IZGRADNJA DRUMSKOG MOSTA PREKO REKE SAVE KOD OSTRUŽNICE

CONSTRUCTION OF ROAD BRIDGE OVER THE SAVA RIVER NEAR OSTRUŽNICA

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1 UVOD

Postojići dramski most preko reke Save kod Ostružnice lociran je u blizini Beograda, u Republici Srbiji. Izgrađen je u okviru prve faze jugozapadne obilaznice oko Beograda. Povećanje saobraćaja, posebno tranzitnog, rezultiralo je potrebom povećanja kapaciteta obilaznice oko Beograda, kako bi se rasteretilo saobraćajno opterećenje autoputa koji prolazi kroz centar grada.

1 INTRODUCTION

Present road bridge over the Sava river near Ostružnica is located near Belgrade, in the Republic of Serbia. It is constructed within the first phase of the south-western bypass around Belgrade. The increase of traffic, especially transit, resulted in the necessity of increasing the capacities of the bypass around Belgrade, to relieve the traffic load on the highway that runs through the city centre.

Slika 1. Lokacija mosta preko reke Save kod Ostružnice

Fig. 1. Location of the bridge over the Sava river near Ostružnica
Izgradnja obilaznice započeta je 1991. godine, a prva faza je obuhvatala poluprofil (desnu traku) autoputa od Dobanovaca do Bubanj Potoka, predviđena da se koristi za dvosmerni saobraćaj do završetka druge faze. Zbog poznatih okolnosti (sankcije međunarodne zajednice, hiperinflacija, ratna dejstva, NATO bombardovanje itd.) izgradnja prve faze je više puta prekinuta, tako da je prva faza na delu od Dobanovaca do Resnika (sektori 1-5) završena u maju 2012. Trenutno su završene obe faze na delu od Dobanovaca do Ostružnice (sektori 1 i 2), radovi na drugoj fazi mosta preko reke Save kod Ostružnice (sektor 3) u završnoj su fazi, a planirano je da preostali radovi na obilaznici (sektori 4, 5 i 6) budu završeni do kraja 2021. godine.

Izgradnja postojećeg mosta preko reke Save (za desnu traku) započela je 1991. godine i trajala je, zbog navedenih okolnosti, sve do 1999. godine. Neposredno pre puštanja sa saobraćaj, 28. aprila 1999. most je delimično srušen tokom NATO bombardovanja, da bi do 2004. godine bio potpuno obnovljen i pušten u saobraćaj. Novi most za drugu fazu obilaznice odnosno levu traku autoputa u konstruktivnom smislu potpuno je idenitan postojećem, pošto su prvom fazom izgradnje bili obuhvaćeni zajednički rečni stubovi za obe mostovske konstrukcije. Izgradnja ove konstrukcije započeta je u julu 2016. godine.

2 KRATKI OPIS MOSTOVSKIH KONSTRUKCIJA

Ukupna dužina mosta je 1.963 m i sastoji se od četiri dela: prednapregnute betonske prilazne konstrukcije na levom obali (L= 592,30 m) i desnom obali reke (L= 699,13 m), armirano-betonske konstrukcije preko autoputa Beograd-Obrenovac (L= 85,30 m) i čelične konstrukcije preko reke Save (L= 586,00 m). Celična konstrukcija je kontinualni čelični sandučasti nosač, s pet raspona, promjenjive visine, od 3,8 m do 7,9 m i najdužim rasponom od 198 m. Ukupna težina čelične konstrukcije je 4250 tona.

3 TEHNOLOGIJA MONTAŽE ČELIČNE KONSTRUKCIJE

Projektovanim tehnologijom montaže bio je predviđen konzolni način izgradnje uz korišćenje plovena dizalice i pivremeni oslonac - čeličnih šipova pobjeđenih u korito reke. Zbog toga je konstrukcija podeljena na 56 montažnih polja, dužine 7,5-11,0 m i teških 60-85 tona. Nakon pregleda rečnog korita magnetometrima, rezultatom je postojanje velikog broja nepoznatih čeličnih objekata koji bi po gabaritima mogli biti neeksplozivno udovica sredstva (NUS). Zbog toga se projektovana tehnologija montaže pokazala visoko-

4 METODOLOGIJA MONTAŽE ČELIČNE KONSTRUKCIJE

 installment

The designed installation methodology envisaged a cantilevered construction using a floating crane and temporary supports - steel piles driven into the river bed. Therefore, the construction is divided into 56 mounting sections, 7.5 - 11.0 m long and weighing 60-85 tons. After the high-resolution magnetic survey of the riverbed, it was discovered that there were a large number of unknown steel objects that could have been unexploded ordnance (UXO). Therefore, the designed installation methodology turned out to be high risky since the
possible UXO could be activated during the driving of steel piles into the river bed.

