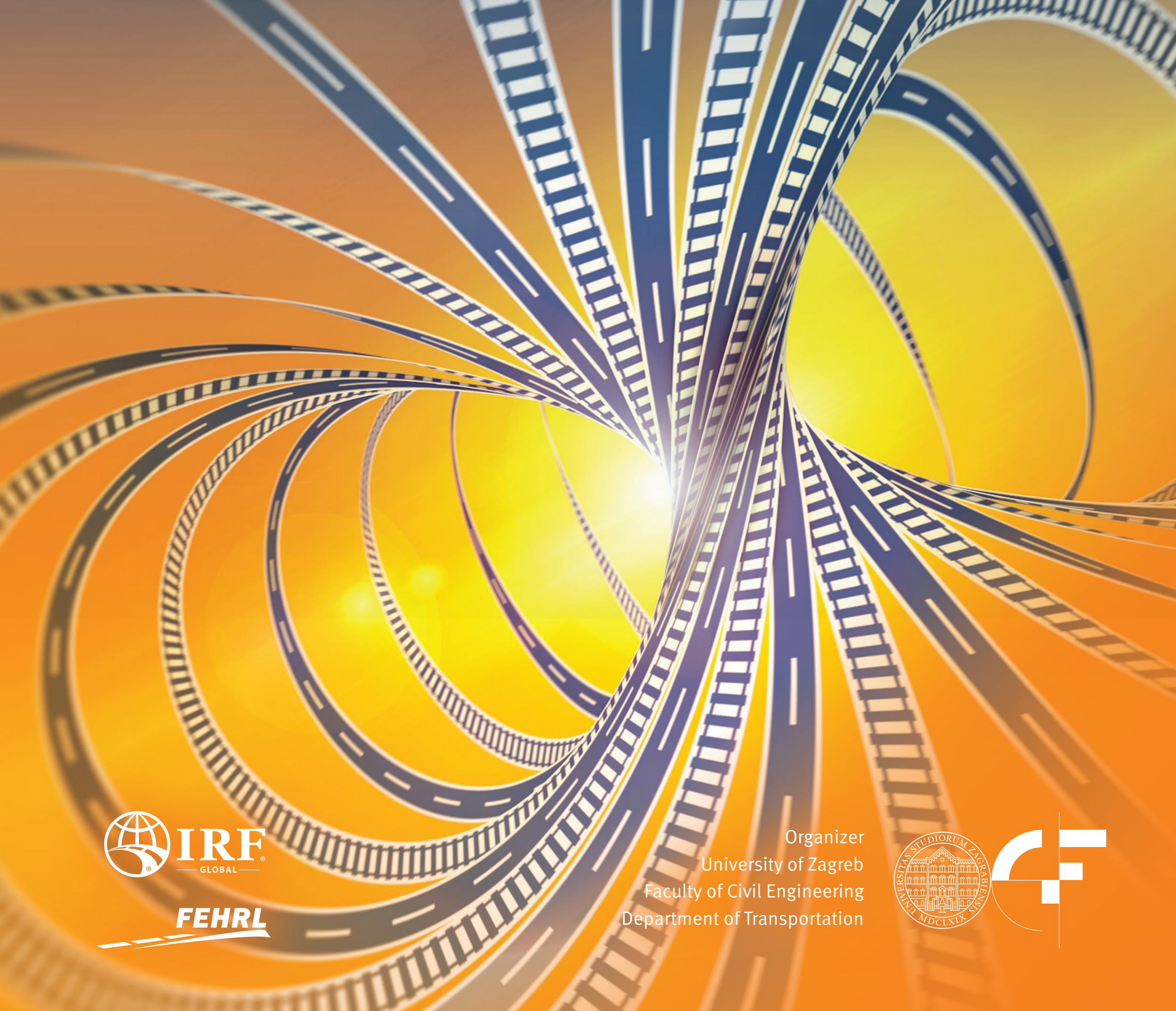
CETRA[2018]

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR



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GENERAL DESIGN OF THE BANJA LUKA – PRIJEDOR – NOVI GRAD HIGHWAY IN THE REPUBLIC OF SRPSKA – SELECTION OF THE OPTIMUM CORRIDOR

