PRIRODNO-GRADITELJSKA CJELINA – MOST U PLANDIŠTU („RIMSKI“ MOST; MOST PREKO RIJEKE BOSNE U PLANDIŠTU)

THE NATURAL AND ARCHITECTURAL ENSEMBLE OF THE BRIDGE IN PLANDIŠTE (THE “ROMAN” BRIDGE; THE BRIDGE OVER THE BOSNA IN PLANDIŠTE)

Orjana LENASI

U radu je predstavljen projekat „Ambasadorov fond za kulturnu zaštitu, 2008“, Most u Plandištu – program zaštite mosta, koji je finansiran od strane Vlade Sjedinjenih Američkih Država.

Projekat zaštite je prvenstveno imao za cilj izradu snimka postojećeg stanja Mosta u Plandištu, čije aktivnosti su bile podijeljene u nekoliko tematskih grupa: a. Sakupljanje i digitalizacija postojeće dokumentacije; b. Izrada projekta postojećeg stanja; c. Izrada programa istražnih radova; d. Provedba istraživačkih radova; e. Nadzor nad provođenjem istražnih radova; f. Obrada rezultata istražnih radova (preliminarna statička analiza, zaključci o stanju prirodno-graditeljske cjeline, preporuke za izradu projekta sanacije); i g. Revizija projekta postojećeg stanja. Osim navedenog vršile su se i aktivnosti na povećanju svijesti o značaju naslijeđa „Moja Bosna i Hercegovina – Moje naslijeđe“, čije su ciljne grupe bili osnovci iz sarajevske regije.

Ključne riječi: most, Plandište, postojeće stanje, Rimski most, istraživački radovi

The paper sets out the project for the protection of the Bridge in Plandište, funded by the US government through the Ambassador's Fund for Cultural Preservation, 2008.

The protection project was designed primarily to survey the current condition of the Bridge in Plandište, which consisted of a number of thematic groups: a) the collection and digitalization of extant documentation; b) conducting a survey of the current condition of the bridge; c) drawing up a programme of investigative works; d) carrying out the investigative works; e) oversight of the investigative works; f) processing the results of the investigative works (preliminary structural analysis, findings of the condition of the natural and architectural ensemble, recommendations for designing a project for repairs and remedial works) and g) a revision of the survey of the current condition of the bridge.

In addition, awareness-raising activities were carried out under the auspices of the campaign "My Bosnia and Herzegovina – My Heritage," of which the target group was primary school children from the Sarajevo region.

Key words: bridge, Plandište, current condition, Roman Bridge, investigative works

Naziv projekta:

Most u Plandištu – program zaštite mosta

Lokacija:

Općina Ilidža, Sarajevo

Struktura tima koji je radio na provedbi projekta:

- Orjana Lenasi, koordinator projekta, arhitekta konzervator,
- Mr. sc. Amra Hadžimuhmedović, arhitekta konzervator, koordinator projekta,
- Mustafa Humo, dipl. ing. građevine,
- Mr. sc. Salko Kolukčija, dipl. ing. građevine,
- Prof. dr. Enver Mandžić, dipl. ing. geomehanike,
- Mirela Mulalić-Handan, arhitekta konzervator, stručni savjetnik za upravljanje projektom,
- Emir Softić, arhitekta konzervator,
- Aleksandra Bunčić, historičar umjetnosti – segment „Moja Bosna i Hercegovina – moje nasljeđe".

Izvor i iznos sredstava kojim se projekat finansira:

Sredstva su obezbijeđena iz Fonda ambasadora SAD-a za očuvanje kulturnog naslijeđa, 2008. koji se finansira iz sredstava Vlade Sjedinjenih Američkih Država - 24,990 $ (32,800 KM). S obzirom da se vrsta radova i njihova količina izmijenila u odnosu na prvobitno odobreni projekat Komisija za očuvanje nacionalnih spomenika je učestvovala u sufinansiranju dijela istražnih radova iz budžetskih sredstava u iznosu od 20.000 KM;
Implementirana sredstva: 52.800 KM.

PODACI O OBJEKTU I LOKALITETU - MOST U PLANDIŠTU[1]

Historijski podaci

Sliv rijeke Bosne je, u prostornom smislu, predstavljao jezgro okupljanja i naseljavanja naroda još u starom vijeku. Lokalitet Ilidže[2] je lociran u nukleusu

1) Komisija za očuvanje nacionalnih spomenika, „Odluka, broj 06.1-2-75/03-3 od 15. marta 2005. godine, o proglašenju prirodno-graditeljske-cjeline – Most u Plandištu (Rimski most, Most preko rijeke Bosne u Plandištu) nacionalnim spomenikom Bosne i Hercegovine", *Komisija za očuvanje nacionalnih spomenika*, 15. 10. 2009. <http://www.aneks8komisija.com.ba/main.php?id_struct=6&lang=1&action=view&id=2533>.

2) (tur.) toplice, banja, tur. izvor ljekovite vruće vode (Škaljić, Abdulah, *Turcizmi u srpskohrvatskom jeziku*, Sarajevo, 1989: 344).

Project title:

Bridge in Plandište – protection programme

Location:

Ilidža Municipality, Sarajevo

Project implementation team:

- Orjana Lenasi, architect conserver, project coordinator,
- Amra Hadžimuhmedović MSc., architect conserver, project coordinator,
- Mustafa Humo, BSc. Civ. Eng.,
- Salko Kolukčija, MSc. Civ. Eng.,
- Prof. Dr. Enver Mandžić, BSc. in geomechanics,
- Mirela Mulalić-Handan, architect conserver, project manager,
- Emir Softić, architect conserver,
- Aleksandra Bunčić, art historian – for the component "My Bosnia and Herzegovina – My Heritage."

Source and amount of project funds:

US Ambassador's Fund for Cultural Preservation, 2008, funded by the US Government - $24,990 (32,800 KM). Given the nature and extent of the works, which were amended after the original project was approved, the Commission to Preserve National Monuments co-financed part of the exploratory works from its own budget, in the sum of 20,000 KM;
Implemented funds: 52,800 KM.

BRIDGE IN PLANDIŠTE[1]

Historical background

Territorially speaking, the river Bosna basin has been the focus of assembly and settlement since ancient times. Ilidža[2] is at the centre of the oldest area

1) Commission to Preserve National Monuments, "Decision no. 06.1-2-75/03-3 of 15 March 2005 designating the historic structure of the bridge in Plandište (the "Roman" bridge; the bridge over the river Bosna in Plandište) as a national monument of Bosnia and Herzegovina", *Commission to Preserve National Monuments*, 15 February 2009. <http://www.aneks8komisija.com.ba/main.php?id_struct=50&lang=4&action=view&id=2533>.

2) (Tur.) hot springs, spa, source of healing hot springs (Škaljić, Abdulah, *Turcizmi u srpskohrvatskom jeziku,* Sarajevo, 1989: 344).

najstarijeg područja sarajevske regije u kom se nalaze ostaci neolitskih, ilirskih i rimskih naselja, kao i termalna kupališta korištena za vrijeme Rimskog, Osmanskog i Austrougarskog carstva, kao i u kasnijem periodu.

Godine 1893. slučajnim je, a od 1896. godine sistematskim, iskopavanjima otkriveno naselje neolitske kulture koja se razvijala oko 2400 - 2000. godine prije nove ere.

Iz rimskih izvora poznato je da su tu živjeli Iliri čija je kultura vezana za željezno doba tj. za I milenij prije naše ere. Nakon oko tri stoljeća permanentnih borbi, Rimljani su 9. godine nove ere zauzeli veliki dio Balkanskog poluotoka, tj. Ilirik.

Kroz Ilidžu prolazi jedna od najvažnijih rimskih cesta, a rimsko naselje „Aquae...S" („Banja...S") je bilo upravno i kulturno središte čitave oblasti. Materijalni ostaci rimske civilizacije nalaze se i na lokalitetima Stupsko brdo, Osijek, Crkvište u Blažuju. Pomoću sistematskih arheoloških istraživanja na Ilidži pedesetih i početkom šezdesetih godina 20. stoljeća, sačuvane su rimske građevine, podni mozaici, keramika, nakit i novac.

U 10. stoljeću ovo područje je središte Vrhbosanske župe, a u 15. stoljeću sjedište sarajevskog sandžaka. Prema ovom društveno-političkom i trgovačkom središtu i od njega vodili su značajni i frekventni putni pravci.

Trgovački put koji je povezivao Dubrovnik sa srednjom Bosnom, išao je preko planine Ivan i vodio do Tarčina odakle se granao u dva pravca: prema Vrhbosni, odnosno prema Visokom. Jedan potez cestovnog kraka prema Vrhbosni i danas je zadržan na potezu Ilidžanske i Sarajevske ceste. Na prostoru Plandišta su se nalazila raskršća puteva koji su dolazili dolinom Bosne sa putevima koji su dolazili sa istoka i juga.

Navedeni podaci o osobenostima mikrolokacije Plandišta, kao i činjenica da u neposrednoj blizini mosta nikada nije postojalo naselje upućuje na zaključak da most nije imao komunalni karakter, nego je bio izgrađen kao most na međugradskoj komunikaciji.

Važnost pomenutih saobraćajnih pravaca, kao i razvoj naselja i kontinuitet naseljavanja na

in the Sarajevo region where the remains of Neolithic, Illyrian and Roman settlements are found, as well as the thermal baths used during the Roman, Ottoman and Austro-Hungarian periods as well as since.

In 1893 a chance discovery, followed by systematic excavations from 1896 onwards, uncovered a Neolithic culture settlement which developed around 2400-2000 BCE.

It is known from Roman sources that the area was settled by Illyrians, whose culture is associated with the Iron Age, i.e. the 1st millennium BCE. After about three centuries of incessant fighting, in 9 CE, the Romans occupied much of the Balkan peninsula, or Illyria.

One of the most important Roman roads ran through Ilidža, and the Roman settlement of "Aquae ... S" was the administrative and cultural centre of the entire district. There are material remains of the Roman civilization in Stupsko brdo, Osijek, and Crkvište in Blažuj. Thanks to systematic archaeological investigations in Ilidža in the 1950s and early 1960s, Roman buildings, floor mosaics, pottery, jewellery and coins have been preserved.

In the 10th century the area was the centre of the župa (county) of Vrhbosna, and in the 15th century it became the centre of the Sarajevo sandžak. Major and well-frequented routes led to and from this social, political and commercial centre.

The trade route linking Dubrovnik with central Bosnia crossed Mt Ivan and led to Tarčina, where it forked, with one fork leading towards Vrhbosna and Visoko. A stretch of the Vrhbosna road still survives along the Ilidža and Sarajevo road. There was a crossroads in Plandište, where the roads from the Bosna valley and those from the east and south intersected.

These specific features of the microlocation of Plandište, and the fact that there was never a settlement in the immediate vicinity of the bridge, suggest that the bridge was not of a communal nature but was built for the purpose of interurban communications.

The importance of these routes, as well as the development of the settlement and continuity of

području Ilidže, dovode do pretpostavke[3] da je na mjestu današnjeg mosta, u rimskom periodu, kao i u srednjovjekovnom periodu postojao neki most, iako o tome nema sačuvanih pisanih dokumenata.

Pisani navodi iz kasnijih putopisa, daju osnovu utemeljenju pretpostavke da je današnji most „temeljito obnovljen, ukoliko nije tada iz temelja i sagrađen" u periodu između 1530[4]. i 1550. godine, jer prvi pisani spomen o mostu na Plandištu ostavlja mletački poslanik Catarino Zeno, koji je 1550. godine prošao kroz Sarajevo. U svom putopisu o rijeci Bosni piše da izvire ispod gore kojoj ne zna imena, te „je odmah velika, preko nje vodi kameni most sa sedam lukova, s kojega se vidi kako iz gore ključa".[5]

Ne zna se ko je „bio taj obnovitelj, ako ne i utemeljitelj mosta", ali među istraživačima, postoje pretpostavke da su graditelji mosta na Plandištu mogli biti: veliki vezir Rustem-paša Hrvat ili Semiz Ali-paša ili Gazi Ali-paša[6].

O popravkama ovog mosta sačuvano je relativno dosta podataka. Citat: „Najinteresantniji podaci potječu iz 1762. godine, kada su zainteresirani građani Sarajeva zatražili od bosanskog vezira da se

habitation in Ilidža, suggest[3] that there was a bridge on the site of the present-day bridge in Roman and mediaeval times, although there is no surviving documentary evidence to this effect.

The writings of later travel chronicles provide a basis for the assumption that the present-day bridge was "extensively renovated, if not actually built from the foundations up" between 1530 and 1550,[4] since the earliest reference in writing to a bridge in Plandište is that of the Venetian envoy Catarino Zeno, who passed through Sarajevo in 1550. In his travelogue, he noted that coming from the north he came to Blažuj ("Blazuda"), where he spent the night. The next day he crossed the river Bosna, after which, as he observes, the entire country is named, noting of the river that its source is beneath a mountain of which he does not know the name, and that it "is immediately a large river, with a seven-arched bridge leading over it, from which one can see it welling up from the mountain."[5]

It is not known who the "renovator, if not the founder of the bridge" was, but the assumption is to be found among scholars that the builders of the bridge in Plandište could have been Grand Vizier Rustem Pasha Hrvat, or Semiz Ali Pasha or Gazi Ali Pasha.[6]

3) „Mandić ovaj most datira u srednji vijek, dopuštajući mogućnost da bude i stariji, konstatuje sličnost po konstrukciji sa mostićem na Tilavi, s tim što je znatno duži, jer je i rijeka Bosna šira. 'Oba pak mosta pokazuju jasno pravac srednjovjekovnog puta, kojim su dolazili putnici sa zapada u Vrhbosnu da odatle produže putovanje prema istoku'. Ako uzmemo u obzir Mandićevu pretpostavku, moramo je dopuniti utoliko što ćemo se podsjetiti da se još u antičko vrijeme trasa puta nalazila na približno istom mjestu, te da je, s obzirom na značaj naselja Aquae S..., na mjestu današnje Ilidže i tu negdje preko rijeke Bosne morao biti prelaz, vjerovatno most. Do danas se sačuvao kod pojedinih autora za ovaj most naziv Rimski most, što je, prvenstveno, bazirano na uzidanim detaljima sa rimskih građevina koji su nadeni na mostu." (Čelić, Džemal, Mujezinović, Mehmed, *Stari mostovi u BiH*, Sarajevo, 1969: 75)

4) „Razlog ovakvoj pretpostavci leži u činjenici da Kuripešić u svom iscrpnom putopisu iz 1530. godine ne spominje ovaj most (dapače, može se zaključiti da ga faktično nije bilo), dok ga, kao što smo vidjeli, K. Zeno čak dosta detaljno opisuje." (Čelić, Mujezinović 76)

5) citirana mjesta, naznačena navodnicima („ ") preuzeta su iz djela: Čelić, Mujezinović 75-76.

6) „Nešto bliže Sarajevu na rijeci Željeznici sagradio je most, u približno isto vrijeme, veliki vezir Rustem-paša Hrvat, pa nije isključeno da se on pobrinuo i o ovom mostu. Također se može pretpostaviti da su obnovitelji mosta Semiz Ali-paša ili Gazi Ali-paša..." (Čelić, Mujezinović 76)

3) "Mandić dates the bridge to the mediaeval period, while allowing for the possibility that it is even older, noting its structural similarities with the small bridge over the Tilava, except that it is much longer, because the river Bosna is wider. 'Both bridges, however, clearly indicate the route of the mediaeval road along which travellers from the west came to Vrhbosna and then onwards to the east.' If this assumption by Mandić is borne in mind, it must be amplified by the recollection that as long ago as antiquity the route taken by the road was approximately the same, and that, given the importance of the Aquae S... settlement in present-day Ilidža, there must have been a crossing somewhere here over the river Bosna, probably a bridge. To this day some authors refer to this bridge as the Roman bridge, which is based primarily on the Roman spoil built into the bridge." (Čelić, Džemal, Mujezinović, Mehmed, *Stari mostovi u BiH*, Sarajevo, 1969: 75)

4) "The reason for this assumption lies in the fact that in his exhaustive travelogue of 1530, Kuripešić does not refer to the bridge (from which it may be concluded that it did not exist), while, as we have seen, C. Zeno gives a fairly detailed description of it." (Čelić, Mujezinović 76)

5) The quotations in double quotation marks are from Čelić, Mujezinović 75-76.

6) "Grand Vizier Rustem-paša Hrvat built a bridge somewhat closer to Sarajevo, on the river Željeznica, at roughly the same time, so it is not im-

most opravi, jer je oštećen i slabo upotrebljiv...

