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Project management during construction of the cross-border Svilaj Bridge

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Professional paper

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This paper presents specific project-management features at various stages of the project. The focus is mostly placed on the limitations and differences between regulations and legal frameworks applied in the territories of the Republic of Croatia and Bosnia and Herzegovina. A special emphasis is placed on preconditions to be met for the delivery of building permit and other documents as needed for the start and realisation of works, on the conduct of expert supervision in accordance with technical regulations applied in both countries and the Engineer's role with regard to realisation of construction contract on behalf of the joint client.

Key words:
Svilaj Bridge, state-to-state agreement, project management, infrastructure project, EU funds

Stručni rad

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Upravljanje projektom izgradnje međudržavnog mosta Svilaj

U radu su prikazane specifičnosti upravljanja projektom s obzirom na faze projekta, a koje se u najvećoj mjeri odnose na ograničenja i razlike propisa i pravnog okvira koji vrijede na teritorijima Republike Hrvatske i Bosne i Hercegovine. Poseban je naglasak na preduvjetima koje je trebalo zadovoljiti prije ishođenja građevinskih dozvola i ostale nužne dokumentacije za početak i izvođenje radova, provođenju postupaka stručnog nadzora u skladu s tehničkim propisima u objema državama i ulozi inženjera u pogledu provođenja ugovora o građenju u ime zajedničkog naručitelja.

Ključne riječi:
most Svilaj, koridor Vc, međudržavni sporazum, upravljanje projektom, infrastrukturni projekt, EU fondovi

Fachbericht

Boris Huzjan, Darko Šošić

Projektleitung für den Bau der zwischenstaatlichen Autobahnbrücke Svilaj

Die Arbeit stellt die Besonderheiten des Projektmanagements in Bezug auf die Projektphasen vor, die sich hauptsächlich auf die Beschränkungen und Unterschiede der in den Gebieten der Republik Kroatien und Bosnien und Herzegowina geltenden Vorschriften. Besonderes Augenmerk wird auf die Voraussetzungen gelegt, die erfüllt sein müssen, bevor Baugenehmigungen und andere notwendige Unterlagen für den Beginn und die Ausführung von Arbeiten eingeholt werden, auf die Durchführung von fachkundigen Überwachungsverfahren gemäß den technischen Vorschriften in beiden Ländern, die Rolle von Ingenieuren bei der Ausführung von Bauaufträgen im Auftrag des gemeinsamen Auftraggebers.

Schlüsselwörter:
Svilaj-Brücke, Korridor Vc, zwischenstaatliches Abkommen, Projektmanagement, Infrastrukturprojekt, EU-Mittel

1. Introduction

The Svilaj Bridge over the Sava River is an integral part of the international Pan-European Road Corridor Vc: Budapest - Beli Manastir - Osijek - Sarajevo - Ploče. Corridor Vc is a part of the European motorway network designated as E-73 that links the north of Europe with the Adriatic and constitutes the backbone of the road transport infrastructure in the eastern part of Croatia. This bridge across the Sava River is also a contact point between the motorway network of the Republic of Croatia and the corresponding network in Bosnia and Herzegovina. The construction of the Svilaj Bridge over the Sava River is one of the key projects of the Croatian highways from the 2017-2020 Public Roads Program and Maintenance Program [1].

The bridge is currently realized as a joint project based on the agreement between the Government of the Republic of Croatia and the Council of Ministers of Bosnia and Herzegovina on the construction of the cross-border bridge over the Sava River at Svilaj with connecting border-zone motorway sections on the Corridor Vc [2, 3]. According to the mentioned agreement, each state will finance 50 % of the works. In Croatia, the role of client is assumed by Hrvatske autoceste d.o.o. and in Bosnia and Herzegovina, the client is the Ministry of Communications and Transport of Bosnia and Herzegovina.

2. Project stages and participants

The Svilaj Bridge construction project can be divided into usual project stages, with some specific elements regarding participants in the project (project stakeholders), as described below:

- Initial acceptance of the project
- Design and obtaining of construction permits
- Procurement of works
- Implementation of construction contract
- Handover of works to final beneficiaries.

2.1. Initial acceptance of the project and adoption of conceptual design

The Svilaj Bridge is a an integral part of Motorway A5 Beli Manastir - Osijek - Svilaj, i.e. of its section from Sredanci to the border with Bosnia and Herzegovina in the Republic of Croatia, and Motorway A1 Svilaj - Sarajevo - Počitelj, i.e. of its Svilaj to Odžak section in Bosnia and Herzegovina. The realisation of the project started in November 2003 when an agreement was signed with Inženjerski projektni zavod d.d., Zagreb for preparation of the entire design documentation and for the conduct of administrative and other procedures as needed for the start of works on the motorway section Sredanci - Bosnia and Herzegovina border, including construction of the Svilaj Bridge. In the scope of this agreement, the preliminary design was made for the motorway section and, on that basis, the location permit for the entire section was delivered in July 2007. Several alternative solutions for the Svilaj Bridge were made in 2008 and, after selection of the final solution, the first version of the conceptual design was prepared for this bridge. In January 2009, the Ministry of Communications and Transport of Bosnia and Herzegovina presented its suggestions and objections to the conceptual design. These were for the most part accepted by the designers and so the final preliminary design of the bridge was completed in October 2009.

This preliminary design defines the type of bridge superstructure and states that two parallel bridges, i.e. two separate structures, will be built for each pavement.

