



MAIN DESIGNS OF BRIDGE REPAIRS ON MAIN ROAD M-8 SECTION: ALJINOVIĆI – SJENICA – NOVI PAZAR

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Abstract

This paper is revealing one example of a complete bridge demolition and design of a new bridge. Moreover, there is a presentation in this paper regarding the substitution of superstructure with required repair and adaptation of substructure, as well as the design of repair with adequate widening to required traffic profile.

Keywords: rehabilitation, repair, data-base, structures.

1 Introduction

Main design of rehabilitation - upgrading of Main road M-8, section Aljinovići - Sjenica - Novi Pazar called for the interventions on existing road structures, i.e. bridges. On the section being the subject matter of this paper there were six minor bridges, which have had river courses as obstacles. As regards the static system, the bridges are as follows: solid simple slabs, hollow simple slabs, continuous girders on two and three spans and simple frames. The design encompassed particularly as follows:

- Existing conditions' determination of bridges;
- Elimination of all established deficiencies on bridges, which have an impact onto the security, functionality and durability of existing structures;
- Adaptation of bridge superstructure elements with the requirements set out for rehabilitation - upgrading of Main road M-8.

In addition to the facts established right on the spot and with thorough inspection of bridges, data from the bridge inspection books meant for Data base were also used. According to established methodology for condition evaluation and damage level, every single bridge was awarded with the rating value, and condition assessment, and likewise the proposition was made for specific type of maintenance, i.e. intervention.

On the basis of analyses regarding the established damages, geotechnical basic data, and hydrotechnical conditions, the decision was made regarding the type and volume of works to be performed on every single bridge.

According to computed ratings (urgent repair), it was established that three bridges were in very poor conditions, and had extensive structural damages, multiple previous repairs which altogether called for a decision to pull them down and substitute them with new structures. On one bridge a complete superstructure - pavement structure was substituted, whereas substructure - pier was repaired. According to ratings, the requirement ensued for two bridges to resort to repair and permanent long-term maintenance. They were repaired completely and widened to required traffic profile.

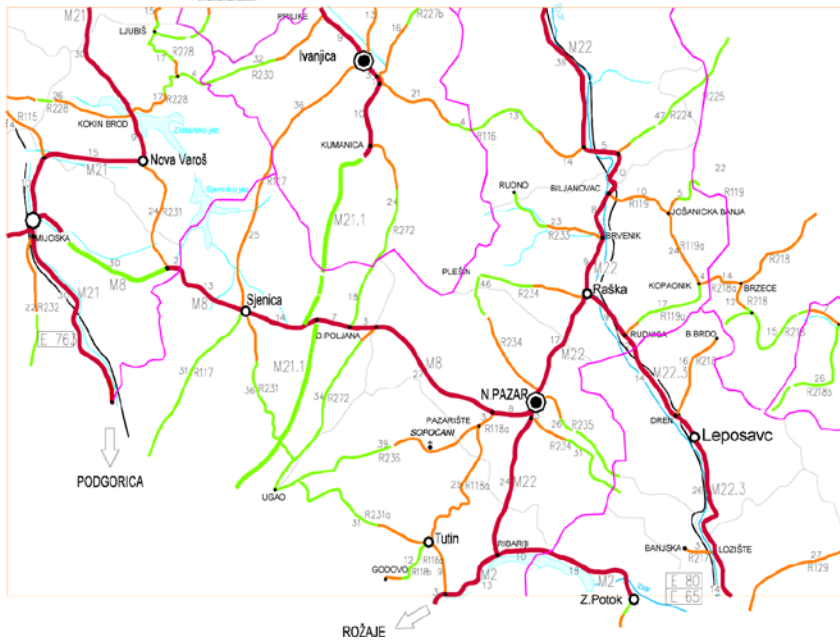


Figure 1 Location of Main road M-8

2 Design of a bridge to be pulled down

Out of three bridges anticipated to be pulled down on Main road M-8, section Aljinovići - Sjenica - Novi Pazar, one is overbridging the river Jablanica.

Within the bridge zone, the existing road is in straight alignment. Finished road level is set on a terrain and is corrugated with a slight downgrade towards Sjenica township. The pavement is with camber having the width of 6.00m within the bridge zone, whereas the shoulders have not been defined.