...Zatim se navodi da je potrebno na kamenom mostu opraviti korkaluk (ogradu) u dužini od 31 aršina i na dva mjesta kaldrmu sa ivicama mosta, te izvaditi iz vode kamenje korkaluka koje se porušilo."[7]

Godine 1952. pri rekonstrukciji puta konstatovano je da most svojom širinom ni približno ne zadovoljava potrebne uslove za odvijanje saobraćaja motornih vozila, pa je u želji da se očuva njegovo autentično stanje, stavljen van upotrebe, a na udaljenosti od cca 150 metara nizvodno od njega sagrađen je novi, armiranobetonski most, koji udovoljava savremenim saobraćajnim zahtjevima. Bitno je napomenuti da se, u situacionom smislu, promijenio i položaj trase novog puta na dionici Ilidža-Blažuj, tako da je kameni most u Plandištu prestao biti funkcionalnim dijelom navedene dionice puta.

Generalni opis

Most na Plandištu predstavlja jedini sačuvani primjerak kamenog mosta izgrađenog preko rijeke Bosne na čitavom njenom toku, a vjerovatno, predstavlja i jedini izgrađeni kameni most preko rijeke Bosne, s obzirom da se za mostove Čekrekči hadži Mustafe i Davud-paše, koji su bili sagrađeni u Visokom, ne zna da li su bili kameni ili nisu.

Iako ime graditelja današnjeg mosta nije poznato, forme, detalji i obrada upućuju na zaključak da je most djelo domaćih majstora.[8]

Građevina ovog mosta je lijepo ukomponirana u prirodno okruženje u kojem se most nalazi, a svi elementi koji utiču na prostornu dispoziciju (silueta podužnog profila mosta, ravničarska konfiguracija terena, veličina vodostaja u raznim godišnjim dobima i razlivenost rijeke Bosne, sa široko razvijenim koritom u ovom dijelu vodotoka) su dobro analizirani što je

7) Čelić, Mujezinović 77-79.

8) „Most je, uglavnom, do danas sačuvao svoj oblik, koji je dobio u 16. stoljeću. Karakteriše ga stilska arhaičnost, koja govori o dobrim majstorima kamenarima, ali ne toliko o poznavanju stilskih oblika onovremene turske arhitektonske škole. To nam daje povoda da zaključujemo da je on djelo dobrih domaćih majstora, možda školovanih na mediteransko-hercegovačkoj tradiciji i donekle upoznatih, i to prilično površno, sa turskim arhitektonskim stilom i detaljima." (Čelić, Mujezinović 76)

Relatively full information on repairs to the bridge has been preserved. "The most interesting details date from 1762, when interested citizens of Sarajevo appealed to the Bosnian vizier to repair the bridge, which was damaged and barely passable." The document goes on to state that "the stone bridge requires repairs to the korkaluk (parapet) over a length of 31 arshins and on two places to the paving at the edges of the bridge, and the removal from the water of the parapet stones that have fallen in."[7]

In 1952, when the road was being reconstructed, it was noted that the width of the bridge was totally inadequate for motor vehicle traffic. As a result, in order to preserve it in its authentic condition, it ceased to be used, and a new reinforced concrete bridge suitable for modern traffic was built about 150 m downstream. It should be noted that the route taken by the stretch of the new road between Ilidža and Blažuj was altered, so that the stone bridge in Plandište ceased to form a functional part of this stretch of road.

General description

The bridge in Plandište is the only surviving stone bridge over the entire course of the river Bosna, and probably the only one ever built, since it is not known whether the Čekrekči hajji Mustafa and Davud Pasha bridges in Visoko were built of stone or not.

Though the name of the builder of the present-day bridge is not known, the form, details and workmanship suggest that it is the work of local craftsmen.[8]

possible that he also took care of this bridge. It may also be assumed that the bridge was renovated by Semiz Ali-paša or Gazi Ali-paša... " (Čelić, Mujezinović 76)

7) Čelić, Mujezinović 77-79.

8) "The bridge has largely preserved to this day the original form it acquired in the 16th century. It is characterized by an archaic style, indicating good local stonemasons but no great familiarity with the stylistic forms of the contemporary Turkish architectural school. This allows us to conclude that it was the work of good local stonemastons, perhaps trained in the Mediterranean-Herzegovinian tradition and thus acquainted to some extent, though rather supervficially, with the Turkish architectural style and details." (Čelić, Mujezinović 76)

rezultiralo prostornim koncepcijskim rješenjem mosta: primijenjene su dugačke prilazne rampe[9] sa inundacionim otvorima[10] (poprečni presjek većeg inundacionog otvora je pravougaonik dimenzija 40 x 100 cm) koji u fazama povećanog vodostaja preuzimaju funkciju odvodnje vode, sprečavajući plavljenje okoline mosta.

Most ima sedam polukružno zasvedenih svodova i niveletu mosta karakterističnu za osmansku mostogradnju: visina i širina čeonih lukova mosta i svodova mosta raste ritmično prema sredini mosta tako da iznad četvrtog, odnosno centralnog luka mosta nastaje najveća nivelaciona prijelomna kota mosta. Svijetla[11] širina prvog svoda, mjereno respektivno od istočne strane mosta prema zapadnoj, iznosi 3,30 metara, drugog svoda 4,10 metara, trećeg 4,90 metara, a širina središnjeg, četvrtog svoda iznosi 5,70 metara.

Dužina prilazne rampe mostu sa istočne strane je 85,30 metra. Dužina mosta iznosi 52,10 metara, širina sa korkalukom 4,55 metara, a visina mosta

9) kojima se postiže podizanje kote mosta - potrebno radi omogućavanja korištenja mosta i u periodima tzv. „visokih voda“

10) otvori u tijelu mosta koji služe za evakuaciju, odnosno prolaz vode prilikom velikih vodostaja i izlivanja riječnih voda iz svog korita

11) „svijetli otvor“ je tehnički termin koji se, u ovom slučaju, odnosi na raspon polukružnog mostovskog otvora izmjeren između stubova mosta, u visini nožice mostovskog stuba (Napom. E. Softić)

The structure of the bridge fits extremely well into the natural surroundings, with all the features affecting the disposition (outline of longitudinal profile, configuration of the terrain, water levels at various seasons and flooding of the river Bosna, with its broad riverbed at this point) studied in depth and resolved appropriately in the construction of the bridge. This is particularly true of the long ramps,[9] with flood openings[10] (the larger of which is rectangular and measures 40 x 100 cm) serving to carry away excess water when water levels are at their highest, so preventing the surroundings of the bridge from being flooded

The bridge has seven round arches, and a roadway typical of Ottoman bridge-building: the height and width of the spandrel walls and barrels of the bridge increase rhythmically towards the centre, with the highest point above the fourth (central) arch of the bridge. The aperture[11] of the first arch, from east to west, is 3.30 m wide, the second 4.10 m, the third 4.90 m, and the fourth and central 5.70

9) which served to raise the level of the bridge, needed to make it passable at times of high water

10) openings in the bridge allowing for the evacuation or flow of water at times of high water and when the river burst its banks

11) this refers to the span of the semicircular barrels of the bridge as measured between the piers at the height of the foot of the piers (Note. E. Softić)

Sl. 1 – Fotografije mosta iz 2005. godine, nizvodna fasada
Illus. 1 – Photographs of the bridge in 2005 , downstreem facade

na najvišem mjestu oko 4,50 metra.

Most ima 6 riječnih oslonaca (poprečni presjek nožice riječnog stuba je cca 1,80 x 5,00 metara) koji na uzvodnoj, jugozapadnoj strani imaju ledobrane-ledolomce, a treći[12] mostovski oslonac na nizvodnoj strani ojačan je zidanim kontraforom od kamena koji je prislonjen uz čeoni zid mosta. Kontrafor, visine cca 3,10 do 3,20 metara, ima pravilnu klinastu formu, čiji je horizontalni presjek pravougaonik.

Korkaluk, visine cca 75 cm i širine cca 30 cm, je od čeonog zida mosta vizualno odvojen izvedbom jednostavno profiliranog kamenog vijenca, a lukovi su u odnosu na čeone zidove mosta su diskretno uvučeni.

Most je zidan u klesanom kamenu krečnjaku koji je spojen krečnim malterom, a kamene ploče korkaluka, kao i kameni segmenti svoda, spojeni su željeznim klanfama i zaliveni olovom. Kolovozna površina mosta je od kaldrme vezane cementnim malterom.

U nizvodnom korkaluku ugrađena je rimska spolija, kamena ploča na čijoj površini se nalazi plitki reljef, zbog čega se ovaj most u narodu često naziva i Rimskim mostom. O tom reljefu nema podataka u dostupnoj literaturi. Na reljefu je prikazana naga figura u stojećem položaju, lijeve noge prekrižene preko desne, sa desnom rukom podignutom iznad glave i lijevom rukom prekriženom preko grudi.

12) posmatrano od istočne strane mosta prema zapadnoj

metres.

The access ramp from the east is 85.30 metres long. The bridge itself is 52.10 metres long, 4.55 metres wide including the parapet, and approx. 4.50 metres high at its highest point.

The bridge has six river piers (the average cross-section of the foot of the piers is approx. 1.80 x 5.00 metres) with cutwaters on the upstream, south-west side, while the third[12] pier is reinforced on the downstream side by a masonry buttress abutting onto the spandrel wall of the bridge. The buttress, which is approx. 3.10 to 3.20 m in height, is of regular wedge shape, rectangular in cross-section.

The parapet, which is approx. 75 cm high and approx. 30 cm wide, is separated visually from the spandrel wall of the bridge by a simply moulded stone string course, and the arches are slightly recessed in relation to the surface of the spandrel walls.

The bridge was built of cut limestone bonded by lime mortar, and the stone slabs of the parapet, like the stone segments of the barrel, are joined by iron cramps fixed in lead. The roadway over the bridge is paved, with the paving stones set in cement mortar.

Roman spoil was built into the parapet on the downstream side, in the shape of a stone slab

12) looking from east to west

Sl. 2 – Uzvodna fasada
Illus. 2 – Upsreem facade

Sl. 3 – Popločanje
Illus. 3 – Paving

Dosadašnje aktivnosti na zaštiti ili istraživanju objekta

Rješenjem Zemaljskog zavoda za zaštitu spomenika kulture i prirodnih rijetkosti Narodne Republike Bosne i Hercegovine iz Sarajeva, br. 685/50 od dana 10.06.1950. godine, spomenik je pravno zaštićen objekt, a Rješenjem Zavoda za zaštitu spomenika kulture Narodne Republike Bosne i Hercegovine iz Sarajeva, br. 02-627-3 od dana 18. 4. 1962. godine, Most preko rijeke Bosne u Plandištu, u državnom vlasništvu (Skupština opštine Ilidža), upisan je u Registar nepokretnih spomenika kulture.

Prostornim planom Bosne i Hercegovine iz 1980. godine *Most na Bosni kod Blažuja*, bio je svrstan u I kategoriju (kategoriju spomenika od nacionalnog značaja).

Dobro se, pod nazivom *Most Plandište* i rednim brojem 528. nalazi na Privremenoj listi Komisije za očuvanje nacionalnih spomenika Bosne i Hercegovine.

Most u Plandištu se nalazi unutar I zaštitne zone (zona najstrožeg režima zaštite) zaštitnog područja izvorišta vode za piće u Sarajevskom polju.

U 20. stoljeću most se koristio za motorni kolski saobraćaj, čiji intenzitet, u godinama poslije II svjetskog rata, dovodi do neprimjerene eksploatacije mosta, uslijed koje se konstrukcija mosta dovela u veoma teško stanje. Radi prilagođavanja karakteristika uzdužnog profila nivelete kolovoza mosta uslovima odvijanja savremenog saobraćaja motornim vozilima, izvedeno je nasipanje mosta i podizanje nivelete na obje oslonačke strane mosta u visini od preko 100 cm nasipa od zemlje i postavljanjem kolovoza od granitnih kamenih kocki, kao i određena betonska ojačanja podvodnih dijelova oslonaca mosta.

Stručnjaci Gradskog zavoda za zaštitu i uređenje spomenika kulture, ranih 80-tih godina 20. stoljeća, evidentiraju deformisanost i rastresenost dijelova zidova, svodova i korkaluka, bočne deformacije zidova (odstupanja ravnina zidova iz vertikalnog položaja i pojavu tzv. „trbuha"), kao i prisutnost dva samonikla stabla koja su prouzročila razmicanje većih poteza zida. Tom prilikom je konstatirano da se, usprkos pobrojanim deformacijama, najveći dio

with bas relief on the surface, as a result of which this bridge is often known to the locals as the Roman bridge. There is no information on this relief in the reference works available to us. The relief is of a naked, standing figure, with the left leg crossed over the right, the right hand raised above the head, and the left arm crossed over the chest.

Activities to date to protect or investigate the property

By Ruling of the National Institute for the Protection of Cultural Monuments and Natural Rarities of the National Republic of Bosnia and Herzegovina in Sarajevo no. 685/50 dated 10 June 1950, the monument was accorded legal protection, and by Ruling of the Institute for the Protection of Cultural Monuments of the National Republic of Bosnia and Herzegovina of Sarajevo no. 02-672-3 dated 18 April 1962, the bridge over the river Bosna in Plandište, state-owned (Assembly of Ilidža Municipality), was entered in the Register of Immovable Cultural Monuments.

The 1980 Regional Plan for Bosnia and Herzegovina lists the *Bridge over the Bosna near Blažuj* as a category I monument (monument of national importance).

The property is on the Provisional List of the Commission to Preserve National Monuments of Bosnia and Herzegovina under the title *Plandište Bridge*, serial no. 528.

The bridge in Plandište is located within Protection Zone I (zone enjoying the highest degree of protection) of the protected zone of sources of drinking water in Sarajevo plain.

During the 20th century the bridge was used for motor vehicle traffic, which became so heavy in the year following World War II as to lead to the inappropriate use of the bridge, causing serious structural damage. To adapt the longitudinal profile of the roadway to modern traffic conditions, it was earthed up and the roadway was raised on both abutment sides of the bridge by more than 100 cm by means of an earth ramp, and the roadway paved with granite setts; there was also some concrete reinforcement to the underwater sections of the piers.

kamenih kvadara mosta može iskoristiti kod prezidivanja mosta, a da se nedostajući, ili posve uništeni komadi nadomjeste novim komadima klesanim od kamena „hreša“.

Radi istraživačko-analitičarskih radova vezanih za istraživanje prvobitnog izgleda nivelete mosta, odnosno prvobitne strukture gornjeg sloja mosta, urađene su tri sonde: na početku kolovozne konstrukcije mosta na njegovoj istočnoj strani, u kolovoznoj konstrukciji iznad drugog mostovskog oslonca na njegovoj istočnoj strani, kao i na kraju kolovozne konstrukcije mosta na njegovoj zapadnoj strani. Sve tri sonde su rađene uz korkaluk mosta na nizvodnoj strani.

Radovi statičko-konstruktivne sanacije, restauracije, konzervacije, koji su poduzeti 80-tih godina 20. stoljeća, mogu se svrstati u sljedeće grupe aktivnosti:

- uklanjanje naknadno dodanog nasipa i kolovozne konstrukcije sa mosta i vraćanje originalnog uzdužnog profila nivelete kolovoza mosta, kao i originalnih struktura gornjeg stroja mosta sa restauracijom kaldrme;

- saniranje i restauracija elemenata vijenaca i korkaluka;

- uklanjanje zemljanog nasipa sa obalnih oslonaca mosta, otkopavanje sedmog luka i svoda na zapadnoj strani mosta, otkopavanje i otkrivanje prilazne rampe kao i uklanjanje samoniklog raslinja i drveća iz zidnih struktura mosta;

- prezidivanje i ispravljanje deformisanih i rastresenih zidanih konstrukcija mosta, te

- saniranje čeonih zidova mosta;

- površinska zaštita i konzervacija spomenika u cilju njegove zaštite od štetnih djelovanja atmosferilija, kondenzata i štetnih uticaja industrijskog zagađenja.

U okviru druge faze, izvršeni su radovi na uređenju prilaza mosta u dužini od cca 50 metara sa obje strane mosta. Restauriran je zemljani kolovoz koji je stabiliziran kaldrmisanim pojasevima u pravilnim razmacima. Izvršena je i sanacija i ispravljanje kamenih podzida na zapadnom prilazu mosta, skidanje dobetoniranih dijelova, kao čišćenje i fugovanje lica zidova.