2.2. Development of final and working designs and obtaining of permits

As agreed between the two countries [2, 3], the Croatian side (Hrvatske autoceste d.o.o.) was responsible for development of design documents as needed for the delivery of construction permit. Both sides were required to harmonize all design documentation details relating to construction of the Svilaj Bridge and related border-zone motorway sections on the Corridor Vc.

Relating to the delivery of permits needed for the start of work on the Svilaj Bridge, it was agreed by the parties that a single construction permit will be issued based on the design documentation prepared by the competent authority of the Republic of Croatia, after fulfilment of preconditions for the delivery of an appropriate approval by the competent authority in Bosnia and Herzegovina. At the same time, before delivery of construction permit, and in addition to the location permit to be procured from the competent autority in the Republic of Croatia, an urban development approval had to be obtained from the competent authority in Bosnia and Herzegovina; this approval corresponds in essence to the location permit issued in the Republic of Croatia. In the scope of delivery of approval by the competent authority of Bosnia and Herzegovina, as needed for the issuance of construction permit in the Republic of Croatia, an administrative procedure had to be carried out to meet all requirements for the delivery of construction permit in Bosnia and Herzegovina, in accordance with prevailing regulations.

The detailed design for the bridge over the Sava River at Svilaj was completed in July 2010. Some minor modifications to the detailed design were then made and this design was finally approved in November 2010, after it was reviewed by the Faculty of Civil Engineering - University of Zagreb, and after submission of objections by reviewers from Bosnia and Herzegovina, which were accepted in totality.

The entire technical solution of the future structure was defined in this detailed design, which calls for construction of two separate structutes to be statically realised as continuous beams over seven spans, with the composite box-type cross section composed of the steel trough part and top (pavement) slab. Double composite action - involving the steel trough part, bottom cocrete slab, and top concrete (pavement) slab - is realized above supports on piers S3 and S4. Individual lengths of superstructure spans are: 70.00 + 85.00 + 100.00 + 130.00 + 100.00 + 85.00 + 70.00 m; the bridge length between abutment axes amounts to 640.00 m [4].

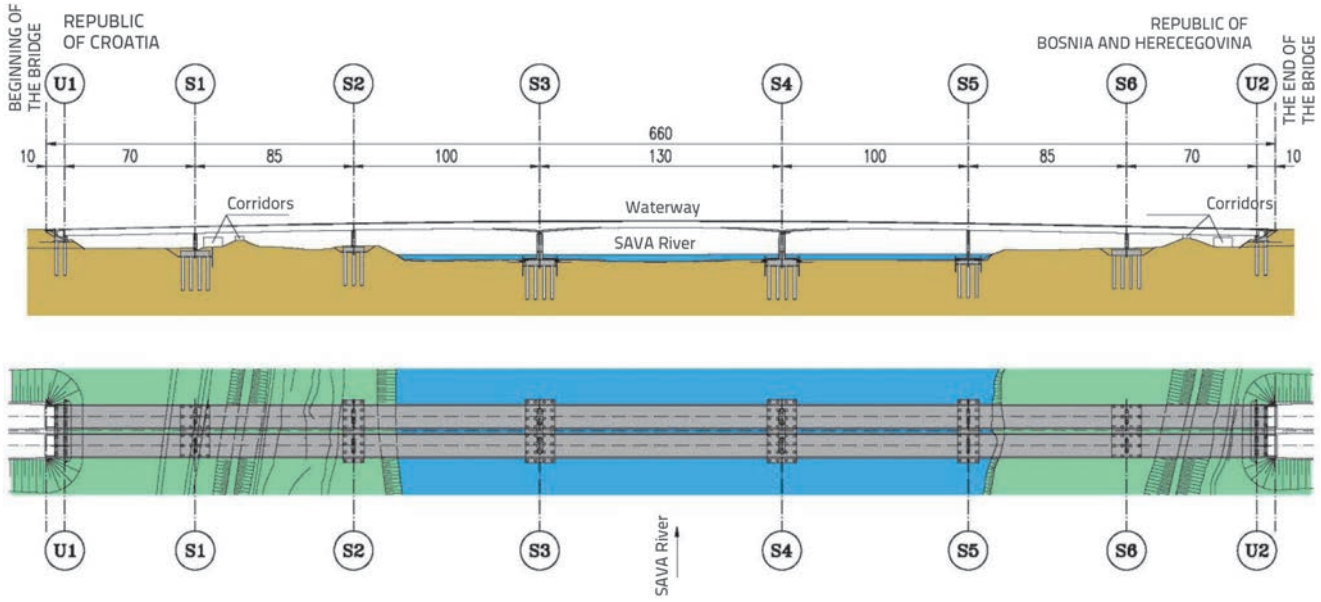

Figure 1. Longitudinal profile and plan view of Svilaj Bridge [4]

The steel trough part varies from 3300 mm to 5500 mm in depth, and the entire bridge is designed as a single expansion system, with expansion joints situated at abutments only. Each pier position is formed of one massive pier with two pot bearings on top of it. These bearings are longitudinally movable, except for the bearings at pier S3, which assume horizontal forces generated by temperature changes and rheology. Four impact transfer devices are planned at pier S4; these devices assume rapid load effects and block sudden longitudinal horizontal displacements due to seismic action and braking, while simultaneously allowing, without significant generation of force, slow displacements due to temperature and rheology [4].

The total bridge width is: 13.50 + 2.00 + 13.50 = 29.00 m. Each of the two structures will be composed of three traffic lanes 3.50 m in width, and a road protection zone 0.50 m in width on both sides of the pavement, but no stopping lane is planned. Thus the total asphalt pavement width extends to 12.00 m. Granite curbs and monolithic concrete footway, 0.75 m in total width, are planned along the edge of the pavement [4].

