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Title	**Incremental Launching of Bridge over the Sava River at Sremska Raca**
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Abstract

The bridge over Sava River on the highway Kuzmin - Sremska Raca (Serbia), designed by Institute of Transportation CIP, consists of two neighbour bridge structures; each has ~15m wide deck with 2 traffic lanes. The main bridge across Sava River, 330m length, having spans 90+150+90m, consists of 2 steel box beams with 5m constant depth. The trapezoidal single-cell box section, with both-sided cantilevers, has upper flange consisting orthotropic plate. Entire bridge steel structure (5500t) was fabricated in Doka Endustri factory in Turkiye. Two box beams were divided in 23 blocks each, consisting of 7 segments per block. The 21 blocks (15m length, 100-174t weight) and 2 blocks (7,5m length) were assembled at site. Afterwards, the blocks linked together by welding on the concrete platform, were protected for corrosion protection and prepared for the incremental launching.

Applying an incremental launching method (ILM) with temporary steel pier in the river and hydraulic systems, the assembled successive sections of 2x15 meters long steel deck were launched into their final positions. The launching was carried out using cables and hydraulic pulling jacks installed on the pier in the river for pulling the bridge structure. The bridge structure was launched over sliding bearings with PTFE-stainless steel devices. The 13 stages of incremental launching process, designed by METALYAPI and DELING, was performed by METALYAPI.

Main Contractor: Tasyapi - Turkiye. Supervision: Institute for Roads / Project Biro Utiber / IMS Institute – Serbia. Client: Public Enterprise Roads of Serbia.

Keywords: steel box beam bridge, incremental launching, sliding bearings, pulling equipment

1 Introduction

The bridge over the Sava River near Sremska Raca is located on the highway Kuzmin - Sremska Raca, which is part of the future Belgrade-Sarajevo highway. It is located at the place where the highway crosses the Sava River on the border between Serbia and Bosnia and Herzegovina. Total length of the bridge is 1312m, whereby the central part of the bridge is the main steel bridge. The structural system of the main bridge is a continuous girder of box trapezoidal cross-section, with total length of L=90.0+150.0+90.0 =330m. Two separate identical bridge structures, at center distance of 16,25m, are designed [2] for each lane of the highway.

2 Bridge Structure

The overall carriageway width in a single bridge structure is 11.50m. Together with safety guardrails and handrails, the single bridge is 14.75m wide, while the total width of the entire bridge structure amounts B=14.75+1.50+14.75=31.0m. The main girder is a single-cell box structure of the trapezoidal cross-section with a constant depth of 5000mm, where the inclined webs are at a distance of 8377mm (level of the upper flange) and at the distance of 6707mm (level of the bottom flange).

Main bridge steel structure has a total length of 330m and weight of around 2700t. It consists of 21 prefabricated pieces length of 15m and two 8,25m (first and last segment). The steelwork was prefabricated and transported to the site in sections of up to 15m long weighing up to 170t. In one stage 30m of structure was to be assembled on assembly area and after that, launched in one day. New segments were to be added after launching.

The carriageway deck of the box girder is designed as a standard orthotropic plate, with trapezoidal longitudinal stiffeners. The box bottom plate has a thickness that varies from 20mm to 45mm. The stability of the bottom plates is provided by trapezoidal longitudinal stiffeners. The webs of the box are of variable thickness, from 14mm to 20mm and 30mm in the zone of intermediate supports, and they are stiffened by L shaped longitudinal stiffeners.

The cross girders of the orthotropic deck plate together with vertical web stiffeners and transverse stiffeners of the bottom flange form rigid frames spaced at 3.0m apart. The additional cross stiffeners (diagonal bracings) of tubular cross sections are placed at every second cross girder (every 6.0m). At supports transversal frames are transformed in solid diaphragms with stiffeners.