In the early 1980s, experts from the City Institute for the Protection and Maintenance of Cultural Monuments recorded the deformation and friability of parts of the walls, barrels and parapet, lateral deformation of the walls (shifting from the vertical and bulging on the walls), and the presence of two self-sown trees causing much of the line of the wall to shift. It was noted that, despite the deformations, most of the stone blocks could be used to rebuild the bridge, and that missing or badly damaged blocks could be replaced by new cut “hreša” limestone blocks.

In order to carry out tests and analytical works to investigate the original appearance of the roadway and the original superstructure of the bridge, three soundings were taken: at the start of the roadway structure of the bridge to the east, in the roadway above the second pier to the east, and at the end of the roadway structure to the west. All three soundings were taken by the parapet on the downstream side.

The structural repair works and restoration and conservation carried out during the 1980s can be classified as follows:

- removal of the later addition of an embankment and roadway from the bridge and restoring the original longitudinal profile of the roadway and the original superstructure, with restoration of the paving,

- repair and restoration of parts of the string course and parapet

- removal of banked-up earth from the abutments of the bridge, excavating the seventh arch and barrel to the west of the bridge, excavating and uncovering the access ramp and removing self-sown vegetation and trees growing in the masonry of the bridge,

- rebuilding and rectifying the deformed and friable masonry structure of the bridge and repairing the spandrel walls,

- surface protection and conservation of the monument to protect it from weathering, condensates and the damaging effects of industrial pollution.

The second stage consisted of works to make good the approach to the bridge over a length of about 50 m on either side. The earth roadway was restored and stabilized with paved strips at regular intervals.

PROJEKAT

Opis stanja objekta prije početka radova

Smatra se jednim od najbolje očuvanih mostova u Bosni i Hercegovini podignutih u vremenu Osmanskog carstva. Danas se po mostu ne odvija promet motornih vozila, već isključivo pješački saobraćaj.

Prilikom uvida u stanje objekta na terenu januara 2005. godine, konstatirano je da se objekat nalazi o relativno dobrom stanju očuvanosti.

Nakon završenih radova 1986. godine, stručnjaci tadašnjeg Gradskog zavoda za zaštitu i uređenje spomenika kulture Sarajevo, su zaključili, da se u narednoj fazi trebaju nastaviti radovi na ispitivanju konstrukcije temelja, te nakon utvrđivanja stanja pristupiti eventualnoj sanaciji ili možda njihovoj rekonstrukciji.

U periodu od 1986. godine pa do danas na mostu su nastala manja oštećenja, kako na kolovozu mosta: došlo je do znatnog oštećenja kaldrmisane površine uzrokovanog atmosferilijama i korijenjem samoniklog rastinja u fugama i na površini kaldrme, tako i na čeonim zidovima - konstatovana su zaprljanja kamena utjecajem atmosferilija, te manja fizička oštećenja kamenih blokova.

Oštećenja istočne prilazne rampe mostu, identična su oštećenjima kaldrme mosta.

Oštećenja korkaluka mosta prije svega se ogledaju u agresivnom djelovanju mahovine i lišaja na površini kamena, te oštećenju kamenih površina korkaluka.

Na uzvodnoj strani stupova mosta djelomično su oštećeni ledobrani-ledolomci, građeni u donjoj zoni od kamena krečnjaka, i u gornjem dijelu od kamena sedre.

Kontraforsko ojačanje trećeg mostovskog stuba (u donjoj zoni građenog od krečnjaka, a u gornjoj od kamena sedre), djelomično se obrušilo na svojoj istočnoj strani.

Komisija za očuvanje nacionalnih spomenika Bosne i Hercegovine je 2005. godine izvršila okvirnu procjenu radova koje je neophodno izvesti na zaštiti graditeljske cjeline, na osnovu čega je napravljen prijedlog projekta zaštite prirodno-graditeljske cjeline Mosta u Plandištu koji se primarno sastojao od inter-

The stone wingwalls on the western approach to the bridge were repaired and rectified, concreted components were removed, and the facades of the walls were cleaned and repointed.

PROJECT

Description of the property prior to the start of the works

This bridge is regarded as one of the best preserved bridges in Bosnia and Herzegovina dating from the Ottoman period. The bridge is no longer used for motor vehicle traffic, but is reserved solely for pedestrian use.

An on site inspection of the structure in January 2005 ascertained that it is in relatively good condition.

On completion of the works in 1986, experts from the City Institute for the Protection and Maintenance of Cultural Monuments of Sarajevo concluded that the next stage should consist of further works to study the structure of the foundations and, once their condition was ascertained, to embark on possible repairs or reconstruction.

Since 1986, minor damage has been caused to the bridge and its roadway: considerable damage to the paved surface caused by weathering and the roots of plants that have sown themselves in the joints and on the surface of the paving and in the spandrel walls; the stone is dirty from weathering; and there is minor physical damage to stone blocks.

The damage to the eastern approach ramp is identical to that to the paving on the bridge.

Damage to the parapet mainly takes the form of considerable moss and lichen growth on the stone, and damage to the stone surfaces of the parapet.

On the upstream side of the piers, the cutwaters (built of limestone below and tufa above) are damaged in places.

The buttress reinforcing the third pier of the bridge (again, of limestone below and tufa above) has partly collapsed on the eastern side.

In 2005 the Commission to Preserve National Monuments of Bosnia and Herzegovina carri-

vencija potrebnih za sanaciju samog mosta (postavka skele, popravak stupova i korkaluka i sl.).

Obrazloženje razloga za provođenje projekta

S obzirom na opisani značaj dokumentarni, historijski, graditeljski, ambijentalni i simbolički značaj mosta, utvrđeno je da je neophodno detaljno istražiti stanje njegove konstrukcije i graditeljskih detalja, te na osnovi toga definirati i provesti hitne mjere zaštite, ako i osigurati izradu projekta trajne zaštite.

Opis faza projekta, sa metodološkim pristupom

U vezi s metodologijom rada, Odlukom Komisije za očuvanje nacionalnih spomenika BiH o proglašenju dobra nacionalnim spomenikom na sjednici održanoj od 15. do 21. marta 2005. godine, utvrđene su mjere zaštite za prirodno-graditeljsku cjelinu – most u Plandištu koje su podrazumijevale izvođenje samo radova restauracije i konzervacije spomenika, uz zabranu motornog saobraćaja i bilo kakvih aktivnosti vezanih za izmjenu vodotoka rijeke Bosne, izgradnju objekata i odlaganje otpada.

U skladu sa svojom odlukom, Komisija za očuvanje nacionalnih spomenika tokom 2005. godine je aplicirala za sredstva iz Fonda ambasadora SAD-a u BiH za očuvanje kulturne baštine, na osnovu okvirne procjene radova koje neophodno izvesti na zaštiti prirodno-graditeljske cjeline koji se primarno sastojao od intervencija potrebnih za sanaciju samog mosta (postavka skele, popravak stupova, korkaluka i hodne površine mosta i sl.).

Komisija je, prilikom vizuelnog pregleda i konsultacija sa stručnjacima za stare mostove, kamene strukture i zidane konstrukcije, uvidjela da je stanje mosta 2007. godine (kada je prijedlog projekta odobren i kada se pristupilo početnim aktivnostima na njegovoj implementaciji) drugačije od stanja mosta kada je pravljen prijedlog projekta 2005. godine. S obzirom da se jedino na osnovi kvalitetnog snimka trenutnog stanja građevine mogu dati ispravne smjernice za njegovu opravku zaključeno je da je neophodno da se izvrši detaljan snimak mosta sa potrebnim istražnim radovima, što je dovelo do restruktuiranja i reprogramiranja prvobitno odobrenog projekta.

ed out an initial assessment of the works needed to protect the monument, on the basis of which a project proposal was drawn up for the protection of the natural and architectural ensemble of the Bridge in Plandište, consisting primarily of the remedial works needed on the bridge itself (erecting scaffolding, repairs to the piers and parapet, etc.

Justification of the project

The documentary, historical, architectural, landscape and symbolic importance of the bridge make it imperative to conduct a detailed study of the condition of the structure and architectural details, to form the basis for defining and carrying out urgent protection measures and to draw up a project for its on-going protection.

Stages of the project, with methodological approach

As regards the methodology, the Decision of the Commission to Preserve National Monuments of BiH designating the property as a national monument, adopted at a session held from 15 to 21 March 2005, set out the protection measures applicable to the natural and architectural ensemble of the bridge in Plandište, which related only to restoration and conservation works and to prohibiting the use of the bridge by motor vehicles, as well as a ban on any activities associated with altering the course of the river Bosna, the erection of buildings or facilities, and the dumping of waste.

In 2005, pursuant to the decision, the Commission to Preserve National Monuments applied for funds from the US Ambassador's Fund for Cultural Preservation, on the basis of the initial assessment of the works needed to protect the monument, consisting primarily of the remedial works needed on the bridge itself (erecting scaffolding, repairs to the piers, parapet and roadway, etc.).

During a visual inspection and in consultation with experts on old bridges, stone structures and masonry construction, the Commission observed that the condition of the bridge in 2007 (when the project proposal was approved and initial project implementation activities began) had altered from its condition in 2005, when the project proposal

Putem projekta Fond američkog ambasadora u BiH za očuvanje kulturnog naslijeđa, 2008. Most u Plandištu – Program zaštite mosta implementiranog u 2008/2009. godini, sredstva koja su prvobitno bila namijenjena za potrebe samih radnji na opravci mosta (postavka skele, popravak stupova i korkaluka i sl.) utrošena su za izradu projekta postojećeg stanja, za detaljne istražne radove (radovi na snimanju stanja mosta – geodetski snimci, arhitektonsko-građevinski snimci mosta i oštećenja, kvalitetna foto dokumentacija geološko-geomehanička ispitivanja i obrada mehaničkih i hemijskih karakteristika materijala) i obradu rezultata istražnih radova sa preporukama za izradu projekta rehabilitacije mosta.

Također, iako je prvobitnim prijedlogom projekta bilo planirano da partner u projektu bude Kantonalni zavod za zaštitu kulturno-historijskog i prirodnog naslijeđa Sarajevo, isti nije učestvovao u implementaciji projekta s obzirom da su smatrali da je vrijeme za implementaciju projekta suviše kratko da bi projekat mogao biti uključen u njihov program rada, s obzirom na ranije preuzete obaveze, ali je dogovoreno da sva dokumentacija nastala prilikom implementacije projekta bude predate na korištenje toj instituciji kako bi se moglo preći u razradu projekta restauracije i konzervacije mosta pod vodstvom Kantonalnog zavoda.

Nova, usvojena metodologija rada na početnim aktivnostima vezanim za zaštitu prirodno-graditeljske cjeline Mosta u Plandištu podrazumijevala je sljedeće aktivnosti koje su se odvijale u dvije faze:

FAZA 1.

- Izradu projekta postojećeg stanja koje je obuhvatalo:
  - geodetski snimak mosta, uključujući tlocrte, fasade, presjeke, deformacije i oštećenja,
  - geodetski snimak obale i korita rijeke u dužini po 50 m uzvodno i nizvodno od mosta,
  - arhitektonsko-građevinske nacrte postojećeg stanja,
  - nacrte, detalje i opis vidljivih oštećenja,
  - tekstualno obrazloženje (tehnički opis),
  - fotodokumentaciju postojećeg stanja;
- Izradu programa istražnih radova koji je obuhvatao:
  - program geološko-geomehaničkih istražnih ra-

was drawn up. Since the only way to provide proper guidelines for remedial and repair works on a building or structure is on the basis of a high-quality survey of its condition at the time the works are to begin, it was decided that another survey of the bridge should be carried out, along with the necessary exploratory works, resulting in a restructuring and reprogramming of the project as originally approved.

The funds approved by the US Ambassador's Fund for Cultural Preservation for 2008 for the protection programme for the bridge, implemented in 2008/2009, were reallocated from the actual remedial works (erecting scaffolding, repairs to the piers and parapet, etc.) to a survey of the condition of the bridge – geodetic surveys, architectural and structural surveys of the bridge and the damage it had suffered, high quality photographic documentation, geological and geomechanical investigations and tests on the mechanical and chemical characteristics of the material) and to processing the findings of the exploratory works, with recommendations for drawing up a rehabilitation project for the bridge.

Although the original project proposal envisaged the Cantonal Institute for the Protection of the Cultural, Historical and Natural Heritage of Sarajevo as the project partner, the Institute did not in fact take part in the project implementation, regarding the time frame as too short to incorporate into its own work programme in the light of previous commitments, but it was agreed that all the documentation arising during project implementation would be made available to the Institute for use when drawing up a restoration and conservation project for the bridge to be led by the Cantonal Institute.

The new methodology adopted in the initial activities associated with the protection of the natural and architectural ensemble of the bridge in Plandište entailed the following activities, which were carried out in two stages:

STAGE 1

- Identifying the current condition of the monument, covering:
  - a geodetic survey of the bridge, to cover the

dova,
- program istražnih radova u cilju određivanja mehaničkih i hemijskih karakteristika materijala nosivih elemenata mosta.

FAZA 2.
- Izradu tenderske dokumentacije za istražne radove;[13]
- Provođenje istražnih radova koje je obuhvatalo:
  - geološko-geomehanička istraživanja,
  - izradu elaborata o geološko-geomehaničkim istraživanjima,
  - mineraloško-petrološka i hemijska istraživanja,
  - izradu elaborata mineraloško-petroloških i hemijskih istraživanja; (*slike 4, 5 i 6*)
- Nadzor nad provođenjem istražnih radova;
- Obrada rezultata istražnih radova koja je obuhvatala:
  - preliminarnu statičku analizu,
  - zaključke o stanju prirodno-graditeljske cjeline,
  - preporuke za izradu projekta sanacije;
- Reviziju projekta postojećeg stanja, programa istraž-

13) Napomena: prilikom provedbe tenderske proceduru tj. pribavljanje najpovoljnijih i najadekvatnijih ponuda za zadovoljenje uslova projektnog zadatka – izvođenje istražnih radova, došlo se do zaključka da je za implementaciju ovog dijela projekta neophodno odvojiti više sredstava nego što je bilo planirano u okviru Projekta koji se implementira iz Fonda američkog ambasadora pa je zaključkom Komisija za očuvanje nacionalnih spomenika iz budžetskih sredstava izdvojila dodatnih 20.000 KM za izvođenje navedenih radova.

Sl. 4 – Fotografije mosta tokom radova 2009. godine
Illus. 4 – Photographs of the bridge during the works in 2009

ground plan, elevation, section, deformation and damage,
- a geodetic survey of the banks and bed of the river over a distance of 50 m upstream and downstream from the bridge,
- architectural and structural drawings of the condition of the bridge,
- drawings, details and descriptions of the visible damage,
- a textual explanation (technical description),
- photographic documentation of the current condition;
- Drawing up a programme of exploratory works, covering:
  - a programme of geological and geomechanical investigations,
  - a programme of research works to determine the mechanical and chemical characteristics of the materials of the bearing elements of the bridge.

STAGE 2
- Drawing up tender documentation for the exploratory works[13]
- Carrying out the exploratory works, covering:
  - geological and geomechanical investigations,
  - a report on the geological and geomechanical investigations,
  - mineralogical, petrographic and chemical tests,
  - a report on the mineralogical, petrographic and chemical tests (*illus. 4, 5 and 6*);
- oversight of the exploratory works;
- processing the results of the exploratory works, covering:
  - a preliminary structural analysis,
  - conclusions as to the condition of the natural and architectural ensemble,

13) During the tender procedure to collect the most competitive bids fulfilling the conditions of the project assignment (conducting investigative works), it was realized that more funds were required for the implementation of this stage of the project than the sum provided by the US Ambassador's Fund for Cultural Preservation. The Commission to Preserve National Monuments therefore allocated an additional sum of 20,000 KM from its own budget for the works in question

nih radova i obrade rezultata istražnih radova.

Dijelovi projekta: izrada projekta postojećeg stanja, programa istražnih radova, nadzor nad provođenjem istražnih radova i obrada rezultata istražnih radova su urađeni od strane „Interprojekt“ d.o.o. Mostar. Sami istražni radovi na lokalitetu kao i izrada elaborata o geološko-geomehaničkim i mineraloško-petrološkim i hemijskim istraživanjima je urađena od strane „GEO ETA“ d.o.o. Sarajevo. Revizija projekta postojećeg stanja, programa istražnih radova i obrade rezultata istražnih radova je urađena od strane Građevinskog fakulteta Univerziteta „Džemal Bijedić“ u Mostaru.