Based on the agreement between the Government of the Republic of Croatia and the Council of Ministers of Bosnia and Herzegovina [2, 3], the Ministry of Sea, Transport and Infrastructure of the Republic of Croatia and the Ministry of Communications and Transport of Bosnia and Herzegovina formed in 2010 the Program Implementation Unit (PIU) and named its members, the purpose being to ensure the greatest possible level of efficiency in the implementation of the project. The scope of action of the PIU, and duties and obligations of its members, were defined in the subsequently framed and approved Rules of Procedure [5].

According to the Rules of Procedure, the PIU will: prepare project implementation plans, give guidelines and make appropriate

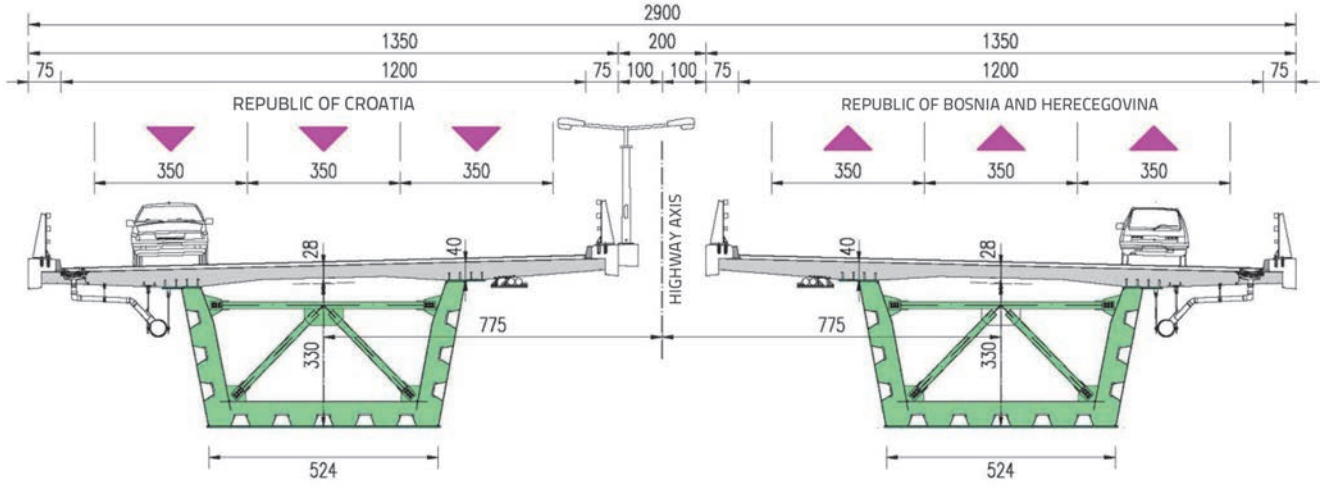

Figure 2. Svilaj Bridge cross-section at mid-span between piers S3 and S4 [4]

decisions in order to contribute to successful preparation for bridge construction in accordance with regulations applicable in the Republic of Croatia and Bosnia and Herzegovina, facilitate procedure for issuing approvals, authorisations and other permits in line with regulations applicable in both countries, estabish cooperation and coordinate activities with competent authorities, select contractors based on an appropriate public procurement procedure, monitor bridge construction and participate in the handover of the facility to the final beneficiary.

Since its establishment, the PIU has actively cooperated in all activities related to the procurement of permits in both countries and it has prepared, based on design documents, appropriate procurement documents and secured preconditions for realisation of such procurements in full accordance with legislation applicable in both countries.

After all preconditions were met in both countries, the bridge construction permit was finally delivered in July 2012.

2.3. Procurement

According to provisions of the agreement [2, 3], an international public tender had to be organised for the procurement of the Svilaj Bridge construction works. It is important to note that, according to the agreement, the cost of bridge construction and riverbed regulation in the bridge area will be equally borne by the parties, while the cost of construction and adjustment of connecting motorway sections in border zones will be borne separately by the parties for sections situated in their respective territories.

A technical part of tender documents, as previously prepared based on the design documentation (detailed design and working design), included *inter alia* the cost estimate for the works, technical specification for the works, and a list of relevant standards and regulations to be respected during construction and subsequent use of the facility.

As an international public tender had to be launched in the scope of a uniform procurement procedure in which Hrvatske autoceste d.o.o. and the Ministry of Communications and Transport of Bosnia and Herzegovina would assume the role of a joint client, the necessary precondition was to prepare the entire tender documentation in accordance with relevant legislation of both countries.

Considering the sources of funding, which will be discussed in further detail later on, one of necessary preconditions was to conduct the procurement procedure based on legislation that has been harmonised with the EU legislation, i.e. with relevant EU directives related to public procurement.

At that time, the legislation of the Republic of Croatia had already been harmonised with the EU legislation, and so the decision was jointly made to conduct the procurement procedure in accordance with the then valid Public Procurement Act of the Republic of Croatia, and that the Public Procurement Act of Bosnia and Herzegovina will not be applied; this decision was approved by the Council of Ministers of Bosnia and Herzegovina in June 2015.

A mixed working group composed of various experts from both countries was formed to provide for proper preparation of tender documents [6] for the Svilaj Bridge construction; this group analysed all aspects and specific features of the project, and legislation applied in both countries, and prepared the documentation needed for launching a uniform procurement procedure.

