REPLACEMENT OF AN OLD STEEL RAILWAY OVERPASS WITHOUT TRAFFIC INTERRUPTION

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Abstract

As part of the Reconstruction and Modernisation of Road I-8 Project in Bulgaria, demolition of an existing single-track steel railway overpass with a span of about 46.5 m and its replacement with a double track bridge designed in accordance with the Eurocodes is planned. As the road and railway traffic cannot be interrupted, it is necessary to temporarily shift the railway line and build a new temporary railway bridge, as well as to change the route of the I-8 in the construction site several times. The report presents information about the different stages of construction: construction and testing of the temporary bridge, removal of the existing steel bridge weighing about 180 tons and construction of the new bridge facility.

Keywords: demolition of old bridges, railway bridges, Eurocodes

1 Introduction

The national railroad network in Bulgaria features a number of old riveted steel bridges, which were built at the end of the 19th and at the beginning of the 20th century. Although these bridges have been in operation for over 100 years, thanks to uninterrupted management and maintenance by the Bulgarian National Railway Infrastructure Company, they are still in good condition from a structural point of view. However, these facilities do not meet the current operational requirements as they have an open superstructure (without a ballast bed) and cannot ensure the operation of high-speed trains. Additionally, in Bulgaria there are no special regulations on structural condition assessment of existing bridges [1, 2].

In the last 15 years a lot of old railway bridges have been replaced with new structures. In general, new bridges comprise a reinforced concrete superstructure in line with the preferences of the owner of the Bulgarian Railway Network. Steel railway bridges are built very rarely – when there is no clearance under the bridge or in case of a skew bridge.

As a part of the Project Modernisation of Road I-8 (E 80) Kalotina – Sofia Ring Road from km 1+000 to km 15+500 it was necessary to design a grade-separated crossing with the main Bulgarian Railway Line 1 Kalotina – Svilengrad. The current crossing consists of a riveted steel railway bridge with a span of 46.5 m over a two-lane road. Due to the widening of the road, it was necessary to find a solution for accommodating a new carriageway. An additional difficulty was the river that flows parallel to the road. The preliminary design provided for a new road trestle passing over the railway with a total length of about 960 m. This design envisaged the left carriageway of the E 80 Road to be located on the first level, the existing railway bridge - on the second level and the new (right) carriageway - on the third level. The trestle consisted of 36 spans with a length 26m each. The superstructure design consisted of nine simply supported prestressed beams with a height of 115 cm and a cast-in-situ slab with a thickness of 20 cm (Figure 1).

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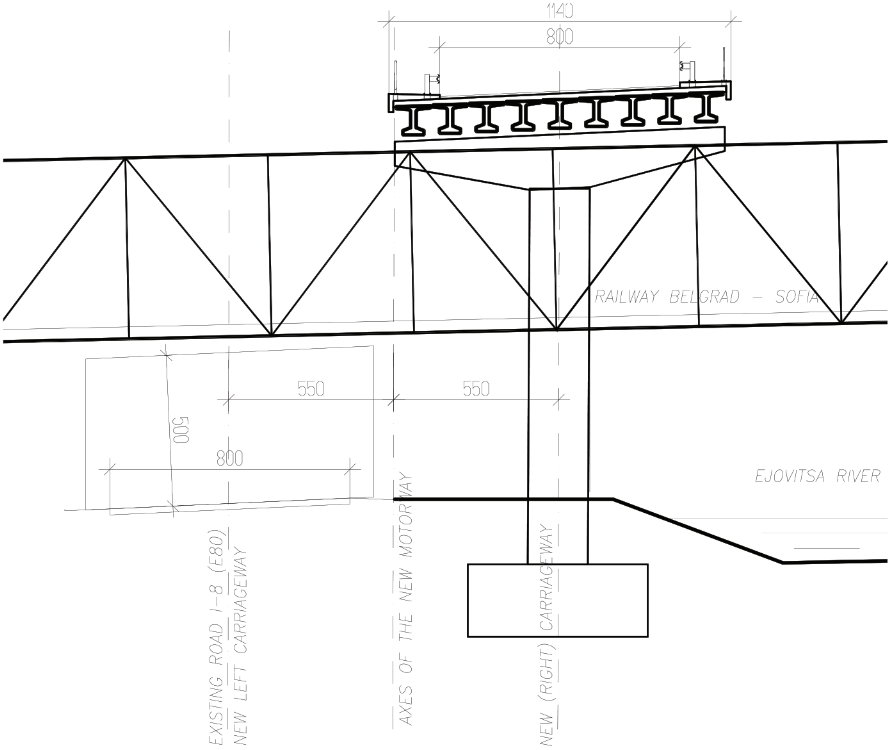

Figure 1 Preliminary design with a new trestle over the railway track – cross section of Road I-8 (E 80)

The main advantage of this option was preserving the existing railway bridge and not disrupting railway traffic during the entire construction period. The disadvantages were the huge length of the new bridge and its position above the river. Almost two thirds of the pier foundations were situated on the riverbed.