Prateće aktivnosti vezane za projekat

Paralelno sa radovima na samom lokalitetu odvijale su se i aktivnosti na podizanju svijesti o značaju naslijeđa. Glavne ciljne grupe ovog dijela projekta su bili osnovci iz sarajevske regije. Osnovna namjera je bila da djeca iz osnovnih škola prošire i steknu nova znanja o kulturno-historijskom naslijeđu, njegovim vrijednostima i značenju uzimajući učešća u projektu putem razmjene znanja, ideja i shvatanja značaja samog naziva „Moja Bosna i Hercegovina – moje naslijeđe“. Bogatstvo naslijeđa Bosne i Hercegovine, i njegova restauracija, očuvanje i unapređenje su prezentirani kao okvir za održivi razvoj. Kao indirekte ciljne grupe ovog dijela projekta su smatrani direktori i uprave škola, nastavnici i roditelji djece uključene u projekat.

Učesnici kampanje su bila djeca iz četiri

- recommendations for drawing up a repair project
- revision of the findings of the current condition, programme of exploratory works and processing the results of the exploratory works.

Determining the current condition of the monument, drawing up the programme of exploratory works, overseeing the exploratory works and processing the results of the exploratory works were carried out by Interprojekt d.o.o. Mostar. The exploratory works on site and the production of a report on the geological, geomechanical, mineralogical, petrographic and chemical investigations were carried out by GEO ETA d.o.o. Sarajevo. The revision of the findings of the current condition, programme of exploratory works and processing the results of the exploratory works was carried out by the Faculty of Civil Engineering of the Džemal Bijedić University in Mostar.

Ancillary project activities

At the same time as the works on site were being carried out, activities were taking place to raise awareness of the importance of the heritage. The main target group of this part of the project was primary school children from the Sarajevo region, and the basic aim was to advance and enhance their knowledge of the cultural heritage and its value and meaning, by taking part in the project through the exchange of knowledge, ideas and views on the significance of the title of this part of the project, “My Bosnia

Sl. 5 – Radovi na mostu 2009. godine
Illus. 5 – Works on the bridge in 2009

Sl. 6 – Uzorci
Illus. 6 – Samples

osnovne škole sa prostora Sarajeva:

- Zavod za obrazovanje djece sa specijalnim potrebama Mjedenica, Sarajevo,
- Centar Vladimir Nazor, Sarajevo,
- Centar za slijepu i slabovidnu djecu i omladinu, Sarajevo,
- Druga osnovna škola Ilidža, kombinovani razredi, Sarajevo.

U okviru pripremnih aktivnosti na organizaciji kampanje održani su sastanci sa direktorima i nastavnicima svih škola na kojima su im je podijeljen prezentacioni materijal i dogovoreni načini organizacije predavanja i radionica za učenike.

S ciljem edukacije djece o značaju kulturnog naslijeđa, izvršena je prezentacija - održan je kratak čas sa učenicima, na temu značaja očuvanja naslijeđa općenito i o spomenicima sa područja sarajevskog regiona, u okviru koje je podijeljen prezentacioni materijal koji bi učenicima pomogao u izradi radova (osnovni podaci o historijatu objekata, fotografije, crteži objekata i materijali neophodni za izradu likovnih i maketarskih radova). Također, u toku samih predavanja djeca su učestvovala i u radionici u okviru koje su pravili modele od gline ili crtali i slikali radove na zadanu temu radionice.

Rezultati projekta, uključujući i popis dokumentacije nastale u toku izrade projekta

Najbitniji rezultat projekta predstavlja izrađen detaljan snimak postojećeg stanja objekta kao preduslov za bilo kakve buduće aktivnosti i zahvate na objektu. Ostali rezultati projekta se ogledaju kroz sljedeće:

- Prikupljena je sva dostupna postojeća dokumentacija o cjelini; projekti i snimci objekta koji su postojali u papirnoj formi prije rata su digitalizovani, dokumentacija je katalogizirana i adekvatno arhivirana, kako bi bila dostupna za sve zainteresovane, posebno za istraživački rad i konzervatore;
- Svjesnost o značaju naslijeđa među djecom je podignuta;
- Projekat je doprinio razumijevanju činjenice da je naslijeđe zajednička vrijednost svih građana i da je njegova rehabilitacija i obnova neodvojivi dio njiho-

and Herzegovina – My Heritage." The rich heritage of Bosnia and Herzegovina and its restoration, preservation and advancement were presented as the framework for sustainable development. The indirect target group of this part of the project consisted of the principals and governors of the schools, the teaching staff, and the parents of the children involved in the project.

Children from four primary schools in Sarajevo took part in the campaign:

- the Mjedenica Institute for Children with Special Needs,
- the Vladimir Nazor Centre,
- the Centre for Blind and Sight-Impaired Children and Youth,
- Ilidža 2nd Primary School co-ed grades.

As part of the preparatory activities for the campaign, meetings were held with the principals and teaching staff of all the schools, at which presentation material was distributed and the way in which lectures and workshops for the children would be organized was agreed.

With a view to educating children on the importance of the cultural heritage, a presentation was held, in the form of a brief lesson on the importance of heritage preservation in general and monuments in the Sarajevo region in particular, during which presentation material was handed out to help the children draw up their own projects (basic details from the history of the monuments, photographs, drawings of the monuments and the materials needed for them to produce their art works and models). During the lesson the children also took part in a workshop during which they made clay models or made drawings and paintings on the subject of the workshop.

Results of the project, including a list of the documentation generated by the project

The most significant result was the production of a detailed survey of the condition of the monument, as the prerequisite for any future activities or works on the monument. The other results of the project were as follows:

- all available extant documentation on the mo-

vog identiteta.

Popis dokumentacije nastale u toku izrade projekta:

- pregled postojeće fotodokumentacije o stanju objekta prije 2005. godine,
- digitalizacija postojećih arhitektonskih nacrta mosta,
- Projekat postojećeg stanja objekta mosta sa prikazom svih oštećenja i deformacija (geodetski snimak mosta i obala rijeke, arhitektonsko-građevinski nacrti mosta, nacrti, detalji i opisi svih uočenih oštećenja, tehnički opis i prateća fotodokumentacija),
- Elaborat o geološko-geomehaničkim istraživanjima,
- Elaborat mineraloško-petroloških i hemijskih istraživanja,
- Elaborat preliminarne statičke analize,
- Elaborat zaključaka kao rezultat istražnih radova na mostu sa preporukama za izradu projekta sanacije,
- prezentacija Projekta, njegovog toka i dostignuća na oficijelnoj web-stranici Komisije,
- prezentacija Projekta u pisanim i elektronskim medijima.

nument was assembled; projects and surveys available in hard copy from before the war were digitalized, and the documentation was catalogued and suitably filed so as to be accessible to all interested parties, particular for researchers and conservers;

- raised awareness of the importance of the heritage among children;
- the project contributed to an understanding of the fact that the heritage is of shared value to all citizens, and that its rehabilitation and restoration is an inseparable part of their identity.

List of documentation generated during the project:

- survey of extant photographic documentation on the building prior to 2005,
- digitalization of extant architectural drawings of the bridge,
- survey of the current condition of the bridge, showing all damage and deformation (geodetic survey of the bridge and river banks, architectural and structural drawings of the bridge, drawings, details and descriptions of all damage observed, technical description and accompanying photographic documentation),
- report on the geological and geomechanical investigations,
- report on the mineralogical, petrographic and chemical investigations,
- report on the preliminary structural analysis,
- report on the findings of the exploratory works on the bridge with recommendations for drawing up a repair project,
- presentation of the project and its outcomes on the Commission's official web site,
- presentation of the project to the print and air media.

MOST U PLANDIŠTU - PREGLED PROVEDENIH ISTRAŽNIH RADOVA

THE BRIDGE IN PLANDIŠTE - OVERVIEW OF INVESTIGATIVE WORKS

Salko KULUKČIJA, Mustafa HUMO, Enver MANDŽIĆ

Projekat postojećeg stanja koji je predmet ovog saopštenja izrađen je u periodu maj – juli 2008. godine. Ukupnim planiranim aktivnostima predviđena je cjelovita priprema za projekat sanacije (zaštite) i to:

- Izrada programa istražnih radova;
- Izrada projekta postojećeg stanja;
- Praćenje i nadziranje istražnih radova;
- Izrada preliminarne statičke analize mosta;
- Izrada zaključaka i preporuka za projekat sanacije.

Podloge za izradu projekta postojećeg stanja

Pri izradi projekta postojećeg stanja korištene su sljedeće podloge:

- Odluka Komisije za očuvanje nacionalnih spomenika o proglašenju prirodno-graditeljske cjeline nacionalnim spomenikom Bosne i Hercegovine, 2005.
- Projektni zadatak koji je obuhvatio:
  - Geodetski snimak mosta;
  - Geodetski snimak obale i korita rijeke;
  - Arhitektonsko-građevinski nacrti postojećeg stanja;
  - Nacrti, detalji i opis vidljivih oštećenja;
  - Tehnički opis;
  - Fotodokumentacija postojećeg stanja.
- Nacrti iz projekta „Sanacija starog mosta na Bosni u Plandištu“: (i) Pogled sa uzvodne strane i (ii) Pogled sa nizvodne strane, Gradski zavod za zaštitu spomenika kulture Sarajevo, 1975.
- Geodetski snimak lokacije, CMT Projekt Sarajevo (za Interprojekt Mostar), juni 2008.
- Fotodokumentacija, Interprojekt Mostar, februar-juni 2008.
- Ručno mjerenje, Interprojekt Mostar, juni 2008.

Na raspolaganju su bila samo dva nacrta iz

The survey which is the subject of this report was conducted in May to July 2008. The projected activities provided for full preparations for the repair (protection) project, as follows:

- drawing up a programme of exploratory works;
- drawing up a survey of the current condition;
- monitoring and oversight of the exploratory works;
- drawing up a preliminary structural analysis of the bridge;
- drawing up conclusions and recommendations for the repair project.

Basis for the survey of the current condition of the monument

The following were used as the basis for drawing up the survey of the current condition of the monument:

- the decision issued by the Commission to Preserve National Monuments designating the natural and architectural ensemble as a national monument of Bosnia and Herzegovina, 2005
- the project assignment, consisting of:
  - a geodetic survey of the bridge
  - a geodetic survey of the river banks and bed
  - architectural and structural drawings of the existing condition
  - drawings, details and descriptions of visible damage
  - a technical description
  - photographic documentation of the existing condition
- drawings from the project for the repair of the old Bridge over the Bosna in Plandište: (i) view from upstream, (ii) view from downstream, City Institute

spomenutog projekta „Sanacija starog mosta na Bosni u Plandištu". U opisu tih nacrta su navedeni slojevi obnovljenog trupa mosta, pa je na osnovu ovih podataka izrađen normalni profil mosta te s tim u vezi dio ovog nacrta (koji se odnosi na trup) treba uzeti uslovno tačno.

Opis konstrukcije mosta i rampe

Most preko rijeke Bosne u Plandištu (Rimski most), izgrađen je na zapadnom izlazu iz Sarajeva, oko dva kilometra nizvodno od izvora rijeke Bosne.

Most je zidana kamena konstrukcija. Ima sedam segmentnih (približno polukružnih) svodova, svijetlih raspona od 3,33 do 5,68 m. Svodovi su oslonjeni na šest riječnih stubova tlocrtnih dimenzija u podnožju cca 1,85 x 4,40 m i dva oporca na lijevoj i desnoj obali. Stubovi se oslanjaju na postament od kamenih blokova debljine cca 30 cm proširen bočno cca 10 cm u odnosu na stubove. Sa uzvodne strane temelj je proširen u trokut koji formira tzv. ledolomac sa stepenastim oblikovanjem po visini. Sa nizvodne strane nije vidljivo proširenje temelja osim kod stuba S3 gdje je inače sa nizvodne strane formiran kontrafor tloctnih dimenzija cca 1,95 x 1,20 m i visine cca 3,20 do 3,30 m. Zbirna dužina svodova i riječnih stubova iznosi 41,56 m sa uzvodne strane, odnosno 41,65 m sa nizvodne strane mosta. Ukupna dužina ograde (korkaluka) iznosi 62,08 m, s tim da ograda na lijevoj obali počinje 7,37 m prije svoda broj L7 (prvi svod počevši od lijevog oporca) i završava 13,15 m poslije svoda broj L1 (prvi svod počevši od desnog oporca). Dalje na desnoj obali, sljedećih 79,90 m proteže se rampa i to prvih 16,49 m u istom pravcu kao i most, a sljedećih 63,41 m sa otklonom od ovog pravca cca 170. Ukupna dužina mosta i rampe iznosi 62,08 + 79,90 = 141,98 m.

Debljina svodova se kreće od 34 do 39 cm.

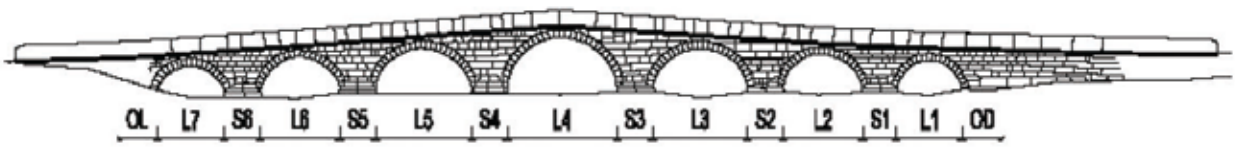
for the Protection of Cultural Monuments, Sarajevo, 1975
- a geodetic survey of the site, CMT Projekt Sarajevo (for Interproject Mostar), June 2008
- photographic documentation, Interprojekt Mostar, February-June 2008
- manual measurement, Interprojekt Mostar, June 2008.

Only two drawings from the project for the repair of the old Bridge over the Bosna in Plandište were available. The description of the drawings referred to the courses of the restored roadway of the bridge, which was used as the basis for drawing up the normal profile of the bridge. As a result, the accuracy of the part of the drawing relating to the roadway should be treated with reservations.

Description of the structure of the bridge and ramp

The bridge over the river Bosna in Plandište (the Roman Bridge) was built at the western exit from Sarajevo, about two kilometres downstream from the source of the Bosna.

The bridge is a stone structure with seven segmental (almost round) arches with a span ranging from 3.33 to 5.68 m. These rest on six river piers with a footprint at the base of approx. 1.85 x 4.40 m, and two abutments on the right and left banks. The piers rest on footings of stone blocks approx. 30 cm thick and about 10 cm wider than the piers. On the upstream side the foundations project outwards in a triangle forming a cutwater, stepped heightwise. On the downstream there is no visible extension of the foundations except in the case of pier S3, where there is a buttress on the downstream side with a footprint of approx. 1.95 x 1.20 m and a height of 3.20 to 3.30 m. The overall length of the arches



Sl. 1 – Uzvodna fasada mosta sa oznakama oporaca (OD i OL), riječnih stubova (S1 do S6) i svodova (L1 do L7)
Illus. 1 – Upstream elevation of the bridge marking the abutments (OD and OL), river piers (S1 to S6) and arches (L1 to L7).

Širina svodova je cca. 4,25 m. Čeoni zidovi su na fasadi istaknuti približno 4 cm u odnosu na svodove. Na vrhu čeonih zidova izrađen je kameni vijenac od kojeg počinje kamena ograda. Ograda je visine cca. 75 cm i širine cca. 30 cm, a hodna širina mosta (između unutrašnjih lica ograde) iznosi cca. 3,85 m.

Gabaritna širina mosta i rampe je cca. 4,60 m. Niveleta mosta je u dvostranom podužnom nagibu od 3,50 do 4,50 (cca. 6-8 %). Primjetan je i neujednačen pad u poprečnom smislu.

Najveća izmjerena visina mosta od korite rijeke do vrha ograde iznosi cca 4,45 m, što je promjenljivo zavisno od količine riječnog nanosa. Utvrđeno je postojanje četrnaest vertikalnih drvenih šipova na nizvodnoj strani i to redom: jedan ispred desnog oporca, dva ispred stuba S1, dva ispred stuba S2, jedan ispred svoda L3, sedam ispred stuba S3 (ispred kontrafora) i jedan ispred svoda L4. Na dijelovima koji su iznad nivoa korita rijeke, vidljivo je da su korištene oblice približnog prečnika 18 cm. Nije poznata dubina pobijanja.

Rampa je takođe rađena kao zidana kamena konstrukcija koja se sastoji od bočnih zidova, nasutog trupa i završne kaldrme. Širina rampe je cca. 4,75 m.

