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REALIZATION OF NEW SAVA RIVER CROSSING IN BELGRADE (SERBIA)

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ABSTRACT: The paper deals with the realization of Sava River Crossing with its approach bridges as first section of Belgrade Inner City Semi-Ring Road (ICSRR). The Sava River Crossing, as the first section of the ICSSR Project (with overall length of 17,5 km), consists of the main bridge across Sava River and so-called South Approach Roads (SAR) and North Approach Roads (NAR). The Ada Bridge carries 6 lanes of vehicular traffic, 2 rail tracks for LRT (future Belgrade metro BGM) and 2 lanes of pedestrian/cycle-way. The bridge has total length of 967 m and 43500 m² bridge deck area. SAR contains altogether 22 bridges (viaducts and ramps) with overall length of 3350 m and 36700 m² bridge deck area. NAR contains altogether 19 bridges (viaducts and ramps) with overall length of 2830 m and 36300 m² bridge deck area. The new Sava River Crossing with its approach bridges is a major infrastructure project realized in Belgrade last years that significantly effects to the reduction of traffic jams of vehicular traffic in the city. Sava River crossing with its approach bridges was completed for roadway traffic by start 2014.

KEY WORDS: Bridge design; Bridge construction; Roadway bridges.

1 INTRODUCTION

In order to reduce traffic congestion in Belgrade city and increase the capacity of the network, it was constructed Sava River Crossing with its approach bridges. The Sava River Crossing, as the first section of the Project named Belgrade Inner City Semi-Ring Road (with overall length of 17,5 km), consists of the main bridge across Sava River (Ada Bridge) and so-called South Approach Roads (SAR) and North Approach Roads (NAR). As a part of the planned Inner City Semi-Ring Road (ICSRR), the Sava River Crossing serves for the distribution of traffic flows between diametric peripheral city zones, and operationally connected to the city highway, it shall allow diversions of highway flows to the Inner City Semi-Ring Road and vice versa. The new Sava River Crossing significantly improves the link from the "old" Belgrade City (on the right bank) to New Belgrade (on the left bank). The new Sava River

Crossing with its Approach Bridges is a major infrastructure project realized in Belgrade last years that significantly effects to the reduction of traffic jams of vehicular traffic in the city. The Sava River crossing with its approach bridges was completed for roadway traffic by start 2014. The LRT traffic will be firstly introduced by tramway, that it is planned for the next year, and later by BGM. The works according to rest NAR Lot 1 is planned for 2015. The whole Project was financed by EBRD & EIB loans and partly by the client - City of Belgrade.

2 PROJECT OF INNER CITY SEMI-RING ROAD (ICSRR)

The new Sava Bridge and approach roads will form the first stage of the first section of the Inner City Semi-Ring Road (ICSRR). Inside the continuously built Belgrade City area, according to General Plan of Belgrade until 2021, it is planned to form ICSRR around the wide central city zone that includes: old Belgrade centre, New Belgrade and centre of Zemun.

ICSRR, with overall length of 16 km, is divided in five sectors - from sector I to sector V (*Fig. 1*). ICSSR starts from west traffic artery T6, passing around the wide central city zone across Sava Bridge (in sector II/1) and 3 tunnels (in sectors II/2, IV and V), leading to Pancevo Bridge across the Danube on the north-east. The overall planned route of ICSRR contains 26 junctions – 10 on the left and 16 on the right bank of Sava River.

