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GEOLOGICAL EVALUATION OF THE STATE OF THE ROUTE M18, SECTION FOCA – HUM, REPUBLIC OF SRPSKA

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ABSTRACT

Improvement of the quality of the route is necessary because of its importance in connecting countries of the Western Balkans to central and western Europe. This is the worst section of the road from Albania via Montenegro and Bosnia and Herzegovina to the corridor Vc, which passes through the central part of Bosnia and Herzegovina. The route of the road is very narrow with sharp bends, which requires its extension, correction, and in some parts relocation. It was therefore necessary first to give geological evaluation of the state of route in terms of exploration and characteristics of the rocks involved in the structure of the ground along the route.

We analyzed the available documentation of previous studies and conducted field data. Summarizing the results available, it was given the evaluation of the degree of exploration of the terrain and the need for new research for detailed consideration of the characteristics of the terrain, especially in the construction of facilities on the route.

Key words: *road route, exploration of the terrain, landslide, geological characteristics, terrain stability*

INTRODUCTION

Route of the main road at section Foca – Hum, length of about 19 km is planned for revitalization and improvement of its quality to the level of the fast road. It will link Albania via Montenegro and Bosnia and Herzegovina to central Europe. The existing route of the road does not fulfill even the minimum requirements, so it is necessary to harmonize the same with its future significance.

The terrain through which passes the route is of complex geological structure and requires a good knowledge of its characteristics to gain access to the preparation of project documentation. The need to revitalize the route, has been present since the eighties of the XX century, and today is in the focus so much that is necessary to complete it as soon as possible.

Geological explorations in this part of the field lasts more than fifty years, which are mainly for the purpose of construction of power plants [1,2]. In the late eighties of the XX century the investigation of the terrain and the route of the road began, but it soon stopped and for the next twenty years there has not been any research for these purposes [3,4,5].

In order to reach to the knowledge of the characteristics of the terrain, and the level of its exploration, either for energy purposes or route of the road, analyzing the results of the research began. They are the basis for planning future exploration work on the route, whether the route passes the same direction or partially corrects or relocate. In addition to the assessment of the results of previous research, a field data and a smaller volume of research works were performed, all in order to express the needs of the type and scope of additional research along the entire route from Foca to Hum.

ANALYSIS OF PREVIOUS RESEARCH

Documentation related to the route of road are divided into three sections, and are classified based on the coverage of the existing technical documentation and construction projects, which designin in smaller part are carried out. Sections of the route are as follows:

- Section 1: stac. km 0 + 000 to km 5 + 559, going by the existing road from Brod at Drina River to Kopilova settlement. Through previous documentation, a reconstruction of the existing road, which involves the enlargement of the road and construction of 9 bus stations. For the purpose of enlargement, on the left and right side of the road is planned a construct of retaining walls with a length of 2680 m.

- Section 2: stac. km 5 + 559 to km 11 + 634, is set hypsometrically in upper part of the field in relation to the existing road, or in the hinterland Kopilovi - Steel Box - Mazocki stream. As part of the route, eight viaducts are projected, of which two are built (viaduct 2 and viaduct 3) and about 1339 m of retaining walls, of which many are built.

- Section 3: stac. km 11 + 634 to km 19 + 134, generally follows the existing road corridor from area Mazocki stream to the border crossing over the river Tara. Due to the requirements of traffic road elements, common enlargement are planned which would be implemented with cuts or embankments. As part of the route, is predicted the construction of eight viaducts, one gallery, about 2375 m of retaining walls, bridge over the Tara River and the border crossing. The position of the bridge over the Tara and the border crossing will be defined later, when the route on the left and the right bank of the river are harmonized, ie on the territory of the Republic of Montenegro and the Republic of Srpska.

Some sections of the route are covered by technical documentation of different levels, but all documentation is not available, even those for which they have already built some buildings. Available documentation were analyzed, although the smallest part of it was related to the route of the road. Results of research for the construction of accumulation and dams Buk Bijela were used only for general review of geological settings, because such surveys are generally carried out on slopes, hypsometrically lower compared to the projected path.

Characteristics of the terrain from stac. km 0 + 000 to km 5 + 559 – section 1

From Brod at Drina River, where it was planned to begin the reconstruction of the road, there were no documentation available for dedicated research. Other geological documentation that were used for the assessment of geological conditions of the field were related mostly to the basic geological survey whose results were presented at the elementary geological map R 1:100 000, list Foca [6]. A smaller part of the area is affected by the research that are needed for the construction of energy facilities on Drina, but are also of regional levels. The degree of exploration of the terrain on this section is very low.