On the location being the subject matter of this paper there is a reinforced concrete bridge with the span of 11.00 m, with overall length of 22.70m. Pavement width on the structure itself

is 6.00m. Pathways on both sides of bridge span section are wide 0.60m each. Overall width of the structure is 7.20m. There are no pathways on wing walls. The span structure is made of 7 intermediate prefabricated girders, with dimensions $b/d = 70/40$ cm and two curb girders, with dimensions $b/d=42/40$ cm, pulled in with transverse cables for interaction attainment. The abutments were constructed with dressed stone blocks. The structure itself is normal. There is a steel pipe in the right abutment filled out with concrete, with steel tapes serving as rocker bearing. On the left abutment the structure is leaning directly onto the pier - fixed end bearing. Pavement structure is made of asphalt-concrete $d=5$ cm, whereas the waterproofing of upper concrete slab has not been anticipated.



Figure 2 View of existing bridge



Figure 3 Pavement structure damage

The last inspection of bridge structure was carried out in the year 2007. The conclusion was drawn, based upon computed bridge ratings, that this bridge required an urgent repair.

By structural analysis regarding the load bearing capacity of existing span structure, for additional permanent loading (new elements of traffic profile) and imposed load (computed load scheme for typical vehicle v 600) one was in a position to obtain ultimate stress on the lower girder's edge $\sigma_1=5.74$ MPa, which exceeded considerably the allowable edge tensile stress under operation, for concrete type MB 40 MPa, $\sigma_{allowable, \infty} = -1.8$ MPa.

Taking into account that the waterflow fills up the entire bridge span profile which caused justified suspicion that the footings of extreme piers were exposed to scouring.

In view of the fact that concrete ground beam, due to the existence of cascade in bridge profile, is not leaning onto the bedding with entire surface, but "hanging" partly, called for suspicion as regards the abutments, and consequently on the stability of entire facility and traffic safety. Based on these facts and recorded deterioration in the structure, the Designer proposed to the Client as follows:

- to remove entire bridge structure;
- to build a new facility with required traffic profile which will fulfill all prerequisites of stability and functionality of the structure as regards security and traffic safety;
- to carry out stream diversion by river bed training upstream from the bridge; to renew the profile by river bed training downstream from the bridge; to perform the lining of river channel, all based on adequate water engineering documentation;
- to prepare design documentation for new facility based on horizontal and vertical elements of upgraded alignment of Main road M-8, geotechnical investigations and conditions, as well as on hydraulic conditions of bridge span for this specific location.

3 Design of a bridge with superstructure substitution

There is a reinforced concrete bridge over the river Goracanska, with solid abutments made of plain concrete. Head wall and standing parallel wing walls are monolithic.

Pavement width within the bridge zone is 6.50m. Shoulders on both sides have the width of 1.00m each.

Bridge span structure has the length $L_k = 12.50$ m. Overall length of this structure, with wing walls is $L=18.30$ m. Pavement width on the facility B_k amounts to 7.00m. Pathways on both sides of bridge span section have the width of 1m each. Overall width of the structure is $B=9.00$ m. The bridge is askew at the angle $\alpha = 14^\circ$.

The span structure is composed by prefabricated girders made of prestressed concrete pulled in with transverse cables in order to attain interaction. Dimensions of 6 intermediate girders are $b/d=100/42$ cm, whereas the terminal ones are $b/d=60/42$ cm. Girders are lightened by two respective cardboard tubes $\emptyset 30$ cm.



Figure 4 View of the bridge and water penetration through pavement structure

In order to fulfill the requirements from TOR as regards the elements of traffic profile on the bridge it was required to build, over existing bridge structure, an additional reinforced concrete deck, with thickness $d=12\text{cm}$, with mutually overhanging cantilevers with the span $l=1.40\text{m}$ for new pathways.

By structural analysis regarding the load bearing capacity of existing span structure for additional permanent loading (new elements of traffic profile) and imposed load (computed load scheme for typical vehicle V 600) one was in a position to obtain ultimate stress on the lower girder's edge $\sigma_1 = -7.51\text{ MPa}$. It was established that the allowable edge tensile stress under operation was exceeded, for concrete type MB 40 MPa, which amounts $\sigma_{bz, \infty} = -1.8\text{ MPa}$. Face surfaces of girders with shield concrete of tie-bars are in direct contact with the embankment materials, so through deteriorated pavement, the water and industrial salt are penetrating into the zone of girders' ends. This caused justified suspicion regarding the conditions of tie-bars, and thereby consequently on the conditions of cables' ends and size of prestressing force in cables.

The deficiency of such structural system is represented by so called "dry" joint between main girders, thus preventing efficient transverse pulling-in, meant for interaction of all longitudinal girders.

