ZAŠTITA KOSINE NA PRISTUPNOM PUTU VE MESIHOVINA

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Sažetak: U radu je izvršen proračun stabilnosti i zaštite kosina na dionici pristupnog puta VE Mesihovina. Proračun je rađen u programu Geostudio (Geo-Slope International Ltd. Calgary, Kanada) uz usvajanje metode Spencera. Nakon izračuna usvojen je tip zaštite koji se koristi u cilju zašite kosina od lokalnih utjecaja.

Ključne riječi: stabilnost kosina, tip zaštite, usjeci.

SLOPE PROTECTION ON WF MESIHOVINA ACCESS ROAD

Abstract: In the paper, calculation of stability and protection of slopes on a section of the WF Mesihovina access road was performed. The calculation was carried out in the software Geostudio (Geo-Slope International Ltd. Calgary, Canada) with adoption of the Spencer method. After the calculation, the type of protection that is used for protection of slopes from local effects was adopted.

Key words: slope stability, type of protection, cuts.

1. INTRODUCTION

Along with existing or planned structures in the influence area, global stability of slopes should be examined with stability analyses or failure probability analyses according to one of the recognized methods:
- in soil with:
  - analytical calculations for assumed slip planes of simple shapes (flat, circular, logarithmic shape of slip plane) in homogeneous surfaces,
  - numerical calculations according to methods for assumed slip planes of circular, plane sections or complex shapes (methods of Bishop, Janbu, Morgenster and Price, Spencer, Sarma ....),
  - numerical calculations based on differential method.
- in stone materials (with reasonable use of the above methods) and with
  - graphical analyses (e.g. Markland test),
  - 2D and 3D analyses of stone block or wedge sliding,
  - numerical analyses according to the distinct element method,
  - slope classification methods (e.g. SMR – Slope Mass Rating).

A circular failure surface can be used for analysis of slopes of relatively homogeneous and isotropic materials. In cases when sliding may occur along the contact of two different layers of a surface or along an exceptionally poor surface layer, exclusive use of circular slip surfaces for stability analysis is not acceptable.

When selecting the calculation method, the following should be taken into account:
- stratification of surfaces,
- presence and angle of incidence of discontinuities,
- filtration and distribution of capillary water pressures,
- do we consider short-term or long-term stability,
- creep due to high levels of shear stress,
- type of failure (circular or arbitrary failure plane; overturning; flow).

When analyzing global stability of surfaces in earth or stone materials, all possible forms and modes of failure should be taken into account.
When analyzing stability, partial safety products must be used according to the principle of limit states method, and so for:
- effective shear angle γ_{φ} =1.25
- effective cohesion γ_{c} =1.25
- undrained shear strength γ_{cu} =1.40
- uniaxial compressive strength γ_{qu} =1.40
- self-weight of the ground γ_{γ} =1.00
- permanent load on the ground surface γ_{G} =1.35
- periodical load on the ground surface γ_{Q} =1.50
- analysis method γ_{M} =1.00 (or according to user's choice).

2. PROVIDING SLOPE STABILITY WITH STRUCTURAL MEASURES

It is possible to provide adequate safety for potentially unstable slopes with (2):
- change of slope geometry,
- vegetation protection (mainly as protection against erosion),
- drainage systems,
- retaining structures, such as stone blocks and gabions of wire netting or geotextile,
- earth or rock bar anchors,
- reinforcement of soil,
- concrete or reinforced-concrete support or retaining structure with or without anchors,
- combination of all the above measures.

2.1. Cut

Cut is a part of road structure that is formed by excavating the existing ground, or by cutting-in.