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Abstract

Objective of this paper is to determine the scope of research together with the analysis of spatial, traffic, geotechnical, hydrological, environmental and climatic factors and limitations, as well as selection of the optimal corridor by using the multicriterion optimization for planned highway route Banja Luka – Prijedor – Novi Grad, which is the subject of General design. Length of the introduced variant amounts 74,30 km. The purpose of the General Design will be to identify possibilities for a motorway construction on the route given in the defined transportation concept of the Republic of Srpska, to define service level on the given motorway in altered conditions in the Republic of Srpska road network, to define environmentally acceptable level of protection of the road and its environment, to propose the most appropriate time schedule for road construction from the aspect of general public interest, to choose the best variant, form a basis for adoption of planning documents and get ready for the next design phase. The most important traffic benefits from new sections between Banja Luka and Novi Grad are as follows: Enabling a modern link primarily between the areas of Banja Luka, Prijedor, and Novi Grad and the existing E-661 motorway at the East, i.e. with the future intersection of two motorways in the Republic of Croatia at the West as well as improving conditions on the road segment in the western parts of the Republic of Srpska, Improving connections between the western parts of the Republic of Srpska and western Bosnia and Herzegovina with the Banja Luka –Gradiška Motorway, Corridor X and the Banja Luka – Doboj Motorway, Relieving the burden on the existing network segment and improving conditions for road users corresponding between Banja Luka and Novi Grad.

Keywords: General Design highway Banja Luka – Prijedor – Novi Grad, Introduced variant

1 Introduction

The project area here studied, i.e. the wider corridor area for designing the Banja Luka – Novi Grad motorway stretches in the length of about 80 km (southeast to northwest) and in the width of about 10 km on the average. In addition, missing service roads on the existing route between Banja Luka and Novi Grad disables separation of local from transit traffic. As a result, farm machines can be perceived on the main road together with illegal feeding roads from fields. In perspective, the planned road from Banja Luka via Prijedor to Novi Grad in the Republic of Srpska primary road network should take over long distance traffic from the existing M-4 main road and partially change conditions on the roads directly linked to it. After the general design stage and/or a synthesis of all physical and planning constraints in the investigated area, an analysis was made to define possible motorway corridors and consider this effort as a transition phase to further technical shaping of possible motorway alignments. Three alignment variants (Variant 1, Variant 2 and Variant 3) were established in the above-mentioned

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corridors. They were obtained by having tried and combined several hundreds kilometres long subvariants before deciding finally which three representative variants to establish.

1.1 Overview of variant solutionts

The first potential corridor (represented by variant 1, length 78,63 km) begins at the starting point and runs westward over hillocks and hills through Kuljani, Barlovci, Ramići and Cerići villages and then bypasses Ivanjska village from the north and continues in the southwest – south direction to Saničani fishpond located southeast from Prijedor where the corridor crosses the Banja Luka – Novi Grad railway line east from Saničani. Bypassing Prijedor from the south, the corridor crosses the Sana River for the first time and after passing through Rizvanovići, Bišćani and Čikota villages it again crosses the Sana River east from Dragotinja village. The corridor continues along the Sana River and main road to Petkovac and the Blagaj River and then goes northwestward to the Una River where the border crossing with the Republic of Croatia should be established.
The second possible corridor (represented by variant 2, length 74,30 km) begins from the starting point and runs westward over hillocks and hills through Kuljani, Barlovci, Ramići and Cerići villages – until that point it coincides with corridor 1 and then turns south from corridor 1. Corridor 2 continues to the north of Ivanjska village and goes westward to the foot of Podkozarje through Babići, Kamičani and Kozarac villages to Prijedor to bypass it from the north. After Prijedor the corridor continues through hilly terrain of Brezičani and Dragotinja villages and near Svodna it overlaps corridor 1 all the time running along the right bank of the Sana River. Next to the Blagaj River corridor 2 goes independently westward to the Una River north from Novi Grad, where the end of investigated area is situated.

