Construction and design features of the Bridge over the Danube River. Bulgaria

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keywords: precast concrete extradosed bridge, continuous bridge, railway and road bridge.

Summary

The main bridge over the Danube River between Vidin (Bulgaria) and Calafat (Calafat) has a total length of 1391 m. It has three different decks depending on the span lengths. The road bridge has a 80 m deck for the non-navigable part of the river and a 180 m deck for the navigable one, thus allowing two navigable channels of 150 m. The railway has 40 m span lengths with intermediate supports at one fourth over the road bridge on the 80 m spans. The span distribution is: 52.0 + 7x80.0 + 124.0 + 3x180.0 + 115.0 m. Expansion joints are included only in the three abutments, thus configuring an integral bridge of 1791 m.

The deck is a precast prestressed concrete single box girder with transversal struts, with a total width of 31.35 m and a depth of 4.50 m. In order to maintain the same deck all along the main bridge, an extradosed cable system and struts to reduce its overtensions are added for the 180 m long spans. The approach railway deck is 8.6 m wide, made of two lateral prestressed concrete girders 1.9 m deep joined by a 0.25 m slab.

The bridge deck was built by free cantilever system with matched precast segments in the central core of the section.

1. Introduction

For the design and construction of the bridge over the Danube River in Vidin some innovative aspects have been taken into account. Both the design of the bridge and the construction procedure have been considered in a unified way. The design and build contract allows this relationship in a proper way. The coordinated alignment design for the railway and railroad allows the construction of a unique bridge deck.

The same deck depth has been used for different span lengths across the Danube River using additional structural schemes like an extradosed cable stayed system. The intermediate struts reduce the stress variation on the stays due to the important live loads from the railway. The structural alternative to these struts would have been an increase of the deck depth at supports.

The deck is completely built in on these struts resulting an integral configuration of the bridge which allows resisting the horizontal forces due to braking and seismic loads on the main pier foundations. This also minimizes the number of joints in the bridge, designing a bridge with 1791 m without expansion joints; only three are included in each abutment.

The bridge deck has had an evolutional construction both longitudinally by balanced cantilever construction and transversely. The main core of the box girder has been completely precast. The lateral cantilevers have been cast in place for the 80 m span deck and partially on the construction yard for the 180 m span deck.

Figure 1. View of the bridge over the Danube river between Vidin and Calafat

2. Main River Danube Bridge

The main bridge over the Danube River has a total length of 1391 m. It has three different decks depending on the span lengths. The road bridge has 80 and 180 m span lengths, the railway has 40 m span lengths with intermediate supports at one fourth over the road bridge on the 80 m spans. The span distribution is: 52.0 + 7x80.0 + 124.0 + 3x180.0 + 115.0 m. The deck is a single box girder with transversal struts made of prestressed concrete. The box girder has a depth of 4.50 m all along the bridge, and a total width of 31.35 m.