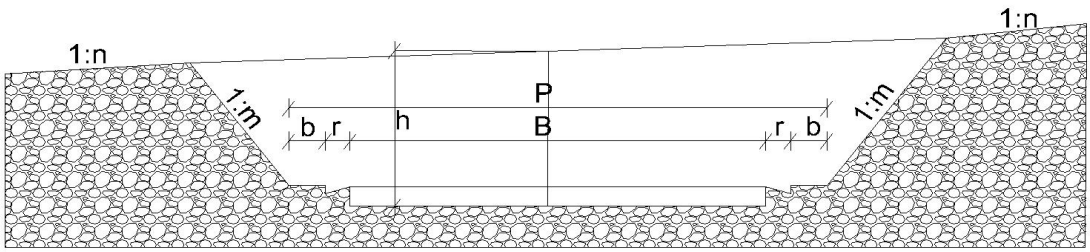


Figure 1. Cut

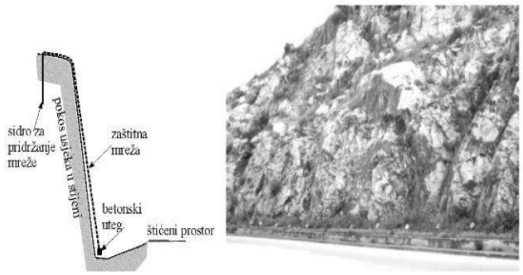
where:
1 : n – ground gradient;
1: m – cut slope gradient;
h – cut height;
P - subsoil width P = B + 2 r + 2 b;
B – pavement width;
r – gutter width;
b – berm width.

Geotechnical design solves the issue of global stability, and so by selecting stable slopes and defining slope protection for individual types of instability. The selected slope gradients must satisfy global stability on most of side cuts, and local occurrences of instability are solved by applying slope protection. Application of slope protection also solves the problem of erosional instability. In order for global stability to be satisfied, the excavation technology should be such as to minimally disrupt the structure. For cuts carried out in rock, it can be expected that some slope stability problems will occur during execution. Global instabilities are expected on limited stretches in weakened and crushed bedrock zones, related to faults. This is where higher presence of clay in cracks, rockfalls and fallout of individual blocks are expected. The geotechnical design defines systematic cut protection measures and defines the types of cut protection from local instabilities. This protection is determined directly in the

field, in the construction stage, by using defined standard solutions in cooperation with the geotechnical and designer's supervision.

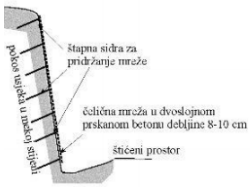
3. PROTECTION TYPES

The following types of protection and planned for protection of slopes from local effects:
TYPE 1 - slope protection by using meshes.
TYPE 2 - slope protection by shotcrete.
TYPE 3 - slope protection by fixing individual blocks with anchors.
TYPE 4 - slope protection by mesh, anchors and steel strands.
TYPE 5 - slope protection using shotcrete, anchors and reinforcement meshes.
TYPE 6 - slope protection by crushed stone infill and treatment of slope face by laying stones in concrete.



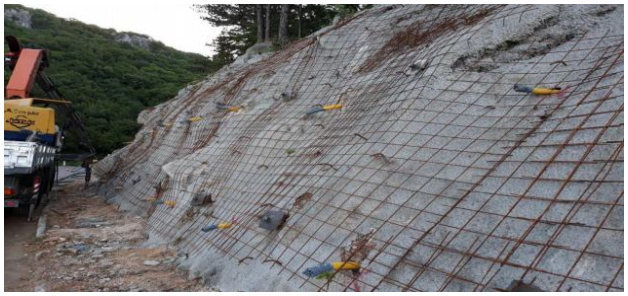
(1)

(2)



(3)

(4)



(5)

(6)

Figure 2. Types of slope protection

3.1. Road profile number 12, 9+075m -adoption of slope protection type

The calculation profile was made based on input data collected in the field (6). On profile number 12, 9+075 (6) there is a cut that is made in the slope on the right side 3.85 m in height, while on the left side there is no cut. On the subject part of the road, cut is designed with gradient 3:1. In the area of the subject cut, rock is mostly visible on the surface, and the bedrock is limestone. Engineering geological mapping was carried out on the subject stretch. Data on soil strength, cohesion and angle ϕ, which were used in calculation, were obtained from the collected data. The following figure shows the cross section of soil where the cut should be made.

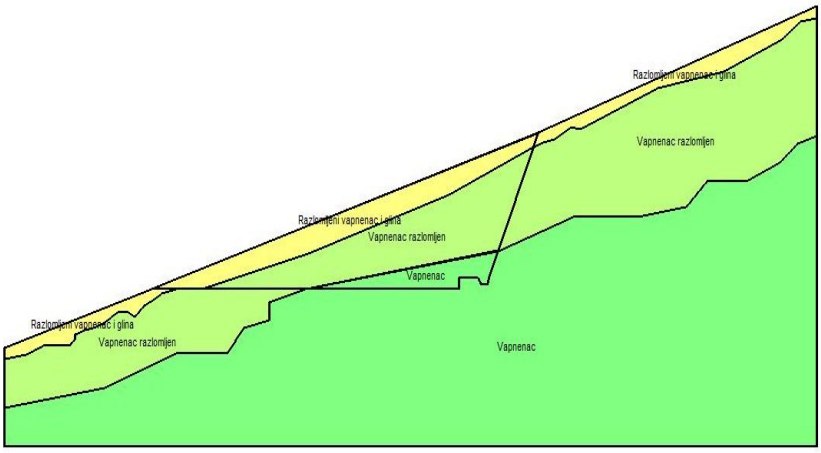


Figure 3. Cross section of soil layers

The stability calculation model is shown in the figure below.