In order to avoid the placement of temporary supports in the riverbed, various alternatives were considered, subject to condition that the already executed parts of the structure are used as far as possible. After considering possible alternatives, new methodology that includes (I) incremental launching over floating pier of the bridge (section previously preassembled on the riverside L=187 m) and (II) lifting of 3 structure sections (L=77 m, G=550 tons) pre-assembled in the shipyard 10 km far from the bridge location, launched into river and transported to the site were selected as optimal in current conditions.

(I) Incremental launching

Bridge section between piers S4 and S6 (L=187 m) was installed by incremental launching since the cross-section is of constant height. This section of the bridge is preassembled on the launching platform located on the riverside and then pushed over the river by hydraulic jacks until reaching final position. This operation is divided in four phases:

- Phase I: launching of 45 m long segment as cantilever, without floating support;
- Intermediate phase I/II: installation of floating support, to enable continuation of launching;
- Phase II: launching of 43 m long segment supported by floating pier, until reaching pier S5;
- Phase III: launching of 44 m long segment as cantilever, without floating support.
− Međufaza III/IV: postavljanje pomoćnog oslonca kako bi se omogućio nastavak podužnog prevlačenja;
− Faza IV: podužno prevlačenje 55 m dugačkog segmenta oslonjenog na pomoćni oslonac, do stuba S4

− Intermediate phase III/IV: installation of floating support, to enable continuation of launching;
− Phase IV: launching of 55 m long segment supported by floating pier, until reaching pier S4

Slika 3. Prva faza podužnog prevlačenja segmenta S4–S6
Fig. 3. First phase of incremental launching of segment S4 - S6

Slika 4. Druga faza podužnog prevlačenja segmenta S4–S6
Fig. 4. Second phase of incremental launching of segment S4 - S6
Konzolna montaža delova konstrukcije iznad stubova S1, S2, S3 i S4

Da bi se omogućilo podizanje segmenta konstrukcije koji su predmontirani u brodogradilištu i transportovani na gradilište rekom, potrebno je formirati osnovu sa koje će se raditi podizanje. Zbog toga je izvršena slobodna konzolna montaža najpre baznih (oslonačkih) segmenta iznad stubova S1, S2, S3 i S4, a nakon toga i susednih segmenta.

Kako bi se obezbedila stabilnost elemenata čelične konstrukcije mosta u ovoj fazi montaže, bilo je neophodno konstruisati i monirati pomoćni alate - privremene oslonce iznad stubova S2, S3 i S4. Pored obezbedenja stabilnosti, ovi privremeni oslonci preuzimaju deo uticaja u fazi dizanja i prenose ih na stubove.

Cantilever assembly of structure segments over river piers S1, S2, S3 and S4

In order to allow the lifting of segments of structure that are pre-assembled in the shipyard and transported to the site by the river, it was necessary to form the basis from which the lifting is to be carried out. Therefore, free cantilever assembly of the base (support) segments above the piers S1, S2, S3 and S4, and subsequently of adjacent segments was performed.

In order to ensure the stability of the steel structure elements at this stage of assembly, it was necessary to construct and install auxiliary tools - temporary supports above the piers S2, S3 and S4. In addition to providing stability, these temporary supports take over some of the impacts during the lift phase and transfer them to the piers.
(III) Lifting of 3 structure sections

The rest of the steel structure was installed by lifting of 3 structure sections (L=77/68 m, G=550/450 tons) previously assembled in the shipyard 10 km far from the bridge location. Additional elements for providing water tightness and navigability were installed before launching the segments into the river. Transport to the site was performed by tugboats and lifting was done by “Derrick” cranes and 4 hydraulic jacks, each capacity of 200 t.

