



CETRA²⁰¹²

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



Organizer
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Faculty of Civil Engineering
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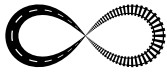
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FINAL DESIGN FOR WIDENING OF BRIDGE OVER NISAVA RIVER, ON THE RIGHT CARRIAGEWAY OF THE MOTORWAY E80: NIŠ–DIMITROVGRAD

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Abstract

On the main M–1.12 road, section Niš–Dimitrovgrad, there is a reinforced concrete bridge over Nisava River. It was designed in 1971 by the Highway Institute, and built afterwards in the period 1972 – 1973. The bridge is a continuous frame construction with three fields, and distribution of spans 10.4 + 20.8 + 10.4 m.

In the course of many years, due to inadequate maintenance, considerable damages occurred on the facility. In the year 2006, the main repair design was prepared, but the work has not been carried out as yet. Because of the preparation of the final design of E–80 motorway, Niš–Dimitrovgrad, it was required to widen both the alignment of the existing main road M–12 and the existing bridge itself. Along with the final design of the Nisava bridge, widening (to the required motorway profile) and necessary repair measures of the structure have been anticipated.

Keywords: reinforced concrete bridge, repair, widening and motorway.

1 Introduction

The existing reinforced concrete bridge over Nisava River, 'NISAVA III' is located at km. 55+221.20 of the Main M–1.12 road, section: Niš–Dimitrovgrad. The bridge was constructed in the period from 1972 to 1973 and is a continuous frame construction with three fields, and distribution of spans 10.40 + 20.80 + 10.40 m in total length of 51.0 m, Fig. 1.

The cross-section of the bridge is comprised of a cruciform reinforced concrete bridge deck built over a crib made of two longitudinal main beams, on centre-to-centre spacing of 5.0 m, with cross girders at every 5.20 m. There are brackets on each side, with 2.65 m spans from the main beam axis and with 1.45 m wide pedestrian pathways on top.

The left (abutment) pier is a reinforced concrete structure with fixed joint bearings and is founded on rock, over a 2.0 m high block of compacted concrete.

The intermediate (river) pier on the left riverbank, with the \varnothing 100 cm cross-section, is founded directly on the rock, on a pad foundation.

The intermediate (river) pier on the right riverbank, with the \varnothing 100 cm cross-section, is founded on a rock over a reinforced concrete well.

The right (abutment) pier is a 10.0 m high reinforced concrete structure with two rocker bearings – reinforced concrete pendulum. Between the head and wing walls there is a material filling. The abutment has been founded over a reinforced concrete pad foundation in a shape of a Cyrillic letter 'П'.



Figure 1 Upstream view of the existing bridge

2 Condition of the existing bridge

Examination of the bridge has been carried out on 29th of March 2006 and it was concluded that during decades of operating, inadequate routine maintenance and untimely repair significant damage to the structure has been made.

Evidence of water penetration has appeared on both abutments, through the expansion device in the area of bearings, as well as confluence down the head and wing walls. Concrete damage has been observed in the area of lower joints in both pendulums, as well as corrosion of pendulum reinforcement. Both of the pendulums deviate from the vertical by about 20 mm. The main beams endings, in the bearings area are, over their entire height, influenced by aggressive water and salt impacts, which penetrate damaged expansion devices, causing severe damage to the concrete layers, while the exposed reinforcement has considerably corroded., Fig. 2.

The pedestrian pathway on the right wing of the S1 abutment was demolished during the formation of an 'illegal' access road to the left bank, for depositing the excavated material during the railway profile widening. Deposited material has partly backfilled the bracket and pedestrian pathways. Not having been designed for vehicle operation, the bracket is exposed to damage. Expansion devices on the pavement and pedestrian pathways are damaged as well, Fig. 3.