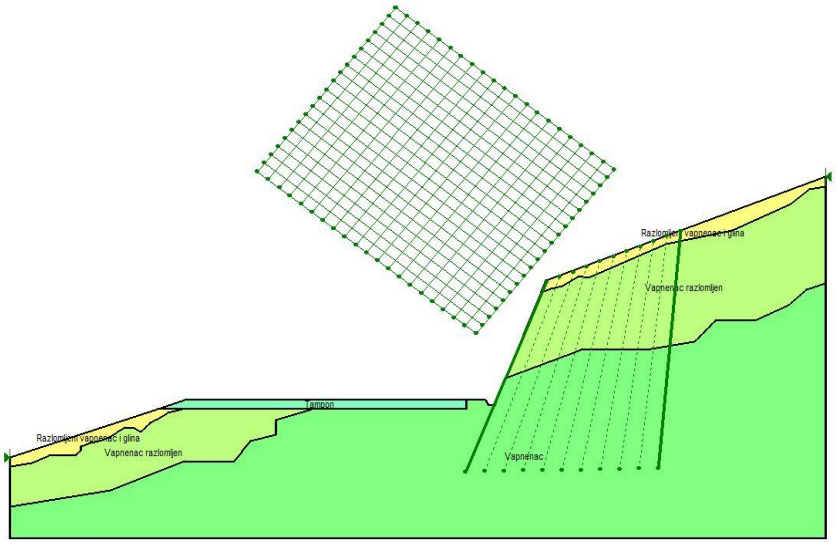


Figure 4. Calculation model

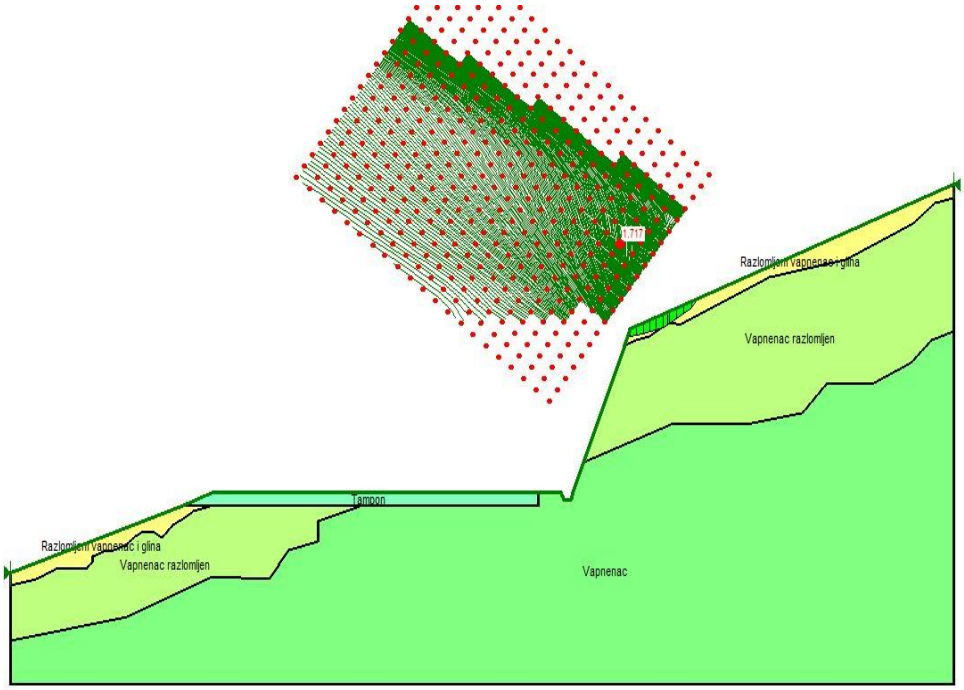


Figure 5. Cut locally

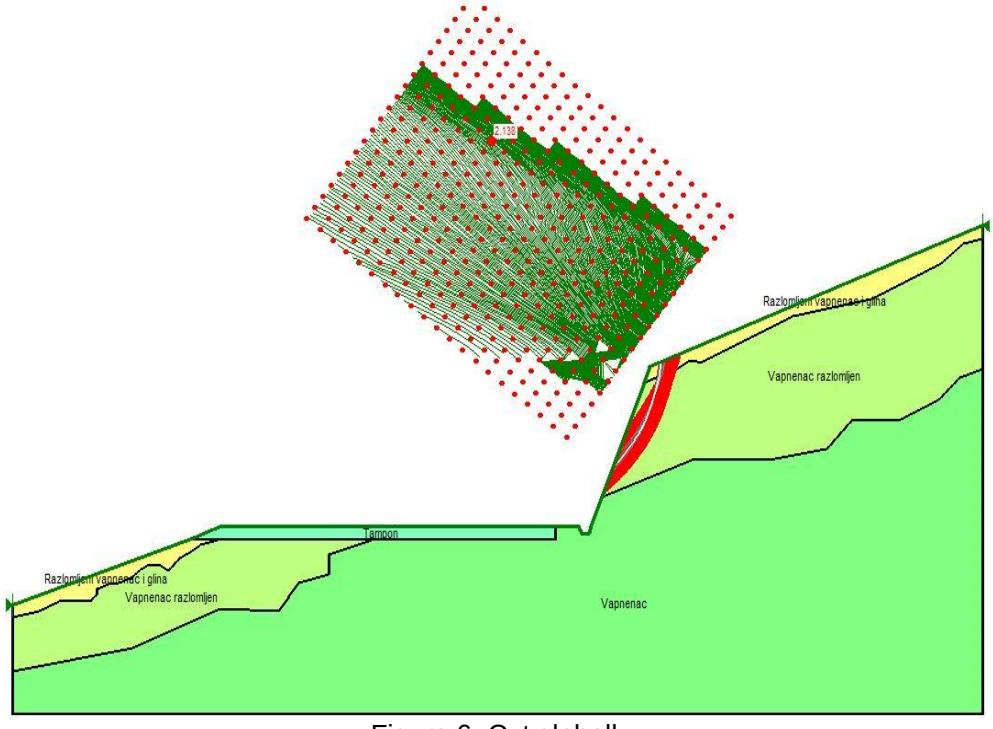


Figure 6. Cut globally

Results of the calculation of cut slope stability according to Eurocode 7 indicate the minimum safety factor: F_{YM} = 1.717 (locally) and F_{YM} = 2.138 (globally), which is higher than the partial soil strength coefficient for drained conditions Y_M = 1.25.

Protection of the cut in rock significantly depends on the quality of blasting and cleaning of slope after blasting. Actual surfaces that should be protected will be determined during the stage of excavation works, through geotechnical supervision.

PROTECTION TYPE 1 is adopted for this cut.
TYPE 1 - is the protection of slopes by using meshes (Guidelines for design, construction, maintenance and supervision on roads, Volume II: Construction, Part 2: Special Technical Conditions, subsection 2.2.2.5.) (8). That is a usual slope protection in stone slopes, which prevents small rocks from falling onto the road. Erosion inevitably occurs on slopes over time due to atmospheric effects, and in particular the freezing and thawing cycles. Meshes prevent stone fragments from falling on the road.

3.2. Road profile number 19, 14+450m -adoption of slope protection type

Calculation profile was also carried out on the characteristic profile, number 19, chainage 14+450, (6) of the access road based on EG mapping and engineering geological model of the terrain. All calculations were conducting with the software Geostudio (Geo-Slope International Ltd. Calgary, Canada) with adoption of the Spencer method.

The calculation profile was made based on input data collected in the field. On profile number 19, 14+450 (6) there is a cut that is made in the slope on the right side 5.05 m in height, while on the left side the cut is 1.65 m in height. On the subject part of the road, cut is designed with gradient 3:1. In the area of the subject cut, rock is mostly visible on the surface, and the bedrock is limestone. Engineering geological mapping was carried out on the subject stretch. Data on soil strength, cohesion and angle ϕ, which were used in calculation, were obtained from the collected data.

The following figure shows the cross section of soil where the cut should be made.