A new design option was submitted during the design process – destroying the existing steel railway bridge and building a new two-span structure spanning over the two carriageways of the road located on the first level. This presented two additional challenges - to ensure uninterrupted railway traffic and to provide an additional carriageway above the river. Solving the first challenge necessitated a temporary railway bridge and a local shifting of the railroad track during the construction of the new bridge. The second problem was eliminated with a correction of the riverbed and designing an RC box channel with a length of about 400 m.

2 Stage one – construction of a temporary railroad track by means of a temporary overpass

During the first stage, a temporary local shifting of the railroad track to a new temporary railway overpass was constructed. The track is situated in a horizontal curve with a radius of 190 m and no reusable facility could be used [3] so a new temporary bridge had to be designed and constructed.

The bridge is two-span (2*8.70m) with a simply supported open steel structure. The two main beams are hot-rolled HE600B (Figure 2). There are four cross beams with the same cross section in each span. The bracing system comprises three additional cross beams with a smaller cross section.

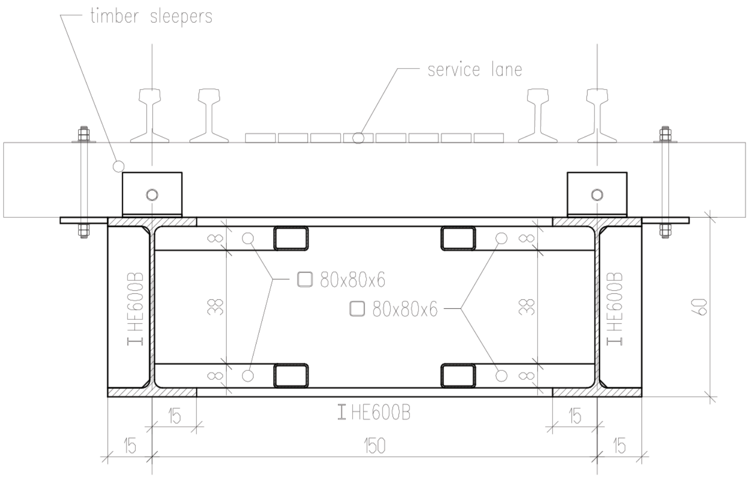

Figure 2 Cross section of the new temporary railway bridge

Elastomeric laminated bearings 200/300/45 were used. These were connected to the substructure and to the steel beams with polymeric glue.
Because of the short exploitation period (about a year) the temporary bridge was designed according to the requirements of the Bulgarian National Rail Infrastructure Company concerning temporary spanning. The heaviest real traffic loads were applied – single-axis loading of 23 tons and six-axes loading of of 19.4 tons at each axis (by means of a Series 06 diesel railway engine) [3] (Figure 3). The two superstructures were preassembled and transported as single units weighing 6.6 tons each (Figure 4).

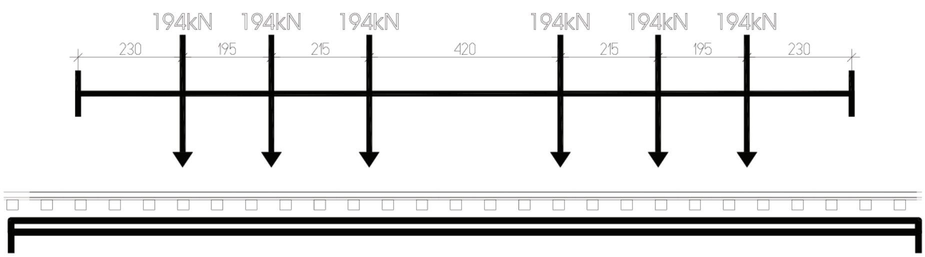

Figure 3 Serie 06 diesel engine– axes loads

Figure 4 New temporary RW bridge – general view with the old riveted bridge in the background