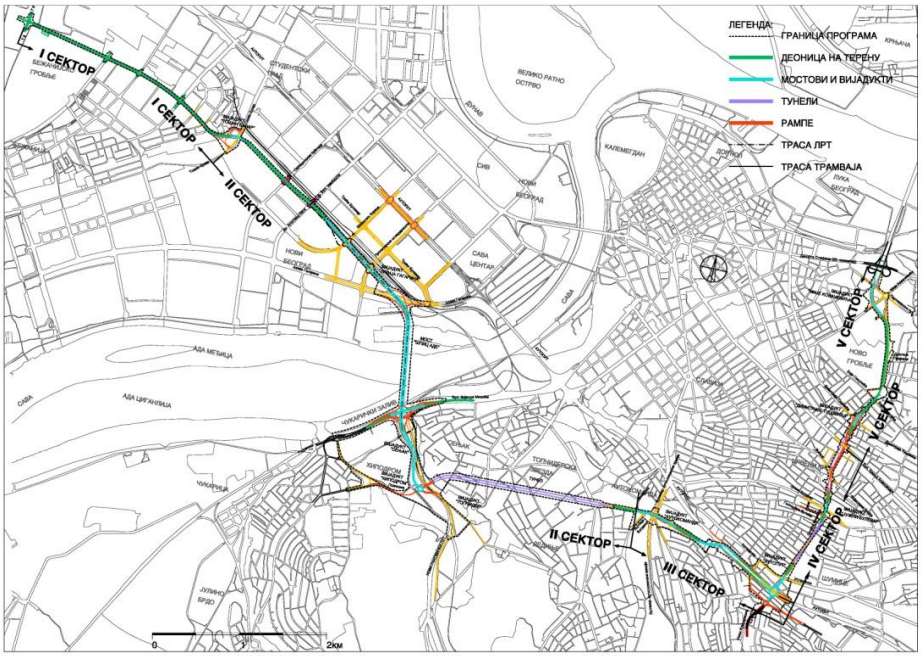

Figure 1. Project of ICSRR – Division in sectors

It is studied the transport and economic effectiveness and justification, of the construction of the first stage of ICSRR. It comprises the section defined as sector II/1 of ICSRR, which includes new Sava Bridge Crossing with both-sided approach roads (SAR & NAR). The resulted traffic flow analysis is presented in *Fig. 2*.

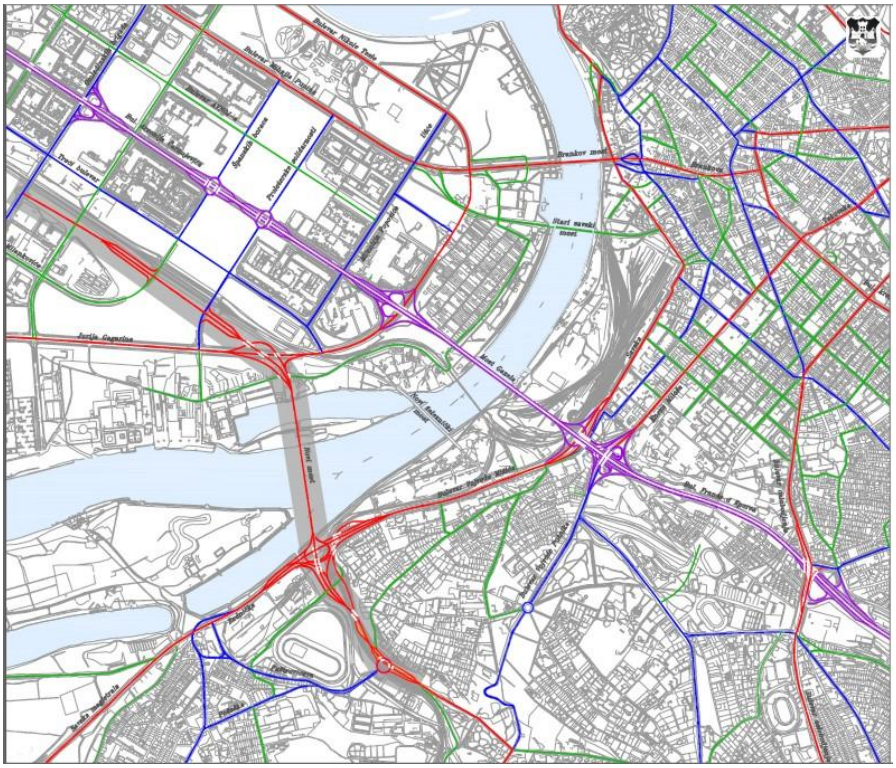

Figure 2. Traffic flow with first stage of ICSRR

Based on the detailed traffic and economic analyses, the following conclusions were established:

1) Without finalization of the first stage of ICSRR there would come to a complete traffic collapse on the previous city network. Therefore, the first stage of ICSRR was urgent necessity.
2) First stage of ICSRR discharges main city bridge around 30% and it brings large traffic savings.
3) The evaluation showed a positive net present value.
4) First stage of ICSRR, as regards traffic, can act well for about ten years. In the meantime it will be necessary to continue constructions of the next stages of ICSRR.

The first stage of ICSRR is traffic and economically justified. The next stages are necessary as well.