Characteristics of the terrain from stac. km 5 + 559 to km 11 + 634 – section 2

The section is partially covered by a detailed research, which started in 1991, but was not completed. It included the geological and geotechnical investigations for the route, viaducts and smaller part of the landslide, on the length of the route of around 2.0 km. 17 of geotechnical boreholes were drilled, total depth of 167.7 m, which are located for the design of stable route through the terrain and landslides. It was also done 10 wells at locations previously planned for 16 bridges, whose location does not overlap with the locations of the new route.

By analyzing the results of the research modern talus slope sediments (DL1 and DL2) were singled out, which represent a substrate of the field whose rocks are strongly weathered, thickness of 10 -20 m from the ground surface. Depth of weathered zone - crust wear, can reach 10 or even 30 m, relative to the surface of the field. The boundary between the slope - deluvial sediments and sediments crust spending substrates that are not transported - eluvial sediments, it is difficult to set up.

Reinterpretation of research results, may generaly lift the border of the substrate of the field to the maximum depth of up to 6.0 m from the ground surface, with the exception of deep, less steep ravines in which are registered remains of old terraced sediments. This interpretation is the starting point, which should be checked with new research, given that these results are a basis for the depth and nature of the foundations of buildings and retaining walls.

Previous works in the field have registered significant landslides, which in 1991 changed the layout. Horizontal displacement and raising vertical alignment many are avoided, and some remained for rehabilitation. Later on some parts of of the field, where they are registered landslides, road route is again lowered to ground, ie instead of viaduct, projected the open route. So again it is actualized problem of solving landslides. With detailed geologic research is necessary to define the terrain features on which you can determine the final route of times in this section.

Characteristics of the terrain from stac. km 11 + 634 to km 19 + 134 – section 3

There are no available results of dedicated research for this section, although in some parts of the route was surveyed, either for landslides or in the process of developing energy facilities. Rating of geological conditions of the terrain was carried out on the basis of using the results displayed in the Main geological map of SFRJ, R 1:100 000, list Foca [6].

CONDUCTED FIELD RESEARCH

During the analysis of the existing documentation it was noted that research in this area is somewhat larger than those whose results have been used. In the absence of such documentation, some questions remain unclear, which required field screening and a minimum volume of investigative work. Along the route of the road is done mapping of the terrain in the corridor width of 200 - 500 m, depending on the type of occurrences and processes on slopes, which were perceived in its entirety from beginning to end appearance. It is also made a number of exploratory trench at the beginning of section 1. Laboratory tests were carried out on samples taken from exploratory trench and the ground during geological mapping [7].

Engineering geological mapping of the terrain conducted a review of of all natural outcrops, as well as observations of the condition of cuts along the existing highway. Special attention is paid to occurrences of instability, moist soil and other similar phenomena in the field, which may be of importance for the assessment of the conditions of the road construction and facilities, especially in places of projected high cuts. During mapping it was performed the separation of solid rocks - rocky and semi - rocky of semi-consolidated and unconsolidated - talus, alluvial-eluvial, proluvial, and alluvial sediments.

Within the solid rocks appearance of rock masses and mechanical discontinuities such as stratification of surfaces, cracks, faults and fault zones, then the degree of cracking and decomposition of cutting masses were determined in detail.

GEOLOGICAL AND ENGINEERING GEOLOGICAL CHARACTERISTICS OF THE TERRAIN

Using the results obtained in this phase of the work, as well as the results of the analysis and interpretation of previous studies, the engineering geological characteristics of the terrain with a special emphasis on ground stability in natural conditions are evalueted.

Morphological characteristics of the terrain along the route road are variable. The hilly terrain belongs to the end of the right side of valley of the river Drina, and shorter part of the section 3, belongs to the steep slopes of the right bank of the river Tara. Short sections of the road were placed in on the old terraced plateaus also on the right bank of the Drina. In the central part of the route, which belongs to the section 2, the route is separated from existing and is constantly rising to the elevation of 591 mnm. Furthermore it gradually begins to fall, retaining the general decline until the end of section 3, or road route that extends to the bridge on Tara.