Figure 2 Vertical impairment and deviation of bearings



Figure 3 Exposed, corroded reinforcement

Basic design anticipates three gullies on the bridge. The first one is without grating; the second has a tub showered with leaves and chippings, while the parts of the third gully are missing. There is only an opening for a gully inside the concrete bracket of the pedestrian pathway which is not located on the designed place, so that the surface pavement water flows over the expansion device before it reaches the opening of gully. In the area of the opening, since

the elements of a gully are missing, the surface pavement water, salt and frost jeopardize the concrete and reinforcement of bridge components and expansion devices. Pedestrian guard rail on the right wing of the S1 abutment was demolished during the construction of an 'illegal' road. The guard rail was damaged by corrosion. On certain places, knuckle and post are completely discontinued, due to damages made by corrosion. Riverbed, as well as the banks is not regulated in the bridge zone. The left bank and the riverbed, upstream from the bridge, are turned into a landfill with a large quantity of stone material excavated during the works on widening the railway profile. Because of material deposition, the first bridge span was virtually covered and the course of the river flow was changed. Water flow has been accelerated by narrowing of the riverbed and it has been directed towards the intermediate pier S3 and the abutment S4, thereby making these piers affected. After a performed visual inspection, damage and condition assessment rating calculation of the existing bridge has been carried out for the period during which the inspection was performed.

- rating value: 927
- condition assessment: unsatisfactory
- type of maintenance: repair planning

The final design for the bridge repair was prepared the same year, but the repair itself has not been performed. For the preparation of motorway E-80: Niš–Dimitrovgrad final design, in 2010, the widening of the existing main road alignment M-12 and of the existing bridge was necessary, Fig. 4. The bridge over Nisava River final design, on the newly designed right carriageway of the E-80 motorway, anticipates bridge widening in accordance with the required motorway profile, as well as the necessary structure repair.

Chief designer of the original final design for the bridge repair and the final design for widening of bridge over Nisava River is Mr Petar Spasić, chief engineer at the Department for design of bridges and structures, The Highway Institute, Belgrade.

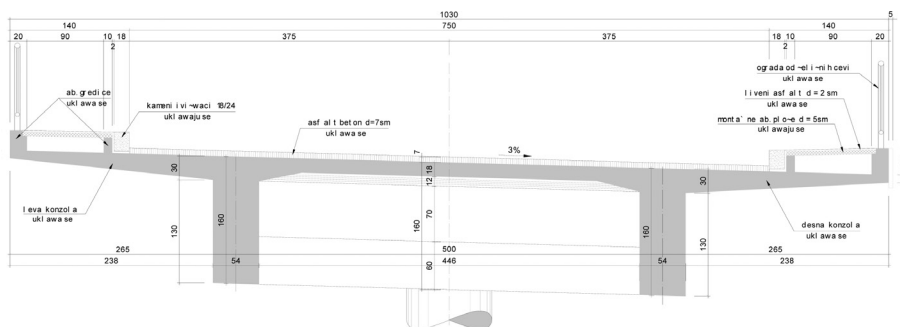


Figure 4 Cross section of the existing bridge

3 The newly designed bridge

Dispositional solution has been used for the design of continuous frame structure with three spans and for the existing bridge, with static span 10.40+20.80+10.40 m with indented cross-section. There are three major beams in the cross section at distances of 5.0 m, Fig. 5. On the outer sides, there are brackets with substructure and an inspection path, each 1.95 m wide. The width of the bridge is aligned with the pavement width on the right motorway carriageway and complies with the requirements of the Terms of Reference of the Employer, and amounts to: $B = 2 \times 1.95 + 10.70 + 2 \times 0.08 = 14.76 \text{ m}$

The formation of the bridge cross section was preceded by preliminary works on removing the elements of traffic profile of the existing bridge, repair works on the bridge frame structure and works on bracing the elements of the existing bridge cross section with the expansion structure. Bracing is achieved through following:

- anchor installation for connecting the old and new bridge deck, and
- boring the holes through ribs of the main beams for a cable line for transversal tightening of cross-girders over intermediate (river) piers and abutments.
- In order to create a cross section of the new bridge, the following works on reinforcing the existing bridge span structure have been envisaged by the design:
 - construction of reinforced concrete 'cover plates' of 0.23 m on the sides and linings of 0.20 m, on the bottom side of main beams,
 - construction of reinforced concrete 'cover plates' of 0.35m on the sides and linings of 0.20 m, on the bottom side of cross girders, above the bearings on the abutments,
 - construction of the reinforced concrete 'cover plates' of 0.20 m on the sides of cross girders above intermediate, river piers.
- works on bracing components – elements of the existing bridge cross section with the expansion structure,
- tightening of the cross girders over intermediate (river) piers and the abutments.