Poprečno na trup rampe izrađena su tri propusta, jedan pločasti bliže mostu i dva segmentna, koji služe za prolaz vode u vrijeme višeg vodostaja. Pločasti propust je raspona 80 cm i visine cca 45 cm. Segmentni propusti su raspona 1,94 i 1,80 m i strijele 0,63 odnosno 0,70 m. (*slike 1, 2 i 3*)

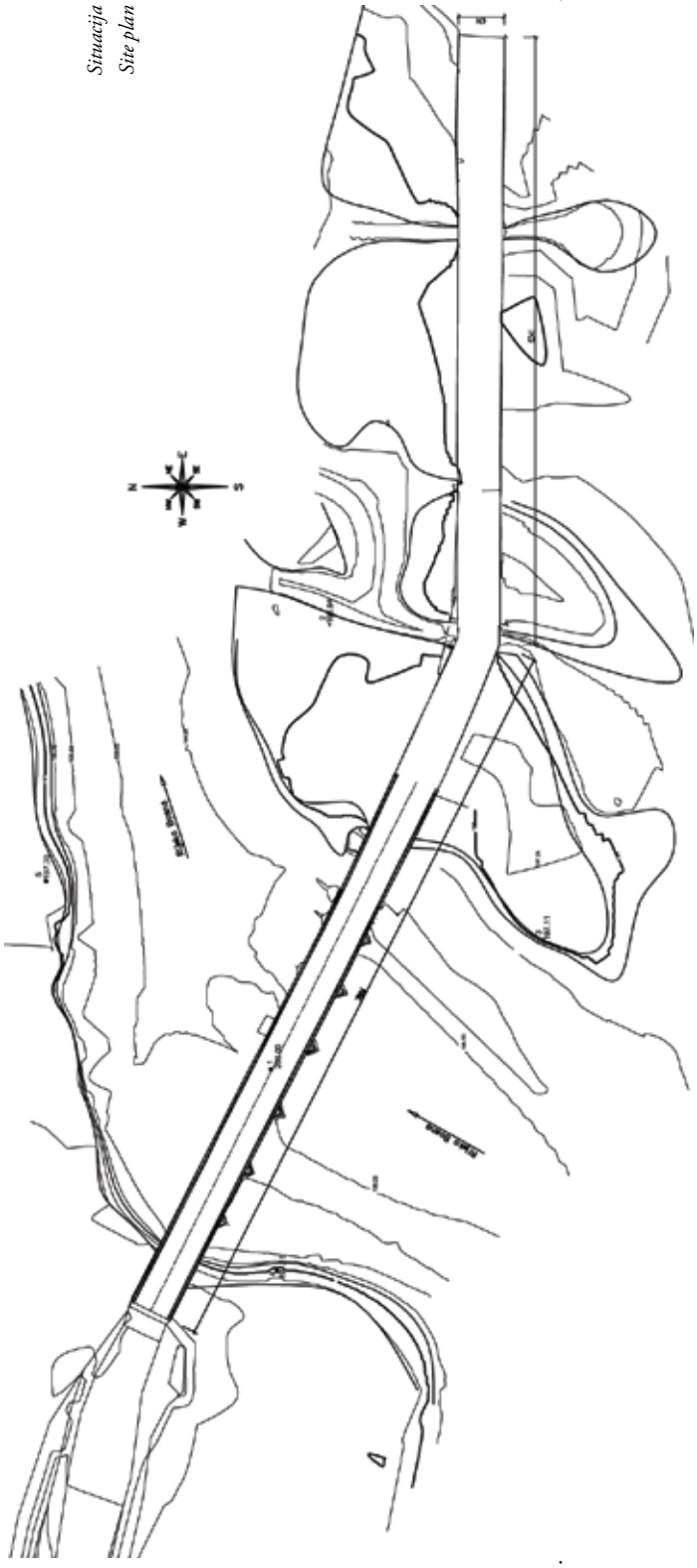
Sl. 2 – Pogled sa uzvodne strane. S desna na lijevo: stub S1, luk L2, stub S2. Jasno vidljiva proporcija u odnosu na čovjeka.
Illus. 2 – View from upstream. Right to left: pier S1, arch L2, pier S2, clearly showing the proportions in relation to the human scale.

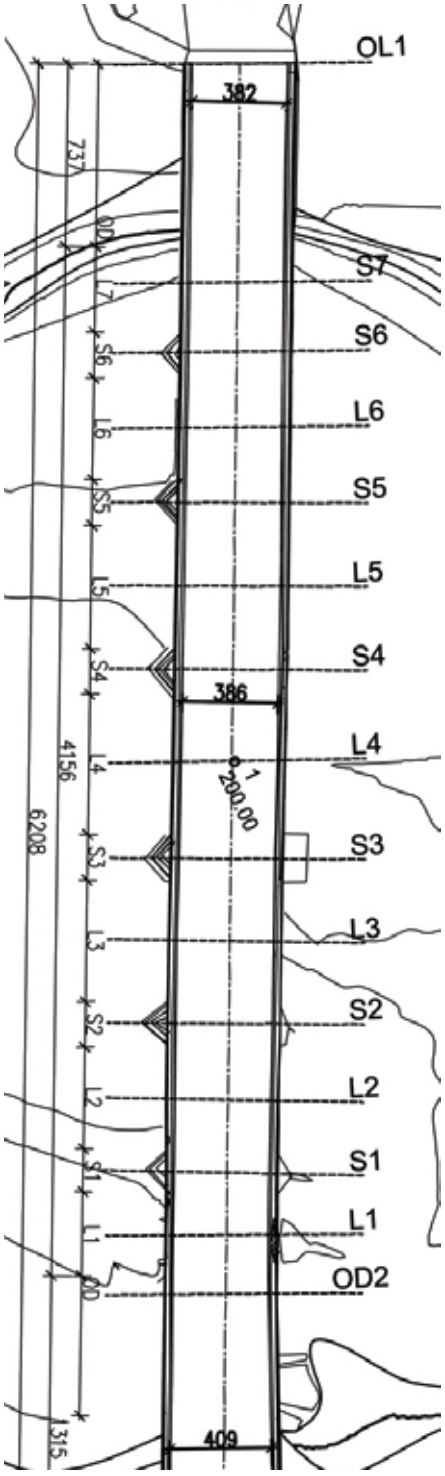
and river piers is 41.56 m on the upstream side and 41.65 m on the downstream side of the bridge. The parapet is 62.08 m in overall length, beginning on the left bank 7.37 m before arch L7 (the first arch from the left abutment) and ending 13.15 m after arch L1 (the first arch from the right abutment). On the right bank, a ramp extends for a further 79.90 m, in line with the bridge for the first 16.49 m and then at an angle of approx. 17° from the line of the bridge for the next 63.41 m. The overall length of the bridge and ramp is 62.08 + 79.90 = 141.98 m.

The arches range in depth from 34 to 39 cm, and are approx. 4.25 m wide. The spandrel walls project outwards from the arches by roughly 4 cm, and are surmounted by a stone string course from which the stone parapet rises. The parapet is approx. 75 cm high and 30 cm wide, and the roadway of the bridge between the inner faces of the parapet is approx. 3.85 m wide.

The bridge and ramp are approx. 4.60 m wide. The roadway slopes at an angle of 3.5 to 4.5° (approx. 6-8%) in each direction, with an uneven transverse fall. At its greatest height, as measured from the river bed to the top of the parapet, the bridge is approx. 4.45 m in height, varying according to the quantity of fluvial deposits. Fourteen wooden piles were found on the downstream side, one by the right-hand abutment, two by pier S1, two by pier S2, one by arch L3, seven by pier S3 (in front of the buttress)and one by arch L4. The sections projecting above the river bed revealed that these consisted of logs with a diameter of about 18 cm. It is not known how deeply these had been driven into the river bed.

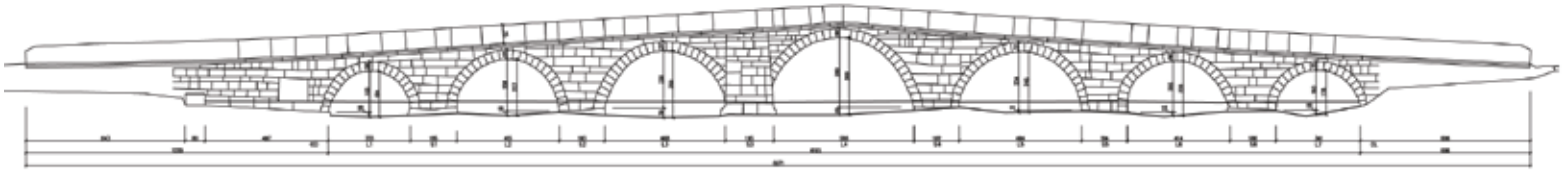
The ramp is also a stone structure consisting of side walls and a metalled cobbled roadway. The ramp is approx. 4.75 m wide. Three culverts pass transversely beneath the ramp, one rectangular, near the bridge, and two segmental, to allow for the evacuation of water during high water levels. The rectangular culvert has a span of 80 cm and a height of approx. 45 cm; the segmental culverts have spans of 1.94 and 1.80 m and a rise of 0.63 and 0.70 m respectively. (*illus. 1, 2 and 3*)



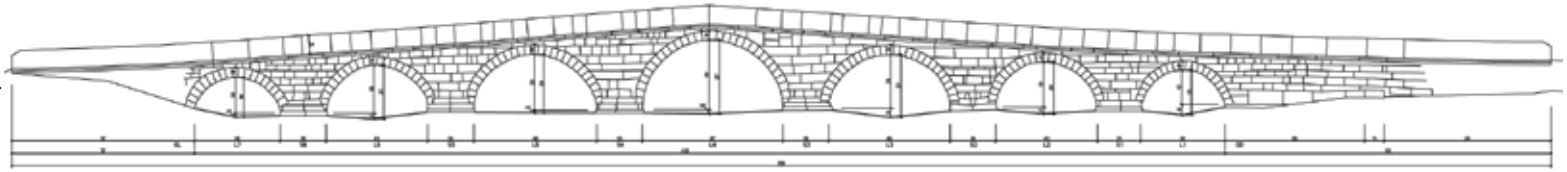


Sl. 3 – Snimak postojećeg stanja mosta
Illus. 3 – Architecture survey of the condition of the bridge

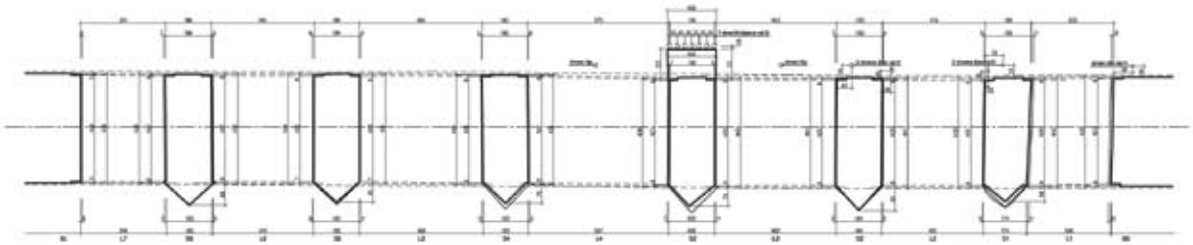
Nizvodna fasada
Downstreem facade



Uzvodna fasada
Upstreem facade



Osnova - presjek kroz stubove mosta
Basis – section through bridge piers



Tabelarni prikaz karakterističnih dimenzija mosta

Detaljne mjere su prikazane na nacrtima u sklopu projektne dokumentacije, ovdje se daje tabelarni pregled karakterističnih geometrijskih veličina. Oznake svodova L1 do L7 kao i riječnih stubova S1 do S6, numerisane su računajući od desne obale ka lijevoj. Oporci (obalni oslonci) su označeni kao OD (oporac na desnoj obali) i OL (oporac na lijevoj obali).

Kod oporaca, u koloni „Dužina", data je mjera od kraja ograde do početka najbližeg svoda.

Uzvodna strana Upstream side						
	Dužina Length	Raspon Span	Strijela Rise	Odnos Ratio	Debljina Depth	Odnos Ratio
	D	**L**	**f**	**L/f**	**t**	**L/t**
	[m]	[m]	[m]		[m]	
OD	13,15					
L1		3,41	1,37	2,49	0,37	9,22
S1	1,74					
L2		4,10	1,81	2,27	0,37	11,08
S2	1,84					
L3		4,90	2,16	2,27	0,39	12,56
S3	1,85					
L4		5,67	2,81	2,02	0,38	14,92
S4	1,83					
L5		4,98	2,24	2,22	0,38	13,11
S5	1,85					
L6		4,10	1,96	2,09	0,34	12,06
S6	1,85					
L7		3,46	1,46	2,37	0,39	8,87
OL	7,37					
Zbir	31,48	30,62				

Tabela 1 – Podužne dimenzije mosta mjerene na uzvodnoj fasadi, sa izračunatim karakterističnim odnosima

Table 1 – Longitudinal dimensions of the bridge measured on the upstream side, giving characteristic ratios

Measurements of the bridge set out in tabular form

The detailed measurements are given on the drawings forming part of the project documentation; the following tables give the characteristic geometric quantities. The arches L1 to L7 and the river piers S1 to S6 are numbered from the left to the right bank. The abutments are marked OD (abutment on the right bank) and OL (abutment on the left bank). In the case of the abutments, the figures in the column headed Length represent the measurements from the end of the parapet to the beginning of the nearest arch.

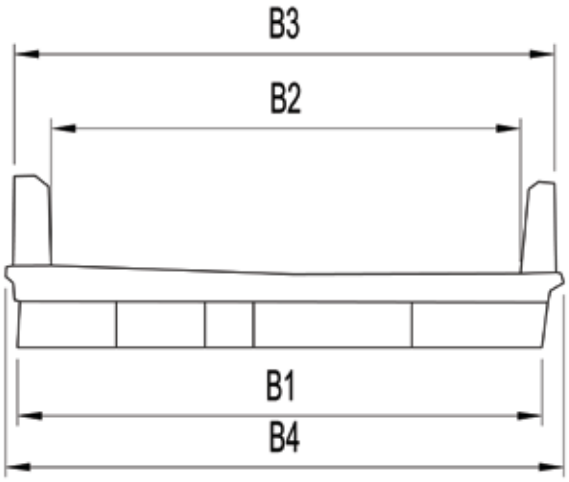
Nizvodna strana Downstream side						
	Dužina Length	Raspon Span	Strijela Rise	Odnos Ratio	Debljina Depth	Odnos Ratio
	D	**L**	**f**	**L/f**	**t**	**L/t**
	[m]	[m]	[m]		[m]	
OD	12,20					
L1		3,33	1,65	2,02	0,38	8,76
S1	1,85					
L2		4,15	2,08	2,00	0,37	11,22
S2	1,83					
L3		4,88	2,30	2,12	0,37	13,19
S3	1,95					
L4		5,68	2,80	2,03	0,38	14,95
S4	1,82					
L5		4,94	2,34	2,11	0,37	13,35
S5	1,84					
L6		4,14	2,05	2,02	0,36	11,50
S6	1,86					
L7		3,41	1,60	2,13	0,35	9,74
OL	6,86					
Zbir	30,21	30,53				

Tabela 2 – Podužne dimenzije mosta mjerene na nizvodnoj fasadi, sa izračunatim karakterističnim odnosima

Table 2 – Longitudinal dimensions of the bridge measured on the downstream side, giving characteristic ratios

Tabela 3 – Poprečne dimenzije mosta, gabaritne širine
Table 3 – Transverse dimensions of the bridge

Gabaritne širine Width				
	Svod Arch	Hodna površina Roadway	Vrh ograde Top of parapet	Vijenac String course
	B1	**B2**	**B3**	**B4**
	[m]	[m]	[m]	[m]
OD		3,85	4,42	4,54
L1	4,18	3,82	4,37	4,54
S1		3,82	4,36	4,54
L2	4,27	3,87	4,40	4,55
S2		3,90	4,47	4,56
L3	4,26	3,89	4,45	4,57
S3		3,85	4,40	4,55
L4	4,25	3,87	4,42	4,56
S4		3,86	4,47	4,59
L5	4,31	3,86	4,44	4,59
S5		3,84	4,40	4,56
L6	4,28	3,80	4,36	4,55
S6		3,78	4,33	4,54
L7	4,30	3,78	4,35	4,53
OL		3,84	4,39	4,58



Sl. 4 – Karakterističan poprečni presjek mosta sa prikazom širina B1 do B4 navedenih u Tabeli 3.
Illus. 4 – Typical cross-section of the bridge showing width B1 to B4 as given in Table 3

Deformacije i oštećenja

Uočene deformacije i oštećenja su detaljno prikazane u sklopu projektne dokumentacije, a ovdje su preuzete samo neka prikazana na slikama 5 do 12.

