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THE TERAIN CHARACTERISTICS OF RAILWAY ALONG THE ENTITY BORDER OF FEDERATION BIH – MAGLAJ, SECTION km 103+500 – MAGLAJ

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SUMMARY

The railway Šamac - Sarajevo was built in the fifties of the twentieth century, as a significant part of the railway that connects the central part of the former Yugoslavia with the Sava River. Later, in the seventies another track of Doboj and Zenica was built what was the most important by that time. In general the railway is situated on the corridor V, which links the Adriatic Sea via Sarajevo and Budapest. Over time, the tracks are worn, damaged and speed has been reduced to about 40 km/hour.

As part of the revitalization of the railway network in the former Yugoslavia, the reconstruction of the Šamac - Adriatic Sea began, which is divided by sections. One of these sectionsis the section km 103 + 500 - Maglaj, a more demanding one compared to previous section from Šamac to the now named section. The point is that the terrain along the route of the railway needs to be viewed from the aspect of geologi cal features, then the characteristics of the embankment so the geotechnical conditions for the revitalization of the railway line for speeds of 120 km/hour can be provided.

Conducted field investigations along the route of the railway, as well as laboratory tests on samples provided enough data in the corridor route, while the wider area could not be perceived because of the mine field. However, the previous studies for the purposes of the General Geological Map, scale 1: 100 000, and field observations along the route line gave a satisfactory level of data for assessment of geological and engineering geological characteristics of the terrain.

Key words: *railway route, terrain characteristics, sediments, embankment, slopes*

INTRODUCTION

The studied section of the railway route from Doboj to Zenica on km 103 + 500 - Maglaj is located on the railway corridor V, which is scheduled in its entirety for revitalization, so the speed of trains from the current about 40 km/h to 120 km/hour can be increased. The revitalization is already done in certain sections, a section between Doboj and Zenica is more demanding and requires more detailed consideration of technical characteristics of existing dikes and the terrain along the route.

During the project, the field research was conducted, which is partly limited due to the mine field along the entire route on which the survey was conducted. Because the railway route mainly passes the slope parts, this is a part of a broader reconnaissance. From the route of the railway field observations were carried out, so that the steeper part of the slope could be seen more clearly, and in some places and the samples for laboratory testing were taken.

Along the railway route, which has two tracks, research works were carried out bytrenchesto the the-bedrock. In the trenches experiments of dynamic circular plate Evdwere carried out and the disturbed and undisturbed samples for laboratory testing were taken. The results of field studies, laboratory tests and previous research for the purposes of the General Geological Map 1: 100000, have provided sufficient data to define the characteristics of the terrain and the condition of the route.

DERIVED RESEARCH WORKS

Complexity of the terrain geological composition along the route of the railway and impossibility of direct approach in a wider belt along the route (because of mine fields), limited research just on the very narrow belts around railway tracks. The railway has two tracks which mostly passes down base of the slopes and laid in the valley of the river Bosna. It represents an important part of the railway corridor V, Figure 1.

