Construction of prestressed structure above Kupa and Dobra Rivers on the Zagreb – Rijeka Motorway

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Summary

On the Zagreb-Rijeka Motorway it was necessary to construct several bigger bridges, two of which across rivers. The Viaduct Drežnik (2485 m long) across the Kupa river and the Dobra Bridge (550m long) across the Dobra river have generally spans of 35 m. Only by bridging river beds it was necessary to insert a double span length (70 m), and that imposes partial modification of the construction method. The bridges have similar deck structures, consisting of precast prestressed concrete girders with cast – in – situ deck slab. Full continuity above the supports is envisaged with non – prestressed reinforcement above all supports, except for those at the river banks, and with partial prestressing – above the river bank supports. The structure above the river bed will be described here in more detail and with main characteristics:

- The use of continuos precast longitudinal girders for the main span (70m)
- The use of construction sequence on the site
- the analysis of the main structural elements

Keywords: precast girders, 70 m span, river crossing, full continuity, construction sequence

1. Introduction

On the Zagreb – Rijeka Motorway it was necessary to construct several bigger bridges two of which across rivers. The Viaduct Drežnik (2485 m long) across the Kupa river and the Dobra bridge (550 m long) are made mostly of spans that are 35 m long. At rivers crossings it was necessary to insert spans of double length (70 m), and that imposed partially modified construction method. Except this river crossings there are no obstacles that impose adopting markedly bigger span lengths and special construction methods, it seamed reasonable to envisage deck structures made of precast girders with deck slabs cast-in-situ. Full continuity of deck structure was envisaged and by non prestressed reinforcement above all supports. except those beside the biggest span length which was prestressed. Road level above the ground is such that the highest piers are not more t hat 20 m high, so span lengths of about 30 m (and even less) would meet aesthetic requirements. However, the soil is such that deep foundation is necessary, and therefore the span length was chosen somewhat bigger. Other obstacles as railway and local roads, impose some restraint on span lengths or on their layout. The span length is, otherwise, determined by precast girders self weight.

2. Bridges Bearing Structure

2.1. Superstructure

The superstructure consists of precast presstresed concrete I-shaped girders, cross girders and deck slab cast-in-situ. Longitudinal girders are 1.82 m high, with exception of part over the river where the girders have parabolic haunches reaching 4.0 m at supports. This parts over the river are also precast girders and, when laid on the piers, they from symetrical cantilivers 17.0 m in length on each side. Axe to axe distance between girders is 2.57 m and on conjunctions it is 2.668 m. On Drežnik viaduct girder flanges are 1.46 m wide and part between them were supported by movable formwork during concreting (Fig. 1a).

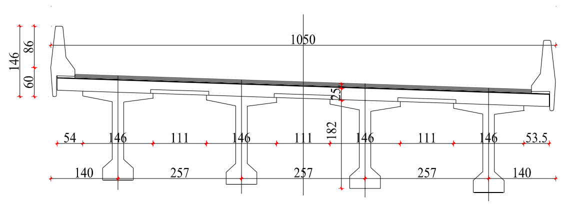

Fig. 1a. Drežnik viaduct cross-section

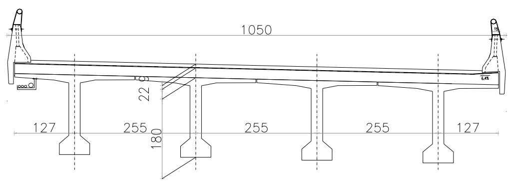

Fig. 1b. Dobra bridge cross-section

Girders on Dobra bridge have flanges which are intentionally wide (2.53 m) to simplify the deck slab formwork (Fig. 1b). In order to bring about composite action on precast girders and deck slab, steel bars projection from girder flanges up to the top reinforcement of the slab were left. Along the borders of the outer longitudinal girders the deck has variable overhangs, because the bridge is curved in plan (Fig. 3.). These overhangs were constructed on suspended formwork. The deck slab depth is 0.25 m, which satisfies most severe durability requirements. Cross beams are of rectangular section, 1.5 m wide.