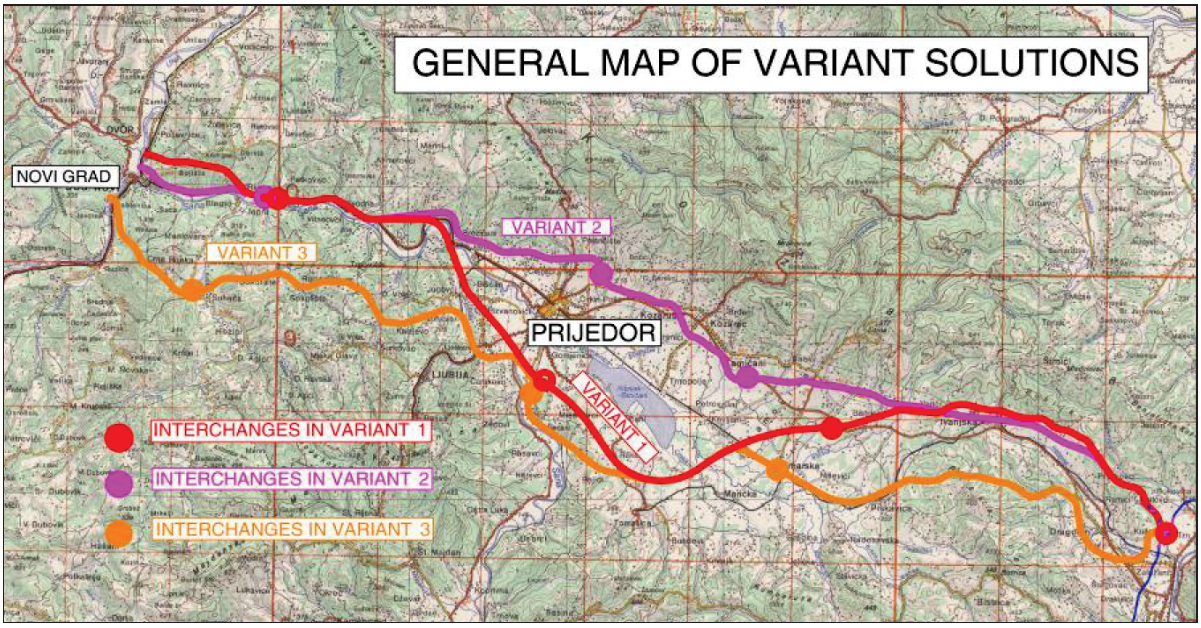

Figure 1 Potential corridors overview with the key alignements

The third possible corridor (represented by variant 3, length 83,84 km) begins at the same starting point as the above-mentioned two corridors, but runs independently through Kuljani and Dragočaj villages and after crossing Piskavica Mt. reaches Omarska village. After the crossing with the Banja Luka – Novi Grad railway line the corridor bypasses Saničani and Prijedor fishponds from the south.The corridor runs westward over hills and mountains through Ljeskare, Kalajevo and Radomirovac villages and after crossing over the Jarpa River turns northwest and reaches the end point in the south from Novi Grad. Potential corridors overview with key alignements are shown in Figure 1.

2 Evaluation and selection of the optimum corridor

The primary objective of variant evaluation was to eliminate any subjective attempt of optimum decision making but to establish a framework for objective decision-making on the basis of the results of a documented comparison of variants formed in an unbiassed way. Evaluation of variants' solutionts has been made by Multi-criteria compromise ranking (the VIKOR method).
Methods of a multi criteria optimization offers opportunity to include all necessary criteria into an evaluation process both those that are expressed in pecuniary terms and those expressed by some other criteria, other than monetary ones. The first and the most important step in the variant evaluation process is to define objectives and criteria for evaluation and their relative weights which will numerically reflect the importance of objectives and/or criteria. The following objectives were considered in the research: min. construction costs, max. distribution of traffic flow, min. travelling time, min. transport consequences, min. economic consequences, max. indirect economic benefits. Evaluation findings by using the VIKOR method, based on the presented criteria, define the following variants solutions favourability sequence: Variant 2, Variant 3 and Variant 1.Variant 2 takes adequately stabile first place and the advantage over variant 3, by 17.9 %, which indicates that for given criteria and their weights, most favourable is VARIANT 2.

3 General records for the introduced Variant 2

3.1 Limiting elements of the alignment in plan and profile

Limiting elements are the calculated minimum and maximum values in the layout, longitudinal profile, cross section and sight distance depending on designed speed (Vr = 120km/h), table 1.