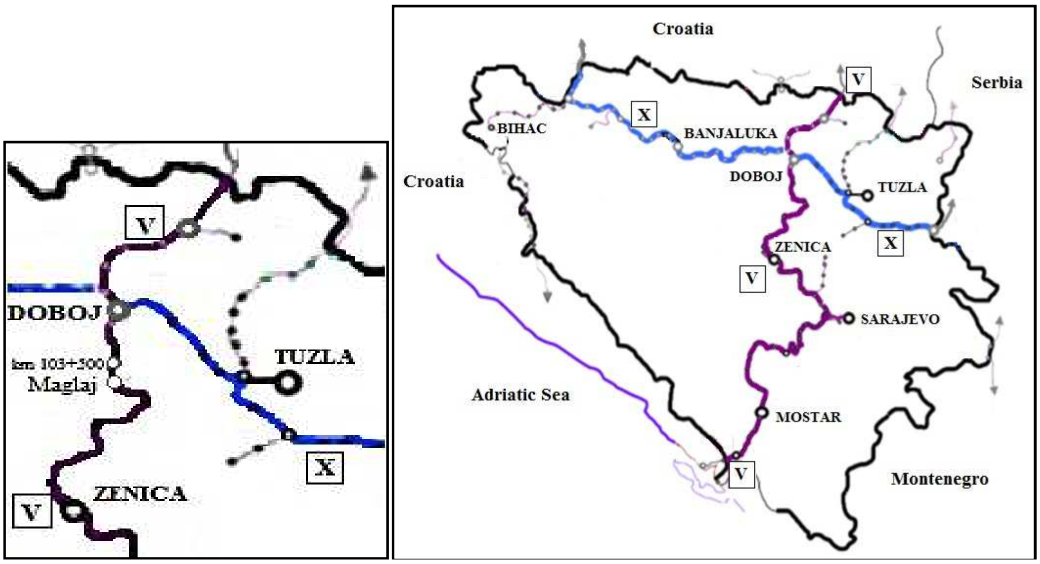

Figure 1. Section km 103+500 – Maglaj on the corridor V route in the Bosnia and Herzegovina

Along the railway route investigations are derived from the side and between the railway tracks. Along the route railway terrain is observed and mapped, and these data were correlated with the data which are previously obtained during the preparation of basic geological mapsSFRJ, R 1: 100000 [1]. Security degree of these data is satisfying in the part of description, but due to lack of access sampling is absent. Reconnaissance of the terrain previously was done. During reconnaissance isolated are characteristic chainages. These chainages have been analyzed more detailedduring the performance of research works.

Research works have been done with task to define depth to the base soil, and went deeper of it for around 0.2 – 0.3 m. Average depth to the base soil is around 0,7 – 1,2 m. Along the old railway tracks depth to the base soil, or thickness of the embankment is less than the tracks which were made 70', situation is shown in Figure 2. The route is characterized by disordered peripheral canals, gaps and low maintenance of embankment.

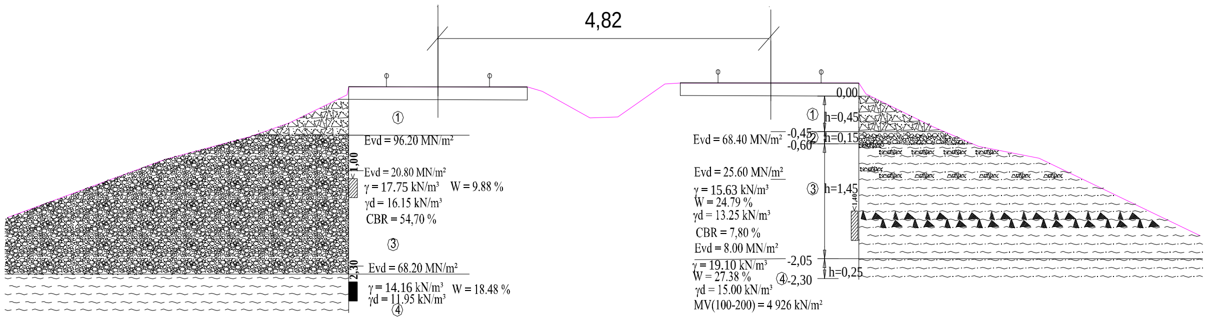

Figure 2. Appearance of the levees along the new and old railway route tracks

Beside reconnaissance and observation of the terrain, along the railway route there were made 52 pits in which were derived dynamic circular plate experiments, disturbed and undisturbed samples for laboratory testing were taken, pits were photographed and mapped on the its open profiles. In each pit it was done at least one dynamic circular plate experiment. In the deeper pits the experiment was repeated with depth, so that in the individual pits sometimes was done even four (4) experiments [2,3,4,5,6,7,8].

GEOLOGICAL CHARACTERISTICS OF THE TERRAIN

The research area is located in the northern part of Bosnia and Herzegovina in the area of Maglaj. The route is placed in the valley of the river Bosna, which was formed by indented river in impermeableJurassic volcanogenic-sedimentary ("diabase-chert") rocks. Shear on the valley of the river Bosna on both sides there are several small valleys and gorges which are formed by casual and permanent flows. The western boundary of the valley Bosnia is represened by theBorja mountain slopes and on the east theOzrenmountain is the boundary.