3 PROJECT REALIZATION OF SAVA BRIDGE-ADA BRIDGE

The Sava Bridge is located in wide central zone of Belgrade, passing over the lower tip of Ada Ciganlija Island – popular recreation area. Thus Sava Bridge is popularly named the Bridge on Ada (or shortly Ada Bridge). The bridge route from New Belgrade side overpasses the "winter storage" bay (130 m), left bank area (170 m), Sava River (350 m), the lower tip of Ada Ciganlija Island (50 m) and Cukarica Bay (180 m).

The design office Ponting Maribor (with DDC Ljubljana & CPV Novi Sad), as it was awarded for concept design proposal, finalized the preliminary design in 2006. The Louis Berger Group Inc. (with local partner Euro Gardi Group Novi Sad), as the awarded Project Manager – Engineer, started in 2007. The consortium POOR-SCT-DSD, as the awarded design-build Contractor, started the works by middle 2008 and the final completion of all finishing works was by middle 2012. The final design is prepared by LAP Stuttgart (with DCF Vienna engaged for foundation design). The project is co-financed mainly by the EBRD loan and partly by the City of Belgrade's own funds. The client is the City of Belgrade - Belgrade Development Land and Public Agency.

Photo 1. Ada Bridge (by night)

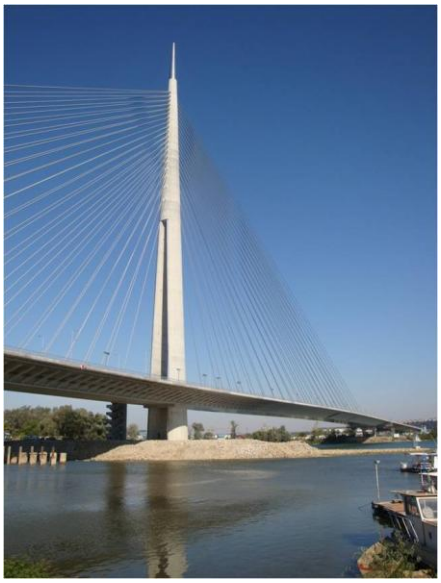

Photo 2. Ada Bridge (by day)

The main bridge across Sava River over Ada Island (Ada Bridge) was constructed in the period 2008 – 2011. The Ada Bridge carries 6 lanes of

vehicular traffic, 2 rail tracks for LRT (future Belgrade metro BGM) and 2 lanes of pedestrian/cycle-way. The bridge deck has a constant depth (4,75 m). The bridge has total length of 967 m, deck width of 45m, that makes 43500 m² bridge deck area. The main bridge part is an asymmetric cable-stayed structure (steel main span of 376 m and concrete back span of 200 m), with a single concrete 200 m high pylon. The bridge deck (45 m width) as a three-cell box (14,5 m width), having an orthotropic steel deck (main span) or concrete deck (back span & side spans), with cantilever parts supported by outer steel struts.

The bridge erection consisted of: both-sided deck launchings (back span 20000 t and side spans 30000t) over temporary piers and one-sided cantilever erection of main span simultaneously with the installation of pair stays anchored in the pylon. The steel erection units (16m length, 45 m width, 330 t weight) were lifted by derrick crane from barges, after preassembling at site from steel segments delivered by ship transport from CRSBG factory (China). All assembling and preassembling splices were welded at site.

The Ada Bridge (*Photos 1 & 2*), with the direct accessing bridges – ramps, was open for vehicular & cycle/pedestrian traffic by 1st January 2012.

4 PROJECT REALIZATION OF NORTH APPROACH ROADS

The so-called Project of North approach roads (NAR-Lot2), on the left bank of Sava River, was contracted according to FIDIC red book, where the final design was enabled by the Client – City of Belgrade. The construction works were carried out mainly by the Contractor Porr (Austria), after withdraw of two non-solvent contractor firms from Slovenia (SCT and Primorje). The Engineer was Louis Berger Group with Euro Gardi Group as local partner. The construction works started in 2011, when by the end of year 3 direct access ramps to Ada Bridge were completed. The rest of NAR (Lot 2) structures were finalized in December 2013 and completely open for traffic by start 2014 (*Photo 3*).