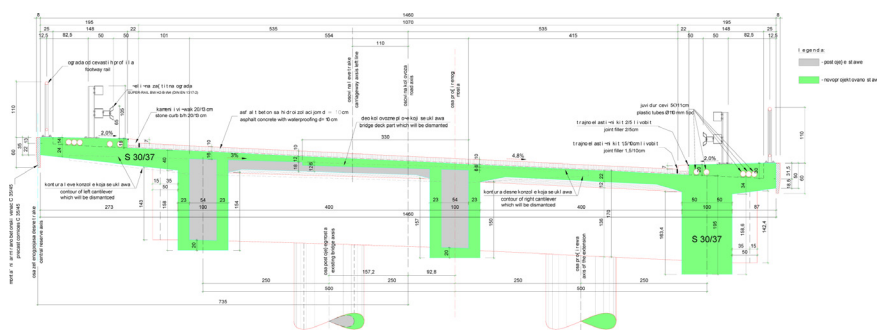


Figure 5 Cross section of the newly-designed bridge

A reinforced concrete cruciform reinforced deck is cast over beams and has variable thickness of 32–22 cm, as a result of the cross falls alignment of the existing pavement with the newly designed motorway cross section. Secondary cross girders (bo x do = 0.3x1.0 m) are cast along with the bridge deck, on centre-to-centre spacing of 5.16 m.

Substructure of the new, widened bridge is comprised of two abutments, S1 and S4, and two intermediate (river) piers, S2 and S3, along with foundations. Choosing piers position within the expansion frame structure is conditioned by the pier position of the existing bridge. The span structure together with intermediate piers forms a continuous frame structure.

Inside the bridge pier cap there is a reinforced concrete cross girder for frame structure, monolithically connected to the pier stem. The height of the new piers, as well as of the existing ones, is 7.00 m.

Pier spots S2 and S3 refer to two reinforced concrete piers with circular cross section - \varnothing 140 cm, at a distance, in the cross section - $\lambda = 5.00$ m. The existing intermediate piers have \varnothing 1.00 m and they have been strengthened by reinforced concrete circular lining $d = 0.20$ m.

In order to establish a connection between reinforced concrete lining used for strengthening the intermediate piers with cross girders and foundations of the existing bridge structure, the design anticipated the following works:

- removal of the reinforced concrete pad segment, on the pier spot S2, for anchoring of lining reinforcement, while preserving the existing pad reinforcement,

- removal of the reinforced concrete pad segment and circular ring of well, up to the pad height on the pier spot S₃, for anchoring of lining reinforcement; while preserving the existing pad reinforcement and part of the wall of the well,
- formation of a new reinforced concrete pad with newly designed dimensions, on the pier spot S₂,
- restoring the removed parts of the well and pad, on the pier spot S₃,
- vertical concrete punching of the existing cross girders above river piers for passage of anchor part of pier reinforcement.