The lowest tender price - based on ranking of tenders that have met all legal, technical and financial requirements - was selected as the criterion for choosing the most favourable bid in this public procurement procedure. At that, care was taken not to make the criteria overly restrictive, i.e. to enable participation of the greatest possible number of tenderers in the procedure, so as to ensure a good-quality competition and, ultimately, the most favourable price for the joint client.

It should however be noted that the tender documents [6] strictly banned submission of alternative tenders, mainly because that would almost certainly result in the initiation of highly complex and time consuming administrative procedures. Such procedures would undoubtedly cause changes to the already prepared design documents and would almost certainly result in the change of the already obtained permits for the start of construction work, while they would also open new issues regarding value for money that would be presented to the joint client, which would in turn reduce transparency of the procurement procedure.

Procurement procedure for the Svilaj Bridge construction works was initiated in September 2015. After public opening of tenders, evaluation by mixed Procurement Committee composed of members from both countries, tenderer selection in accordance with the Committee's opinion, and end of complaint procedure, the Contract for the construction of the Svilaj Bridge over the Sava River was finally awarded on 15 July 2016 to the consortium of tenderers composed of Viadukt d.d., Zagreb, and Hering d.d., Široki Brijeg. The contract sum amounted to € 22,308,022.34, exclusive of VAT, and the works were to be completed in two years.

In addition to procurement of works, it was additionally necessary to award contract for expert supervision during construction of the Svilaj Bridge. Although legislative acts and regulations relating to construction works are quite similar in both countries there are still some differences and specific features, which is why separate supervision services had to be provided for in the Republic of Croatia and in Bosnia and Herzegovina. This was also necessary because all technical and legal requirements applicable in the two countries had to be met for building-inspectorate supervision and procurement of operating permit.

For these reasons, Hrvatske autoceste d.o.o. awarded the expert supervision contract, via public tender, to Centar za organizaciju građenja d.o.o. Zagreb, while the Ministry of Communications and Transport of Bosnia and Herzegovina awarded similar contract to Institut IG, Banja Luka.

Main principles for the provision of construction management and supervision services on the project are explained below.

2.4. Realisation of construction contract

The Svilaj Bridge construction contract is based on the FIDIC Conditions of Contract, i.e. on the "Red Book" issued in 1999 [7]. During preparation of tender documents, a special attention was paid to the definition of special conditions of contract so as to ensure an efficient project management on this construction project, considering complex relations between participants and a specific administrative and regulatory framework of the project. In order to regulate relations and communication between participants in the project and to define joint project management procedures, the PIU set its "Joint contract management principles" [8]. These principles advise participants in the project that all project related decisions must be consensual and harmonised, and that equal treatment must be reserved to teams and support services of joint client, and to expert supervision teams, which includes respect of procedures of individual participants in the project.

One of significant preconditions for realisation of this construction contract was definition of the role of the Engineer who makes all decisions relevant to the contract as based on FIDIC forms.

On the Svilaj Bridge construction project, the role of Engineer is jointly assumed by the Chief Supervising Engineer appointed by Hrvatske autoceste according to the Construction Act, and the Supervising Engineer - Coordinator, i.e. Team Leader, appointed by the Ministry of Communications and Transport of Bosnia and Herzegovina.

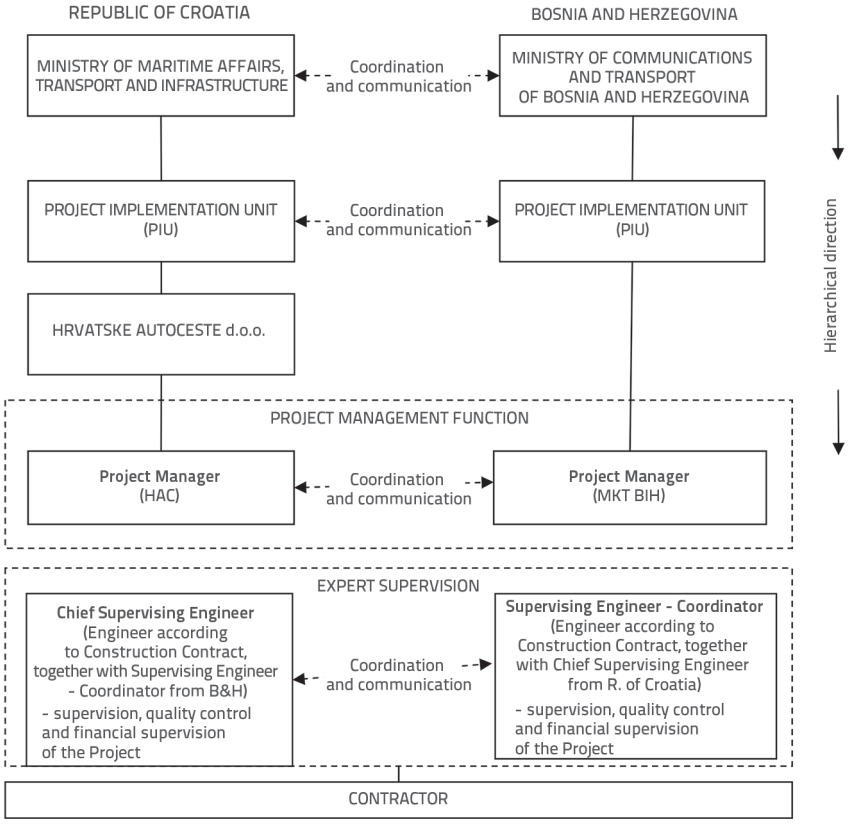

Figure 3. Project Management diagram

All decisions are made unanimously, but prior approval by the joint client is needed for decisions relating to additional payments or construction deadline extensions.