The named field and immediate surroundings, in relation to the genesis, is characterized by two types of relief: fluvial – accumulative and erosive–denudation. From the hypsometrical and morphometric view, the lowland type and the mountain type were developed.

In the valley of the Bosnia river, the riverbed represents the strongest form of fluvial erosion. The general direction of the river Bosna valley, from Maglaj to entity demarcation line, stationary km 103 + 500, is the north – southstretching. The hydrographic network of the area is well developed. In periods of intense rainfall the permanent and temporary streams have torrential character.

The railway route on the studied section and its wider surrounding is made of recent sediments of the river bed, which consists of quaternary (Q) sediments, coarse gravel - sandy material and fine-grained clay with a significant participation of coarse grained fractions, alluvial (al) sediments of the Bosna river, proluvialsediments (pr) and deluvial (dl) fans, neogene-miocene dacite (M), sandstones and sandy clay with fragments of rocks (J, K) and igneous rocks of jurassic volcanic-sedimentary ("diabase-chert") melange (J2,3), presented by microgabbro and massive peridotites [1,6,7,9].

Based on previous and implemented research, it can be concluded that the river valley is built from quaternary sediments, and the slopes which contour the valley are built by deep igneous rocks of Jurassic "diabase-chert" melange (massive peridotites and microgabbro), jurassic-cretaceous sandstones and sandy clays with clastic and neogene volcanic rocks and dacite. Deluvial plains are formed on steep slopes made of igneous rocks.

The recent sediments of the river Bosna (a), whose riverbed represents the strongest form of fluvial erosion in the valley, are heterogeneous and formed as the deposition of coarse and fine-grained sediments of the Bosnariver and its tributaries. They are presented by sandy clay, sand and gravel sand. They are characterized by intergranular type of porosity.

The alluvial sediments of the river Bosna (al), have formed the alluvial plain with the left and right riverbed sides. Subordinated to them are fine-grained fractions presented by silty clay and sandy gravel, which is formed by sub littoral horizons of alluvial plain. The thickness of these sediments is variable and not determined by the executed investigations.

Proluvial sediments (pr) are made of silty clay, sand, rocks and debris of which are significant peridotite, dacite, microgabbro and other rocks in small percentage content. The particle size distribution is uneven, poorly sorted with frequent horizontal and vertical transitions. They are formed by depositing the material of permanent and temporary surface flows. The thickness of these sediments is not permanent. On the ground surface they are registered in the local streams and on the left (west) side of the railway station plateau in Maglaj.

Slope sediments (dl) form the plains along the steep slopes of varying thickness, ranging from 1.0 m to hypsometrically highest parts the plain, to > 5.0 m, in some places even 5.0 to 10.0 meters in the hypsometrically lower parts of the plain. They are built from silty sand and clay sediments with high content inwards jurassic rocks of "diabase-chert" formations and neogene dacite which is formed on these slopes. The surface zone are made of humus with the remains of organic matter, variable in thickness.

Miocene dacites (M) have been identified in surface on the left side of the railway tracks. They appear in two narrow zones. These dacites also build immediate base of delluvial and proluvial sediments. With massive peridotites which extends in the direction of the north,dacites are in fault zone contact. They are not sufficiently explored in depth, but do not represent a special significance for the railway route.

Sediments of the **Jurassic-Cretaceous age (J, K)** are represented by sandstones and sandy clay with clastics (rock fragments). Clays are sandy with a variable percentage of rock fragments content and gradually change into clayey sand and debris. They are isolated on the surface. In some parts of the route railway tracks laid over these sediments.