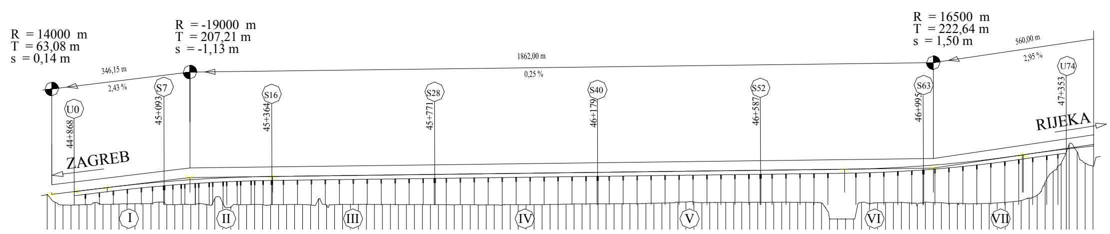

Fig. 2. Longitudinal profile of Dreznik Viaduct

Their top merges into the deck slab, which has haunches at the joint with them, and their bottom is 0.3 m below the bottom of the longitudinal girders. This enables faultless concreting of the connection between longitudinal girders and cross section. The distance between the bearings ensures favourable distribution of bending moments along the crosss beam, so that span moments are appromximately equal to those above supports. The longitudinal girders protrude into the cross beam by 0.35 m on average, and the space between the longitudinal girders is roomy enough so as to enable of transversal and suspension reinforcement (for partial suspension of the longitudinal girders).

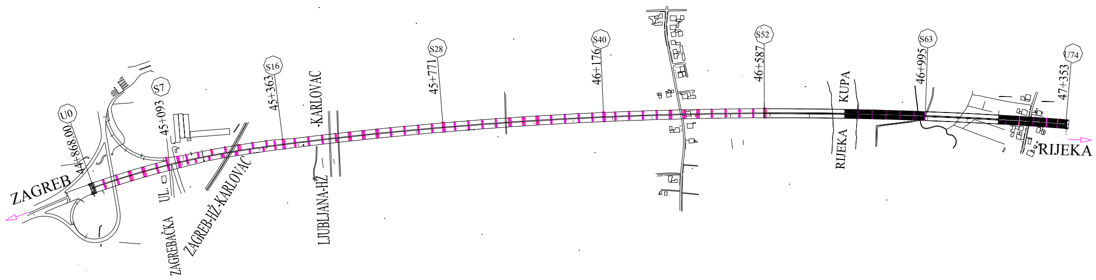

Fig. 3. Layout plan of Dreznik Viaduct

2.2. Substructure

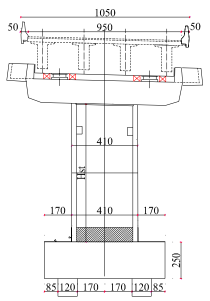

Fig. 4. Characteristical pier shape

Single, hammer shaped piers were constructed. Cross-section of piers was determined on the basis of statical and aesthetical considerations but also bearing in mind the simplicity of construction. Hammer shaped pier caps serve not only as permanent supports to longitudinal girders but also as temporary support for longitudinal girder mounting (Fig. 4).

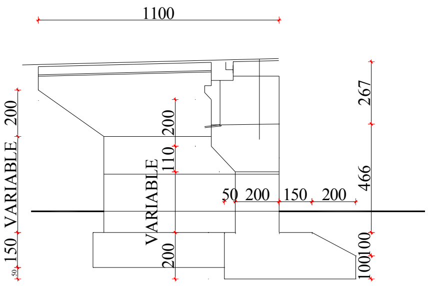

Fig. 5. Abutment side wiev

The abutments of both bridges are horse-shoe shaped. They have a massive bearing wall, with slightly corbelled breast wall. The wing walls are fixed in connection with bearing wall and partly supported with step like footings(Fig. 5). Bridges are founded on piles with exception of abutments and first two piers on Rijeka side are founded on flat foundations.

2.3. River crossing construction sequences

Dreznik viaduct and Dobra bridge structures differ only at crossing of rivers because Dobra bridge has shifted display of piers due to skew crossing over river Dobra. Therefore only Dreznik viaduct (fig. 6.) construction will be shown here