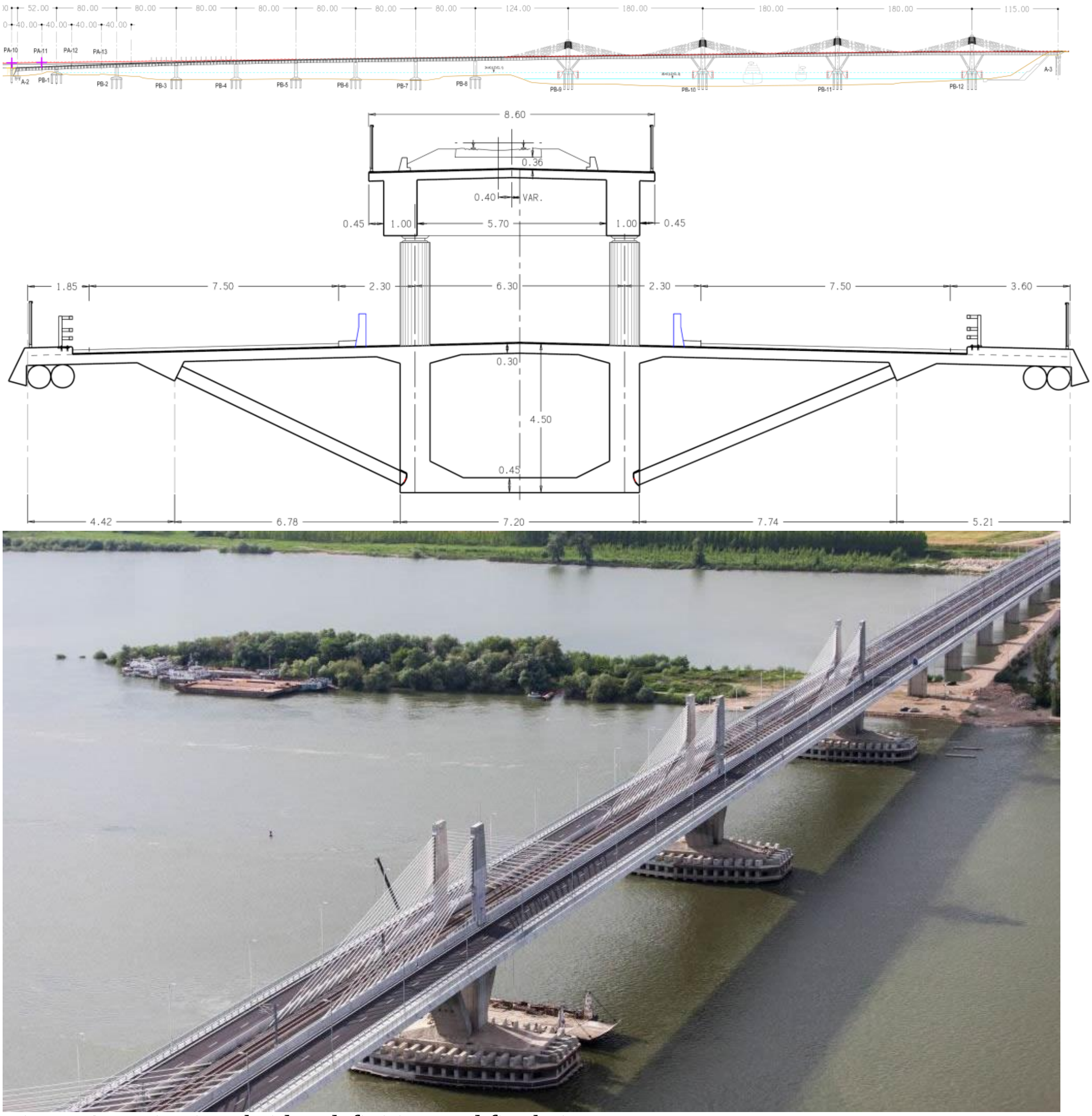

Figure 2. Main river bridge definition and final view

The girder lower slab thickness varies from 0.45 m to 0.75 m. The webs have an initial thickness of 0.50 m which increases to 1.30 m over the supports. Considering this significant web thickness, no diaphragm is included over the piers in a second stage, greatly simplifying the construction of the deck. In order to achieve that, the bearing axes have to be as close as possible to the web axes. Thus, small spherical bearings have been designed, locating them close to the outer face of the pier, and separating the transversal guide from the axial bearings.

To complete the cross section, there are two families of slanted struts which create two intermediate supports to the upper slab. The transversal struts are located every 4.30 m in the 80 m spans and every 4.186 m in the 180 m spans.

The construction of the decks has been done through a balanced cantilever system with precast segments. The matched precast segments have been the main core of the box girder. The rest of the cross section has been cast in situ with a special form traveller in the 80 m deck, and partially in the yard for the 180 m deck.

The 80 m span deck has been built by free cantilever system with a gantry girder. The precast segments are 2.15 m long, with a maximum weight of 1000 kN. The 180 m span decks has been built by free cantilever system with the extradosed stays and lifting the segments from the river. The precast segments are 4.186 m long, with a maximum weight of 2500 kN.