Table 1 Limited elements of the alignment in plan and profile

Layout plan	**Values**
max. length straight sections between two curves	L = 2400 m
min. length straight sections between two curves	Lp = 480 m
min. circular curves	R = 700 m
min.lenght ot transition curve	L = 65 m
min. stopping sight distance	Pz = 260 m
Longitudinal profile	
max. longitudinal grade	i = 2.5 %
min. longitudinal grade	i = 0.5 %-fill / 0.8 %-cut
max.superelevation	irv = 0,75 %
min.radius of vertical curve sag	Rv = 6000 m
min. radius of vertical curve crest	Rv = 17000 m
Cross sections	
width of lanes	t_v = 2x(3,75 +3.50) m
width of verges	t_i = 2x(0,50 i 0,20) m
width of shoulders	b = 1,5 m
min. cross grade of asphalt pavement	ip = 2,5 %
max. cross grade of asphalt pavement	i_{pk} = 7 %
width of emergency lanes	tz = 2,50 m
width of climbing slow lanes	ts = 3,25 m
width of central reserve	Rt = 4.0 m

The reference level of the highway in sections' lenght, up and down gradients are at alternation, ranging from slight to limit values. The highest reference level gradient amounts 4.0 % on the high-country terrain. Passing over deep ravines and depressions by greater bridges, the alignement will not disturb the surrounding landscape. The highway is situated on embankments and cuttings at alteration, as well as side cuts. While engineering roadbed slope inclination, geotechnical, aesthetic and safety criteria have been taken into consideration, as well as required quantities and availability of local materials.

3.2 Drainage of the motorway

The principle adopted is that roadway runoff is polluted and needs to be treated before being discharged into a recipient. The adopted runoff treatment method will include retention ponds. Runoff will be controllably channelled through gullies and storm water channels, identically graded as the road reference level, to retention ponds located along the route and discharged laterally into them. Therefrom it will be discharged through filters into a recipient. This dewatering method with gully piping and storm water pipes will form a closed dewatering system for polluted runoff and will prevent it from infiltrating into the surrounding ground.

3.3 Pavement structure

The pavement on a new thoroughfare is designed to respond to rank, traffic forecast and vehicle types, table 2. The surfacing matches the road rank, longitudinal gradients, cross falls and runoff dewatering system. Pavement design is therefore based on the knowledge and observance of properties of material in bedrock and subsoil, materials to be used for construction, type and frequency of vehicle runs, traffic regime and knowledge of climatic and hydrological conditions.

Table 2 Newly designed flexible pavement structure for travel and fast lanes consists of the layers

Flexible pavement structure	Lanes	Emergency lane
Asphalt concrete AB 11s	5.0 cm	5.0 cm
Bituminous base course BNS 22 sA	7.00 cm	7.00 cm
Bituminous base course BNS 32 sA	8.00 cm	-
Screened crushed stone, 0/31.5 mm	15.00 cm	23.0 cm
Screened crushed stone, 0/63 mm	20.00 cm	20.00 cm

3.4 Interchange

The starting point for the considered variants is "Glamočani" grade-separated junction (interchange) that connects the future Gradiška – Banja Luka (E-661) motorway section to the newly designed Banja Luka – Novi Grad motorway, Figure 2. In the considered variants "Glamočani" grade-separated junction is of "triangle" type, planned for speed of Vr = 80 km/h. An increase of speed to Vr = 100 km/h would require major demolition of existing, generally dwelling units (58 houses). This interchange is located north of Banja Luka and complies with the planning documentation. On the route are also predicted interchange: "Omarska", "Prijedor" and "Novi Grad".
"Omarska" grade-separated junction (km 29+850), it is located at about 8.5 km northwest from Omarska village at the crossing of the motorway and the M-4 main road. "Omarska" interchange is of "trumpet" type with all necessary slip roads. An overpass is designed at the crossing point with the motorway, Figure 3.