Karakteristične grupe vidljivih deformacija i oštećenja mogu se opisati kako slijedi:

- U horizontalnoj projekciji vidljiv je manji otklon gornjeg dijela mosta (iznad svodova) od pravca povučenog kroz krajnje tačke. Ovaj otklon se može uočiti i na geodetskoj podlozi;

- Opterećenje sa stubova je preneseno na tlo preko temeljnog postamenta rađenog od kamenih blokova debljine približno 50 cm. Uočen je nedostatak maltera u dijelu spojnica kao i u manjem obimu podlokanost (moguće uvući štap ispod donje kote);

- Podlokanost je naročito izražena na mjestu te-

Deformation and damage:

The deformations and damage observed are set out in detail in the project documentation; only some are shown here, in illus. 5 to 12.

The typical groups of visible deformations and damage may be described as follows:

- in horizontal projection, a minor deviation of the upper part of the bridge was observed above the arches from a line drawn through the end points. This deviation can also be seen on the geodetic base;

- the load is transferred from the piers to the ground through the footings, which consist of stone blocks about 50 cm thick. Mortar was seen to be missing from some of the joints, as well as lesser areas where the footings have been eroded or undercut (it is possible to insert a stick underneath);

melje kontrafora ispred stuba S3. Jasno je vidljiva razmaknutost kamenih blokova kao i lokalna oštećenost i ispadanje dijela bloka;

- Na svodovima su uočene manje deformacije i oštećenja koja se mogu grupisati u sljedeće kategorije:
  - Lokalno oštećenje bloka (dio bloka nedostaje),
  - Podužne pukotine na nizvodnoj fasadi u blizini tjemena dijela svodova,

- the erosion or undercutting is particularly marked on the footings of the buttress in front of pier S3. The stone blocks can clearly be seen to have gaps between them, with local damage and parts of the blocks fallen away;

- minor deformations and damage were observed on the arches, which can be classified as follows:
  - local damage to blocks (part of a block missing),

Sl. 5 – Prikaz temelja i početka luka. Vidljivo karakteristična slaba popunjenost spojnica u temeljima. Primijećena podlokanost temelja na više mjesta.

Illus. 5 – View of the footings and base of the arches, showing typical erosion of the joints in the footings and undercutting of the footings in several places

Sl. 6 – Vidljivo karakteristično prisustvo mahovine i sitnog rastinja na temeljima, lukovima i čeonim zidovima.

Illus. 6 – View showing typical presence of moss and minor plant growth on the footings, arches and spandrel walls

Sl. 7 – Oštećenje dna kontrafora ispred stuba S3 na nizvodnoj strani. Primijećena značajna podlokanost i otvaranje spojnica na dijelu kontrafora.

Illus. 7 – Damage to the base of the buttress in front of pier S3 on the downstream side, showing significant undercutting and joints opening up on part of the buttress

Sl. 8 – Vidljiva karakteristična lokalna oštećenja blokova čeonog zida i to naročito oštećenja rubova na spoju sa lukom.

Illus. 8 – Showing typical local damage to the blocks of the spandrel wall, and in particular damage to the edges where they join the arch

- Tragovi procjeđivanja s gornje strane,
- Mahovina u donjem dijelu;

- Čeoni zidovi su u manjoj mjeri obrasli sitnim rastinjem i uočena su lokalna oštećenja kamenih blokova;

- Kameni vijenac i ograda imaju manja lokalna oštećenja;

- Kaldrma je u manjem obimu obrasla sitnim rastinjem.

- longitudinal cracks on the dowstream façade near the footings,
- traces of percolation from above,
- moss on the lower part;

- there is some minor plant growth in the blocks in the spandrel walls, and local damage to the stone blocks;

- the stone string course and parapet have some minor local damage;

- there is some minor plant growth in the paving.

Sl. 9 – Vidljiva karakteristična lokalna oštećenja kamenih blokova lukova

Illus. 9 – Showing typical local damage to the stone blocks of the arches

Sl. 10 – U manjem obimu primijećeno otvaranje spojnica između blokova lukova

Illus. 10 – Showing lesser instances of joints opening up between the blocks of the arches.

Sl. 11 – U manjem obimu primijećeni tragovi procjeđivanja kroz spojnice lukova

Illus. 11 – Showing lesser instances of traces of percolation through the joints of the arches

Sl. 12 – U manjem obimu, na nizvodnoj strani, primijećene podužne pukotine u tjemenu lukova

Illus. 12 – Showing lesser instances on the downstream side of longitudinal cracks at the apex of the arches

II DIO: PREGLED PROVEDENIH ISTRAŽNIH RADOVA

Za potrebe analize stanja Mosta u Plandištu i buduće projektovanje mjera zaštite bilo je neophodno izvesti određena istraživanja. Savremene metode analize stanja historijskih zidanih konstrukcija traže utvrđivanje niza parametara, kao ulaznih vrijednosti, za proračune, koji pokazuju stanje konstrukcije i mogućnosti iznalaženja optimalnih mjera zaštite. U tu svrhu je nakon izrade Projekta postojećeg stanja u julu 2008. godine izrađen Program istražnih radova koji je realizovan prema specifičnim zahtjevima i predviđenom obimu u periodu maj – juli 2009. godine. U toku istraživanja ukazala se potreba za povećanjem obima istraživanja pojedinih parametara obzirom na otkrivene uslove i bušenjem dobiveni materijal, što je i urađeno.

Provođenje istražnih radova povjereno je firmi „Geo-eta“, d.o.o, Sarajevo, voditelj radova dr. Enes Ramović, a nadzor nad istražim radovima vodili su akademik prof. dr. Enver Mandžić i mr. Salko Kulukčija.

Cilj istraživanja

Provedena istraživanja na Mostu u Plandištu imala su za cilj:

- upoznavanje sa uslovima temeljenja mosta vezano za:
  - dubinu temeljenja stubova mosta,
  - geološki sastav i inženjersko-geološka svojstva tla na vertikalnom profilu na mjestu svakog stuba gdje je izvedeno bušenje i na horizontalnom profilu kroz korito rijeke Bosne u zoni temelja,
  - debljinu temeljnih kamenih blokova mosta,
  - svojstva materijala u dijelu temelja mosta,
  - svojstva temeljnog materijala na kome je izvedeno temeljenje u zoni uticaja temelja po dubini,
  - sastav temeljnog tla po dubini;
- upoznavanje sa fizičko–mehaničkim karakteristikama i vrsti kamena od koga su građeni pojedini elementi mosta, posebno s obzirom na čvrstoću kamena;
- upoznavanje sa mineraloško–petrološkom građom kamena u cilju njegove determinacije;

PART II. OVERVIEW OF EXPLORATORY WORKS CARRIED OUT

Certain investigations were essential in order to analyze the condition of the Bridge in Plandište and future projected protection measures. Up-to-date methods of analysis of the condition of historic masonry structures require that a number of parameters be determined as initial values for the computations showing the condition of the structure and the potential for identifying optimal protection measures. To this end, after surveying the existing condition in July 2008, a programme of exploratory works was drawn up and carried out between May and July 2009, in line with the specific requirements and projected extent. During the investigations, it became clear that the investigations of certain parameters would have to be increased in extent in the light of newly-discovered circumstances and drilling the material obtained, which was duly carried out.

The firm Geo-eta d.o.o. of Sarajevo was commissioned to carry out the exploratory works, led by Dr. Enes Ramović, with the works oversight led by Academician Prof. Dr. Enver Mandžić and Salko Kulukčija MSc.

Aims of the investigations:

The aims of the investigations on the Bridge in Plandište were:

- to identify the condition of the footings in relation to:
  - the depth of the footings of the piers,
  - the geological composition and geo-technical engineering characteristics of the soil in vertical profile at the point of each pier, which was carried out by drilling, and in horizontal profile through the bed of the river Bosna in the zone of the footings,
  - the thickness of the stone blocks of the footings,
  - the characteristics of the material of the footings,
  - the characteristics of the material on which the footings were laid in the zone of impact of

- upoznavanje sa karakteristikama starog maltera preko njegovog hemijskog sastava.

Obim istražnih radova

Za rješavanje postavljenih zadataka izrađen je Program istražnih radova na osnovu kojeg su provedeni sljedeći terenski i laboratorijski radovi:

- izrada osam subvertikalnih bušotina u zoni temelja prosječne dubine 4,8 m;
- izrada četiri kose bušotine u zoni lukova prosječne dužine 3,1 m;
- izrada dva istražna raskopa uz temelje oporaca mosta;
- ispitivanja standardne dinamičke penetracije, ukupno 23 opita;
- ispitivanja Šmitovim čekićem;
- mineraloško-petrografska ispitivanja, 11 uzoraka iz subvertikalnih i 7 iz kosih bušotina;
- hemijska ispitivanja maltera, 10 uzoraka izvornog maltera;
- geomehanička ispitivanja tla, 8 uzoraka;
- geomehanička ispitivanja kamena, 16 uzoraka.

Terenska istraživanja

Geotehnička bušenja

Ukupno je izvedeno osam subvertikalnih bušotina u području temelja, po jedna pored svakog oslonjačkog mjesta, i četiri kose bušotine kroz stubove S2 do S5. Korištena je bušaća garnitura sa rotacionim

Sl. 13 – Geotehničko bušenje u području temelja

Illus. 13 – Geotechnical drilling in the area of the footings

the foundations by depth,

- the composition of the foundation soil/subsoil by depth;
- to identify the physical and mechanical characteristics and type of stone used to build the various components of the bridge, with particular regard to the resistance of the stone;
- to identify the mineralogical and petrographic content of the stone so as to identify it;
- to identify the characteristics of the old mortar by analyzing its chemical composition.

Extent of the investigations:

In order to carry out the various tasks, a programme of exploratory works was carried out as the basis for conducting the following field and laboratory works:

- eight subvertical drillings in the zone of the footings, with an average depth of 4.8 m;
- four diagonal drillings in the zone of the arches, with an average length of 3.1 m;
- two exploratory excavations by the footings of the abutments;
- standard dynamic penetration tests, 23 tests;
- Schmidt hammer tests;
- mineralogical and petrographic tests, 11 samples from the subvertical and 7 from the diagonal bores;
- chemical tests of the mortar, 10 samples of the original mortar;
- geomechanical soil tests, 8 samples;
- geomechanical stone tests, 16 samples.

Field investigations

Geotechnical drilling

A total of eight subvertical drillings were made in the area of the footings, one by each footing, and four diagonal drillings through piers S2 to S5, using an hydraulic drill jig with a constant rotational core, to avoid any undesirable impact on the environment. The drilling was not done by erecting the drill jig on prefabricated scaffolding, as proposed in the programme, but by mounting it on a special tractor trailer. The operation and manoeuvring of the trailer and drill jig caused no degradation of the river bed.

kontinuiranim jezgrovanjem na hidraulični pogon, tako da nije moglo doći do nepoželjnih uticaja na okolinu. Bušenje nije izvedeno postavljanjem bušaće garniture na montažnu skelu kako je to bilo predviđeno Programom, nego je kao nosač korištena specijalna traktorska prikolica. Tokom rada i manevra prikolice sa garniturom nije došlo do degradacije korita rijeke.

Nabušeno jezgro propisno je slagano u metarskim intervalima u sanduke, fotografisano i inžinjersko-geološki kartirano. Procenat i kvalitet izvađenog jezgra zadovoljava važeće standarde. Svi uzorci za laboratorijska istraživanja su uzeti u prisustvu nadzornog organa.

Geološko-geomehaničkim istraživanjima je pokazano da temeljno tlo predstavljaju naslage šljunka pretežno sitnozrne granulacije. U gornjem dijelu horizonta, od dna temelja pa do dubine cca 3 m, šljunak je više zaglinjen, a u donjem dijelu od 3 do 5 m sadrži znatno manju količinu glinovite-ilovačaste materije.

Kose bušotine kroz stubove su pokazale da ispunu u stubovima S2, S4 i S5 predstavlja pijesak i šljunak koji su isprani tokom bušenja. U stubu S3 je nabušena kompaktna ispuna od svijetlosivih krečnjaka.

Istražni raskopi

Izvedena su dva istražna raskopa – po jedan uz lijevi i desni oporac na nizvodnoj strani mosta. Na površini je utvrđen sloj humusa debljine 20 cm jako pjeskovit i zaglinjen. Ispod se nalaze šljunkovito – pjeskoviti aluvijalni sendimenti. Dubina lijevog raskopa iznosi 130 cm, a desnog 60 cm. Dubina iskopa odgovara približno koti temeljenja oporca. Nisu uočena proširenja temeljnog zida u odnosu na zid oporca.

Standardni penetracioni test (SPT)

Ispitivanja standardne dinamičke penetracije (SPT) su provedena u svih osam subvertikalnih bušotina u skladu sa DIN-om 4094. Rezultati testa na dubini od 1,0 do 1,3 m su pokazali da se N_{30} nalazi u intervalu od 14 do 32 udaraca, na dubini od 2,2 do 2,5 m se N_{30} kreće u intervalu od 23 do 29 udaraca, a na dubini od 4,15 do 4,45 m je N_{30} u intervalu od 30 do 41 udaraca. Stepen zbijenosti za SE tlo pod vodom može se prema DIN-u 4094 izračunati iz obrasca

The drill cores were laid a metre apart in boxes, photographed, and logged for geotechnical engineering data. The percentage and quality of the extracted cores met current standards. All the samples intended for laboratory analysis were taken in the presence of the overseeing body.

The geological and geomechanical investigations revealed that the foundation soil consists of deposits of fairly fine-grained gravel. In the upper part of the horizon, from the bottom of the footings to a depth of about 3 m, there was a considerable admixture of clay with the gravel, while at a depth of 3 to 5 m there was significant less clay-loam matter.

The diagonal drillings through the piers revealed that the infill in piers S2, S4 and S5 consisted of sand and gravel, which were washed out during drilling. In pier S3, a compact infill of light-grey limestone was drilled.

Exploratory excavations

Two exploratory excavations were carried out, one by the left abutment and one by the right, on the downstream side of the bridge. A 20 cm thick surface layer of humus with a considerable admixture of sand and clay lay over a gravelly, sandy alluvial sediment. The left excavation was 130 cm deep and the right, 60 cm, roughly corresponding to the level of the footings of the abutments. The footings were not found to be wider than the abutment wall.

Standard penetration test (SPT)

Standard penetration tests (SPT) were carried out in all eight subvertical drillings in line with DIN 4094. The results of the test at a depth of 1.0 to 1.3 m revealed N_{30} at intervals of 14 to 32 blows, at 2.2 to 2.5 m at intervals of 23 to 29 blows, and at 4.15 to 4.45 m at intervals of 30 to 41 blows. The degree of compactness for SE soil under water may be calculated according to DIN 4094 by using the formula $D=0.1+0.39\lg N_{30}$. Thus ${}_{\min}N_{30}=14$ gives $D_{14}=0.55$; and ${}_{\max}N_{30}=41$ gives $D_{41}=0.73$. The foundation soil may thus be said to be well compacted. It was shown that the foundation soil compactness increases with depth, so that although the soil was rather less com-

$D=0,1+0,39\lg N_{30}$. Za $_{min}N_{30}=14$ dobije se $D_{14}=0,55$; za $_{max}N_{30}=41$ dobije se $D_{41}=0,73$. Prema tome, možemo reći da je temeljno tlo dobre zbijenosti. Dokazano je da zbijenost temeljnog tla sa dubinom raste, te iako je u zoni uticaja temelja ta zbijenost nešto manja, ona je u granicama dobre zbijenosti (D=0,5...0,8).

Korelacija laboratorijski dobivenih parametara tla i parametara koji se mogu približno odrediti iz opita SPT, pokazuje dobru suglasnost prema standardno korištenim dijagramima iz literature i pravilnika.

Ispitivanje Šmitovim čekićem

Pored geotehničkih bušenja i uzimanja uzoraka za laboratorijska istraživanja, na terenu su izvedeni opiti Šmitovim čekićem na svim litološkim vrstama stijenskog materijala ugrađenog u most. Utvrđena je orijentaciona vrijednost jednoaksijalne čvrstoće na pritisak svakog od identifikovanih stijenskih materijala, koji je u blokovima ugrađen u most. Karakteristično je da je konstrukcija mosta izgrađena, u glavnom, od četiri vrste stijenskog materijala, koji je bez bilo kakve pravilne zakonomjernosti ugrađivan u most. Prema vrsti stijenskog materijala, ispitivanja Šmitovim čekićem izvedena su na:

- krečnjačka breča sedrificirana (sa šupljinama), najviše zastupljenoj u lukovima, male čvrstoće ($6<\sigma<20$ MPa);
- krečnjačka breča (bez šupljina), malo zastupljenoj, čvrstoće ($14<\sigma<22$ MPa);
- sedra krečnjačka, dosta zastupljena, veoma male čvrstoće ($2<\sigma<6$ MPa);
- krečnjak masivni, bijeli, malo zastupljen, velike čvrstoće ($23<\sigma<39$ MPa);
- krečnjak masivni, sivi, malo zastupljen, velike čvrstoće ($23<\sigma<39$ MPa).