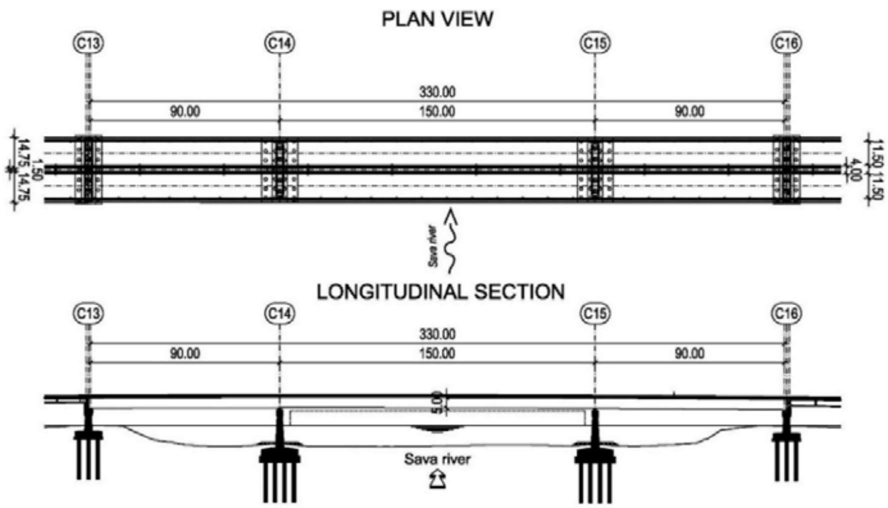

Figure 1: Sava Bridge Layout

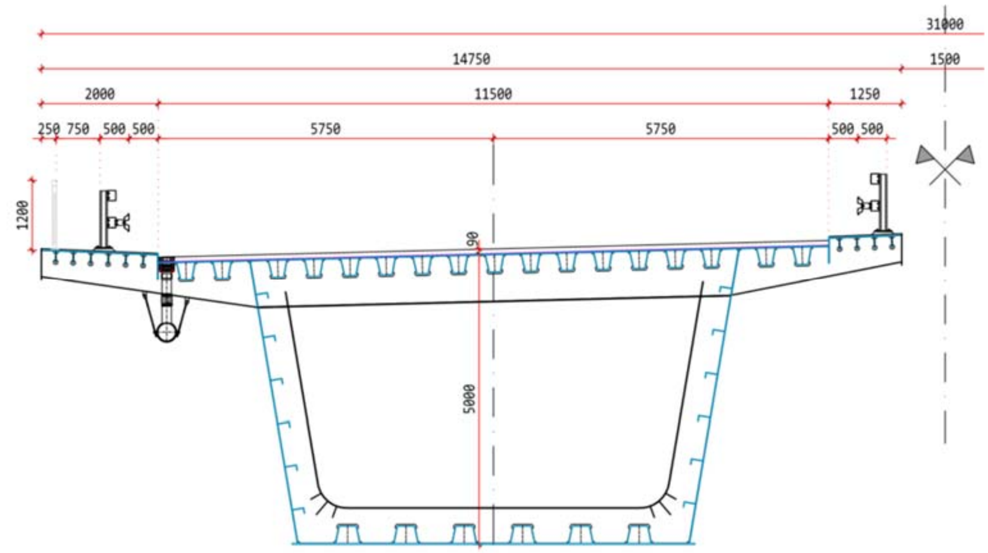

Figure 2: Sava Bridge Cross-Section

In one stage 30m of structure was to be assembled on assembly area and after that, launched in one day. New segments were to be added after launching.

Loading during the launching was determined by construction stage analysis using SOFISTIK software. Therefore, an increasing the web thickness was not an option, additional vertical stiffeners are added, which were not required for the final in-service conditions.

During bridge launching, the static system was changing continually. Therefore, each bridge position had to be verified. Box section flanges and webs had to resist the varying internal forces and support reactions. Verifying bending, shear and torsion, special attention was paid to local buckling of compression flange and to the problem of patch loading of steel box at the supports.