The above mentioned principles relating to project management, and to joint activities of client representatives and expert supervision teams from both countries, are used to define the structure and method of keeping site diaries, to verify and check quantities according to contractor's documents, and to make quality control and quality assurance checks, all in order to ensure compliance with current legal and technical requirements applicable in both countries. This has enabled elimination of most technical and administrative obstacles that could have had a negative impact on implementation of the project.

No problems that could point to inadequacy of the above described project management system have been registered so far in the implementation of the project.

2.5. Handover of works to final beneficiaries

Framework of joint maintenance and use of the Svilaj Bridge is also defined by state-to-state agreement [2, 3]. Although the bridge maintenance responsibility has generally been set due to the fact that international road border crossings are to be built on the A5 motorway in the immediate vicinity of the bridge and will be operated under responsibility of the Ministry of Finance of the Republic of Croatia and the Indirect Taxation Authority of Bosnia and Herzegovina, additional agreements will have to be made before the bridge is opened to traffic between Hrvatske autoceste, Ministry of Communications and Transport of Bosnia and Herzegovina, Ministry of Finance of the Republic of Croatia, and the Indirect Taxation Authority of Bosnia and Herzegovina, in order to define all communication protocols, movements in the border crossing zone and distribution of maintenance ant traffic operation costs in the border crossing zone.

3. Financing

As indicated in the introduction, bridge construction costs are equally shared (50 % : 50 %) between Hrvatske autoceste d.o.o. and the Ministry of Communications and Transport of Bosnia and Herzegovina. Hrvatske autoceste finances the costs out of its own funds, i.e. through the European Investment Bank (EIB) loan, while the project is additionally co-financed from EU funds via the Connecting Europe Facility (CEF). Co-financing via the mentioned instrument can be realized up to € 7,194,077.00 or up to 57.97 % of acceptable costs of the project.

The Connecting Europe Facility (CEF) is normally used to co-finance projects relating to construction of new and improvement of existing transport, energy, and telecommunications infrastructure and, in the projects relating to the sector of transport, this mostly concerns cross-border projects, elimination of bottlenecks, realizing missing links, projects related to transport management systems, innovations, projects aimed at lowering environmental impacts, increasing energy efficiency, increasing traffic safety, etc.

Thus in September 2016, Hrvatske autoceste signed with the Innovation and Networks Executive Agency (INEA) - through which CEF co-financing is realised - the Contract for the Allocation of Nonreimbursable Funds, based on project application following the open invitation by CEF - Transport in 2015.

Properly justified costs of Hrvatske autoceste that are co-financed through the Contract for the Allocation of Nonreimbursable Funds are the costs of construction and expert supervision on the project, costs of project management that include salaries and other costs of Hrvatske autoceste personnel engaged on the project, and costs of promoting co-financing of European Union projects.

Table 1. Sources of financing for 50 % of project cost to be covered by Hrvatske autoceste d.o.o.

Sources of financing	Financial contribution as related to justifiable costs
CEF-Transport	€ 7.194.077.00
1. Own funds of the beneficiary: a) EIB loan	€ 5.215.923.00 € 5.215.923.00
2. National budget	€ 0
3. Regional / local budget	€ 0
4. Income generated by the company	€ 0
5. Other sources	€ 0
TOTAL	€ **12.410.000.00**

The Ministry of Communications and Transport of Bosnia and Herzegovina finances its half of the project from national budget and from the Contract for the Allocation of Nonreimbursable Funds via the Western Balkan Investment Framework (WBIF), through which the sum of € 25,090,000.00 was allocated to Bosnia and Herzegovina for co-financing: construction of the Svilaj to Odžak motorway section, B&H border crossing, and Svilaj Bridge.

4. Bridge construction

The construction work on the Svilaj Bridge started in the early September 2016. After on-site establishment, the contractor proceeded with site mobilisation, which was completed by the late October 2016. The site was formed on both sides of the river and, immediately after on-site establishment, the contractor started to fabricate reinforced-concrete piles for bridge foundations.

Design objectives have so far been successfully realized on the project, in full accordance with the principle of harmonisation of activities between participants in the project. All project risks were identified in a timely manner during realisation of the project, and appropriate measures for their minimisation of complete elimination have been undertaken according to the construction contract and the state-to-state agreement [2, 3]. The most important risks involved bankruptcy of one of the contractors, which occurred immediately after the start of construction work, fluctuations on the market of key materials caused by long-term economic crisis in the region, namely regarding availability of resources for the production of steel structure, and significant deviations in the actual Sava River water levels, as related to water levels specified in available statistical information.

The design team of the joint client has been continuously supervising the progress on the project by checking respect of individual milestones, financial realisation of the contract, and compliance with time schedule approved by the client. All participants in the project have been advised adequately and in a timely manner about all aspects of the project. No significant deviations from the design documents and no great variations in the quality of works have been registered on the project, as a result of adoption of adequate inspection and reporting mechanisms.

The above described risks have resulted in some disturbance of the initially planned work schedule and, to counter the problem, the initially adopted time schedule was modified so as to take into account actual on-site conditions; appropriate corrective measures were also adopted with regard to the allocation of resources to the contractor.

An overview of works planned and realised so far is presented by individual technical segments in the following section.

4.1. Bridge substructure

The following constructions are specified in the detailed design of the bridge [4]: bridge foundations, upstream and downstream facilities on joint foundations, and six pier positions depending on the height and disposition of bearings and expected load. All piers are elliptical in cross-section, and their size is adjusted to the size of bearings at individual positions.

