Professional paper
UDC: 625.721:628.52 (497.6 Doboj)
DOI: 10.7251/afts.2014.0611.017D
COBISS.RS-ID 4571416

GEOLOGICAL CHARACTERISTICS OF THE TERRAIN ON THE HIGHWAY CORRIDOR Vc SECTION JOHOVAC – DOBOJ JUG, stac. km 10+754 – 15+820

Đurić Neđo[1]

[1]*Technical Institute Bijeljina, E. mail:* nedjo@tehnicki-institut.com

ABSTRACT

HighwayCorridor Vc as the most significant route in Bosnia and Herzegovina requires detailed analysis of geological characteristics of the field along the route of its propagation. The route is divided into several parts, according to geographical, geological and spatial properties of the field. One of the most complex sections of the highway is the section Johovac – Doboj Jug, subsection UsoraKaruse. It is not that complicated because of natural properties of the ground only but also because of inability to choose the most optimal route due to the presence of a number of residential buildings. Selected route is quite demanding in terms of field research and its construction, since it will be entirely built in the embankment, and there arefive bridges and another roadjunction along the route.

By the field examination, geological properties were defined with analyzed seismicity level for the area, as well as engineering – geological and hydrogeological characteristics of the terrain. At the construction sites of prospective facilities, additional investigations will be carried out and resulting data will together with existing, constitute a basis for development of geotechnical project.

Key words: *route, facilities on the route, sediments, relief, faults*

INTRODUCTION

Highway Corridor Vc passes across the central part of the state, mainly through the valleys of rivers Bosna and Neretva. It is a part of European corridors V, of which one lineVc separates in Budapest, extends toward Croatia, Bosnia and Herzegovina and enters Croatia again, where it connectsto the planned Adriatic-Ionian Highway, figure 1.

Geological investigation of the field for the purpose of the construction of Corridor Vc highway, were conducted in several phases, from the collection of existing documentation, its analysis and planning of necessary research, to the final consideration of field properties as a basis for development of the Main design. As a part of previous research, main characteristics of the field were defined, required for creation of basic geological map 1: 10000, and dedicated investigations observed in more details overall properties of the terrain.

On the section Johovac – Doboj Jug, a subsection Usora – Karuse was singled out from stac. km 10+754 – 15+820, which is quite complex both in terms of route selection and characteristics of the field. Appropriate field investigations were carried out with exploration works and laboratory tests. Collected results are sufficient for more clear presentation ofgeomorphological, geological, engineering-geological and hydro-geological properties of the field. Parameters obtained during the field and laboratory test, together with consideration of terrain properties from the aspects analyzed, are sufficient to conduct a geotechnical analysis for the road route.

Figure 1 Corridor Vc route through Bosnia and Herzegovina

For the objects on the route, it is necessary to perform additional investigations in order to provide more detailed data required to define conditions for their foundation.

GEOLOGICAL PROPERTIES OF THE FIELD

Geological mapping of the field, exploratory boreholes and cuts and accompanying field penetration investigations were conducted during the research. Investigations were planned to such an extent that obtained results together with data of previous researchdefine a geological composition of the field and collect sufficient data on soil and rocks characteristics for the purpose of geotechnical field analysis along the road route[1,2].

Geomorphological properties

Terrain of the subsection, from Usora to Karusa, is characterized by lowland relief, exceptof distinct northern part where the route is laid over the slope terrain[3,4]. Overall, the area of Usora hypsometrically lies at altitudes of up to 275 above sea level. In hydrographic network, watercourse of Usora is dominant, along which is developed a relatively dense network of temporary flows, mainly of centrifugal type. All streams are drained into the river Usora.
In genetic terms, relief along the observed area belongs to:

- fluvial – accumulative and
- erosion – denudation type of relief

Fluvial – accumulative type of relief was formed by fluvial – accumulation processes in the valley of the river Usora. It has been developed in two subtypes:

- Terraced – accumulative relief, which is emphasized on the right bank of the river Usora in the hinterland, upstream and downstream of the considered area, and it does not have a direct connection to the route.
- Contemporary accumulation relief along the river Usora, typical for dynamic, seasonal change of the amounts of deposits and deposition of dragged and suspended sediments, mainly along the riverbed, and to a smaller extent along tributaries too, such as Ularicastream.Delevelled remains of abandoned meanders are numerous because a watercourse of Usora, due to

dynamic changes of the water flow, very often rapidly changes its riverbed. This flow regime has occurred recently.