Patch loading was related to the stability of thin webs under high in-plane compression forces. As the bridge moved over the supports (including temporary one), the reaction force was transferred through the web panels between transversal stiffeners (diaphragms). Patch loading resistance was calculated according to Eurocode. Method to determine the critical force was numerical using FEM of a panel including horizontal and added vertical stiffeners.

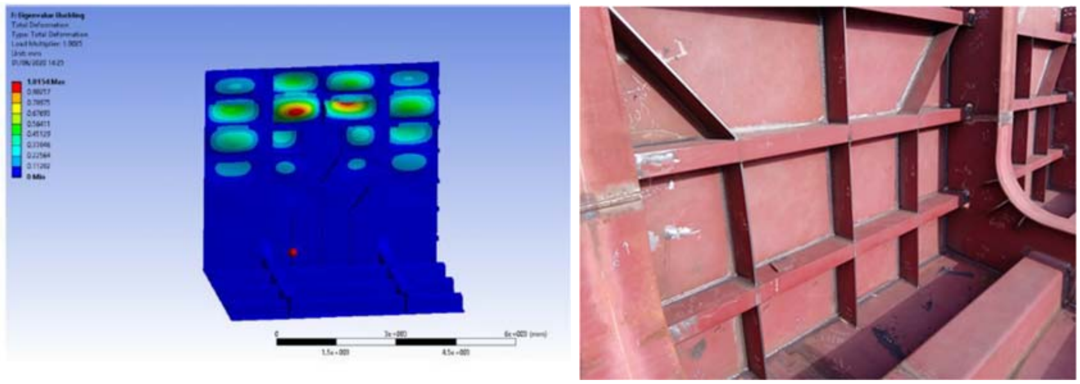

Figure 3: Additional vertical stiffeners

Patch loading was related to the stability of thin webs under high in-plane compression forces. As the bridge moved over the supports (including temporary one), the reaction force was transferred through the web panels between transversal stiffeners (diaphragms). Patch loading resistance was calculated according to Eurocode. Method to determine the critical force was numerical using FEM of a panel including horizontal and added vertical stiffeners.

3 Incremental Launching Method

The incremental launching was carried out in 13 stages for both steel bridge structures, in the average periods of 2 weeks. Both steel bridge structures were launched simultaneously in time intervals of couple days.

Applying an incremental launching method (ILM) with a temporary steel pier in the river and hydraulic systems, the assembled successive sections of 2x15 meter long steel segments were launched into their final position. The launch was carried out using cables and hydraulic jacks, installed on the pier in the river for pulling the bridge structure. The bridge structure was pulled over sliding bearings with Teflon and stainless-steel devices