After completing the construction works and before putting the bridge in operation, the temporary bridge was tested with static loading. A dynamic test was not required due the very low permissible speed – 30 km/h. A loaded hopper doser with a total weight of 64.1 t was used as a loading device (Figure 5).
Two load cases were tested - one for each span. According to the approved method statement for the test, the deflections of both superstructures were measured with dial indicators (deflectometers). Additionally, the normal stresses in one cross section in the middle of the span were determined for one of the beams through measuring the relative deformations in the bottom flange, in the middle of the web and in the upper flange.
Due to the simple bridge structure and the precise 3D FEM used in preparation of the method statement, all the measured parameters – deflections and normal stresses - are very close to, but still smaller than the relevant theoretical values.

Figure 5 Static load test of the temporary railway bridge

3 Second stage – demolition of the old bridge

The old bridge had riveted steel superstructures. It was built in 1923 by Bruckenbau Flender AG. The main longitudinal elements were two simply supported trusses with a span of 46.48 m and a height of 6.20 m.
After putting into operation of the new temporary track, preparation for demolishing the old bridge started immediately. The first step was to excavate the embankment behind the Sofia side abutment and to construct a temporary road there (Figure 6).
After moving the road traffic along the temporary road section, the dismantling of the rails and the timber sleepers, railings and pedestrian platforms began. Due to the huge weight of the bridge and the lack of enough space for positioning a large crane it was necessary to divide the superstructure into three parts using eight temporary supports (heavy-duty towers)–four for each main truss. These supports were designed to carry the self-weight of the structures and the additional wind action. After the temporary supports were assembled, all structural elements that carried only traffic loads – the longitudinal beams and the nosing bracings were dismantled. In order to ensure the spatial stability of the three parts of the superstructure, some additional steel elements were provided. After that the steel trusses were separated and lowered onto ground level (Figure 7).

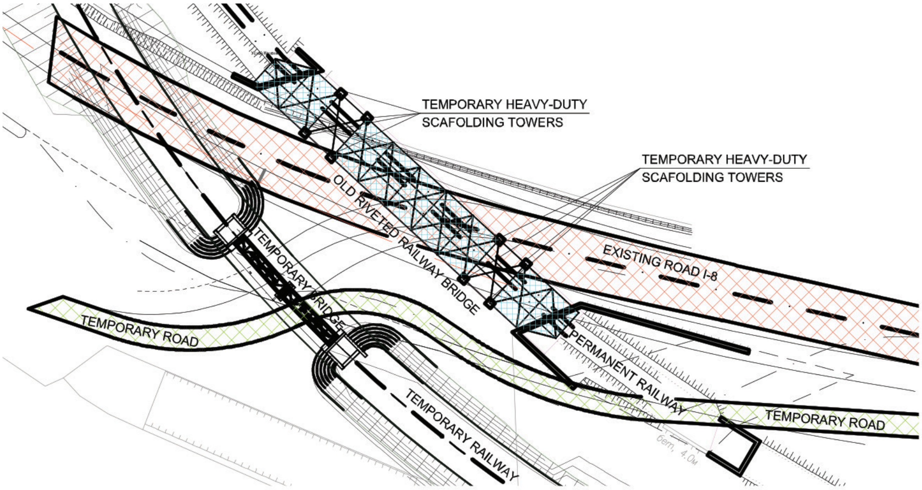

Figure 6 The temporary road during the dismantling of the old bridge – general layout

Figure 7 The middle part of the steel superstructure of the old bridge is lowered with two cranes

4 Third stage – construction of the new permanent bridge

At the preliminary design stage a couple of options for the structure of the new bridge were investigated. Due to the skew railway bridge, the limitation of the vertical clearance and the requirements to provide a double track overpass, a two-span tunnel-type frame structure (2*11.85 m) was decided on. In plan view, the two parts of the structure spanning the two carriageways of the road have a length of about 50 m each and they are shifted along the railway track axis at about 30 m (Figure 8). The bridge deck has a total depth of 90 cm. In order to avoid the need for scaffolding during construction and thus to ensure uninterrupted traffic on the I-8, the deck consists of pre-cast RC elements with a thickness of 60 cm and a cast-in-situ slab with a thickness of 30 cm. The abutments are solid walls with a thickness of 80 cm. To provide better visibility to drivers on the road, the middle bridge support is a line of columns with rectangular cross section. The foundation was designed with end bearing piles with a diameter of 100 cm and lengths between 10 and 13 meters (a total of 76 piles) supported at moderately weathered marls.