- Phase I: lifting of section MP2-MP8, L=77 m, G~550 t
- Phase II: lifting of section MP32-MP38, L=77 m, G~550 t
- Phase III: cantilever installation of segments MP13-MP16 and MP24-MP27 by floating crane
Faza IV: podizanje sekcije MP17-MP23, L=68 m, G~450 t

Phase IV: lifting of section MP17-MP23, L=68 m, G~450 t

Slika 8. Predmontaža sekcija konstrukcije mosta u brodogradilištu
Fig. 8. Pre-assembly of steel structure sections in the shipyard

Slika 9. Rečni transport sekcija konstrukcije mosta
Fig. 9. River transport of structure sections
4 INFORMATION ABOUT PROJECT, EMPLOYER, DESIGNER, CONTRACTOR AND SUPERVISION

In addition to the construction of bridge structures, the scope of project also includes a road section - the left lane of the highway 955m long, as well as all supporting works (collection and purification of atmospheric waters, public lighting, traffic signs and road furniture, road reserve landscaping etc.) The employer is Public Enterprise "Roads of Serbia", and the works are funded by a loan from the European Investment Bank. The design documentation was prepared by the Belgrade “Highway Institute” and the part of the design related to bridges was made by the company “Mostprojekt AD” from Belgrade. The contractor is a consortium consisting of Strabag AG - Ed. Zublin AG – Dywidag Bau GmbH – PZP Zajecar A.D. (Strabag d.o.o.). The subcontractor for the production and installation of the steel bridge structure is company “Mostogradnja AD” from Belgrade, which also in the past built the existing right-line bridge. Supervision of the works was entrusted to the consortium comprising UTIBER Kozuti Beruhazo Kft. - Project Biro UTIBER d.o.o. - Institut IMS AD.
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Drumski most preko reke Save kod Ostružnice, ukupne dužine 1.963 m, sastoji se od armirano-betonskih prilaznih konstrukcija na levoj i desnoj obali reke, dok je srednja konstrukcija preko reke Save kontinualni čelični sandučasti nosač, s pet raspona, ukupne dužine od 586 m. Montaža čelične konstrukcije prvobitno je planirana konzolnom ugradnjom 56 sekcija-montažnih polja, korišćenjem plovne dizalice i privremenih oslonaca - čeličnih šipova pobijenih u korito reke. Nakon pregleda rečnog korita magnetometrima visoke rezolucije, ova se metodologija pokazala visokorizičnom zbog mogućeg postojanja neeksplodiranih ubojnih sredstava (NUS), preostalih nakon NATO bombardovanja, koja bi mogla biti aktivirana tokom pobijanja čeličnih šipova u korito reke. Da bi se izbeglo postavljanje privremenih oslonaca u rečnom koritu, projektovana metodologija montaže čelične konstrukcije morala je biti izmijenjena. Nakon razmatranja mogućih alternativa uz uslov očuvanja već izvedenih radova, kao optimalna u datim uslovima, usvojena je nova metodologija koja uključuje: (I) podužno prevlačenje sekcije mosta S4-S6 ukupne dužine 187 m uz korišćenje pomoćnog plutajućeg oslonca, (II) konzolnu montažu delova konstrukcije iznad rečnih stubova S1, S2, S3 i S4 i (III) podizanje tri sekcije konstrukcije L=77(68) m.

Ključne reči: Ključne reči: drumski most, Ostružnica, armirano-betonske prilazne konstrukcije, kontinualni čelični sandučasti nosač, konzolna gradnja, prevlačenje/potiskivanje čelične konstrukcije.

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Road bridge over the Sava river near Ostružnica, with a total length of 1.963 m, consists of reinforced concrete approach structures on the left and right riverside, while the middle structure over the Sava River is 5-span continuous steel box girder, with a total length of 586 m. Construction of steel structure was originally planned by cantilever installation of 56 sections, using a floating crane and temporary supports - steel piles placed in the river bed. After the high-resolution magnetic survey of the riverbed, this methodology has proved to be highly risky due to the possible existence of unexploded ordnance (UXO) left after NATO bombing, that could be activated during the piling into the riverbed. To avoid installation of temporary supports in the riverbed, the original methodology for the assembly of the steel structure had to be revised. After considering possible alternatives and to preserve already executed works, new methodology that includes (I) incremental launching over floating support of the bridge section S4-S6 with a total length of 187 m, (II) cantilever assembly of structure segments over river piers S1, S2, S3 and S4 and (III) lifting of 3 structure sections L=77(68) m, was selected as optimal under the given conditions.

Key words: Key words: road bridge, Ostruznica, reinforced concrete approaching structures, continuous steel box main girders, cantilever bridge construction, launching of steel structure.