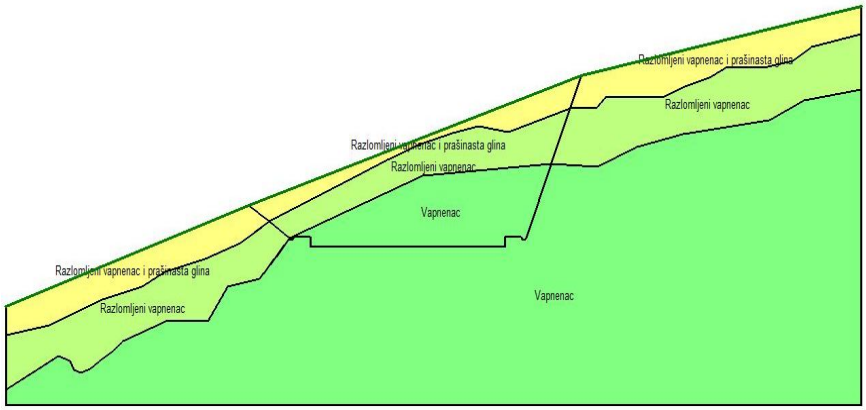


Figure 7. Cross section of soil layers

The stability calculation model is shown in the figure below.

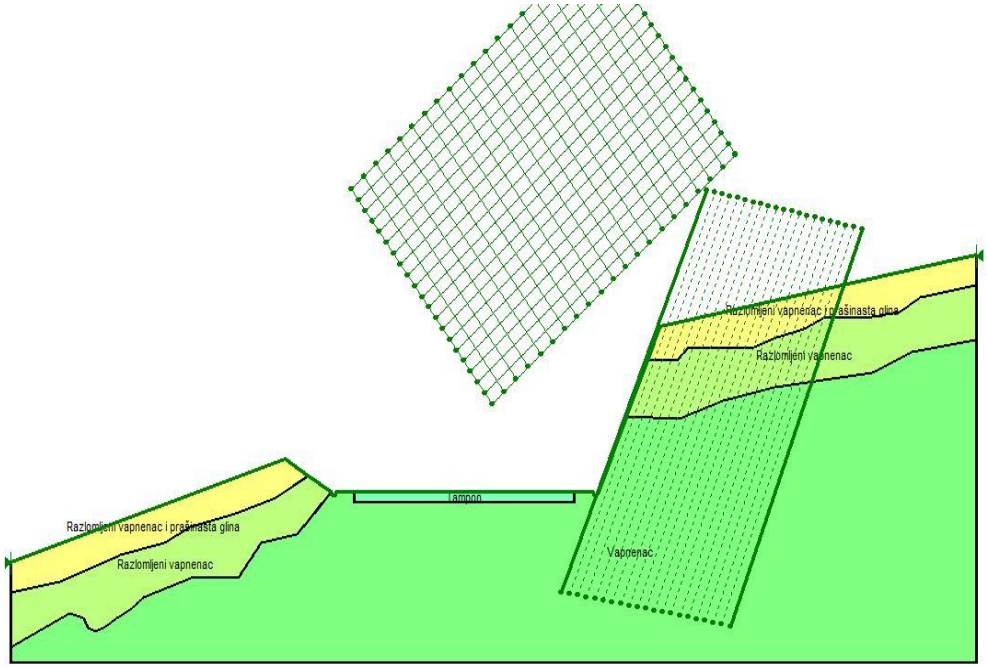


Figure 8. Calculation model

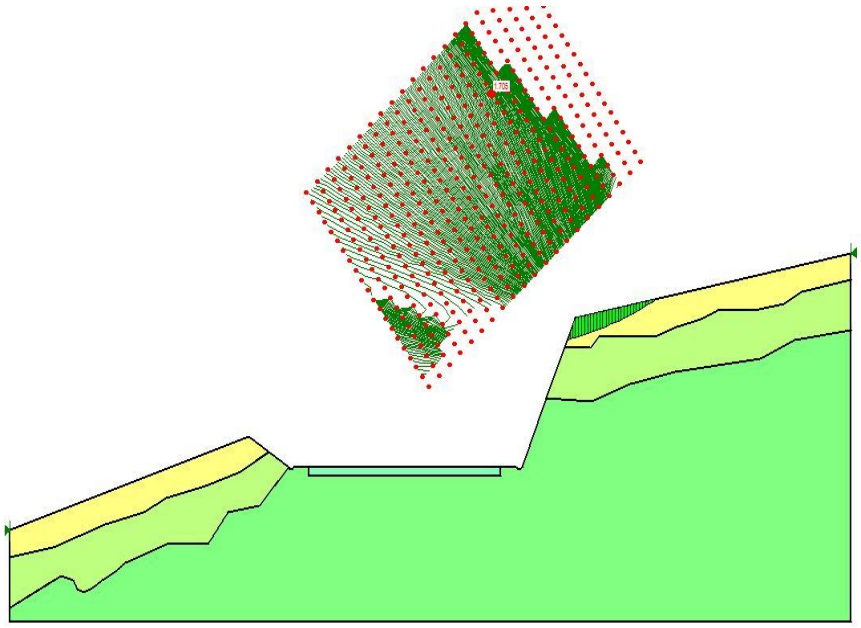


Figure 9. Cut locally

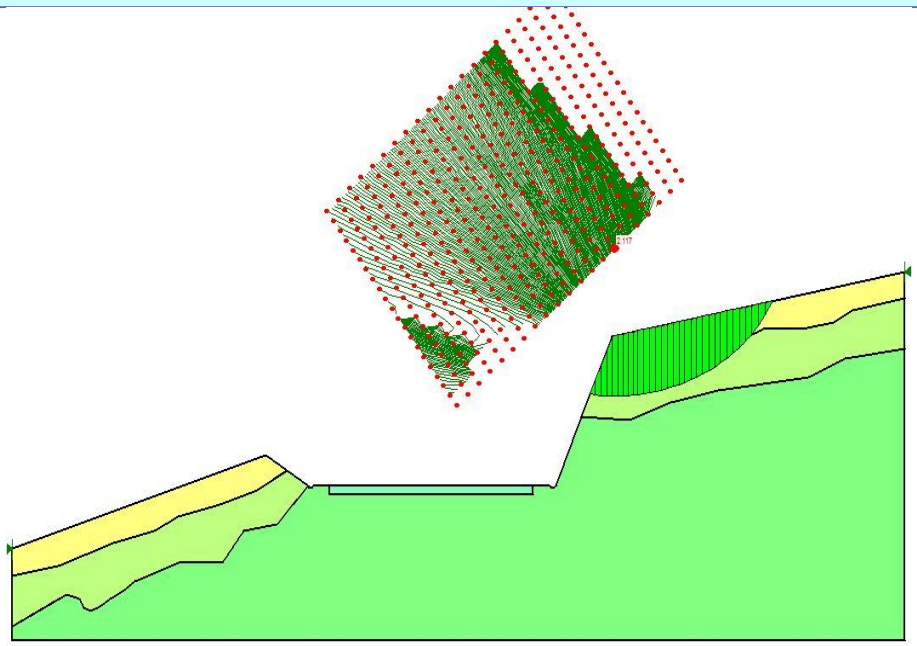


Figure 10. Cut globally

Results of the calculation of cut slope stability according to Eurocode 7 indicate the minimum safety factor F_{YM}=1.705 (locally) and F_{YM}=2.117 (globally) which is higher that the partial soil strength coefficient for drained conditions Y_M=1.25.
PROTECTION TYPE 2 is adopted for this cut.
TYPE 2 - is the protection of slopes by mesh and shotcrete (Guidelines for design, construction, maintenance and supervision on roads, Volume II: Construction, Part 2: Special Technical Conditions, subsection 2.2.2.5.) (8). This work comprises protection of slopes of rock materials that are susceptible to erosion due to climatic or mechanical effects, i.e. where rocks are susceptible to more intense weathering and where there are layers or pockets of clay. Slope protection with shotcrete is applied in places where more intense erosion is expected on slopes. Positions for application of TYPE 2 protection are determined during excavation of the cut, through geotechnical supervision. After excavating a working level, mesh is placed like in TYPE 1 protection, and a protective layer of shotcrete 3-5 cm in thickness is applied over the meshes. In order to prevent hydrostatic pressure from forming between the rock mass and shotcrete, it is planned to make short drains (soakaways) 3.0 m in length. Drilled drains are made on a grid 2x2 m.

4. CONCLUSION

Protection of slopes is one of the most important parts of design when constructing roads. Two types of protection are treated on two characteristic examples of cuts on a section of the access road for WF Mesihovina. Calculation profiles were carried out on profiles 12 and 19, (1) in the software Geostudio (Geo-Slope International Ltd. Calgary, Canada) with adoption of the Spencer method. For locations of the characteristic profiles 12 and 19 of the access road, on the basis of EG mapping, engineering geological model of the terrain is presented with extraction of separate units. This example shows project solutions and obtained safety

factors, based on which guidelines are given on how to perform the protection, for which type and at what gradient.

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