Igneous rocks of Jurassic volcanic-sedimentary formations ($J_{2,3}$) are characterized by the presence of micro-gabbro and massive peridotites. Micro gabbros are a higher part of intrusive igneous rocks of Jurassic volcanic- sedimentary formation. They have massive structure and are partly cracked. Surface of the natural relief represents the crust of its decomposition. These rocks build terrain south of the Maglaj railway station plateau. Massive peridotites are lower part of intrusive igneous rocks of Jurassic volcanic-sedimentary formation. Build the northern part of the field where over them was precipitated deluvial deposit. They represent a solid intrusive igneous rocks, which are characterized by a greater degree of cracking.

ENGINEERING-GEOLOGICAL CHARACTERISTICS OF THE TERRAIN

Within the framework of engineering-geological characteristics of the terrain defined are characteristic of rocks with their boundaries and thickness of individual lithological members, then the genesis, composition and degree of degradation [3,4,5,7,10,11]. Separated are zones of the terrain according to the degree of stability and their impact on the route of the railway.

Embankment (e)has heterogeneous composition, various thickness along the tracks, what depending on morphology of the terrain. Since the railway is with two tracks that were built in time range from around 30 years, embankment at second track is much higher. It builds lower structure of railway, and mostly is made of sandy gravel and debris with variable percentage of fine-grained fractions, then of sand and gravely sand.The embankment is well consolidated and differently compacted, depending on the influence of side factors which impair its stability. First of all it is surface water in the areas where channels are not regulated or water drainage channels are poorly maintained and not serve their purpose. Generally, embankment layer has good physical and mechanical characteristics.

Recent sediments of the river bed (s) and alluvial sediments of the river Bosna (al) make the greater part of the railway route. They have heterogeneous composition, which is result of different deposition conditions. Fine-grained and coarse sediment of the Bosna River are products of sedimentation along major course of river Bosna its side tributaries. These sediments are presented with fine grained to coarse grained fractions of gravel and sand, with occasional layers of clay. The surface area is low plastic and compressible, has bad physical - mechanical parameters. With depth soil properties improve, so it has good bearing capacity and high to low compressibility. In natural conditions, the shallower zones are conditionally favorable bigger loading anddeeper cutting. River embankment has intergranular porosity and represents a hydrogeological collector with significant quantities of water.Water level oscillates during the year. In periods of higher rainfall groundwater zone is reduced or disappears.

Proluvial sediments (pr) are represented by silty clay, sand, rocks and debris of rocks which built slopes on whose bottom debris is formed. They are unequalin grain size and have unfavorable physical - mechanical properties, variable plasticity, porosity and strength. In the surface zone sediments are less consolidated, with depth degree of consolidation is better, considering presence of debris material.They have intergranular porosity, medium to small permeability, occasionally are water saturated environment. They are stable in natural conditions, conditionally stable and unstable at a deeper cuttings and larger loads, represents weak point on the railway route.

Slope sediments (dl) are presented with silty sand and clay sediments. Contain also debris from paleorelief rocks (peridotite, dacite, micro gabbro). Sediments have intergranular porosity, medium to small permeability, depending on the presence of clay component. They are medium to poorly compressible, have conditionally favorable stability.In natural conditions mild slopes represent a stable environment, while steep slopes are conditionally stable to unstable. They are characterized by recent processes of erosion, dredging as well as sliding processes.During engineering field activities in the area cuts environment is marked as conditionally stable to unstable. In these sediments are registered zones of unstable terrain, or landslides zones, with fossil and active character.

Neogene - miocenedacites (M) are located in the hinterland of deluvial clay sediments or build their immediate basis. These are hard volcanic rocks of good physical and mechanical characteristics, which for its filtration characteristics are impermeable rocks and have the function of hydrogeological insulator (aquiclude). If the massif cracking is significant,the fractured type of porosity may occur and form a fractured aquifer. In natural conditions, as well as the terms of engineering activities, they represent a stable environment, where high slopes can be formed.

Sandstones and sandy clay with fragments of rocks (J, K), where sandstones are participating in forming of the final part of the railway. They are characterized by intergranular porosity and for its filtration characteristics are in medium to slightly permeable rocks and represent hydrological insulators. They have good capacity andmoderate compressibility. In terms of construction and the larger load, the ambience is conditionally stable, but at deeper cuttings, because of very adverse water impact, the environment is conditionally stable to unstable. Clays are very weak rocks, with poor physical and mechanical properties. They are characterized by intergranular porosity and are in medium to slightly permeable.