Erosion – denudation reliefis expressed in distinct northern part of the subsection, above Makljenovci, in the area of "new" junction and toward the portal of the tunnel "T2". It is developed on clastic clay-marl-sandy medium, that is on volcanogenic – sedimentary rocks of Jurassic age.Relief that was formed over these rocks is characterized by mild morphologic forms and slopes of uneven, but gentle longitudinal inclinations.

The exception is a limestone skarry in the area of Karusa, on the left bank of Usora, near the bridge Tesanjka 2. Erosion-resistant limestone mass "protrudes" here from the surrounding terrain, height of about 15 m. It presents a typical "olistolithic" remain of previous (older) erosion relief [4]. Considering the limited area of about 2.500 m^2 and the height, this limestone block does not have defining character for determination of the relief type, but it has indicative role for the field genesis and a particular importance for the construction conditions of the bridge Tesanjka 2.

Geological composition of the field

In geological structure of inner areas of the field, up to a depth of the research, only Quaternary and Jurassic sediments were identified [3,4,5].

Sediments of Jurassic age, are the oldest sediments in the research area. The built geological basis of the field from stac.km 12+060 up to km 15+820, figure 2. They are presented by thin-layered rock of ophioliticmelange of which the most typical representatives are dark grey, dark blue and "dirty" reddish-brown to black pelite-aleurolite, aleuorites, sandstones, claystones, marls and limestones. These sediments are extremely folded and intensely tectonically disturbed. Apart from being unevenly alternated, vertically and laterally, alternated members of melange change their positions at short distances, both in azimuth as wellasin attitude.

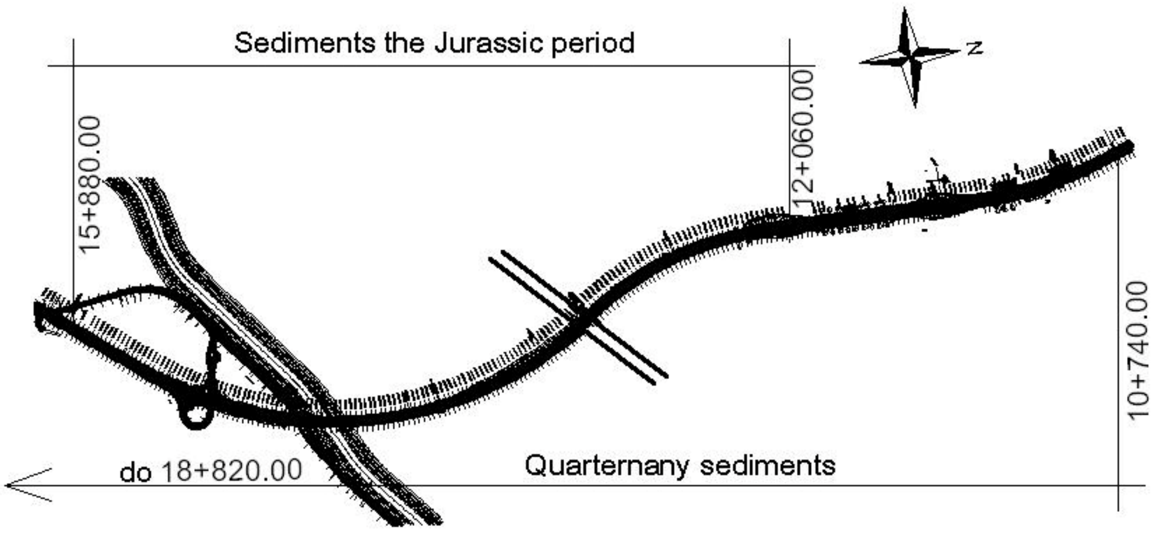

Figure 2 Longitudinal profile of the field on the section Usora – Karuse

Rock masses of geological basis are intensely physically and chemically degraded, and these zones are particularly isolated and identified as masses of decomposed substrate, and almost a whole Jurassic complex in the field is "covered" by Quaternary sediments of different genetic backgrounds.