Photo 3. NAR – Viaducts with ramps

NAR project (Lot2) contains:

- Two parallel roadway viaducts ICSRR, carrying 2x3 traffic lanes, having length 980m each;
- Five access ramps to ICSRR, having total length 506m;
- One double-track railway viaduct, firstly for tram traffic and later for light metro (BGM), having length 906m;
- One embankment of reinforced soil for incorporation of tram/BGM line into the existing network, including the tram/BGM station.

NAR contains 19 bridge structures, with overall length of 2830 m and 36300 m² bridge deck area.

Photo 4. NAR – Viaducts over J. Gagarina street

Both 980m long ICSRR viaducts are divided in six independent bridge structures with 3-8 spans, varying from 24,0m till 42.5m, dictated by the existing obstacles needed to be over passed (streets or non-displaceable installations). The most significant bridge structures is pair of 281m long deck over J.Gagarina street (*Photo 4*), with main span of 42,5m and variable depth of 1,6-2,6m. The all other viaduct superstructures (*Photo 5*) have a depth of 1,4 m (3-6 spans of 24-34m).

Although the construction of NAR was contracted according to FIDIC red book, i.e. with the final design enabled by the Client, the Contractor made the design modifications with reference to the point "Value engineering" of FIDIC contract conditions. Consequently, the design was modified with respect to contractor's technology of works and the positions of piers were adopted to the exact installation locations, that made cost savings for the Client. Furthermore the modifications in design resulted in more favourable architecture look of viaducts and lower maintenance costs because the classical concrete hinges are changed by fixed link and ICSSR viaducts were constructed as semi-integral type of bridge structures (deck: slab-type with 2 girders, deep foundation on bored piles).

Photo 5. NAR – viaducts

Taking into account the site configuration, the construction works of superstructure were carried out by relatively simple scaffoldings – tube type scaffold mainly and heavy scaffold for the street flyovers. The special building challenge were foundation works in leafy underground communal installations and construction works under frequent city traffic with minimum traffic closures.

The rest works according to next Lot 1, in the frame of North approach roads, are planned for 2015.

5 PROJECT REALIZATION OF SOUTH APPROACH ROADS

The so-called South approach roads (SAR), on the right bank of Sava River, link the Ada Bridge with: Radnicka interchange, Hippodrome interchange and the existing tram network (*Fig. 3*).

The construction works were carried out by the Contractor Porr (Austria) according to yellow FIDIC contract conditions. The Engineer was Louis Berger Group with Euro Gardi Group as local partner. The works started in 2011, partly finished in 2012-2013 and they were finalized in autumn 2013, when SAR completely open for traffic.

The Radnicka interchange (*Photo 6*) contains:

- Two parallel roadway viaducts ICSRR, carrying 2x2 traffic lanes, having length 380 m each;
- One viaduct for 2-track LRT, firstly for tram later for light metro (BGM), having length 906m;
- The elevated ring for circle traffic flow, carrying 2 traffic lanes, having length 251m;
- Two overpasses (flyovers) in Radnicka street, carrying 2x3 traffic lanes over 5 rail tracks railways and Topcider River, having length 385m each;

- Eight access ramps to ICSRR, having total length 1012m.

SAR contains altogether 22 bridges (viaducts and ramps) with overall length of 3350 m and 36700 m² bridge deck area.