Igneous rocks of Jurassic volcano- sedimentary formations ($J_{2,3}$) are presented by microgabbro and massive peridotites.

- Microgabbros are belonging to solid volcanic rocks with good physical mechanical properties, high capacity and load,which are suitable for high stable cuts. The rock massif isfractured. The cracks can be classified into the following families:$30^0/32 – 34^0$, $82^0/60^0$, $340^0/70^0$. The Surface of natural relief represents the crust of decomposition and is characterized by a very high degree of fracturing. The intense landslide of passages of different dimensions of this zoneis noticeable. By filtration characteristics they are impermeable rocks and have the function of aquiclude. In the case the massif is fractured, afracturedaquifer can be formed.

- Massive peridotites are solid and deep igneous rocks, with good physical and mechanical properties, high capacity and load, which are suitable for high stable cuts. In steep slopes and cuts, the rock massif is fractured and the cracks can be classified into following families: $261^0/8^0$ with spacing from 30.0 to 80.0 cm, $220^0/75^0$ with spacing from 20.0 to 30.0 cm and $104^0/85^0$with spacing of about 10.0 cm. The distance between the walls of cracks is in range from 1 to 5 mm. Cracks with smaller spaces between the walls are with smooth surfaces and coalesced or filled. The fracturing of the massif is reduced by its features and makes it susceptible to poor processes of surface erosion. Critical areas are represented by parts of slopes with less steep slopes and there is deposited the surface cover of decomposed degraded material 0.50 to a maximum of 2.5 m in thickness. By filtration characteristics they are impermeable rocks and have the function of aquiclude. In the case the massif is fractured, a fractured aquifer can be formed.

According to the degree of stability and suitability of the terrain, the mentioned sediments are separated as:

- Unstable terrains
  - deluvial slopes sediments (dl) with very steep slopes
  - sandy clays sediments with clastites in the deeper layers (J,K)
  - microgabbros at the top of the notch, where intensive escarpment is present ($J_{2,3}$),
  - massive peridotites in the terrain which is exposed to erosion ($J_{2,3}$),
  - zones with gentle slopes, where is deposited the surface cover of decomposed degraded material ($J_{2,3}$),
- conditional stable terrain
  - deluvial slopes sediments (dl) with steep slopes
  - sandy clays sediments with clastites (J,K)
  - microgabbros and massive peridotites zone with increased fragmentation of rocks ($J_{2,3}$)
- stable terrain
  - other sections along the track.

HIDROGEOLOGICAL CHARACTERISTICS OF THE TERRAIN

Hydrogeological characteristics of the studied areas are conditioned by heterogeneous lithological composition and complex lithostratigraphicassembly.

Hydrogeological properties of selected lithostratigraphic units are predisposed by lithological composition, type of porosity, pore size of material which participating in the rock composition, as well as their position within the field [4,5,7,12,13]. In the field can be defined rocks with following categories hydrogeological categories:

Medium water permeable rocks with intergranular porosity are presented dominantly by clayey sand and gravel in the alluvial deposits of the river Bosnia. Fine-grained silty clay fraction presents for its filtration characteristics weak to waterproof environment and has the function of hydrogeological isolator. Coarse grain fraction has better filtration characteristics, represents a medium to well permeable environment with intergranular porosity and has function of hydrogeological collector in which is registered confined karts aquifer.

In the alluvial deposits near Maglaj, it is formed collector whose thickness is up to 10.0 m. Estimated value of the coefficient of filtration is: $K = 10^{-4} – 10^{-5}$ m/s, partly in zones of smaller pollution with fine-grained fraction $K = 10^{-2} – 10^{-4}$ m/s. Level of ground water is free at a depth of 4.0 to 5.0 m. Small depth of ground water level in the collector is a problem during foundation of embedded facilities located in hypsometrically lower parts of the valley.