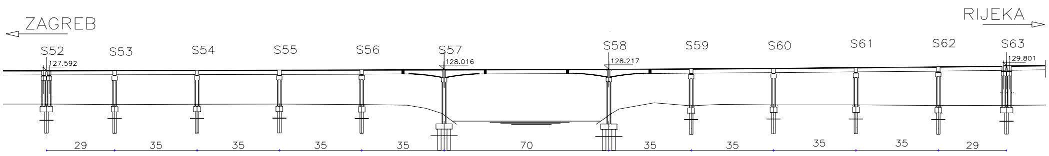

Fig. 6. Longitudinal section of Dreznik viaduct

Part of the structure at river crossing differs a lot from the other parts. Piers at river banks and pile cap dimensions are bigger. Number of piles is increased (from 4 to 6). Pile cap is positioned above water level so complicated ground hole protection could be avoided. For protecting the piers most sensitive part it was filled with fill concrete up to the level of 6 m. Pier cap at the top of the pier was constructed in two phases due to construction of main span over the river. Girders at main span have alternating hight. They are concreted at ground level and than mounted to the pier. There they were connected by two Dywidag bars to the pier cap. After all four girders were mounted, deck slab and compression slab at the bottom of girders parabolic haunches were constructed (Fig. 7).

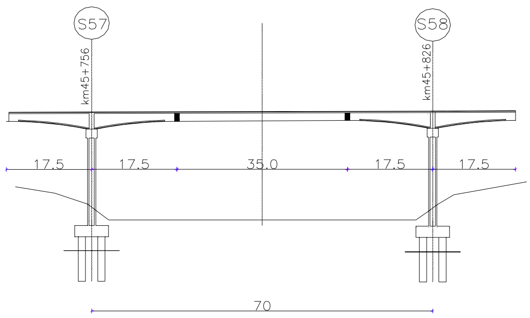

Fig. 7. Longitudinal section of the river crossing

Fig. 8. Girder erection from river

After all four riverbank pier positions were completed, regular girders 35 m long were implanted from river between existing supports (Fig. 8). Girder mounting was done by two car-cranes. Since girder depot is out of reach of car-crane handle, girders had to be transported to the position for lifting. This was done by two heavy trucks. One girder end was then taken by first car-crane and was transfered to the ponton-bridge on the river. For that purpose ponton bridge consisting of three parts was fixed to four foundatons specially constructed for that purpose. To enable equal transfer of loads along the the ponton bridge specially constructed steel girders were put on it (Fig. 9). Special turning pedestal was put on potvon bridge girders, to enable rotation of girder when supported on it. It enables rotation if both vertical and horizontal plane. Girder is fixed to the pedestal during transport over the river. To ensure ponton bridges traveling in designated direction steel wires were placed for moving of the bridge. Before middle span girder erection, side cross girders were constructed to ensure structure stiffness. The problem here was transporting car cranes accros the bridge which was at that time being constructed.

Fig. 9. Ponton bridge

Fig. 10. Temporary support

Car-crane position depends on girders self weight, hight they have to lift the girders and possible obstacles that are in front of girders while mounting. Girder weight is G=750 kN while approximate height to which it is lifted is h=22,0 m. When the girders are lifted and positioned they are supported by temporary steel supports shown at Figure 10. Each girder has separate support. At this point cross girders in middle span across the river was constructed. This was the moment in which structure was connected and started acting as continuous system.

Each girder across river was prestressed with two tendons. This was sufficient to bear girder self weight. When girders were lifted two continuous tendons 140 m long were prestressed. These tendons insured longitudinal connection of structural parts in cross river span. The tendons were drawn in girders through holes left in deck slab. After construction of wet joints deck slab over the river span could be constructed. Totally completed river crossing is shown on Figure 11.

Fig. 11. Complete river crossing view

3. Conclusion

The part of the structure above the river is presented here in more detail, because all the works on this part of the bridges, apart from works which have to be done on other bridge sections, which do not appear elsewhere (continuity tendons, bottom compression slab, tendons in deck slab etc.). The infrastructure had to be executed in the usual way, but this didn't apply totally to the foundations. As mentioned before viaduct is founded mostly on piles with pile-cap on top except for two piers at the end of the viaduct and abutments. Construction of Dreznik Viaduct and Dobra Bridge was done in most standard way. Therefore contractor was able to use most standard equipment. The span construction of which is being presented here is not a specially long span (70 m) but its length is not the main issue here. There are different ways of constructing this kind of spans. The way of construction presented here is in its largest parts construction with precast elements. Therefore contractor was not obligated to buy new and non-standard equipment which lowered costs of construction. A lot of preparatory work and design calculations were to be done to complete construction of such a demanding part of structure. This and similar situations show how interaction between designers and contractors on the field should be conducted.