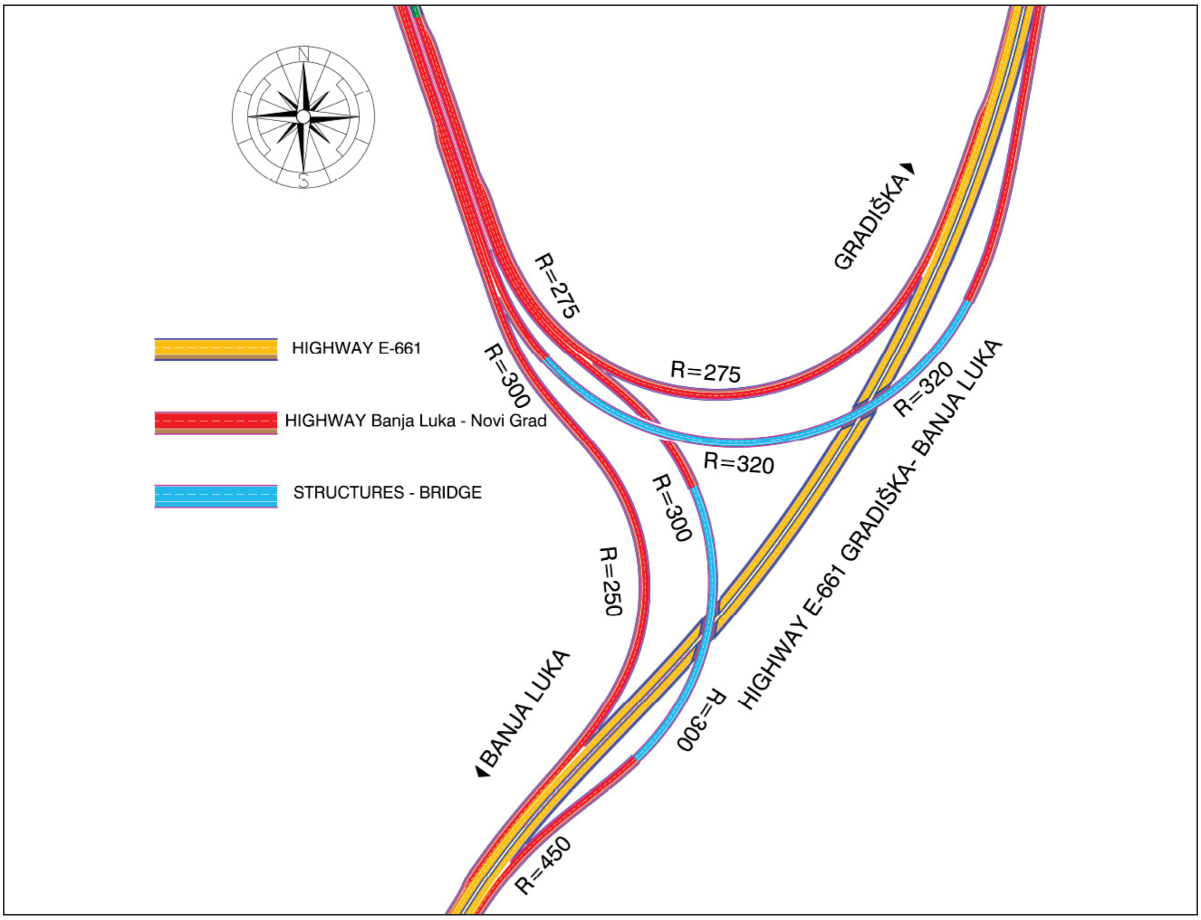

Figure 2 Interchange "Glamočani"

