

## Geological characteristics of the terrain along Vc corridor between Sava river and Sarajevo town

MIRZA BAŠAGIĆ<sup>1</sup>, NIJAZ ŠKRIPIC<sup>1</sup>, FERID SKOPLJAK<sup>1</sup>

<sup>1</sup> Civil Engineering Faculty of University of Sarajevo, Geology Institute, Stjepana Tomića st. 3, 71000 Sarajevo, B&H; E-mail: mbasagic@lol.ba.

**Received:** March 25, 2007

**Accepted:** August 20, 2007

**Abstract:** On the basis of analyzed geological, tectonic, seismic-tectonic, hydro and engineering geological characteristics of terrain, in this paper are reviewed geotechnical conditions for construction of highway, as a part of Vc Corridor through Bosnia and Herzegovina, between Sava river in the north and Sarajevo, i.e. Tarčin town in the south. Along northern half of BH-highway, 165 km long, it would be necessary to construct 37 tunnels in total length of 30.2 km and 119 bridges (viaducts) with 13 road junctions. Highway route mainly extends along river Bosna valley, in terrain with heterogeneous geological structure and complex structural-tectonic structure. It diagonally crosses structure of Dinaric Alps and active seismic-tectonic zones with intensity of up to 7 EMS. In regards to structural-geologic relations, subjects of change are also hydrogeological categories, porosity and functions of rock masses. However, highway is not in collision with water supply systems or significant water source areas. Regarding the fact that hard and stable rock masses are dominant in terrain, up to 3/4 of considered terrain belongs to favourable category for construction works. Exceptions are zones with thick covers along notches and particularly instable landslide zones within Zenica and Kakanj areas. Those parts, unfavourable for construction works are placed in about 1/4 of considered route.

**Key words:** highway, corridor, geological structure, tectonic structure, seismic-tectonic zones, hydrogeological and engineering geological characteristics, stability, and favourability for construction works

### INTRODUCTION

In the aim of establishment of direct road connection between Baltic and Adriatic Sea, in other words between countries of north, central and south Europe, construction of a highway in Corridor Vc is

planned (Baltic-Adriatic). South part of future highway is also placed through Bosnia and Herzegovina, in length of 330 km. From the north state border, from the bridge across Sava river near Svilaj, highway is placed along river Bosna valley and in the area near Modriča, Doboje, Tešanj,

Zenica, Sarajevo and Mostar cities, in its south part, along valleys of river Neretva, it connects to Adriatic - Ionic motorway in Republic of Croatia. North half part of BH corridor, in length of 164.93 km extends between Sava River and Sarajevo (Tarčin). Inside mentioned section, 37 tunnels in total length of 30,253 m shall be constructed

as well as 119 bridges (viaducts), in other words structures, and 13 junctions (road loops). This paper represents review of geological-tectonic, seismic-tectonic and hydrogeological-engineering geological characteristics of terrain and geotechnical conditions for construction of highway along mentioned section.

## RESULTS AND DISCUSSION

### Physical and geographic characteristics

Relief between Svilaj and Tarčin is uneven in morphologic aspect. Up to Doboj it belongs to a plain south edge of Pannonia lowland. From Doboj to Tarčin, road route in its main part extends along the valley of river Bosna, inside Dinaric Alps massif with hilly-mountain relief. The lowest altitudes are in the north, along riverbeds of Bosna and Sava, between 85 - 120 m a.s.l. In south direction, in the area of mountain ranges, altitude increases from 500 to over 1000 m a.s.l.

### Geological structure

In geological structure, rock systems of Phanerozoic

- Palaeozoic rock systems (Pz) compose south part of reviewed terrain. They are composed of phillite, quartz-sericite schist with lenses of lidite, quartzite, quartz-porphyre, dolomite, limestone and marble of Devonian (D), and Permian conglomerate, sandstone and shale (P), and to Permian Triassic (P,T) belong shaley marly limestone in the area of Tarčin.
- Mesozoic rock systems (Mz) compose middle part of terrain. They are characterized with great variety of facies.
- Within lower Triassic ( $T_1$ ) represented are sandstone, schist, marl and limestone, and both stages of middle Triassic ( $T_2$ ) are composed of limestone and dolomite of Anisian ( $T_2^1$ ), and igneous-sedimentary formation of Ladinian ( $T_2^2$ ). Massive microsparite belongs to upper Triassic ( $T_3$ ).
- Jurassic sediments (J) are extended from river Rudanka and Doboj, to Nemila. Dominant is igneous-sedimentary formation, more precisely ophiolite "melange".
- Transitional horizons of Jurassic and Cretaceous (J, K) are represented in flysch like rocks, as "Nemila" ( $^1J,K$ ) and "Vranduk" sediments ( $^2J,K$ ).
- Upper Cretaceous ( $K_2$ ) is characterised with so called "carbonate flysch" (limestone, breccia, subordinating pelite-alevrolite and marl in exchange).
- Cainozoic (Kz) is represented with sediments of Palaeogene, Neogene and Quaternary, which are extended in Posavina and along valley of Bosna.