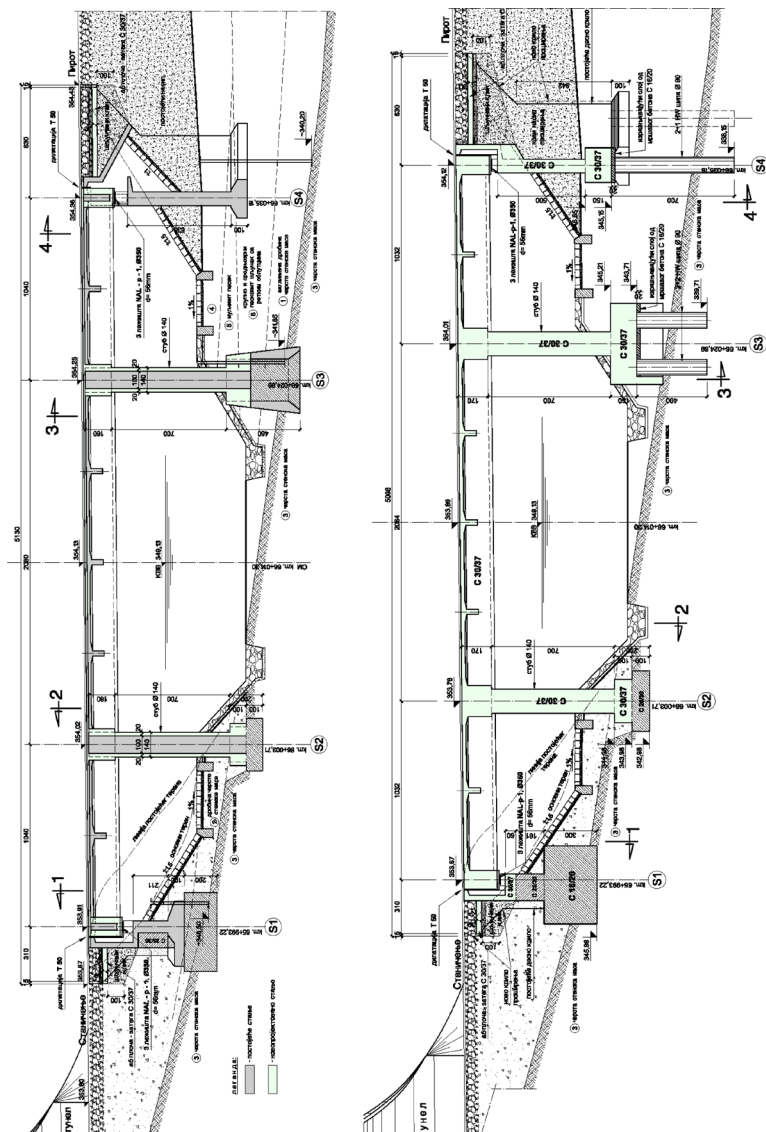


Figure 6 Longitudinal profile of the existing bridge and the newly-designed bridge

The new intermediate (river) pier S₂, on the left riverbank, has been founded directly on the rock, on the pad foundation. Founding of the new pier, on the pier spot S₃, shall be carried out on a 'battery' made of four piles. Reinforced concrete piles with large diameter, type HW Ø 90 cm, have been adopted. Connection between the piles 'battery' and stem of the intermediate pier is achieved through reinforced concrete deck, square at the base. Design length of piles on the pier spot is L_s = 4.00 m. Solution for the abutments is conditioned by specific features resulting from the position and the existing piers structure and field configuration, which requires that founding should be performed directly on the rock as well as on the existing pier (pier S₁), i.e. on reinforced concrete piers with large diameter type HW Ø 90 cm, and length L_s = 7.00 m (pier S₄). The existing (abutment) pier S₄ has been founded over a strip foundation filled with gravel and sand material. The existing abutments are ridged box reinforced concrete structures. The abutments are formed by head walls, point-bearing wing walls with suspended wings, bearing beams for supporting a span structure of the bridge and parapet beam with transition slabs (pier S₄).

River regulation is designed for the bridge area, and it would provide banks protection with stone blocks, and thereby would secure the abutment S₁ from potential erosion and removal of unstable riverbank material. In calculating the static impacts, computational pattern of traffic load - v 600 + v 300, as well as SOFISTIK software package was used.

4 Conclusion

The purpose of this paper is to show the complexity of works regarding the design, as well as the construction works, because of the simultaneous performance of repairs, strengthening and widening of the existing bridge structure. The implemented technical solutions during the works on strengthening and widening of the span structure and piers of the existing bridge require particular attention during the following:

- construction and assembly of scaffolding and formwork; construction of scaffolding must provide the stability of span structure during the execution of works on removing the parts of supporting elements of the existing bridge,
- inspection, recording and grouting of cracks d³ 0,2 mm on some parts of the existing bridge span structure,
- installation of anchor fittings for the connection of new, reconstructed concrete reinforcements with reinforced concrete permanent structure of the existing bridge, concrete works on reinforcement of permanent structure of the existing bridge, concrete works on new reinforced concrete permanent structure of the bridge expansion,
- execution of works on cross girders tightening, for bracing the existing and the new bridge span structure.

All works shall be executed in the purpose of obtaining a safe and operational facility with a long service life.

References

- [1] The existing design documents, prepared at the Highway Institute.