Mostly water impermeable to poorly water permeable rockswith predominant intergranular porosity. They are presented with sandy clay with clastics belonging to Jurassic-Cretaceous flysch.

Mostly impermeable to poorly water permeable rocks with prevailing cracked porosity are presented with sandstones of Jurassic-Cretaceous flysch and Miocene dacite. The rocks with fracture type of porosity formed broken aquifer with smaller yields. The most important source of this porosity type is located in the zone of fault contact between the peridotite and massive dacite.

Impermeable rocks are represented by rocks of volcanic-sedimentary formation, micro gabbros and peridotites. Smaller quantities of groundwater occur in cracked peridotites.

Impermeablerock with intergranular porosity are built by sediments from layers of proluvial fan and deluvial material. They are presented as sandy clay with high content of paleorelief rock fragments. Their filtration coefficient range within the limits $K = 10^{-6} – 10^{-7}$ cm/s.

GEOTECHNICAL CHARACTERISTICS OF THE TERRAIN

By engineer geological aspects, natural areas that form the terrain are extracted, ascertained in situ investigations. Basic characteristics of individual lithological members are [7,14,15,16,17] :

Clay, silty sandy with gravel is a natural ground or the highest lithological member in the vertical column - alluvial (al) sediments, medium hard to hard consistency, compressible and in low plasticity. The following parameters of laboratory tests of samples are given below:

- natural humidityω = 27,11 – 29,01 %
- optimal humidity by Proctor$\omega_{opt.}$ = 12,37 %
- laboratory CBR = 16,70 %

Sand, silty is a soil from recent sediments, lower lithologic member in the vertical column - alluvial (al) sediments, with the next values:

- natural humidityω = 15,33 – 18,48 %
- optimal humidity by Proctor$\omega_{opt.}$ = 11,83 %
- laboratory CBR = 18,20 %

Deluvial silt-sandy clays, is a soil formed from deluvial deposits. High in plasticity and compressibility. Laboratory values are given below:

- natural humidityω = 23,59 – 30,48 %
- Atteberg limits:
  - liquid limitω_l = 63,54 %
  - plastic limitω_p = 28,39 %
  - plasticity index I_p = 35,47 %
  - liquidity index I_l = 0,059
  - consistency index I_c = 0,941
- optimal humidity by Proctor$\omega_{opt.}$ = 11,83 %
- laboratory CBR = 18,20 %

Deluvial silty sand is a soil formed from deluvial deposits. Laboratory values are given below:

- natural humidity ω = 19,86 %
- optimal humidity by Proctor $\omega_{opt.}$ = 10,68 %
- laboratory CBR = 28,50 %

Jurassic –cretaceous sand, silty sand is the soil formed on jurassic-cretaceous flysch. It is characterised by the next parameters.

- natural humidity ω = 15,57 %
- optimal humidity by Proctor $\omega_{opt.}$ = 11,88 %
- laboratory CBR = 21,80 %

GEOTECHNICAL CHARACTERISTICS OF TECHNOGENEOUS MATERIALS

Are represented by materials that build a part of the terrain where the railroad is placed. Their geomechanical [7,14,16,17] and hydrogeological characteristics are as follows:

Upper layeris made of crashed limestone, dirty, mixed with other materials, sizes from 8.00 to 10.00 cm. It has relatively good physical - mechanical characteristics. The thickness of the layer ranges from 0.2 to 0.9 m. The values of dynamic modulus deformation Evd are the following:

- The dynamic deformation modulus (MN/m^2)
  - Evd = 20,03-76,27, Ev_1= 19,29-75,50, Ev_2= 45,66-140,00

Lower structure consists of a protective tampon layer made of sandy gravel and embankment layer built of different mixtures of materials such as natural soil material from borrow pits (clay, silty sand, sand, gravel) and technogenic materials (crushed aggregate with clay sand infill).

Lower layer is made of protective buffer layer made of gravel and sandy layer. The embankment is built of different mixtures of materials such as natural soil material from borrow pits (clay, siltysand, sand, gravel) and technogeneous materials (crushed aggregate with clay sand infill).