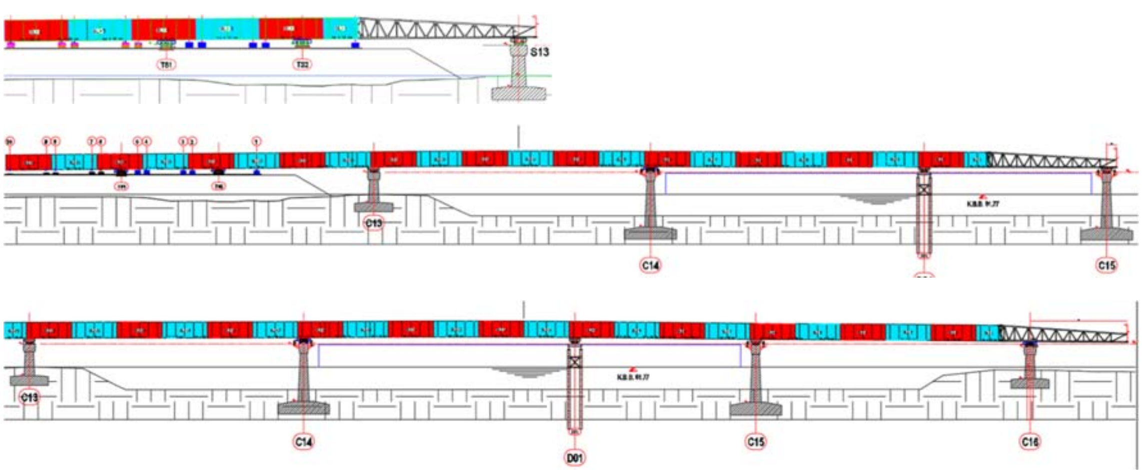

Figure 4: Stages of Incremental Launching: a) stage 1; b) stage 8; c) stage 12

Each segment was consisting of seven assemblies, which were joined on assembly yard by means of welding and/or bolting. The maximum cantilever during launching was 91m, with 42m long launching nose used to reduce the cantilever of bridge itself to 49m.

The bridge geometry of vertical curvature and pre-chamber had to be considered for launching. To solve the problem, vertically adjustable support is provided at second permanent pier C14 and two at launching pad TS-1 and TS-2. Other supports, including on temporary pier are fixed (on last pier C16 is adjustable as it is transported from TS-1). This arrangement of supports allowed full control of reactions. The supports are adjusting in order to avoid lift-off or unacceptably high support reactions. Maximum vertical displacement of adjustable supports was 800mm and was achieved using hydraulic jacks.

Figure 5: Launching of Bridge Structure

4 Temporary Structures

4.1 General

The temporary structures were used for launching performance: temporary pier D01, nose truss and sliding bearings. The other used equipment contained: pulling lugs, anchor blocks, steel strands and guiding devices. For the purposes of assembly and launching of the bridge structure a temporary embankment was erected on the shore, on which there was an assembly yard with gantry cranes, supports for assembly and sliding bearings.

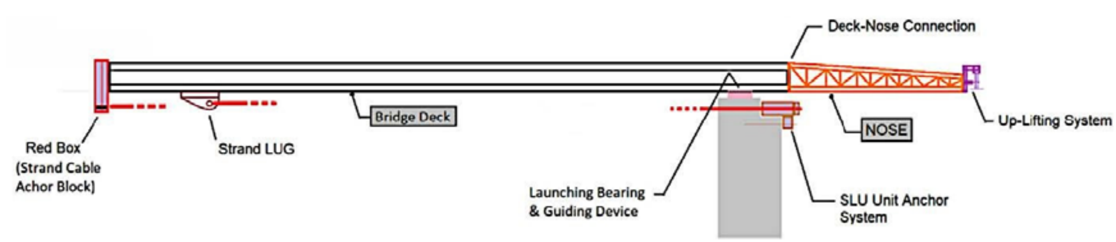

Figure 6: Incremental Launching Equipment

4.2 Sliding Bearing

Sliding bearings with elastomeric bearings and guiding devices were installed on each abutment, which were replaced by the original bearings after completion of the launching operation. They were temporary structure supports for sliding the bridge structure over them. They will be put on the top of piers C13-C14-C15-C16, on the temporary support in the river D01 as well as on the supporting concrete pads TS1 and TS2 over the precast yard filling area. There were two types of launching (sliding) bearings;

ones were fixed over the piers (in the C14-C16 axis), and the others, adjustable in vertical direction, were placed over the precast yard filling area (in TS1 and TS2 axis). The sliding bearing had the inox plate on the top, and the elastomeric bearing part under the sliding surface to adjust the main bridge girder bottom plate imperfections.

Figure 7: Assembly yard

During launching, sliding contact pads were inserted alternately between the sliding supports and the bottom flange of the bridge girder. These pads were made of 8mm thick elastomeric bearing, on the lower side of which, the PTFE (Teflon) plate was placed. PTFE slid on the inox and the deck bottom plate contacted the elastomeric bearing of the PTFE plate while pulling the bridge. During the launching, elastomeric bearings enabled deflection which provided maximum contact surface between sliding bearing and bottom flange of the bridge.