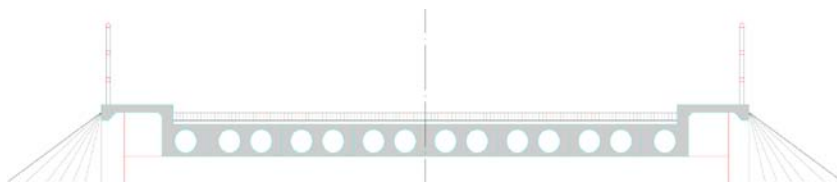


Figure 5 Cross-section of existing structure

As regards the aforementioned, the proposal was made to the Client as follows:

- Substitution of bridge span structures;
- Reconstruction of support zones on abutments;
- Repair of existing head and wing walls of abutments
- Design documentation for the works thereof has to be brought into accord with horizontal and vertical elements of upgraded alignment of Main road M-8.

Moreover, this design documentation is also providing for the repair of all damages and removal of all deficiencies as recorded in the course of inspection.

4 Design of a bridge to be widened

Reinforced concrete bridge over Grabovica river in Sjenica township is a frame structure, with bridge span 19.00m long, and overall length of 25.00m . Pavement structure is composed of reinforced concrete slab, with variable thickness from 55cm at midspan to 115cm on abutments. Bridge pavement width amounts to 8.00m , respective pedestrian cantilevers width amounts to 3.30m each, whereas overall width amounts to 14.60m .

The bridge is askew at the angle $\alpha = 30^\circ$, and was built in 1956.

On the basis of bridge structure inspection and in accordance with condition assessment methodology and level of damages, one was able to draw a conclusion that an extensive long-term maintenance interventions had to be carried out.

It was established that there were calcification traces of water penetration on head carcass of abutments, through pavement slab. Due to the damage of water-supply pipe and permanent wetting of its structure, the separation of abutment stone cladding and washing out of terrain behind the abutment appeared.



Figure 6 Reinforcement corrosion on pathway cantilever

On lateral surfaces of pavement slab there are white, calcified spots originating from aggressive impact of water and salt, as well as “stalactited” formations. On the bottom side of main girder - sheeting rail there are also visible calcified spots, partly damaged protective layer of concrete, whereas denudated reinforcement corroded.

Concrete at the end of cantilever of pathways is damaged by the impact of atmospheric water and industrial salt, reinforcement is denudated and corroded. There are no drip channels, so that the water from stair treads is penetrating into and wetting the lower surface of cantilevers. Steel profiles whereupon the installations have been hung corroded as well.



Figure 7 Calcification due to water penetration through the structure

Steel guard-rail on the bridge is partly damaged by corrosion, part of panel is missing and it is without prescribed height, thus not providing full protection for pedestrians on the bridge. River channel within the bridge zone is regulated and cased with stone. It is overgrown with vegetation and is not cleaned from river detritus, and waste, muck and garbage.

- 1 Present traffic profile elements on the bridge: pavement width and pathways width comply with conditions set forth in TOR. Remaining elements of present traffic profile on the bridge: curbs, railing and fasciae do not fulfill the conditions indicated in TOR.
- 2 The Designer proposed to the Client to undertake following actions:
 - Repair of all damages of bridge span structure,
 - Repair of the link between bridge and road base,
 - Repair of damaged installations set across the bridge,
 - Repair of damaged river channel casing.

Moreover, this design documentation is also providing for the repair of all damages and removal of all deficiencies as recorded in the course of inspection.

- Repair of pavement slab cracks by grouting,
- Repair of concrete surface damages due to penetration of water and salt through pavement slab,
- Repair of corroded reinforcement,
- Preparation of protective coating (preservatives) on concrete structure surfaces,
- Design of temporary road and vertical signs provides for the repair works, on the bridge over Grabovica river, to be carried out in two phases, by alternating closure of right and left pavement lanes.

5 Conclusion

Long-standing lack of routine maintenance of bridges leads to considerable damages, which require extensive funds in order to bring the bridges into safe and functional conditions for all road users.

Prestressed, hollow girders, with “dry joints”, without reinforced concrete slabs over them, proved to be a poor structural solution, since they are exposed to undisturbed penetration of atmospheric water and industrial salt through the structure itself.

Heavy passenger traffic, and particularly goods traffic on the section under study were not of large scale. However, the damages on bridge structures would have been much more extensive if there were higher figures on goods traffic.

References

- [1] Pravilnik o tehničkim normativima za određivanje veličina opterećenja mostova, Službeni list SFRJ, br. 1, 1991. (in Serbian language)
- [2] Pravilnik o tehničkim normativima za beton i armirani beton, Službeni list SFRJ, br. 11, 1987. (in Serbian language)
- [3] Postojeća projektna dokumentacija Instituta za puteve, Beograd, Srbija (in Serbian language)