Protective layer (tampon) is built of sandy gravel. Grain diametar which correspond to the ordinate 60% - d_{60} range 1,415 do 19,990, and grain diametar which correspond to the ordinate 10% - d_{10} range 0,0599 do 0,825, what indicates that materijal which is inbuilt in the tampon layer have similar granulometric composition in all examined sections. According to Allen Hazen formulas, soil unevenness degree C_u range 24,68 do 355,33, which indicates that tampon layer has moderately uniformn to unequal composition. Basic paramerers are as follows:

- Natural moistureω = 2,26 – 9,41 %
- Optimal moisture by Proctor-u u $\omega_{opt.}$ = 7,41 – 10,16 %
- Value of laboratory CBR = 31,60 – 71,12 %
- The dynamic deformation modulus (MN/m^2)
  - Evd = 19,15-82,50, Ev_1= 10,50-63,16M, Ev_2= 18,00-136,80

Thicknessper tested chainages where protective layer was not possible to separate from the layers of the embankment, range from 0.06 m - 0.6 m. In some sections this layer is not inbuilt.

Embankmentis built of different mixtures of materials such as natural soil material from borrow pits (silty clay, sand, sand, gravel) and technogenic materials (crushed aggregate with clayey sandy infill), Figure 3.

Grain diameter which corresponds to the ordinate 60% - d_{60} range 0,951 to 29,13, and grain diameter which correspond to the ordinate 10% - d_{10} range from 0,0031 to 1,994, what indicate that materijal which is inbuilt in embankement have similar granulometric composition on the all examined sections. Grain diameter in earthen embankements which correspond to the ordinate 60% - d_{60} range from 0,0301 to 0,0722, and grain diameter which correspond to the ordinate 10% - d_{10} range from 0,0015 to 0,0028.

According to Allen Hazen formula soil unevenness degree C_u range from 4,50 to 688,60 what indicate that materijal of embankement has unequal composition, and in the earthen embankements soil unevenness degree C_u range from 25,62 to 31,79, which indicate that material in the earthen embankments has unequal composition.

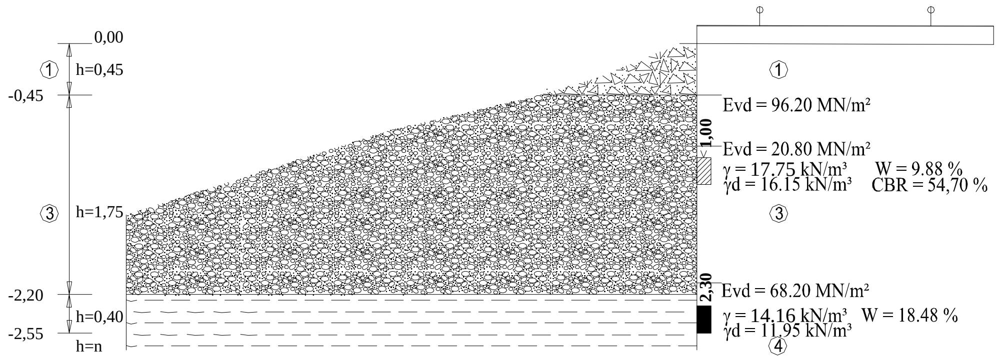

Figure 3. Embankement appearance on the new railway route tracks

Basic parameters are as follows:

- Natural moisture
  - tehnogenous materialω = 2,54 – 32,20 %
  - earthen embankementω = 15,51 – 24,79 %
- optimal moisture by Proctor
  - tehnogenous material$\omega_{opt.}$ = 7,02 – 10,69 %
  - earthen embankement$\omega_{opt.}$ = 12,35 – 15,22 %
- value of laboratoryCBR-a
  - tehnogenous materialCBR = 27,40 – 75,30 %
  - earthen embankement CBR = 7,80 – 13,60 %
- The dynamic deformation modulus by depth of embankement have values as follows u MN/m^2:
  - 1,0 - 1,5 m Evd = 14,40-64,30, Ev_1= 11,00-62,30, Ev_2= 19,10-138,60
  - 1,5 - 2,0 m Evd = 14,90-47,07, Ev_1= 11,23-42,84, Ev_2= 19,70-104,00
  - >2,0 m Evd = < 10-68,20, Ev_1= 18,50-66,20, Ev_2= 15,05-146,49.