Rectangular pier foundations measuring 33.80 x 11.30 x 2.50 m are used for piers S1, S2, S5 and S6; they are founded on 24 reinforced-concrete piles. Rectangular pier foundations measuring 33.80 x 15.80 x 3.50 m are used for piers S3 and S4; they are founded on 32 reinforced-concrete piles. Abutments are horse-shoe shaped and monolithic, and they have expansion joints. Abutment foundations are similar at both bridges; they are rectangular in shape and their dimensions are 28.20 x 6.95 x 2.50 m [4].

Foundation works started by construction of reinforced-concrete piles, which involved drilling with appropriate drilling rigs, reinforcement placing, and pile body concreting by means of a tremie pipe. Steel casing tubes 1500 mm in external diameter were used in pile drilling all the way down to the designed pile top level.

Figure 4. Pile drilling rig at abutment U1, Croatian side

Figure 5. Pile heads and blinding concrete for pile cap at pier position S6, B&H side

Pile drilling was preceded by appropriate investigations in order to determine dimensions of piles and foundations of the bridge. Results obtained during these investigations show that firm clay and silt layers (CH, CI, CL/CI, MI, ML) are located on Croatian bank down to the depth of 4.50 m to 5.50 m, while these layers extend down to the depth of 6.50 m to 7.00 m on B&H bank. These layers lie on mixed sandy silty layers (SFs), locally, and deeper down, with admixtures of fine gravel. Generally very well compacted clayey gravel layers (GC) have been registered in the Sava riverbed at the bottom of all boreholes [4].

Reinforced-concrete piles and foundations on all pier locations were dimensioned based on the mentioned soil investigation results. In this way, it was established that 12 piles 150 cm in diameter and 18.00 m in length, horizontally arranged in two rows, will be realized at each abutment, while 24 piles, 150 cm in diameter and 18.00 m in length, horizontally arranged in three rows, will be realized at pier positions S1, S2, S5, and S6. The pile length was set to 20 m at pier position S5 because the presence of a clay lens was established in this zone. 32 piles 150 cm in diameter and 18.00 m in length, horizontally arranged in four rows, were planned at pier positions S3 and S4. It was also determined that piles below the terrain level and in the Sava riverbed will be linked with pile caps ranging from 2.50 m to 3.50 m in thickness, depending on pier location [4].

Reinforced concrete piles were realized with two separate pile drilling rigs, located on either bank of the Sava river.

Foundations for piers S1, S3, S4, and S5 were excavated by protecting the foundation pit with the structure composed of sheet piles type PU 22^{-1} S355, 12 m in length, and the corresponding bracing system, with continuous ground water pumping in foundation pit, and thus the works were carried out in a protected and relatively dry environment. Foundations for piers S2 and S6 were excavated without protection by the above described sheet piles and wide excavation because it was established, taking into account the excavation bottom level and ground water level, and based on calculation results, that the stability of foundation pit is not endangered [9].

Protection and excavation of foundation pits in the Sava riverbed was conducted on the other side from rock-filled working platforms which, thanks to their size, slope and other technical characteristics, allow access of mechanical plant to pier positions.

Figure 6. Foundation pits at pier position S3, Croatian side, with pile cap reinforcement already in place

Figure 7. Construction of pier S4, Bosnia and Herzegovina side

Other than for foundation work, these work platforms are also used for placing temporary supports and for the assembly of steel structure at the bridge superstructure level. Foundation works in the Sava riverbed were an especially delicate phase

of works as the work had to be carried out in a limited time period of favourable weather, i.e. usually from the late April to early November when, according to available statistical data, low water levels can normally be expected.

After completion of foundation work at one pier the work continued with fabrication of the pier itself; substructure work was completed after realization of all piers.

As to substructure work, it was determined - in accordance with design documents - that the cross section of piers S1, S2, S5 and S6 will be invariable. The dimensions of these piers are 8.00 x 1.80 m; their sides are curved and the curvature radius is 0.90 m. The cross section of piers S3 and S4 is variable along the height, and measures 9.11 x 3.35 at the bottom and 8.00 x 3.00 at the top. The inclination of longer and shorter sides is 8:1 and 25:1, respectively. Abutments are monolithic, horseshoe-shaped and similar for both bridges; they are equipped with expansion joints [4].

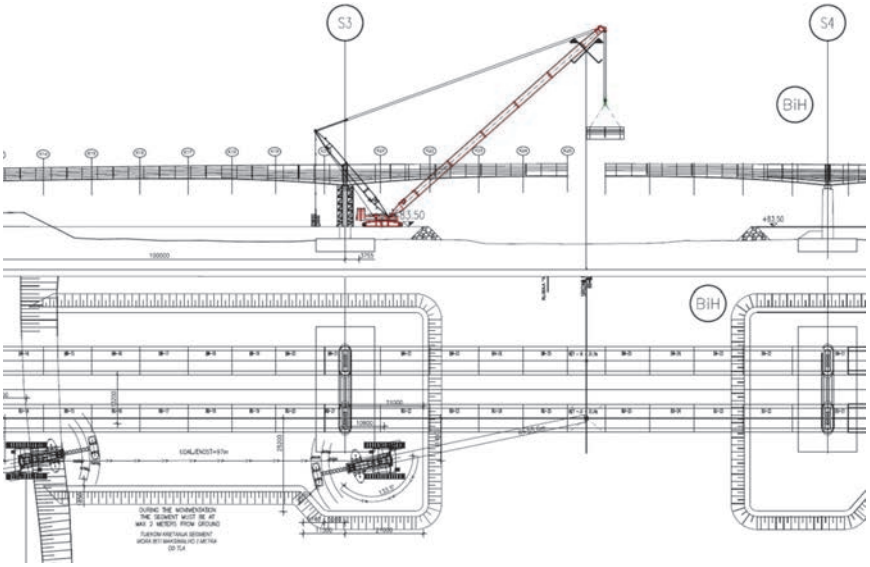

Figure 9. Diagram showing assembly of the final steel structure element from the temporary platform erected in the Sava riverbed [11]