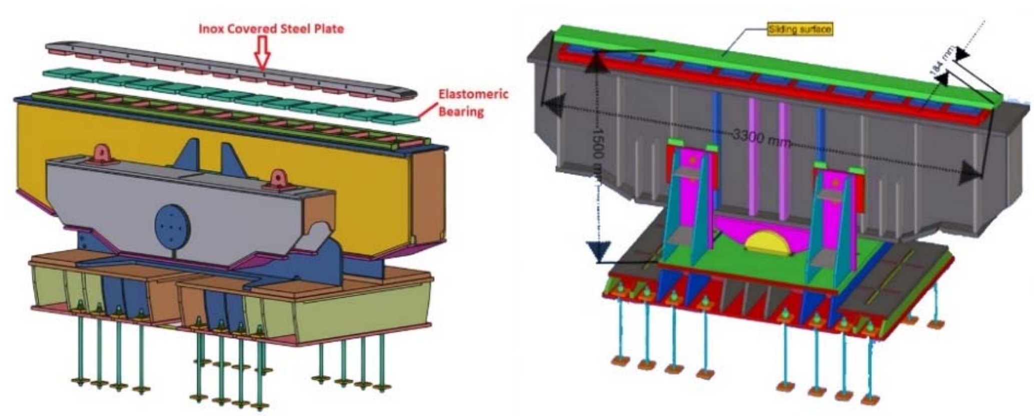

Figure 8: Sliding Bearings: a) adjustable; b) fixed

4.3 Launching Nose

Steel nose was a temporary steel structure, with approximately 42m length and 60 tons weight. It was assembled in front of the deck, to be able to reach the forthcoming pier before the deck elements. The vertically acting hydraulic cylinders were placed in front of the nose, which pushed the nose upwards when reaching the next pier.

4.4 Guiding Devices

The guiding devices were used for preventing the lateral movements of the bridge deck. These temporary structures were placed next to each sliding bearings and they were adjustable in the vertical as well as in the transversal direction.

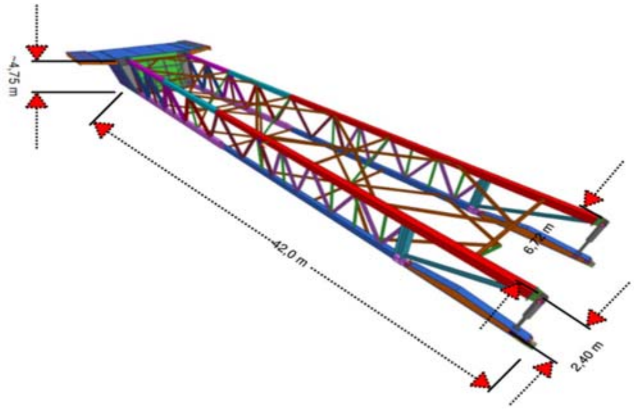

Figure 9: Launching Nose

Figure 10: Guiding Devices

4.5 Pulling Equipment

The system contains pulling steel strands that launch (pull) the main bridge. There was one abutment wall for each bridge structure (left & right). The abutment walls were put over the top of the C13 pier (Figure 11).

The moving of assembled bridge structures in incremental launching process was operated by 2 hydraulic HSL20006 strand jacks with capacity of 200 tons. An additional braking system consisting of two HSL7006 cranes with a capacity of 70t was used for braking in the event of the structure stopping during launch.

Strand jacks powered by electrical hydraulic power packs and controlled by single operator from central location for increased safety systems were ensuring full control of launching operations.