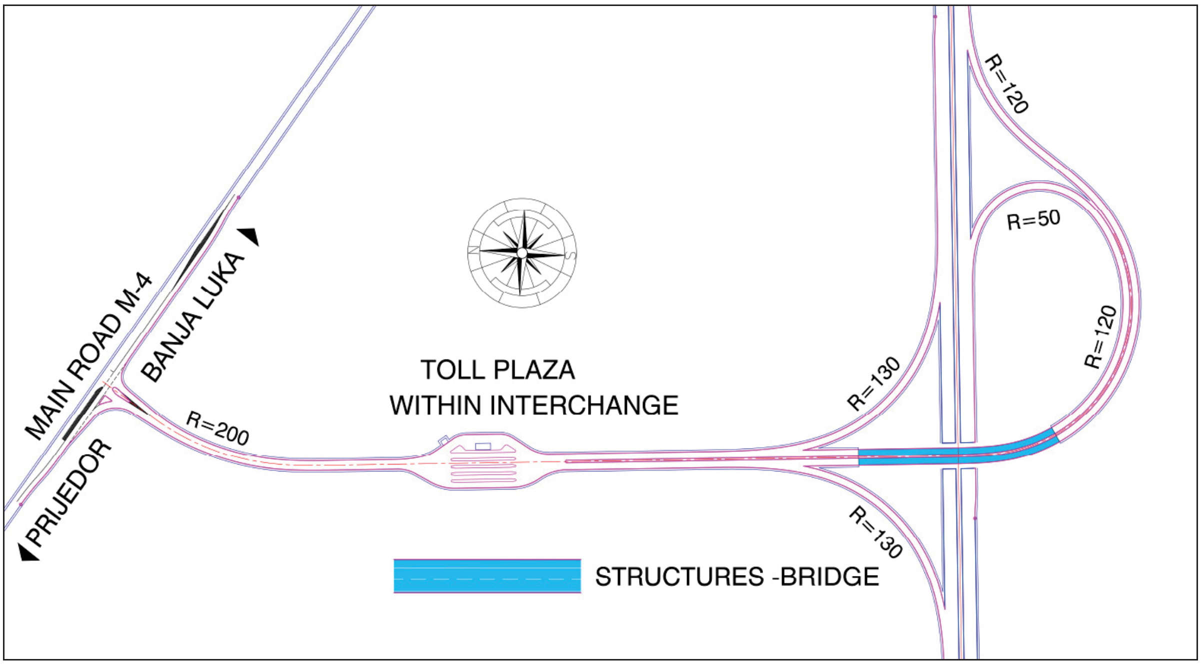

Figure 3 Interchange "Omarska"

The grade-separated junction will include a toll plaza with five lanes (toll points), two lanes in each direction and a mid-lane to be used in either of two directions, if necessary. The rightmost and leftmost lanes will be 4.50 m wide for outsize vehicles. Other lanes will be 3.50 m wide. Toll islands will be 52 m long suitable for installation of modern toll collection system.

A median dividing traffic flows will extend towards the motorway and enable two-way traffic, which will improve the traffic safety significantly. "Prijedor" grade-separated junction (km 42+200), it is located at about 4 km northeast from Prijedor at the crossing of the motorway and the future Prijedor bypass. Prijedor interchange is of "trumpet" type with all necessary slip roads. An overpass is designed at the crossing point with the motorway, Figure 4. The grade-separated junction will include a toll plaza with five lanes (toll points), two lanes in each direction and a mid-lane to be used in either of two directions, if necessary. The rightmost and leftmost lanes will be 4.50 m wide for outsize vehicles. Other lanes will be 3.50 m wide. Toll islands will be 52 m long suitable for installation of modern toll collection system. Space for a maintenance base is reserved in the toll plaza zone. A median dividing traffic flows will extend towards the motorway and enable two-way traffic, which will improve the traffic safety significantly. This front toll plaza is designed at km 48+100 behind "Prijedor" grade-separated junction so that "Novi Grad" grade-separated junction will be without toll collection.