All abutments and piers are realized in sections using smooth formwork, and will finally be lined with granite stone 15 cm in thickness for protection against floating objects, ice and branches, and to prevent damage caused by sediment transport. All abutments and piers on the Svilaj Bridge were completed in the late October 2018.

4.2. Bridge superstructure

Superstructure works include fabrication and assembly of steel structure, deck slab construction, construction of pavement structure, kerb laying, realization of reinforced-concrete cornice and footway.

Figure 8. Completed steel structure up to pier S5, platform with macro-elements and temporary supports between piers S5 and S4, Bosnia and Herzegovina side

The steel structure of the bridge superstructure is currently being fabricated and, according to the previously prepared and confirmed workshop drawings, it is divided in longitudinal direction into 51 segments of the upstream bridge and 51 segments of the downstream bridge, approximately 12 to 13 m in length, so as to enable economical transport and assembly. Each segment is composed of three elements 2.40 m in width [10].

Elements relating to spans S1 - U1, S1 - S2, from U2 - S6 and S6 - S5, which are situated outside of the Sava riverbed, were mounted directly onto the previously placed temporary supports, and fixed in place on the spot.

Spans S2 - S3, S3 - S4, and S4 - S5, which cross the Sava riverbed, were fixed into their final position in the period of low water levels. To minimise disturbance to the flow of water, and in case of flooding of temporary platform for the assembly of steel structure, the assembly of only three temporary supports per span was planned along the upstream and downstream parts fo the bridge for the assembly of spans S2 - S3, and S4 - S5. Subsequently, during realisation of works, and following the designer's approval, an additional temporary support was added immediately next to piers S3 and S4 for safety reasons and to facilitate assembly of the steel structure. The elements of these spans were previously assembled on the work platform situated in the flood zone of the river, i.e. outside of the Sava riverbed.

The temporary work platform which was used, as already mentioned, for the construction of piers S3 and S4, was also used for the assembly of the steel structure of spans S2 - S3, S3 - S4, and S4 - S5 on the upstream and downstream parts of the bridge. Due to its geometry and compactness, the work platform was suitable for the movement and operation of cranes up to 600 t in capacity, which were used for handling and

final assembly of previously assembled elements of the streel structure.

The assembly of steel structure in the mentioned spans was conducted in parallel from both sides, from abutments towards the middle of the bridge. Once the steel structure was assembled from abutment U1 to pier S3 and from abutment U2 to pier S4, conditions were created for the removal of temporary support and for the start of deck slab concreting in accordance with the previously set concreting schedule. The assembly of the central part of the bridge can be realized in parallel with deck slab concreting operations in the first two spans on each bank, and is carried out by previous assembly of macro-segments about 50 m in length, each composed of three to four segments, which will be linked with the previously assembled steel structure [11]. Thus the macro-elements will be assembled on both banks onto the previously assembled and welded steel structure, which is finished until pier S3 on Croatian bank and until pier S4 on the bank of Bosnia & Herzegovina [11].

Temporary pylons about 2 m in height will be placed above piers S3 and S4 onto the steel structure to enable assembly of the central span; at the assembly stage, the steel structure will be tensioned via these pylons with two cables each composed of 19 strands 0.5 " in diameter [11].

This assembly method is used to reduce moment on the cantilever, and to enable accurate regulation of heigh at cantilever ends. The final central segment about 10.00 m in length with be assembled after vertical levelling of ends at both banks of the river. Once this element is connected with the structure, it will no longer be a cantilever structure but rather a continuous one, and conditions will be created for the release of temporary cables and removal of temporary pylons above piers S3 and S4 [11].

Once the structure is fully connected, it will be possible to concrete bottom slabs above piers S3 and S4, ant to complete concreting of the deck slab in accordance with the previously defined schedule. In order to enable handling and movement of the crane, considering its size, it will first be necessary to connect and assemble downstream facilities and, subsequently, the upstream facilities as well.

As already indicated, after connection of the upstream and downstream structures, the work will continue on the deck slab which is in fact a reinforced-concrete slab transversely prestressed with non-composite 4.00 x 0.62" cables made of high-quality steel strands, spaced at 0.50 m intervals [11].

This slab is realized *in situ* in full width (12.90 m) using moveable formwork, and the work is scheduled as defined in design documents. The slab thickness is variable, i.e. It is 40 cm above the web of the main girder, and is reduced to 28 cm in the mid-span, and to 25 cm at the end of the cantilever. The slab is made to act compositely with the steel trough via shear connectors, which are welded to flange plates in the steel structure fabrication plant. The main reinforcement for the deck slab is installed in transverse direction in the span, while it is installed in both longitudinal and transverse directions above central bearings where the slab is in tension [4]. After completion of the deck slab, monolithic reinforced-concrete cornices will be realized using a purpose-made moveable formwork, and then granite kerbs and footway will be realized. The deck slab will in the end be protected on both sides by rigid traffic barrier type BN4. In addition to these works, it will also be necessary to realize the pavement structure; it will be composed of:

- waterproofing layer 1.0 cm in thickness
- protective asphalt concrete layer AB11 3.5 cm in thickness
- Split mastic asphalt layer, SMA 16, 4.5 cm in width.