Hydrographic network is well developed, usually represented by a constant, periodic and torrential flows whose valleys are narrow and steep. Deep in the hinterland the hills are sloping down to the Drina riverbed, which drains the largest part of the surface water. Temporary streams at the end of section 3, are drained into the river Tara.

The geological structure of the terrain, characterizes rocks of the lower Carbon age, then Permian-Triassic and Lower Triassic. Of the younger Quaternary deposits significant role make sediments of slope processes represented as talus, proluvial and colluvial deposits. Plains along the river Drina build fluvioglacial and fluvial deposits.

The rocks of the lower carbon age (C1), are the oldest rocks of the studied field. They sre presented by the sandstones, alevrolytes, conglomerates, shales and schists. Along the whole section 1 and almost the entire length of section 2, are representing a substrate field. In the field section 3 are present to a little more than half of the roadway.

Rocks of Permian Triassic age (P, T), form a complex of clastic sediments in which are present mostly red and gray quartz sandstones and conglomerates, and subordinate are present shale clay - quartz and feldspar. Contact with the older rocks of the lower carbon do not match to kordantant and are affected with more rasjeds, and the younger rocks of the lower Triassic are affected with more rasjeds. In the field section 2 and section 3 to areas Vitich, Permian Triassic age rocks occur mainly in hypsometrically higher parts of the slopes, outside the corridor of the routeof the road. Only are present in area Susanj, in the field of Corridor of section 2 (km 2 + 600 to km 3 + 600). From Vitoch area (section 3, km 4 + 000) to the mouth of of the Tara and Piva (km 7 + 200), the Permian-Triassic clastic sediments build up the edge of the slope of the right side of the Drina River valley, ie the slope along the corridor which extends the roadway.

Lower Triassic rocks (T1), are presented with complex of clastic sediments within which dominate purple and greenish sandstones, then gray-green schistose and marly shales. They build the final part of the terrain road route of corridor, or part of the field belonging to the right bank of the river Tara.

The sediments of Quaternary age (Q), occupy a significant place in the total structure of the ground, within the route corridor road. In relation to their genesis, we identify the terraced sediments and sedimentary of slope processes.

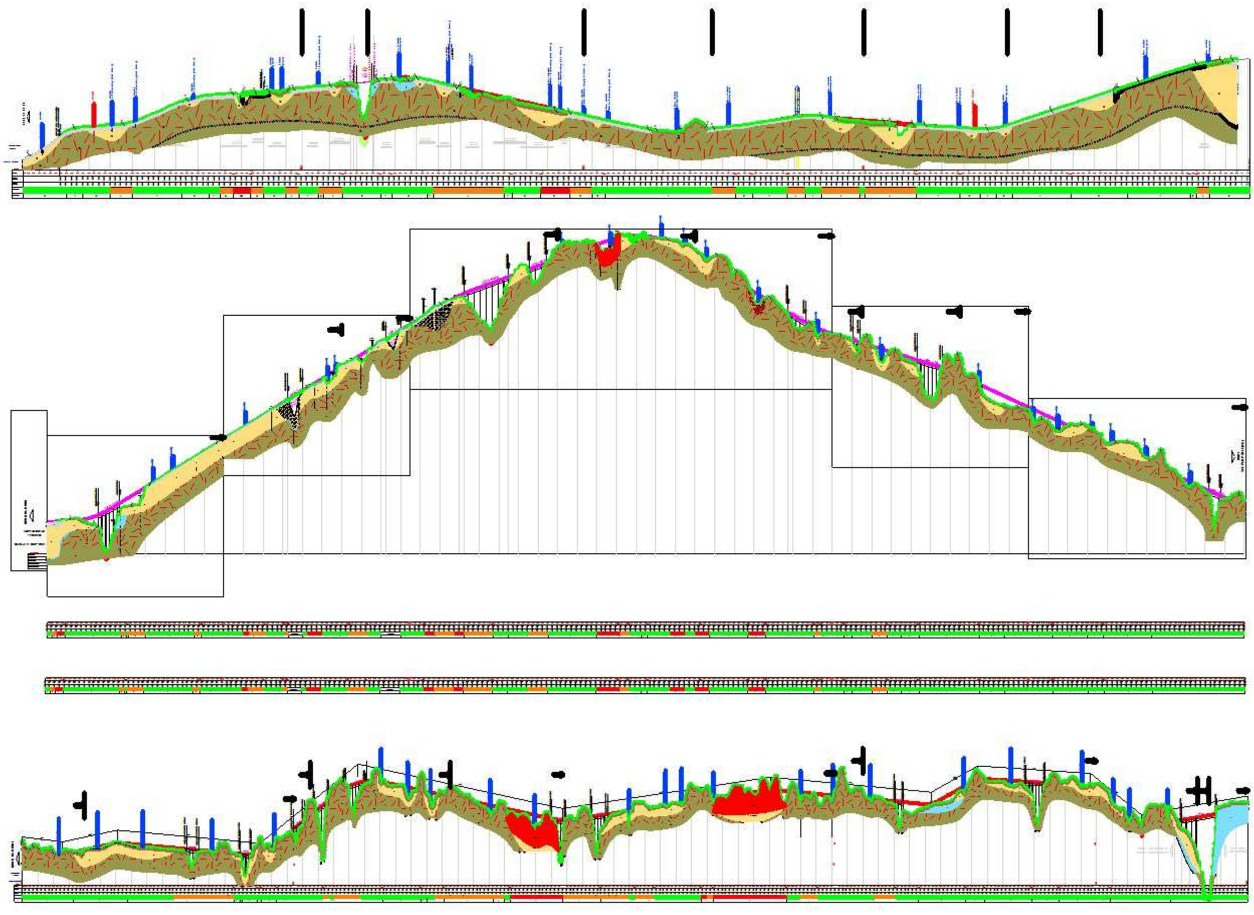
Terraced sediments (t1), according to the results of previous research are presented in gravelly - sandy sediments complex. They build the outer part of the route, ie section 3, where registered thickness is about 60 m [8]. On the other places where there are registered sediments of old terraces, it was drilled at depths of 17.3 to 6.0 m below the talus sediments.