Figure 3. Construction of the main river bridge, both 80 m and 180 m deck

3. 180 m bridge piers and foundations

The piers PB9 to PB12 are for the 180 m span deck. They support the deck and the pylons for the extradosed cable system. The pier under the deck is a single box girder 9.70 m wide and a variable dimension longitudinally, from 4.90 to 5.40 m, with walls 1.00 to 1.20 m thick. The pylons above the deck level are two rectangular sections 1.20 m wide and variable dimension longitudinally, from

4.50 to 4.90 m. The total height varies from 38.7 to 44.8 m. From the foundation a pair of concrete struts connects the deck to the foundation 14.70 m apart the support axis. Piers PB9 to PB12 are founded over 24 concrete bored piles of diameter 2.0 m, with a pile cap 15.0 m long, 40.0 wide and 6.0 m deep. The four combined Piers PB9 to PB12 have a very important strength against longitudinal horizontal forces due to friction on the pot bearings under service conditions or seismic forces and ship impact forces under accidental conditions. Thus, the main river bridge abutments do not support any longitudinal forces from the bridge but the bearing friction ones, so they do not present any special feature.

In order to provide protection against ship impacts, a new type of prestressed grillage has been designed, combining precast vertical pieces which have holes to join with longitudinal horizontal beams which give continuity between the precast pieces. These latter ones are cast in situ. The protection of the pile caps is located above the maximum water river level under emergency situation, 36.60 m, and the mimimum level, 25.50 m. The foundations have been verified to resist the vessel and barges impact forces according the design basis and the Eurocode-1 Part 7.

Figure 4. 180 m main river bridge foundations and ship impact protections

4. Approach Structures on the Bulgarian side

The approach structure to the main bridge over the Danube has a total length of 400 m. The span distribution is: 32.0 + 9x40.0 + 8m. It is a railway bridge which crosses above the road carriageways on embankment. The deck is a twin girder with transversal slab made of prestressed concrete. The girders are rectangular solid sections which have a depth of 1.90 m and a width of 1.0 m. The slab is 0.25 m thick.

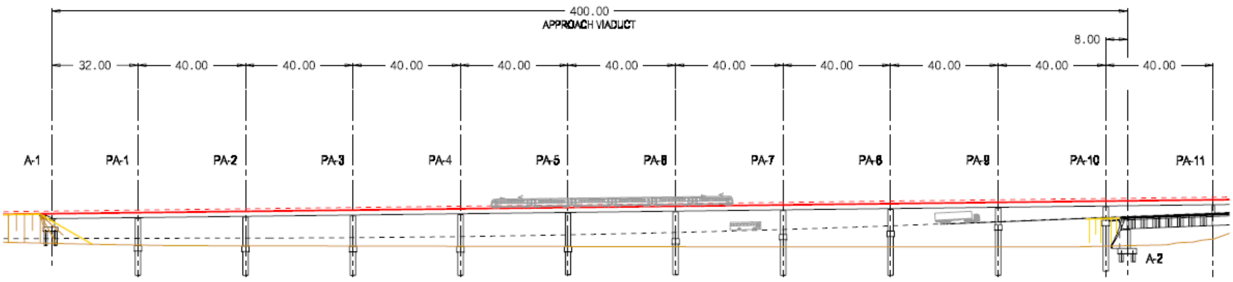

Figure 5. Elevation and final view of the 40 m railway approach bridge

All the bearings from the railway bridge are elastomeric ones, free in the longitudinal direction and guided in the transversal one. Its dimensions rank from 600 x 700 x 160 mm in pier pA1 to 1550 x 1000 x 400 in pier pA10. Such a bearings are used to highly reduce the seismic forces, using both legs of the piers to resist lateral forces.

5. Conclusions

The second bridge over the 600 km Danube border between Bulgaria and Romania has been finished including the following features:

- One unique bridge for railway and road, improving its aesthetical view and minimizing its costs.
- Integral bridge, with a 1791 m continuous deck and only three expansion joints in the abutments.
- Concrete precast bridge, trying to minimize construction time and using the significant experience of the contractor with this kind of bridges, studying thoroughly all the connections between precast and cast in situ parts to ease its construction and reassure its performance.