Quaternary sediments strike over the whole area of the consideredfield and have a direct contact with the road route. These materials were formed by the processes of decomposition, transport and disposal of rocks of geological substrate or by anthropogenic activity during the construction of roads and facilities. Depending on the genesis, following types of Quaternary sediments, that is surface covers, are distinguished:

- anthropogenic materials of the embankment
- alluvial sediments and
- eluvial – deluvial covering

Anthropogenic materials of the embankment are the least represented type of covering. They are made of shaly detritus, broken stone, gravel, sand, bricks and other filling materials. They have a variable thickness, from a few decimeters only up to 1.0 – 2.0 meters maximally.

Alluvial sediments are presented by washing sediments of flood faciesand facies of riverbed. Flood facies sediments are dusty-sandy clays, dust and muddy-clayey sands, thickness of 0.2 to 1.9 m, and riverbed faciessediments are presented by gravels and sands, thickness from 1.0 – 5.2 m, in average about 2.7 m.

Eluvial – deluvial sediments strike over the slopes of initial part of the subsection up to the bridge Tesanjka 2, and on the part of the slope from existing road up to the end of the observed route, that is to the tunnelentrance. By its material composition, they are mainly dusty-sandy clays with less or more fine-grained detritus, that is fragments of basic rocks, of interchangeable thickness from 2.2 to 3.0 m.

Tectonic structure of the field

According to the structural – tectonic composition, wider area of the research field belongs to structural – facial unit of central – ophioliticmelange which is build of sediments of "oceanic crust" and ultra-basic rocks appearing as olistoliths, basic spilite, diabases, serpentinite and other sediments less represented.

Sedimentary formations are presented by clastites and their mutual relations are irregular, even chaotic, without pronounced primary structures. Unequal structural – textural characteristic further contribute to that, namelyvery variable vertical and lateral presence of particular lithological members, then uneven stratification and undefined mutual connections, and in particularlyunderlying position of the limestone mass on the left side of Usora towards the surrounding rocks.

Spatial coverage of the research area is relatively small, confined to the part of the Usora valley within the area of less than 8 km^2. Basic rock masses are covered with Quaternary covering over the almost entire surface of the field. Therefore, it was not possible to empirically record and measure tectonic elements, and consequently it was not possible to more precisely definetectonic features of the field.

Seismotectonic properties

Along the Corridor Vc in northern Bosnia, within major fault zones, faults of the valley of rivers Sava and Bosna can be identified, as well as Sprecanifault, which extends to the west, along the valley of the river Usora. Observed beyond, this area is tied to a deep Vrbas fault of Banja Luka and Prijedor [6],whichcan be significant for the highway route.

Faults of the valley of rivers Sava and Bosna comprise the area of Derventa, BosanskiBrod and Odzak, then BosanskiSamac and Modrica. Tectonically, this area mostly covers the "south Sava fault" and a deep fault along the valley of the river Bosna. Maximum intensity of the earthquake along the river is 7^0 and 8^0 MCS, while along the river Bosna from Svilaj to Maglaj the intensity of the earthquake is 7^0 MCS.

Spreca and Usorafaults, are traced by gravimetric analysis and registered epicenters at the stretch Zvornik – Tuzla – Doboj – Tesanj – Teslic. Maximum intensity of the earthquake is 7^0 MCS. Indirect indicators of the existence of deep faults are occurrences of thermal and mineral waters along this stretch, and contemporary movements of Tuzla and Doboj blocks in terms of emergence, and Spreca and Usora valley in terms of subsidence. According to a mentioned phenomena these faults are active even in contemporary age although abrupt movements of the blocks are rather rare and no occurrences of earthquakes of intensity over 7^0 or 8^0 MSC were recorded, nor the higher frequency.

Considering structural – tectonic, engineering – geological and geo-mechanical characteristics of the soil, the impact of possibly expected earthquakes, generated fromSpreca-Usora focal area, to the objects of the future road, can be significant. Therefore, this area should be seismically explored in more details, particularly in terms of correction of seismic level between 6^0 and 8^0 MCS.