Deluvial (dl) and alluvial - eluvial (dl - el) sediments are spread along the entire route road as an isolated slope deposits in pin parts of the slopes or in wide valleys of temporary or permanent water streams. Although genetically they not belong to the same formations, they are classified together into a single group because the boundary between them difficult to identify. Featured are sections of rocks of different seed size and composition which are immersed in clay mass. By size are tiny to large debris, often blocks, and by composition clastic and carbonates.

Hydrogeological characteristics of the terrain, dependent on the lithological composition of the rocks, their state of decomposition and tectonic damage. Generally it can be assessed that the rocks of road route of corridor are waterproof to poorly permeable with the function of hydrogeological insulator to relative hydrogeological collector.

To a complex of waterproof rocks belongs rocks of the field substrate presented with sandstones, conglomerates, shales and shales. Permeability of surface coverage ie alluvial and eluvial-alluvial sediments complex is directly depending on the material composition. Terraced gravel - sandy sediments are well permeable rocks with the function of hydrogeological collectors. The water level is dependent on the water level of rivers Drina and Tara.

Engineering geological characteristics of the terrain are seen primarily in terms of the structure of the terrain and slope stability on the field. Construction of the field is determined primarily based on analysis of previous studies on accumulation and dam Buk Bijela [9], and prospection surveys along the entire route, picture 1. Rock masses are classified into specific categories - environments that in static terms are acting as a whole. For a given engineering geological structure clearly is evident the complexity of geological settings along the route, except the vertical component is due proportions, less emphasized than in picture 1, posebno u dijelu trase na dionici 2.



Picture 1 Forecasting engineering geological terrain profiles, sections 1,2,3. R 2000/200

In the corridor of the route complex clastic sediments - sandstones and conglomerates and metamorphic sediments - schistose marl and shales, were separated in an environment regardless of different deformable characteristics. Due to frequent changes and out crop in vertical section and horizontal spreading of individual lithological members, the whole complex of sediments in general sense, is separated into a single brittle to quazi plastic environment.

Characteristics of brittle environment are presented by sandstones and conglomerates,and if shales are prevailing environment behaves as a quasi plastic. If the instability of the terrain is present, it is mainly related to the quasi-plastic part of the environment or to clayish part of the complex that is more weathered and degraded. Slide plane is formed on the contact of these two areas, within the complex sediments. The formation of instability is related to the position of the layers. As explored terrain layers fall mainly into the slope, the environment is not suitable medium for the development of instability, regardless of the steep inclination of hillsides, but represents a fixed basis of landslides.

