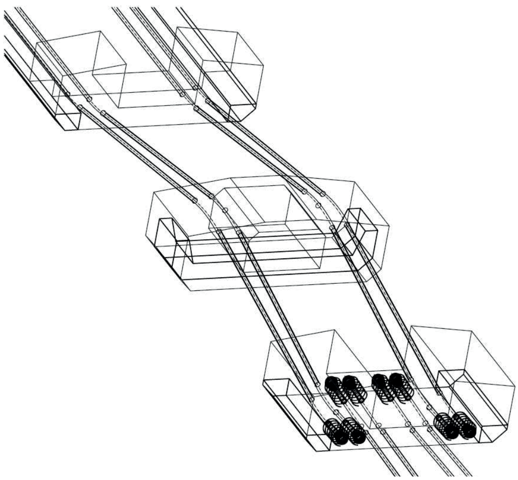

Fig. 3: Schematic lay-out of external post-tensioning

cated meshes of vertical and horizontal reinforcement which simply ended as straight bars in top and bottom flange without a proper anchoring of reinforcement in the compression zone of the flange (see especially bars 5, and 13 in Fig. 2).

This detailing makes it questionable if sufficient connection between compressive struts and vertical reinforcement in the webs is available. The guidelines of Rijkswaterstaat (Ministry of Transportation) for the recalculation of existing structures do not allow utilising more than 50% of the capacity of shear reinforcement lacking proper anchoring. Consequently shear capacity in the longitudinal direction was insufficient and the box-girders must be strengthened in this direction. This was done by external post-tensioning inside the box-girders primarily aimed at reduction of the shear-force in the webs. The external tendons were positioned in between the existing corbels in the box-girder. For load transfer of the tendon reaction forces additional concrete diaphragms inside the box-girder were installed.

To prevent excessive frictional losses it is not desired to have continuous tendons over the full length of the box-girder of 512 m. Intermediate anchors should also be installed in some of the diaphragms. Due to the limited accessibility moving the heavy post-tensioning jacks from one diaphragm to another should be avoided as much as possible. This effected the way tendons were lapped. Over the length of the box girder 4 Dywidag tendons with 19 strands dia. 15,7 mm are installed. In total 4 diaphragm types are necessary: end diaphragms in the first and last span, diaphragms at the supports, mid-span diaphragms where tendons are lapped (comparable to the end diaphragms), and ordinary mid-span diaphragms. FE calculations have been made to determine the forces and force distributions in the diaphragms and adjacent sections of the box-girder. Basically the diaphragms have been designed in such a way that the loads from the post-tensioning tendons are transferred to the box-girder with only a minimal increase of local bending forces in the original box-girder. All diaphragms have been designed in C35/45 self-compacting concrete.

The capacity of the glued-in anchors for the fastening of the diaphragms was calculated based on the measured strength of the (lightweight) concrete. To prevent conflicts of the glued-in anchors with the location of the well documented internal tendons the position of some of them were verified by carefully removing the concrete on top of the tendons.

After removal of the formwork HDPE ducts dia. 109/125 mm were installed between the steel tubes extending from the diaphragms. After installation of the strands these were stressed to the required level. Finally the post-tensioning ducts were filled with a cement grout.