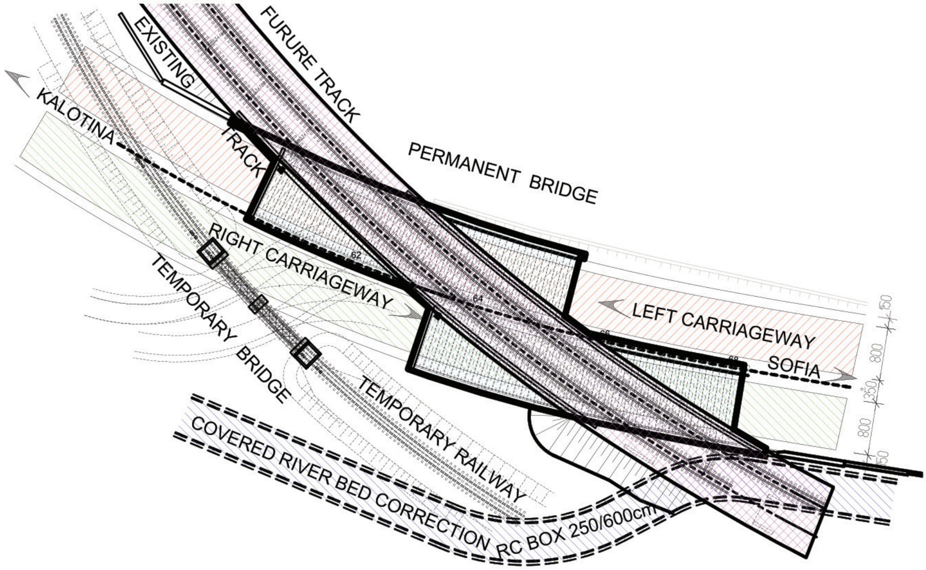

Figure 8 General layout of the temporary and the permanent bridge

The permanent railway bridge was designed in full compliance with the Eurocodes. All RC structural elements were designed in accordance with [4]. In addition to all permanent and traffic actions (Load models LM 71, SW/0 and SW/2), the bridge was designed for seismic action with ag = 0.11g, a ductility factor q = 1.5 and an importance factor YI = 1.4 [5].
During the entire construction process, the road traffic was only suspended for several brief periods of a few minutes while the RC panels were mounted. At the time of the writing of this paper the bridge structure has almost been completed. The deadline for putting the permanent railway bridge into operation is at the end of April 2022.

Figure 9 The structure of the new railway bridge is almost completed

5 Conclusion

Rehabilitation and reconstruction of existing roads and railways almost always causes difficulties with traffic organisation during the construction period. One of the main challenges is to provide minimal traffic disruptions. This is true to the greatest extent when replacement of existing bridges is designed. Two different approaches for designing this complicated crossing of a main road and a main railway line in Bulgaria are shown:

- Building a new road trestle with a total area of about 11, 000 sq.m. without disrupting the railroad traffic but with significant expected difficulties when constructing the new track;
- Replacing the old riveted bridge with a new bridge with a total area of about 1, 200 sq.m. - almost 9 times less that the area of the road trestle. The new bridge provides a double-track railroad. The complicated temporary traffic organisation and the necessity for building a temporary overpass were the largest drawbacks of the adopted design option but the future doubling of the railway track will be conflict-free and without any disruptions to the rail traffic in the area.

References

[1] Topurova, I., Geissler, K., Grasse W.: Prinzipien zur Beurteilung bestehender stählerner Brücken, International Scientific Conference, Sofia, 2006.

[2] Topurova, I.: Tragfähigkeits- und Restnutzungsdaueranalyse stählerner Straßenbrücken unter detaillierter Berücksichtigung der Verkehrsbeanspruchung, Diss. TU Berlin, Shaker Verlag, Aachen, 2015.

[3] Uzunov, A.: Operation and maintenance problems of steel bridges operated by the Bulgarian State Railways, Part 3 - Operation and maintenance procedures, Sofia, 2004.

[4] BDS EN 1992 – 2 Design of reinforced concrete structures - Part 2: Bridges

[5] BDS EN 1998 – 2 Design of structures for earthquake resistance - Part 2: Bridges