The complex deluvial and delluvial - eluvial ie debris - argillaceous sediments were separated in a quasi plastic environment. By lithological composition the extracts and blocks are of sandstone, conglomerates, siltstones and limestone therefore from rocks of the substrate field. Shales as an integral part of the complex of the substrate, are easy to consume and switch in clay mass that surrounds the debris material and thereby fills the gaps in the total mass. Such diversity of composition and state of the environment creates a great heterogeneity and anisotropy in terms of engineering and geotechnical properties.

Ground stability was studied through the field susceptibility to the development of erosion processes and instability of the process in terms of slipping. Instability processes are developed through active and old landslides and unstable slopes. According to the results of previous research, the greatest instability of the corridor appear in the deluvial and delluvial - eluvial the decomposed material, given the large share of clay fraction. It is generally assessed that almost all slopes along the route, which slope is greater than 200 and which are at near surface part are covered with a thick layer of sediment > from 2.0 m - quasi plastic protection, or are unstable or are potential sites for the development of instability in terms of cuts.

The slopes of the terrain over which the path is projected are submissive to erosion, both surface and liner. The reason for that is in lithological composition of the rocks, their condition and properties. Rock masses are permeable, which is why most of the storm water are drained by surface through, occasional torrential flow type. Because of the high degree of decomposition of rocks, process erosion of coastal side and cutting of their riverbed is constant and emphasized. From the point of construction, it is important to know in order to protect the property from erosion or ensure its stability. Typical examples of strong line erosion along the corridor of the route are almost all streams flowing approximately perpendicular to the axis of road.

DISCUSSION

As part of the revitalization of the road network in the countries of Western Balkans, preparations began for the improvement of the road from Albania through Montenegro and Bosnia and Herzegovina to the Corridor Vc, where is still performed connecting with roads to central and western Europe. One of the worst stock on the motorway is part of the road Foca - Hum, a length of about 19 km. The significance of these sections was observed in the late eighties and early nineties of the twentieth century when they first started the research. On the start part of the road certain research field were carried out, especially in the part where are constructed or started objects that are planned along the route. Also, studies were performed on the individual where were activated landslides endangering the route.

The current route is narrow with many sharp bends and crossings over a larger number of smaller or larger watercourses. Therefore, the route on certain sections is corrected or fully extended, and is guided so that there are fewer objects on the track, whether are viaducts, bridges, culverts or retaining walls. At the end of the road, ie on the border with Montenegro is planned its correction with the bridge over the river Tara.

The terrain along the road alignment is very complex both in terms of geological structure, and modern geological and engineering processes. The degree of earlier exploration of the field is not satisfactory, which approached the study of existing documentation and a field prospecting. Previous documentation was not fully accessible, particularly those related to the construction of energy facilities, and has to do with the route of the road. However, based on available documentation and field visits, is given the geological assessment of the status of the route and isolated areas of the field according to the degree of stability [9,10].

The criteria for determining the zones are the lithological composition of the rocks and materials of the substrate or cover, which will be affected by the construction work, then their condition and properties. Special emphasis at zoning is given to the slope stability in natural conditions and zavodnjenosti field. Three zones are as follows:

- I zone is representing all sections of the road which would be built on a stable part od the terrain where the cuts and embarkments would be built in rocks of the substrate ie mainly in brittle environment with favorable hydrological conditions and favorable position of slope layers in relation to the route cuts
- II zone, representing all sections of the road that will be built on a stable part of the field where the cuts and embankments will be and build in slope sediments - argillaceous debris material, ie in quasi-plastic environment with locally unfavorable hydrological conditions
- III zone, representing all sections of the road that will be built on an unstable part of the field where the cuts and embankments will be build in the rocks of the substrate ie in brittle to quasi-plastic environment with locally unfavorable hydrological conditions and local adverse situation in slope layers
- IV zonae, representing all sections of the road that will be built on an unstable part of the field where the cuts and embankments will be build in slope sediments - argillaceous debris material, ie in quasi -plastic environment with unfavorable hydrological conditions
- V zone, representing all sections of the road that will be built on slopes affected by active processes of landslides whether they are affected by sliding rocks of the substrate or the processes have developed in the diluvial and alluvial - eluvial sediments cover ie quasi plastic environment.

It is realistic to expect that after a detailed geotechnical investigations of individual zone change as per their stac. locations and by category zone.

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