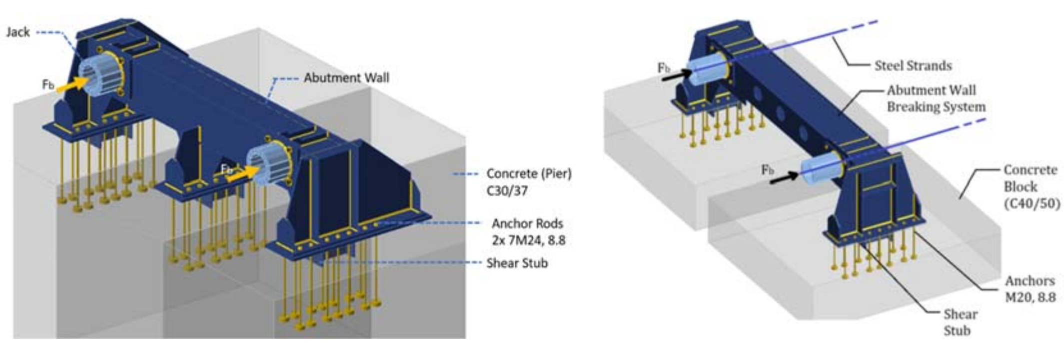

Figure 11: Pulling equipment: a) pulling system; b) braking system

4.6 Strand Lugs

The pulling lug is a temporary structure that was used repeatedly to pull and slide the bridge decks over the launching bearings. The breaking lug was used as breaking device during launching and after launching. It has been running in reverse since launch. In the last phase, the red box was also used to pull and slide the bridges over the launch pads.

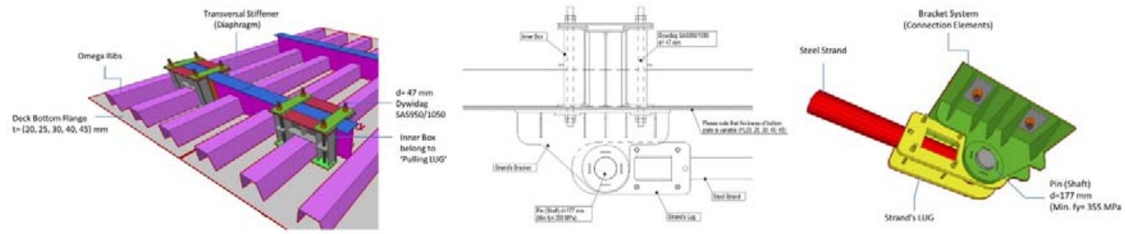

Figure 12: Strand Lugs

4.7 Red Box

Red box temporary structure, having been installed to the end of the bridge deck was used for pulling and the bridge structure over the sliding bearings in the last phases of launching.

Figure 13: Red Box

4.8 D01 Temporary Piers

The temporary piers were constructed for each bridge structure (left & right). They consisted of 2 groups of 4 steel piles. The Ø813x12 tubular pipes, grade of S355J2H were used for temporary piers. Distances between piles (center to center) were 5.0m in the longitudinal direction and 3.0m in the transversal direction. In the longitudinal and transversal directions, the piles were connected by vertical bracings.

Additionally, the horizontal X bracings were installed at the top and the bottom of vertical bracings. Piles were connected at the top with two double HEA 700 beams that were used as a support for main longitudinal welded I beam 400x1100mm (2x400x35+1030x20). Main beams were used as a support for sliding bearing. Two IPE 600 were provided for guiding device and 6 IPE 200 for working platform.

Figure 14: Temporary Pier D01

5 Conclusion

The construction of bridge over the Sava River at Sremska Rača, in terms of the applied technology, was harmonized with the design solution. It is a good example of an efficiency of the overall execution of the steel bridge structure. The design solution of two box girders structures of constant depths fully corresponded to the applied incremental launching technology. By creating productive site facilities, including the original concept of sliding equipment, the erection works were carried out as on a conveyor belt. From the start of construction in Turkey up to the end of incremental launching in Serbia, complete construction of the 5500 tons bridge were completed in just 13 months.

6 References

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