Banja Luka – Prijedor area does not belong to the Corridor Vc but its seismogenic activity is of great importance. It is confined to active parallel faults that intersect with the deepest Vrbas fault. Area with maximum earthquake intensity of 9^0 MCS is connected with Banja Luka vicinity. Being the strongest intensitythere, a level of earthquake magnitudes rises to 8^0 east of Banja Luka.Isoseismal line 8^0 MSC is of direction N – S and it is located to the west of the highway route, at a distance of 5 – 12 km.

Based on the results of field research and laboratory test, a correction of the basic level of seismicity was made according to Medvedev, table 1. It was determined that subsurface part of the soil of the subsection Usora – Karuse, in terms of seismicity belongs to the third category, and deeper parts of the field, where a foundation of the objects will be performed, belongs to the first category of groups b and c. According to these investigation results, it is necessary to perform a correction of the basic level of seismic intensity, that is a correction of hazard and seismic acceleration and values of gravitational coefficient.

Table 1. Correction of the basic level of seismicity according to Medvedev

Category of the soil by its seismic properties	Type of rock (soil)	Level of seismicity		
		7	8	9
		Determination of seismicity		
I	a) Solid rocks: granite, limestone, sandstone. b) Semisolid rocks: marl, clayey sandstone. c) Unbound sediments: detritus, gravel and sand at depth of groundwater h>15 m.	(-1) 6	(-1) 7	(-1) 8
II	a) Clayey rocks - dry. b) Sandstones and clays at depth of groundwater h>8 m. c) Gravel and detritus at depth of groundwater 6<h<10 m.	7	8	9
III	a) Clays (loam) in a plastic state. b) Sands and clays at depth of groundwater h<4 m. c) Gravel and detritus at depth of groundwater h<3 m.	(+1) 8	(+1) 9	(+1) 10

ENGINEERING – GEOLOGICAL PROPERTIES OF THE FIELD

Engineering – geological characteristics of the terrain were identified through geological structure of the field, lithological composition, relationships between individual lithological members, depth of subsidence, then hydro-geological properties and functions of particular lithological complexes and types, depth and fluctuations in groundwater levels, processes and phenomena manifested on the surface of the field with assessment of susceptibility to further development and possible impact on the route and facilities. Diversity of rock masses, that is diversity of mapped units, reflects heterogeneity of lithological composition and anisotropy of the tectonic complex [7].

Engineering – geological categorization and classification is based on lithogenetic criteria, that is on the exploration of the field and knowledge of relationships between engineering – geological properties and lithogenetic features of identified rock masses as basic mappingunits [8,9].

According to a degree of homogenous consistency, rock masses are categorized in two main taxonomic units, that is lithological types (LT) and complexes (LC). Further, according to a degree of diagenesis and bond strength of bond between minerals and mineral aggregates, taxonomic units were divided in two basic groups and they are:

- hard and soft rocks
- cohesive and loose soils.

Hard and soft rocks build two lithological complexes and one lithological type of geological substratum. Within geological substratum, lithological entities of weakened and fresh substratum were isolated, as well as a lithological type of limestone.

Cohesive and loose soils extend in continuity on the surface of the field whose composition and physical – mechanical properties directly depend on lithogenetic background. Soils present natural subsoil for the construction of the highway embankment. Cohesive soils present lithological complex of eluvial – deluvial sediments, and loose soils are presented by anthropogenic materials of the embankment and alluvial formations in varieties of floooffacies and facies of riverbed.

HYDROGEOLOGICAL PROPERTIES OF THE FIELD

Hydrogeological features of lithostratigraphic units are predisposed by formational - geological structure, lithological composition and structural porosity.Two basic hydrogeological categories of rock masses [10,11] were isolated in the field:

- permeable rocks
- impermeable rocks

Permeable rocks are classified into rocks of intergranular porosity and rocks of fractural-karstic porosity.

Rocks of intergranular porosity are classified into low-permeable rocks and well-permeable rocks. Low-permeable rocks of intergranular porosity are eluvial – deluvial (el-dl) sediments, alluvial sediments of flood facies (al, p), then anthropogenic materials of the embankment (n). They are built of dusty-sandy-clayey materials and subordinately of detritus and gravel. Filtration properties are within the limits $k = 10^{-4} – 10^{-6}$ m/s and coefficient of permeability $T = 10^{-4}$ m/s. Well-permeable rocks of intergranular porosity are alluvial sediments of riverbed facies (al). They are built predominantly of gravel and sand, and subordinately of clayey particles too. Estimated filtration parameters of these loose deposits are: filtration coefficient $k = 10^{-2} - 10^{-4}$ m/s and coefficient of permeability $T = 10^{-1} – 10^{-3}$ m/s.