4.3. Road furniture and signalisation

Before opening to traffic, the bridge will be equipped with road furniture and signalisation complying with latest state-of-the-art standards. Thus an automatic weather station with appropriate sensors and probes for the collection of weather-related data will also be installed on the bridge. The weather station will be linked with the Regional Traffic Management and Monitoring Centre (RCNUP). Based on data coming from sensors and video surveillance equipment installed at motorway sections leading to the bridge, conditions will be created for high quality and efficient management of traffic via changeable message signs, informing drivers about dangerous upcoming situations and limitations.

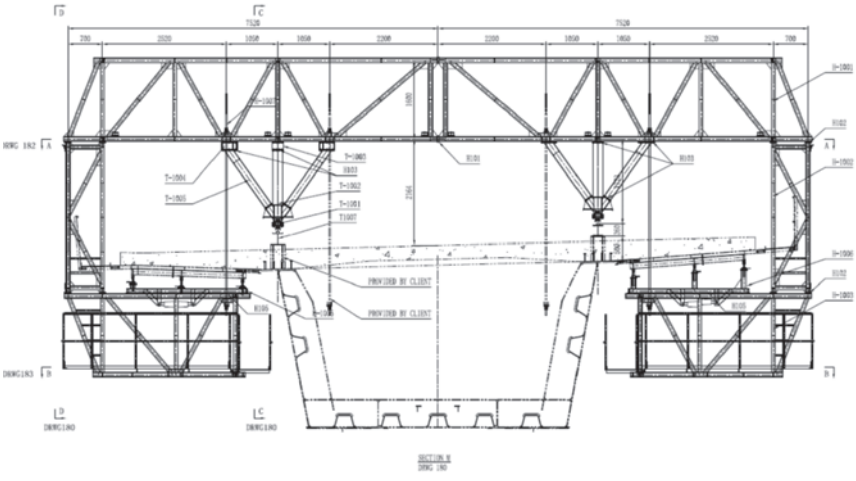

Figure 10. Moveable formwork for realisation of the deck slab [10]

In addition to road furniture, the bridge will also have a discrete decorative lighting and navigation signals in LED technique.

Decorative lighting is provided to place visual emphasis on the bridge, which will be achieved by lighting the piers S3 and S4 with narrow beam spotlights, visually highlighting piers and their stone revetment, while at the same time marking limits of the navigable

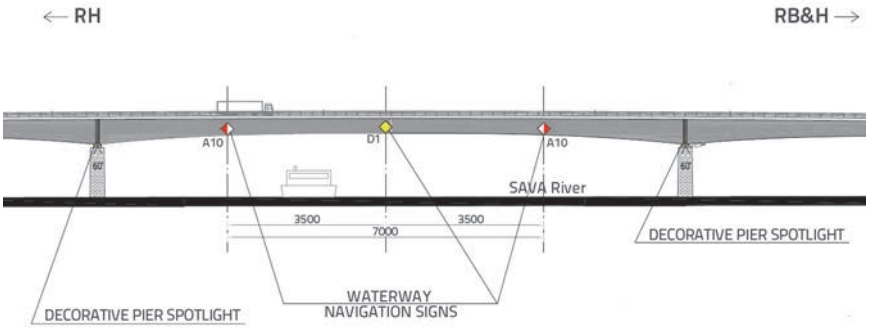

Figure 11. Navigation signs on the completed bridge [4]

waterway. External sides of the bridge and bottom part of the box will also be lighted with narrow beam spotlights, so as to maintain the lighting balance in relation to piers S3 and S4 which will be specially emphasized.

In addition to external contours of the structure, traffic barriers will also be lighted which, other than being decorative, has the purpose of increasing traffic safety by enabling drivers to gain an increased sense of direction and the sense of bridge limits, and by increasing optical visibility of the pavement.

As already mentioned, lighted marks of navigable waterway, with internal LED lighting, will be provided to ensure safe operation of river traffic. These marks will be placed on the superstructure above the navigable waterway limits. All signs marking the navigable waterway will be 100 x 100 cm in size, and they will be realised as LED lighting decorations.

5. Bridge operation

It is expected that the bridge will be completed and opened to traffic in the second half of 2019. The opening to traffic of this bridge will eliminate the missing link between motorway networks of the Republic of Croatia and Bosnia and Herzegovina, which will ultimately improve traffic connections between the two countries.

The full potential of the Svilaj Bridge will be reached after completion of the A5 motorway from Osijek to Hungary, the border motorway section in Hungary, and the road corridor Vc in Bosnia and Herzegovina, all of which constitutes high priority for establishing proper transport links between the three countries.

6. Conclusion

In the light of the above considerations, it can be concluded that the Svilaj Bridge over the Sava River is an example of good practice in the management of large-size infrastructure cross-border projects. The above statement is based on the fact that, despite very complex legislative and administrative framework, and a great number of project participants in the territory of both countries, most problems that could have had an unfavourable influence on the fulfilment of project objectives have been successfully overcome through establishment of appropriate project management mechanisms, while the impact of other problems has been reduced to minimum through development of a clear project risk management strategy.

The experience to be gained on this project can certainly be applied on other similar infrastructure development projects, the number of which is expected to increase due to to the cohesion policy of the European Union, i.e. establishment of links with neighbouring member countries and possible territorial extension of the European Union.

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