Ograda mosta je, za razliku od ostalih dijelova mosta, izgrađena pretežno od samo jedne vrste stijenskog materijala, koga čini krečnjak čvrstoće $\sigma<23$ MPa.

Procjena jednoaksijalne čvrstoće na pritisak kamenih blokova ispitanih Šmitovim čekićem izvršena je korištenjem dijagrama sa slike 2. Korelacija laboratorijski utvrđene čvrstoće i čvrstoće koja se može približno odrediti korištenjem Šmitovog čekića pokazuje dobru suglasnost.

pact in the zone of influence of the footings, it is still within acceptable limits (D=0.5...0.8).

Correlating between the soil parameters obtained in the laboratory and those that can be roughly determined from the SPT shows a good degree of agreement with the diagrams in reference works and guidelines in standard use.

Schmidt hammer test

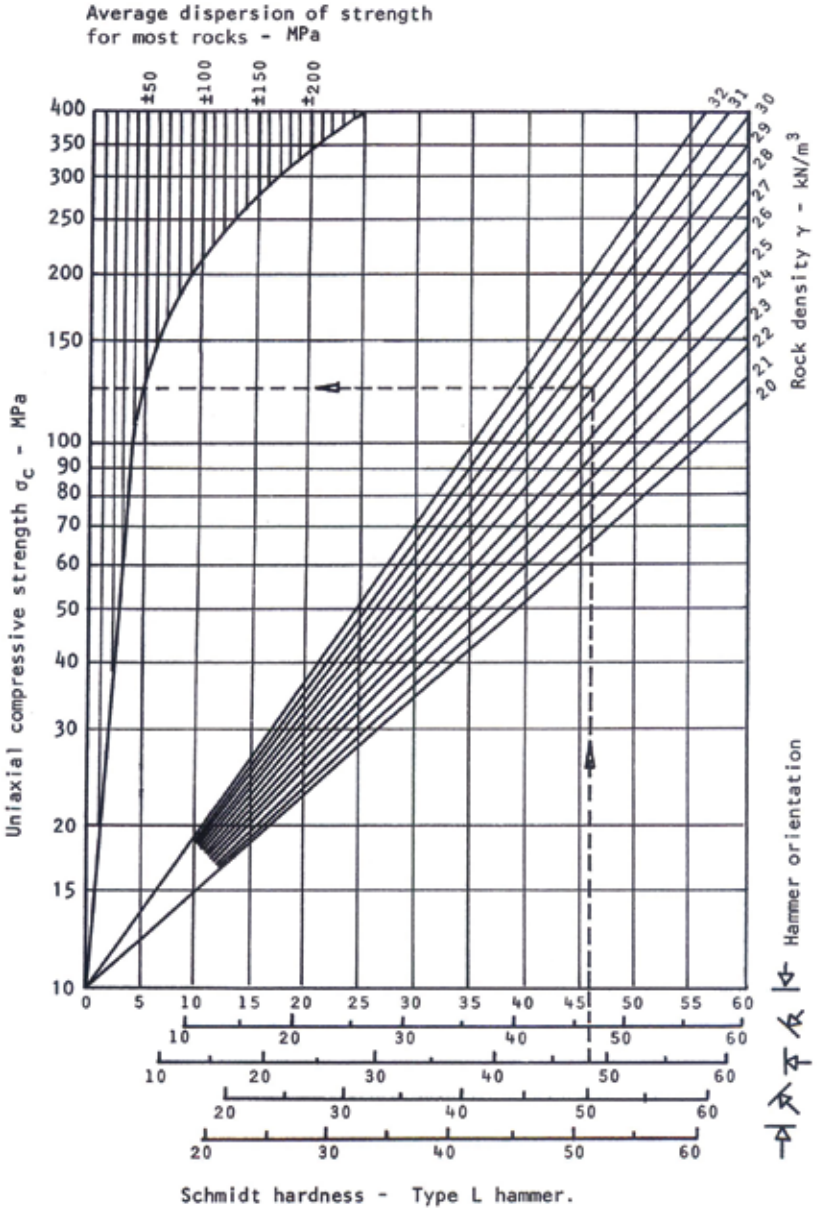
As well as geotechnical drillings and taking samples for laboratory analysis, Schmidt hammer tests were carried out on site on all lithological types of rock built into the bridge. The approximate value of uniaxial compressive strength was identified for each type of rock used as blocks to build the bridge. A feature of the bridge is that it was largely built of four types of rock, used in no particular proportions. The Schmidt hammer test was carried out on the following types of rock:

- calc tufa breccia with cavities, mainly in the arches, of low compressive strength ($6<\sigma<20$ MPa);
- limestone breccia without cavities, little used, compressive strength ($14<\sigma<22$ MPa);
- calc tufa, quite widely used, of very low compressive strength ($2<\sigma<6$ MPa);
- massive limestone, white, little used, of high compressive strength ($23<\sigma<39$ MPa);
- massive limestone, grey, little used, of high compressive strength ($23<\sigma<39$ MPa).

Unlike the rest of the bridge, the parapet consists mainly of a single type of stone – limestone with a resistance of $\sigma<23$ MPa.

The uniaxial compressive strength of the stone blocks tested by Schmidt hammer was estimated using the diagram (fig. 2). Comparisons between the resistance calculated in the laboratory with that estimated using the Schmidt hammer test revealed a good degree of correlation.

σ_c is given by the graph as 125±50 MPa. Note that the hammer should always be perpendicularto the rock surface.



Relationship between Schmidt hardness and the uniaxial compressive strength of rock, after Deere and Miller[100].

1 MPa = 1 MN/m² = 10.2 kg/cm² = 145 lb/in²
1 kN/m³ = 102 kg/m³ = 6.37 lb/ft³.

Sl. 14 – Korelaciona veza između Šmitovog čekića i jednoaksijalne čvrstoće na pritisak stijene (Ebert Hoek, John Bray 1977)

Ilus. 14 – Relationship between Schmidt hardness and the uniaxial compressive strength of rock (Ebert Hoek, John Bray 1977)

Laboratorijska ispitivanja

Laboratorijska ispitivanja provedena su na karakterističnim uzorcima dobivenim geotehničkim bušenjem i ručnim uzorkovanjem. Provedena su mineraloško-petrografska i geomehanička ispitivanja kamena, mineraloško-petrografska i hemijska ispitivanja izvornog maltera i geomehanička ispitivanja tla.

Mineraloško-petrografska ispitivanja kamena

Mineraloško-petografska ispitivanja kamena izvedena su na uzorcima uzetim iz subvertikalnih i subhorizontalnih bušotina. Ukupno je analizirano 18 uzoraka. Ispitivanjima su obuhvaćeni makroskopski opis stijene, mikroskopski opis petrografskih preparata i strukturno-teksturne karakteristike uzorka na osnovu čega je izvršena njihova petrografska determinacija. Prema laboratorijskom izvještaju firme Geominis Beograd ispitivani uzorci u najvećem broju determinisani su kao polimiktni srednjezrni do sitnozrni konglomerati. Matriks stijene kao i preovlađujući klasti su karbonatnog karaktera. U izvještaju stoji da prisustvo klasta metamorfita i sedimenata ukazuje na šire dinamičke uslove sedimentacije u bazenu, te da bi se stoga determinisani konglomerati uslovno mogli okarakterisati kao intraformacijski. Sa geomehaničkog aspekta ispitivani uzorci su sagrađeni od stijena različitih mehaničkih karakteristika, te stoga, u cjelini predstavljaju fizičko-mehaničke diskontinuitete. (Geo-minis, 2009)

Geomehanička ispitivanja kamena

Geomehanička ispitivanja kamena provedena su na 16 uzoraka kamena od kojih su neki istovremeno uzeti sa uzorcima za prethodno opisana mineraloško-petrografka ispitivanja. U okviru ovih ispitivanja određena je zapreminska težina u suhom stanju i jednoaksijalna čvrstoća na pritisak u skladu sa standardima BAS B.B8.012 i B.B8.032. Svi uzorci su zasićeni vodom prije određivanja čvrstoće, a odnos prečnika i visine je približno jedan.

Iz subvertikalnih bušotina ispitano je sedam uzoraka krečnjačke breče i jedan uzorak bijelog krečnjaka. Zapreminska težina krečnjačke breče varira od 19,16 do 22,48 KN/m^3. Jednoaksijalna čvrstoća na

Laboratory tests

Laboratory tests were conducted on typical samples obtained by geotechnical drilling and manual sampling. Mineralogical petrographic and geomechanical tests were carried out on stone, mineralogical petrographic and chemical tests on the original mortar, and geomechanical tests on the soil.

Mineralogical petrographic rock tests

Mineralogical petrographic tests were carried out on stone samples taken from the subvertical and subhorizontal cores. In all, 18 samples were analyzed. The tests covered a macroscopic description of the rock, a microscopic description of petrographic slides and structural textural characteristics of the samples, which were used as the basis for petrographic identification. According to the laboratory report by the firm Geo-minis Belgrade, most of the samples were identified as polymict medium to fine-grained conglomerates. The matrix and the predominant clasts were carbonate in nature. The report states that the presence of metamorphic and sedimentary clasts indicates the wider dynamic sedimentation conditions in the basin, as a result of which the conglomerates could be described as intraformational. From the geomechanical perspective, the samples tested were composed of rocks with varying mechanical characteristics, with overall physico-mechanical discontinuities (Geo-minis, 2009).

Geomechanical rock tests

Geomechanical tests were carried out on 16 stone samples, some of which were also taken as samples for the mineralogical petrographic tests described above. These tests determined bulk density in the dry state and uniaxial compressive strength in line with BAS B.B8.012 and B.B0.032 standards. All the samples were soaked in water prior to determining their compressive strength, and the ratio between diameter and height was approximately equal.

Seven samples of limestone breccia and one of white limestone from the subvertical cores were tested. The bulk density of the limestone breccia ranges from 19.16 to 22.48 KN/m^3. The uniaxial

pritisak ovih uzoraka varira od 6,44 do 22,7 MN/m^2. Ispitani uzorak bijelog krečnjaka iz subvertikalne bušotine B-5 ima zapreminsku težinu od 26,30 KN/m^3 i čvrstoću na pritisak od 37,88 MN/m^2.

Iz kosih bušotina ispitano je šest uzoraka krečnjačke breče i dva uzorka bijelog krečnjaka. Zapreminska težina krečnjačke breče varira od 22,07 do 23,76 KN/m^3. Jednoaksijalna čvrstoća na pritisak ovih uzoraka varira od 7,83 do 19,7 MN/m^2. Uzorci bijelog krečnjaka imaju zapreminsku težinu 23,06 odnosno 24,08 KN/m^3, i čvrstoću na pritisak 22,85 odnosno 38,64 MN/m^2.

U subvertikalnoj bušotini B-8 je nabušen uzorak betona u području temelja. Ovaj beton vjerovatno datira iz perioda prethodnih sanacija. Utvrđena je zapreminska težina uzorka od 22,90 KN/m^3 i čvrstoća na pritisak 28,69 MN/m^2.

Mineraloško-petrografska ispitivanja izvornog maltera

Mineraloško-petrografska ispitivanja maltera izvedena su na 10 uzoraka od kojih je uzet prah za hemijska ispitivanja. Ispitivanje mineralnog sastava izvršeno je mikroskopski u reflektovanoj svjetlosti. Svi uzorci su tretirani sa razblaženom HCI kiselinom, zatim su oprani i prosijani kroz sito 0,76 mm. Mineralno-petografska ispitivanja su izvršena na nadrešetnoj i podrešetnoj frakciji. Iz analize se vidi da je dominantan karbonat-krečnjak sa učešćem od 80 do 90%. Pored toga javljaju se u manjim količinama rožnaci, dijabaz, kalcit i kvarc. U samo jednom uzorku se pojavljuje glina i terra rosa. Rezultati ove analize zajedno sa rezultatima hemijske analize, nakon detaljne obrade i komparacije, mogu biti korišteni za buduće eventualno spravljanje replike izvornog maltera.

Hemijska ispitivanja izvornog maltera

Kako je naprijed navedeno, hemijska ispitivanja izvornog maltera su izvršena na 10 uzoraka na kojima su izvršena i mineraloško-petrografska ispitivanja. Uzorkovanje izvornog maltera je bio veoma zahtjevan posao jer je trebalo pregledati sva dostupna mjesta gdje bi stari malter mogao biti prisutan. Izvorni malter je nađen u svodu propusta na pristupnom

compressive strength of these samples ranges from 6.4 to 22.7 MN/m^2. The sample of white limestone from subvertical core B-5 had a bulk density of 26.30 KN/m^3 and a compressive strength of 37.88 MN/m^2.

Six samples of limestone breccia and two of white limestone from the diagonal cores were tested. The bulk density of the limestone breccia ranges from 22.07 to 23.76 KN/m^3, and their uniaxial compressive strength ranges from 7.83 to 19.7 MN/m^2. The samples of white limestone have a bulk density of 23.06 and 24.08 KN/m^3 and a compressive strength of 22.85 and 38.64 MN/m^2 respectively.

In subvertical drill B-8 a sample of concrete in the foundations region was drilled. This concrete probably dates from earlier repairs. The sample was found to have a bulk density of 22.90 KN/m^3 and a compressive strength of 28.69 MN/m^2.

Mineralogical petrographic tests on the original mortar

Mineraological petrographic tests were carried out ten samples, from which powder was taken for chemical testing. The mineral composition was examined under the microscope in reflected light. All samples were treated with dilute HCl acid, washed and passed through a 0.76 mm sieve. Mineralogical petrographic tests were carried out on the material that passed through the sieve and the material that did not. The analysis reveals a predominance of carbonate limestone of 80-90%, with smaller proportions of cherts, diabase, calcite and quartz. One sample only contained clay and terra rossa. The results of this analysis and of the chemical analysis may be of use, following detailed processing and comparison, in possible replication of the original mortar.

Chemical tests on the original mortar

As noted above, chemical tests were carried out on the 10 samples of the original mortar on which mineralogical petrographic tests were also conducted. Taking samples of the original mortar proved to be a very demanding affair, since each accessible place where there might have been some original mortar had to be examined. Original mortar was found in the arch of

dijelu mosta iz pravca Ilidže i nabušen je u kosim bušotinama. Pripremljeni uzorci su po protokolu poslati u Acme Analytical Laboratories u Vancouver gdje je provedena kompleksa hemijska analiza. Sadržaj jedinjenja i elemenata koji utiču na hidrauličnost maltera dat je u tabeli 1 sa procjenom indeksa cementacije. Potrebno je napomenuti da cementni malter za ispunu, koji je korišten u ranijoj sanaciji, nije bio predmet ispitivanja.

Geomehanička ispitivanja tla

Laboratorijska ispitivanja uzoraka tla provedena su na uzorcima rahlog materijala, kao temeljnog tla, dobivenog bušenjem. Određeni su parametri: zapreminska težina u vodozasićenom i suhom stanju, kohezija, ugao unutrašnjeg trenja, modul stišljivosti i granulometrijski sastav. Parametri kohezije i ugla unutrašnjeg trenja određeni su opitom direktnog smicanja, a modul stišljivosti endometarskim opitom. Provedeno je osam opita, po jedan uzorak iz svake subvertikalne bušotine. Prema rezultatima laboratorijskih ispitivanja zapreminska težina u vodozasićenom stanju varira od 20,69 do 22,26 KN/m^3, a u suhom stanju od 18,76 do 20,26 KN/m^3. Kohezija je izmjerena smo u jednom uzorku svega 5,4 KN/m^2, te se može smatrati da računski nema kohezije. Ugao unutrašnjeg trenja varira od 25,1^0 do 42,9^0 i ima relativno veliku disperziju. U korelaciji sa SPT opitima može se preporučiti da se u daljnjim analizama usvoji računski ugao unutrašnjeg trenja od 30^0. Modul stišljivosti za interval opterećenja od 20 do 30 N/cm^2, varira od 645 do 4444 N/cm^2. Dokazano je da šljunkoviti materijal, kao temeljno tlo, veoma brzo dostiže svoju maksimalnu zbijenost, da ima visoki ugao trenja kod nulte kohezije, te da je po granulometrijskom sastavu to materijal vrlo neravnomjernog sastava.