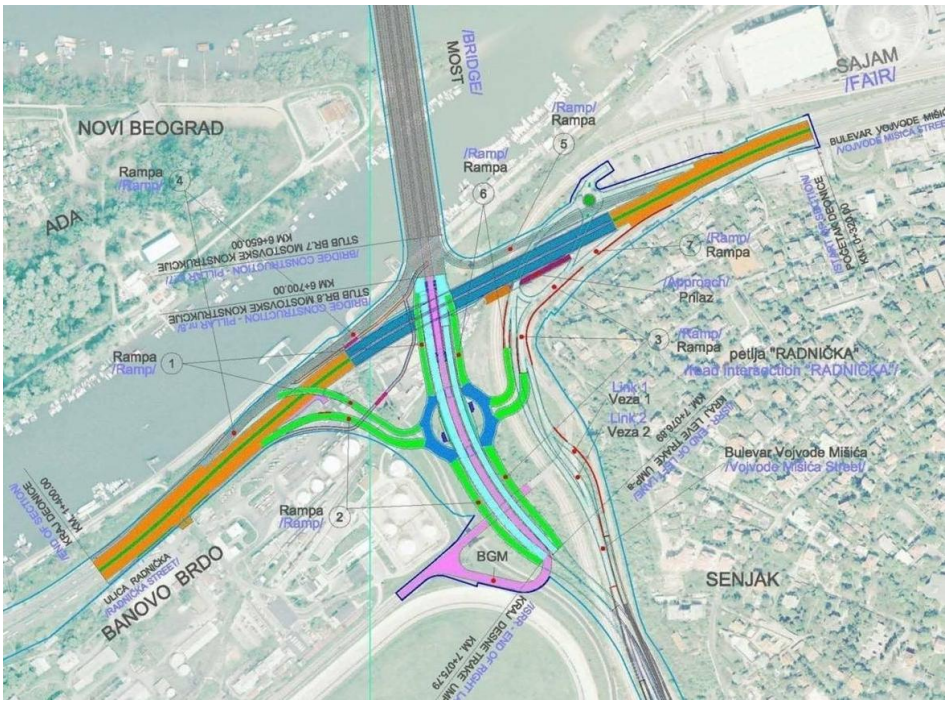

Figure 3. SAR – Plan view

Project realization of South approach roads (SAR) was more complex than NAR project, not only because of the complexity of bridge structures to be constructed but also due to the other contract conditions.

- The building works were contracted according to FIDIC yellow book – design & built contract. The preliminary – tender design was enabled by the Client.
- The building site was very limited by: Hippodrome area, Jugopetrol oil tanks complex and a distinguish Senjak residential area.
- In the building site area they were present: 4-tracks railway line, 1-track industrial railway line, 2-track tramway line and Topcider River.
- The interchange was built at the crossing place of crowded Radnicka street and 5-tracks railway line, where the existing 2-track railway overpass and roadway underpass to be changed into 2 flyovers, carrying 3 traffic lanes each, with minimal disturbance of roadway traffic flow and non-closure of railway traffic.

Photo 6. NAR – Viaducts with ramps

Both 980m long ICSRR viaducts are divided in three independent semi-integral type bridge structures with 4-5 spans (27,7 - 31.5m), with constant depth 1,6m (slab-type deck of pre-stressed concrete).

The 502m long LRT viaduct is divided in three independent semi-integral type bridge structures with 6 -7 spans (29,8 - 32,0m), with constant depth 1,6m (slab-type deck of pre-stressed concrete). The 251m elevated ring is circle continuous beam-type bridge structure over 16 spans of 15,7m each, 13,1m wide, with constant depth 1,45m. (slab-type deck of pre-stressed concrete).

The access ramps to ICSSR are semi-integral type bridge structures over 3-6 spans (28,8 – 33,5m), with constant depth 1,45m (slab-type deck of pre-stressed concrete). The most significant bridge structures is pair of about 385m long flyover along Radnicka street, with main span of about 46m, with constant depth 1,6/1,7m (slab-type deck of pre-stressed concrete).

During the execution of the works the different building technologies were applied, as well as scaffolding systems: tube scaffolds, heavy scaffolds and movable scaffolds.

The most complex building operation was the construction of pair of viaducts in Radnicka street across 5-tracks railway line, carried out to change the existing one-direction roadway overpass and underpass. Because of limited height over the railway line the special scaffolding system was applied that enabled to construct the deck in main span in several steps (*Photos 7-10*), as follows.

- Erection of special scaffold to carry the suspended formwork for deck concreting 1,5m over the designed alignment.
- Lifting of scaffold mounted on the ground, reinforcing and cable works, concreting and pre-stressing.
- Dismounting of scaffold – concrete deck structure is carried by 16 strong tendon bars anchored in concrete deck.
- Devolvement of concrete deck structure to the designed alignment.

Photos 7-10. NAR – Main construction stages of viaduct in Radnicka street

6 CONCLUSIONS

It should be pointed out that the whole Project of Sava River crossing with its approaches (Ada Bridge project, NAR project & SAR project), was successfully realized due to exceptional engagement of all participants: Client (City of Belgrade - Belgrade Development Land and Public Agency), Investors (EBRD, EIB & City of Belgrade), Contractor (mainly PORR Austria, DSD Germany, SCT Slovenija, with its subcontractors) and Engineer (Louis Berger Group, with local partner Euro Gardi Group).

The realization of Project significantly reduced traffic jams in the city.

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