Rocks of fractural – karstic porosity are limestones of the Middle Triassic (T_2^1) with estimated filtration parameters rangingwithin limits, $k = 10^{-4} - 10^{-5}$ m/s and coefficient of permeability $T = 10^{-3} – 10^{-4}$ m/s.

Impermeable rocks are presented by Jurassic members of geological substrate where fractural porosity is weekly expressed. In hydrogeological terms, they have a role of hydrogeological barriers where collectors are not formed and springsdo not occur.

CONCLUSION

Route of the highway Johovac – Doboj Jug is one of the most complex sections, both in terms of geological properties of the terrain and a spatial distribution of residential buildings. The largest part passes through lowland relief except for the part in the far north where it is laid in a slope.
Sediments of Quaternary and Jurassic age participate in geological composition. Sediments of Jurassic age present a basis of the field with aleurolites, sandstones, shales, marls and limestones. Tectonically, they are significantly disturbed. Being like that, they present a decomposed substrateover which,along the entire length of the highway route, lies Quaternary sediments of various genetic backgrounds. Quaternary sediments were formed as a result of natural contemporary processes related to decomposition, transport and deposition of rocks of geological substratum or by anthropogenic

activities related to some activities in the field. Within the seismotectonic analysis faults were identified in the valley of rivers Sava and Bosna, as well as Sprecani fault which extends along the valley of the river Usora. More broadly, research area is connected to a deep Vrbas fault.

In engineering – geological terms, rock masses are categorized into rocks and soils. Rocks define a substrate of the field and they are identified as hard and soft rocks. Cohesive and loose soils continuously lie over the substrate presenting natural subsoil for the embankment of the highway. Depending of the formational – geological structure, lihtological composition and porosity, rocks are in hydrogeological terms classified into two categories, as permeable and impermeable.

(Received 11. August 2014, accepted 12. September 2014)

REFERENCES

[1] Group of authors. Research on performed investigations of the field on the route of the Highway Corridor Vc, the river Sava – Doboj, Lot 3, level of conceptual design. Book 3.FPD of Technical Institute Bijeljina, Bosnia & Herzegovina, 2009.
[2] Group of authors. Programme of engineering – geological, hydrogeological and geotechnical investigation works for the route of the Highway Corridor Vc, Doboj Jug. IPSA Sarajevo. Fund of professional documents IPSA Sarajevo, Bosnia & Herzegovina, 2011.
[3] Olujić J., Sunarić-Pamić O., Pamić J. (1974). BGM 1:100.000. Explanation of the sheet Teslic. State Geological Institute Belgrade, Serbia, 1974.
[4] Pamić J. et.al. OGK 1:100.000. (1979). Explanation of the sheet Teslic. State Geological Institute Belgrade, Serbia-
[5] Lausević M., Jovanović, Č. BGM 1:100.000. (1983). Explanation of the sheet Doboj. Geological Institute Belgrade, Serbia.
[6] Vidović M. (1974). Geological contributions for the study of seismic activity in the field of Bosnia & Herzegovina. Seismological Institute Sarajevo, Bosnia & Herzegovina.
[7] Group of authors. Engineering-geological map of SFR Yugoslavia 1:500.000 with explanation. State Geological InstituteBelgrade, Serbia, 1969.
[8] Đurić, N. (2009). Fundamentals of geology and engineering geology.Faculty of Civil Engineering Subotica, Technical Institute Bijeljina, Serbia, Bosnia.
[9] Santrač, P. (2000). Tehnology of Protection Against Cađillary Moisture. Budapest, Hungary. "Proc. 2nd Int. Build. Technočogy and Management. sec. I, No. 3.
[10] Komatina M. et.al. (1980). Hydrogeological map of SFR Yugoslavia 1:500.000. State Geological Institute Belgrade, Serbia.
[11] Đurić N. Hydrogeological and engineering – geological investigations. (2011). Subotica. Faculty of Civil Engineering Subotica, Technical Institute Bijeljina, Serbia, Bosnia.