Technogenous materials building up the lower railway structure have the following filtration characteristics [4,5,7,12,13]:

Protetcive layer (tampon), filtration coefficient range:

- K = 2,95 x 10^0 – 3,18 x 10^{-3} cm/s, which indicates that the material is very permeable

Embankement layer, filtration coefficient range:

- In the embankements built of sandy gravel K = 2,19 x 10^0 – 8,78 x 10^{-3} cm/s,which indicates that the material is very permeable
- In the embankement layer built of clayey gravel, clayey debris and clayey sand K = 2,88 x 10^0 – 4,25 x 10^{-5} cm/s, which indicates that material is very do middle permeable
- In the earthen embankements K = 2,01 x 10^{-6} – 5,24 x 10^{-7} cm/s, which indicates that material is middle to low permeable

Earthling'splanum (subsoil), filtration coefficient in earthenplanum are:

- alluvial (al) sediments range: K = 1,92 x 10^{-6} – 5,24 x 10^{-7} cm/s, which indicates that the material is slightly permeable
- diluvial (dl) sedimennts range: K = 3,95 x 10^{-5} – 1,75 x 10^{-6} cm/s, which indicates that the material is slightly permeable.

SEISMICITY OF THE TERRAIN

Seismicity of the terrain is defined by the seismological map of the SFRJ, 1987, for return periods of 50, 100, 200 and 500 years. The studied area is located in the V degree zone of MSK – 64 for the return period of 50 years, in the VI degree zone of MSK - 64 for a return period of 100 years, in the VII degree zone of MSK - 64 for a return period of 200 years and in the VIII degree zone of MSK - 64 for a return period of 500 years.

CONCLUSION

The conducted field research was done with the task to consider the characteristics of the terrain along the route of the railway between Doboj and Zenica on stationary km 103 + 500 - Maglaj. The railroad is intended for reconstruction in order to increase the speed of trains from the current 40 km/h to 120 km/hour. On the route of the railway, there are two tracks, one which was built in 1947 and another 30 years later. The field research in the part of the route that applies to both tracks was conducted, while the broader area was observed from the route, since the area outside the route is mined. Investigating trenching was conducted, the Evd experiments were done and samples taken for laboratory testing.

The route mainly passes by the base of the slope, respectively is placed in the valley of the river Bosna. The terrain along the route is of complex geological structure. By detailed analysethe next members are isolated: sediments of the river bed, which consists of Quaternary (Q) gravel - sand and fine-grained clay dust materials with significant participation of coarse grained fractions, alluvial (al) sediments of the river Bosna, proluvial (pr) and deluvial (dl) sediments, then neogene - miocene dacite (M), sandstones and sandy clays with fragments of rocks (J , K) and igneous rocks of jurassic volcanic- sedimentary ("diabase - chert") formations ($J_{2,3}$) presented microgabbros and massive peridotites .

The terrain is mostly conditionally stable to unstable, depending on the slope angle and sediment characteristics involved in structure. The steeper parts of the slopes are unstable, but the less steep slopes are unstable in terms of artificial disturbance of their natural balance. Poor maintenance of the terrain along the route of the railway, which has an impact on the railroad tracks, disrupted the stability of the slopes in some areas to the point of endangering the tracks.

The embankment characteristics determined by field and laboratory tests are different but in general can be taken to meet the minimum criteria. Yet along the entire route it is necessary to improve its features and reconcile them to both tracks. The values determined in Evdexperiments in the trenches are different and with the depth of the embankment are deteriorating, especially in the the peripheral channels for surface water drainage with poor maintenance.

The investigations are satisfactory at the level of detail, taken in account that the given section is divided into stationaries, where the characteristics of the terrain along the route and its immediate surroundings are complex.

The measures for the reconstruction of the railway, which will be able to meet the required speed will so be presented.

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