- Palaeogene, more precisely Palaeocene-Eocene sediments (Pc,E) are developed in clastic and carbonate facie, and Eocene sediments (E) are composed of limestone-sandstone and facie of flysch.
- Oligocene-Miocene sediments (Ol, M) are represented with conglomerate, sandstone, marl, clay and travertine limestone.
- Neogene (N) is composed of sediments of Miocene and Pliocene. Miocene (M) sediments are conglomerate, sandstone, clay, marl and limestone with occurrences of coal in Sarajevo-Zenica and Šeher-Žepče basin. Pliocene and Pliocene-Quaternary rock systems (Pl; Pl,Q) are sand, gravel and clay, and in Pliocene, coal also occurs.
- Quaternary surface covers of detritus-sand-clay composition have significant extension, especially in Posavina and on the slopes along river valleys, especially in parts where basic terrain structure is composed of clastic, clayey-marly sediments.

### **Tectonic structure**

In tectonic aspect, the area of road route belongs to a region of inner Dinaric Alps and it extends over so called “zone of Palaeozoic schist and Mesozoic limestone”, with central ophiolitic zone. Main folding structure is represented with fold of Bosnian flysch which crosses middle part of road route near Nemila. As main fault structures, determined are Spreča-Kozara and Busovača deep faults. Besides deep faults, there are also faults of the first category (Neo tectonic faults), and faults of the

second category that crosses surface parts of terrain along the road route.

### **Seismic-tectonic zones**

Deep fractures represent areas of contemporary tectonic movements that are the most common causes of occurrence of earthquakes. In that aspect, there are following seismic-tectonic zones: Sava - Modriča; Modriča - Doboj; Usora - Maglaj; Žepče - Vranduk and Sarajevo – Zenica basin. Within those zones, prognosticated intensity of earthquakes for returning period of 500 years is 6 ° – 7 ° EMS.

### **Hydrogeological relations**

According to hydrogeological categories, porosity and functions of rock masses, in terrain are represented water permeable and watertight rocks. Water permeable rocks are characterised with crack-cavernous and intergranular porosity structures, and according to permeability and functions there are highly water permeable and moderately water permeable underground and surface aquifers. Springs occur mainly in carbonate rocks of crack-cavernous porosity. In rocks of intergranular porosity, formed are “free” water bearing layers out of which water is used for water supply, like they are water sources in Odžak, Rudanka near Doboj, Jelah near Tešanj, near Žepče, Zenica, Kakanj, Sarajevo, etc. Watertight igneous, metamorphic and clayey-marly sedimentary rocks, in dependence of structural position, have a function of hydrogeological barriers in terrain.

### **Engineering geological characteristics**

According to engineering geological clas-



**Figure 1.** Geological map of Bosnia and Herzegovina (HRVATOVIĆ, H., 1999)

sification, rock masses are divided as main mapped units and selected in taxonomic units as: lithological types (LT), complexes (LC) and suites (LS). According to grade of diagenesis and strength of bonds of mineral aggregates, selected units are divided into two basic groups:

- hard and soft rocks, in other words masses of geological substrata, and
- coherent and incoherent soil, in other words surface covers of different genesis types.

Within group of hard and soft rocks, selected are 22 lithological complexes (LC) and 13 lithological types (LT). And within group of coherent and incoherent soil, se-

lected are 6 lithological complexes (LC). On the basis of engineering geological characteristics, performed was classification and definition of rock masses as real environments where highway would be constructed. According to stability and endangerment of contemporary exodynamic and techno-genetic processes and occurrences, and satisfaction for construction, selected are three categories:

- the first category: instable areas, unsatisfactory for constructions;
- the second category: conditionally stable areas, conditionally satisfactory for constructions;
- the third category: stabile areas, satisfactory for constructions.