Procjena indeksa cementacije (hidrauličkog modula) izvornog maltera

Na osnovu iskustvene formule iz literature (Eckel, 1928) i podataka hemijskog ispitivanja izvornog maltera izračunat je indeks cementacije - nivo hidrauličnosti ispitivanog maltera.

the culvert on the approach area of the bridge from the Ilidža direction, and cores taken in diagonal drillings. The prepared samples were sent in the prescribed manner to Acme Analytical Laboratories in Vancouver, where a complex chemical analysis was carried out. The composition of the chemical compounds and elements affecting the hydraulic qualities of the mortar is given in Table 1, with an estimate of the cementation index. It should be noted that the cement mortar infill used in earlier repairs was not tested.

Geomechanical soil tests

Laboratory soil-sample tests were carried out on samples of friable subsoil material obtained by drilling. The parameters determined were bulk density in the saturated and dry state, cohesion, angle of internal friction, compressibility module and granulometric composition. The parameters of cohesion and angle of internal friction were determined by testing direct shearing, and the compressibility module by endometric test. Eight tests were carried out, on one sample from each subvertical core. The results of the laboratory tests revealed that bulk density in the saturated state ranges from 20.69 to 22.26 KN/m^3 and in the dry state from 18.76 to 20.25 KN/m^3. Cohesion as measured in one sample only was a mere 5.4 KN/m^2, indicating that there is no computable cohesion. The angle of internal friction ranges from 25.1^o to 42.9^o, with relatively high dispersion. Comparison with the SPT test suggests that a computational angle of internal friction of 30^o be used in further analyses. The compressibility module for load intervals of 20 to 30 N/cm^2 ranges from 645 to 4444 N/cm^2. It was shown that gravelly material as subsoil rapidly reaches its maximum compressibility, that it has a high angle of friction at zero cohesion, and that it is extremely uneven in granulometric composition.

Estimated cementation index (hydraulic module) of original mortar

The cementation index or degree of hydraulicity of the mortar tested was calculated on the basis of tried and tested formulae (Eckel, 1928) and the results of the chemical tests.

Tabela 4 – Podaci o učešću komponenti u uzorcima maltera preuzeti iz Izvještaja o rezultatima hemijskih ispitivanja maltera, Acme Analytical Laboratories, Vancouver (Geo eta, 2009)

Table 4 – Proportion of components in samples of mortar, from the report on the chemical tests conducted on the mortar by Acme Analytical Laboratories, Vancouver (Geo eta, 2009)

	Komponente koje utiču na hidrauličke osobine Components affecting hydraulic qualities						Indeks cementacije Cementation index	Opis hidrauličnosti Hydraulic quality
Uzorak Sample	**SiO2**	**Al2O3**	**Fe2O3**	**CaO**	**MgO**		**C.I.**	
	%	%	%	%	%			
RMM-01	12,29	1,95	0,86	41,46	4,59		0,78	jako hidraulično strongly hydraulic
RMM-02	27,71	4,03	1,57	34,88	2,85		2,14	jako hidraulično strongly hydraulic
RMM-03	14,51	3,04	1,15	42,02	1,27		1,02	jako hidraulično strongly hydraulic
RMM-04	6,76	1,38	0,68	42,54	7,17		0,40	slabo hidraulično weakly hydraulic
RMM-05	19,62	4,37	1,63	37,89	1,15		1,54	jako hidraulično strongly hydraulic
RMM-06	19,73	4,39	1,51	38,03	1,03		1,55	jako hidraulično strongly hydraulic
RMM-07	20,66	5,25	1,64	37,43	0,86		1,68	jako hidraulično strongly hydraulic
RMM-08	19,24	4,98	1,69	37,90	1,05		1,54	jako hidraulično strongly hydraulic
RMM-09	20,31	4,80	1,63	37,68	1,04		1,62	jako hidraulično strongly hydraulic

Indeks cementacije (ili hidraulični modul) prema Eckelu (1928):

$$C.I. = \frac{2{,}8 \times \%SiO_2 + 1{,}1 \times \%Al_2O_3 + 0{,}7 \times \%Fe_2O_3}{\%CaO + 1{,}4 \times MgO}$$

gdje je

C.I.	=	0-0,15 nije hidraulično
0,15-0,3		subhidraulično
0,3-0,5		slabo hidraulično
0,5-0,7		umjereno hidraulično
0,7-1,1		jako hidraulično
>1,1		prirodni cement

(1,0 hidrauličnost uporediva sa Portland cementom)

Cementation index (or hydraulic module) after Eckel (1928):

$$C.I. = \frac{2{,}8 \times \%SiO_2 + 1{,}1 \times \%Al_2O_3 + 0{,}7 \times \%Fe_2O_3}{\%CaO + 1{,}4 \times MgO}$$

where

C.I.	=	0-0.15 non hydraulic
0.15-0.3		sub hydraulic
0.3-0.5		weakly hydraulic
0.5-0.7		moderately hydraulic
0.7-1.1		strongly hydraulic
>1.1		natural cement

(1,0 hydraulicity comparable with Portland cement)

Preliminarna statička analiza

Koristeći parametre dobivene provedenim istraživanjem analizirana su dva aspekta nosivosti, ključna za ocjenu nosivosti cjelokupne konstrukcije:

- stabilnost lučne konstrukcije višerasponskog mosta;
- nosivost temelja.

Stabilnost lučne konstrukcije je analizirana pomoću računarskog programa RING 1.5 (www.shef.ac.uk/ring), dok je analiza kapaciteta nosivosti temelja provedena pomoću računarskog programa DC-Bearing (www.dc-software.de). U ovim analizama su razmatrana granična stanja nosivost u skladu sa savremenim konceptom parcijalnih koeficijenata sigurnosti na strani uticaja (opterećenja) i na strani otpora (materijala).

Koncept proračuna pomoću programa RING podrazumijeva postepeno povećavanje intenziteta zadatog korisnog (saobraćajnog) opterećenja do one veličine (granično opterećenje) pri kojoj dolazi do gubitka stabilnosti odnosno pojave dovoljnog broja zglobova i formiranja mehanizma. Odnos između graničnog i zadatog korisnog opterećenja predstavlja ukupni faktor sigurnosti koji se dobije kao krajnji rezultat proračuna. U konkretnom slučaju, za parcijalni faktor sigurnosti za saobraćajno opterećenje prema EC multiplicirano sa dinamičkim faktorom, ukupni faktor sigurnosti treba biti veći ili jednak 1,829. Za slučaj djelovanja vlastite težine mosta i jedinične sile od 1kN rezultati zadovoljavaju zahtijevani nivo sigurnosti. Za slučaj djelovanja saobraćajnog opterećenja V120 odnosno V300, zahtijevani nivo sigurnosti je zadovoljen samo ako se uzme u obzir povoljan uticaj pasivnog otpora ispune.

Korištenjem programa DC-Bearing, a za parametre tla u skladu sa Elaboratom o inžinjersko-geološkim i geomehaničkim istraživanjima (Geo eta, 2009), te prema standardu DIN1054:2005/ DIN4017:2006 analogno EC7, uzimajući u obzir da je računska dubina temeljenja prosječno 20 cm izračunat je računski kapacitet nosivosti temelja od 227 kN/m^2 (što je zbog djelomičnih nanosa/podlokanosti, prema stanju na terenu, najniža očekivana vrijednost). Kriterij nosivosti je dat izrazom $N_d \leq$

Preliminary structural analysis

Using the parameters obtained by the tests, two aspects of bearing capacity were analyzed, crucial for an assessment of the bearing capacity of the entire structure:

- the stability of the arch structure of the multispan bridge;
- the bearing capacity of the footings.

The stability of the arch structure was analyzed using the RING 1.5 computer program (www.shef.ac.uk/ring), and the analysis of the bearing capacity of the footings was conducted using the DC-Bearing computer program (www.dc-software.de). These analyses covered the limit bearing capacity in line with the contemporary concept of partial safety coefficients for action (load) and resistance (material).

The computation concept using the RING program entails gradually increasing the intensity of the given load (traffic) to the limit load at which there is a loss of stability, with the emergence of a sufficient number of joints and the formation of a mechanism. The ration between the limit and given load is the total safety factor, obtained as the end result of the computation. In this specific case, for the partial safety factor for a traffic load according to EC multiplied by the dynamic factor, the total safety factor should be equal to or greater than 1.829. in the case of the action of the bridge's own weight and a unit force of 1kN, the results fulfil the required safety level. In the case of a traffic load of V120 or V300, the required safety level is satisfactory only if the positive action of the passive resistance of the infill is taken into account.

Using the DC-Bearing program and the soil parameters from the report on the geological and geomechanical engineering tests (Geo eta, 2009), the computational bearing capacity of the foundations was calculated according to DIN1054:2005/ DIN4017:2006 standards analogous to EC7, taking into account that the computational depth of the foundations is on average 20 cm, yielding a bearing capacity of 227 kN/m^2 (which is due to some bedloads/undercutting, as illustrated by the situation

R_d, pri čemu je N_d računska vrijednost opterećenja na temelje. Ovaj kriterij je zadovoljen samo za slučaj djelovanja vlastite težine mosta i pješaka – bez saobraćajnog opterećenja od vozila. Ako se doda računsko opterećenje od servisnog vozila (V120), tada je ukupno opterećenje približno jednako računskom kapacitetu nosivosti –prekoračenje iznosi oko 4%. Treba naglasiti da dubina temeljenja (ukopavanja) značajno utiče na kapacitet nosivosti, tako da se npr. za dubinu od 25cm dobije računski kapacitet nosivosti od 240 kN/m^2. Svrha ovog osvrta na dubinu temeljenja jeste samo da se naglasi da je za proračun odabrana najmanja očekivana vrijednost, koja daje najmanji kapacitet nosivosti. (Interprojekt, 2009)

Zaključna razmatranja

Na osnovu provedenih istraživanja može se konstatovati da most egzistira u kompleksnim uslovima vezanim za temeljenje i vrstu temeljenja na šljunku, različitu čvrstoću pojedinačnih blokova, različitih vrsta stijenskog materijala ugrađenih u most, postojanje veziva cementnog maltera na spolja vidljivim površinama i starog hidrauličkog maltera unutar konstrukcije mosta. Djelovanjem vode i leda pojedini blokovi stijene u temeljima mosta su u trošnom stanju, sto je dokazano bušenjem i ispitivanjem uzoraka, a vidljivo je i na terenu. Temeljene mosta izvedeno je plitko i različite dubine od stuba do stuba mosta. Konsolidacija temeljnog tla pod djelovanjem opterećenja mosta je potpuno završena, što znači da nikakva dodatna slijeganja ne treba očekivati ni u uslovima izvedbe sanacije mosta. Lom temeljnog tla pod djelovanjem opterećenja mosta nije nigdje indiciran jer nisu evidentirana krivljenja temeljnih stopa, nema propadanja pojedinačnih temelja, nema pukotina na stubovima ili lukovima koji bi inicirali početnu fazu loma temeljnog tla. Preliminarnom statičkom analizom je dokazano da ispitano temeljno tlo ima dovoljan kapacitet nosivosti za sopstvenu težinu mosta bez savremenog saobraćajnog opterećenja.

Na osnovu preliminarne statičke analize stabilnosti lučne konstrukcije, uz konzervativan pristup da ne dolazi do aktiviranja pasivnog otpora ispune, može se samo zaključiti da most nema dovoljan kapa-

on the field, the lowest expected value). The bearing capacity criterion is expressed in the formula Nd ≤ Rd, where Nd is the value of the load on the footings. This criterion is met only for the action of the bridge's own weight and pedestrian traffic, without motor vehicle traffic. If the computational load of a service vehicle (V120) is added, then the total load is almost equal to the computational bearing capacity – with the overrun being ca. 4%. It should be noted that the foundation (embedment) work has a significant impact on the bearing capacity, where, for example, a depth of 25 cm yields the computational bearing capacity of 240 kN/m^2. This review of the depth of the foundation work is designed to make it clear that the lowest expected value, which yields the lowest bearing capacity, has been selected for the analysis. (Interprojekt, 2009).

Concluding observations

On the basis of the tests and investigations carried out, the bridge can be said to exist in a nexus of conditions associated with the foundations and the type of footings on gravel, the varying strengths of the blocks of stone, the various types of rock used to build the bridge, and the presence of cement mortar on the visible exterior surfaces and of old hydraulic mortar inside the bridge structure. The action of water and ice on some of the blocks of stone in the footings has left them in poor condition, as demonstrated by drilling and tests on the samples, but which can also been seen in situ. The bridge stands on shallow foundations of varying depth from pier to pier. The foundation soil is fully consolidated under the load of the bridge, which means that no further subsidence is to be expected even when repairs are carried out on the bridge. There are no indications of subsoil failure under the load of the bridge, given that no signs of distortion to the footings, the failure of any of the footings, or cracks in the piers or arches were observed, any of which could have suggested the early stages of subsoil failure. The preliminary structural analysis revealed that the subsoil has sufficient bearing capacity for the bridge's own weight without the additional load of modern traffic.

citet nosivosti za slučaj djelovanja saobraćajnog opterećenja od servisnog vozila (V120) niti saobraćajnog opterećenja (V300). Preliminarna analiza ukazuje da bi se ovaj vrlo oprezan i strog zahtjev, mogao promijeniti uz bolje poznavanje ispune odnosno uzimanje u obzir pasivnog otpora ispune. Poznato je da postoji projektna dokumentacija na osnovu koje su rađeni zahvati oko 1980. godine. Može se očekivati da bi se istraživanjem ove dokumentacije došlo do pouzdanih podataka o ispuni. Međutim, imajući u vidu da je analiza kapaciteta nosivosti temelja pokazala da temeljno tlo nema kapacitet da prenese druga opterećenja osim vlastite težine mosta i pješaka, to je neophodno da se trajno zadržati sadašnji režim zabrane prelaska motornih vozila preko mosta.

U sklopu projekta postojećeg stanja opisane su uočene deformacije i oštećenja. Sa aspekta nosivosti bitno je obratiti pažnju i riješiti problem dislokacije ili nedostatka temeljnih blokova kao i na uočeno podlokavanje temelja. Propust na pristupnoj dijelu mosta iz pravca Ilidže nije bio predmet prethodnih sanacija pa blokovi iz stropa vise i zahvaljujući povoljnoj uzglobljenosti još uvijek nisu urušeni. Razmotriti potrebu saniranja-ojačanja riječnog korita u cilju sprečavanja daljnjeg podlokavanja – erozivnog hidrauličkog djelovanja rijeke. Uočena su također i manja oštećenja i nedostaci (opisani u Projektu postojećeg stanja) koja treba obraditi u sklopu glavnog projekta. Riječ je o lokalnim oštećenjima, tragovima procjeđivanja, sitnijem rastinju i slično. Neophodno je dati tehnička rješenja sanacije manjih oštećenja kako bi se spriječilo pogoršavanje sadašnjeg stanja.

The preliminary structural analysis of the stability of the arch structure, subject to the conservative approach of not activating the passive resistance of the infill, suggests that the bridge has insufficient bearing capacity for either service vehicles (V120) or motor vehicle traffic (V300). The preliminary analysis suggests that this extremely cautious, strict approach could change if the nature of the infill were to be better known or its passive resistance were to be taken into account. The project documentation used for the works in around 1980 is known to be extant. It is to be expected that a study of this documentation would provide reliable data on the infill. However, bearing in mind that the analysis of the bearing capacity of the foundations revealed that the foundation soil lacks the capacity to transfer any load other than the bridge's own weight and that of pedestrians, it is essential to maintain the current ban on motor vehicle traffic over the bridge as a permanent restriction.

The survey of the existing condition of the monument included a description of the deformations and damage observed. From the perspective of bearing capacity, it is essential to attend to and resolve the problem of the removal or absence of blocks from the footings and the undercutting of the footings. The culvert on the approach to the bridge from the Ilidža direction was not included in earlier remedial works, and the roofing blocks are hanging, though they are sufficiently well joined not yet to have fallen. Consider the need to repair and reinforce the river bed to prevent further undercutting by the erosive hydraulic action of the river. Minor damage and missing elements (described in the survey of the existing condition) were also observed and should be covered by the main project. These consist of local damage, traces of percolation, minor plant growth and so on. Technical solutions for making good minor damage should be provided to prevent further deterioration.

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