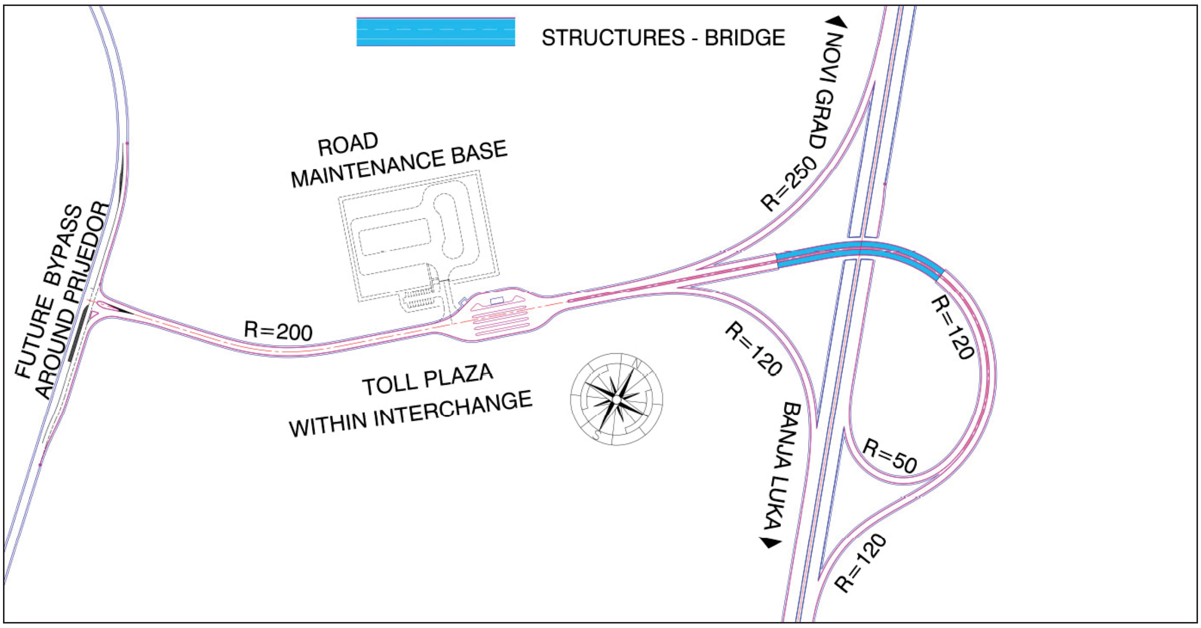

Figure 4 Interchange "Prijedor"

"Novi Grad" grade-separated junction (km 65+150), it is located at about 9 km east from Novi Grad in the area where the motorway approaches the M-4 main road and an interconnection is possible. "Novi Grad" interchange is of "half cloverleaf" type with ingress/egress lanes in each direction, independently connected to the M-4 main road by two at-grade junctions, Figure 5.

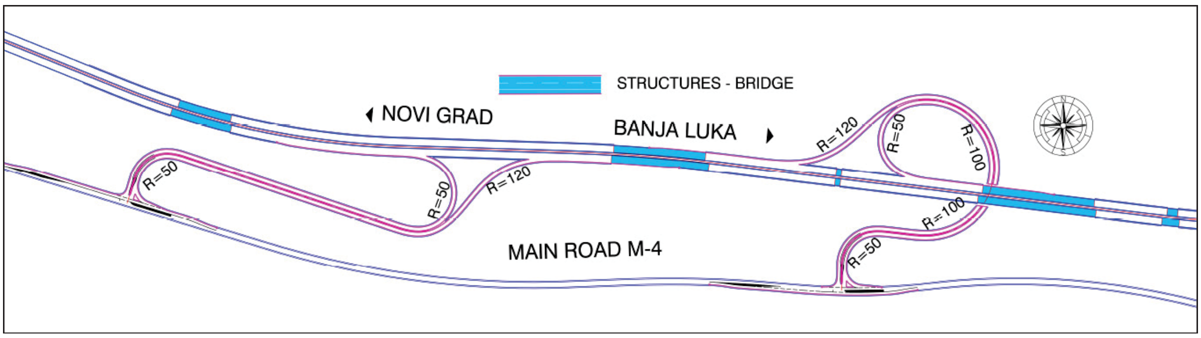

Figure 5 Interchange "Novi Grad"

A median between traffic flows will extend towards the motorway and enable two-way traffic, which will improve the traffic safety significantly. Two-way traffic on ingress/egress lanes (Novi Grad end) will run through an underpass.

4 Submission of papers

Based on the terrain and wider area analysis of the alignment Banja Luka – Novi Grad, which is the subject of the General design, a consideration of capacity to design variant alignment layouts, which would be represented by three corridors, has been approached. Research of the south corridor lead to the conclusion that Variant 3 is an extremely low operational solution, due to very inappropriate terrain topography and different spatial and natural limitations, which would cause huge investments.
Analysis of the proposed variants indicates that variants 1 and 2 differ in layouts and reference levels in the section nearby Prijedor (one of them is located northbound, and the other one southbound form Prijedor). The longest distance between these two variant solutions is approximately 11 km.
Based on detailed analysis and comparison of all three proposed corridors (represented by Variant 1, Variant 2 and Variant 3), taking into consideration the above mentioned criteria, it is designers view that the Variant 2 should be accepted as the optimal one. Construction of section from Banja Luka to Novi Grad will bring, to the Republic of Srpska, a good quality highway connection with the Republic of Croatia, as well as significant improvement in traffic capacity and service level on the East-West route in the Republic of Srpska.

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