In reviewed section that is 164.93 km long, 3/4 of road route is placed in stabile terrain, satisfactory for construction, and only 1/4 of road route is placed in conditionally, and instable terrain.

### **Geotechnical conditions for constructions**

In aspect of geotechnical conditions for construction, the following can be summarised:

- In plain parts, which are composed of gravel-sand sediments, difficulties during construction are not expected, besides local occurrence of higher levels of underground water, what should be considered during disposition of road route level.
- In aspect of satisfaction for construction, that areas belong to category of satisfactory and stabile terrains.
- Middle part of road route, between Doboj and Zenica, is characterised with heterogeneous lithological composition and variable physical-mechanical characteristics of rocks that create complex geotechnical conditions for constructions.
- In that part, along road route, occurrences of disturbed stability of slopes could be expected, especially in parts where thicker covers are present as well as in parts of substrata that are more decayed, in portal parts of tunnels and zones of foundations of bridge constructions (tunnel Crni Vrh, tunnels between Ozimica - Nemila, bridges over river Bosna, etc).
- In aspect of geological-geotechnical conditions for construction, the greatest difficulties are expected in the area of bypassing city of Zenica, because road route between Donja Gračanica and Drivuša is placed along instable and conditionally stable slopes.
- Along section Drivuša - Kakanj, road route is placed in terrain that is composed of clastic sediments with formed thicker cover and decayed parts of basic substrata, and landslide Tičići should also be emphasized, which together with "Zenica" landslides represent the most important occurrence of instable parts of terrain.
- Within tertiary marly-clayey rocks along tunnel, occurrences of rock yielding, underground pressures, rock collapsing, etc. should be expected, while in carbonate-clastic zones, some better conditions could be expected.
- Along section between Vlakovo and Tarčin, road route is mainly placed inside tunnels in limestone and igneous-metamorphic rocks, but construction conditions could be evaluated as satisfactory.
- In aspect of construction of tunnels, limestone and "healthy" igneous-metamorphic rocks represent satisfactory working environment, even though fault zones could be expected in them together with scattered outbursts and occurrences of underground water.

## CONCLUSIONS

On the basis of analysed relevant engineering geological parameters: lithofacie composition, conditions and characteristics of rock masses, morphologic characteristics, exodynamic geological processes and occurrences, angle of stability of natural slopes, hydrogeological and seismic characteristics along Corridor Vc in section between river Sava in the north and Sarajevo, more exactly Tarčin in the south, it can be concluded that geotechnical conditions for

construction are satisfactory in the most part. Regarding the fact that in terrain dominating are hard and stabile rock masses, that means that 3/4 of reviewed section belongs to more satisfactory category for construction. Exceptions to this are zones with thicker covers in notches and especially instable zones of landslides in the area of Zenica and Kakanj. Suitability for construction is represented also with a fact that road route of future highway is not in collision with water supply systems or more significant water sources.

## REFERENCES

- BAŠAGIĆ, M., LANGOF, Z., ŠKRIPIC, N., SKOPLJAK, F. (2005): *Highway in Corridor Vc, Planning-study documentation, Technical study, Elaborate on engineering geological, hydrogeological and geotechnical conditions for construction*. Book 2.3, LOT N° 1&2, IPSA, Sarajevo, pp. 1-31.
- BRAČINAC, Z. (1966): *Basic seismic-tectonic map of SR BH, 1:200,000*. Institute for engineering geology and hydrogeology, Sarajevo.
- ČIČIĆ, S. (2002): *Geological composition and tectonic of terrain of Bosnia and Herzegovina* (in Bosnian). Sarajevo, 311 p.
- HRVATOVIĆ, H. (1999): *Geological guide through Bosnia and Herzegovina, Monographic* (in Bosnian). *Geological Herald.*; XXIV, Sarajevo, pp. 1-203.
- ROKIĆ, L. (1989): *Role and importance of engineering geological modifiers to engineering geological characteristics of terrain of middle Bosnia*. Institute for geotechnics and foundations, Civil Engineering Faculty of Sarajevo, Sarajevo, pp. 1-169.
- VIDOVIĆ, M., MOJČEVIĆ, M. (1975): *General Tectonic Map of Bosnia and Herzegovina*. Seismic Institute of BH, Sarajevo.