Preservation of slope stability along the by-pass Vlora

Maintien de la stabilité des pentes dans le contournement de « vlora »

Bozo L.
POLIS University

Allkja S.
ALTEA& GEOSTODIO 2000 Shpk

ABSTRACT:The development of the tourism in Albania is a very profitable branch of the economy. For this reason we have request to construct much new roads. One of them is the road to Jonian sea side which is with rarely beautiful nature. In this zone has constructed much restaurants, hotels, touristic resorts, but the access to them is difficult because the low quality of the existing roads. In these conditions is decided construction of the by-pass Vlora, and we have accomplished the geological and geotechnical study along the track of the new road. By this study we have in evidence : a) all dangerous phenomena's which can appear during the construction of the road, b) the sites where the road will passes by viaducts and bridges, c) the zones where the road will passes by cuts, d) the zones where the road will passes by embankments. In this paper we would like to present our study about the road's section which passes by cuts in hills terrain. By in situ tests and laboratory tests we have determined the kind of cuts, their geometrical forms in manner to protect environment and stability of slopes. Also we have take some classifications of cuts in this road regarding real conditions of the terrain.

RESUME: Le tourisme en Albanie est l'une des activités les plus profitable pour l'économie du pays. Afin d'en accélérer le développement, le pays à souhaiter construire un grand nombre de nouvelles routes. L'une d'entre elle est la route qui conduit au littoral de Jonian, site naturel d'une grande beauté. Dans cette zone ont été construits beaucoup d'hôtels, de restaurants et des stations touristiques. Malheureusement, l'accès au site de Jonian est difficile à cause des routes de qualité médiocres. Aussi, a été décidé la construction du coutournement de "Vlora" et à cette occasion, de nombreuses études géologique et géotechnique ont été effectué. Grace à ces études in-situ, nous avons pu a) détecter les phénomènes dangereux qui sont susceptibles d'apparaitre pendant de la construction de la route, b) identifier les sites où la construction de la route Allait induire la construction de viaducs et de ponts, c) les zones des excavations seraient nécessaires, d) les zones où des remblais devraient être édifier. Dans cet article, nous souhaitons présenter notre étude sur la portion de route pour laquelle des excavations ont été réalisées. Par le biais d'essais in-situ et d'essais de laboratoire, nous avons pu dimensionner les excavations à effectuer en tenant compte de la problématique de la stabilité des talus.

KEYWORDS: cutting, slope, stability, geological study, geotechnical study, environment, classification.

1. INTRODUCTION

The new road "By-pass Vlora" passes in the hill's and mountain's zones, which intersects several small streams and rivers. In the 29 km of their length 80% of the road passes in cutting and 20% in embankment. The hills of east part of the city Vlora are longitudinal of the direction of the Vlora By-pass. These hills are built from sedimentary rocks and they form steep rocky slopes. The soft slopes of these hills are transformed into agricultural lands, while the deep slopes are covertures with small trees. The intention of the study is the determination of the physical and mechanical properties of the soils and rocks encountered in the area where will passes the new road. The data taken from field and laboratory works will be useful to made the detailed road project for embankments, cutting, new bridges, or viaducts etc. Also from geological and geotechnical study can judge for the dangerous phenomena's which can appear during the construction and exploitation of road and for the selection of the construction material. These properties are determined by specimens from bore-holes, trial pits, refraction seismic tests, field tests, and laboratory tests. We wont to present in our study the following problems:
The evidence of the dangerous phenomena's for the road and environment.
Determination of the physical and mechanical properties of the soils and rocks in this zone.
The evidence of the zones where the road passes in cutting and their calculation.
Classification of the different cutting's types.
Engineering measures for the protection of the equilibrium of the slopes and environment in the zone of the new road.

2. PHYSICALGEOLOGICALAND GEODYNAMICAL PHENOMENA'S

By Albanian geological map, existing investigations and new information from our study, in the zone where will passes the new road, we have evidenced or observed the following geological phenomena's:[1]

2.1. *Erosion Phenomenon*

This phenomenon is visible in all hilly part of the road's axis. The heavy rainfall, the current of the surface water, the inclination of the slopes, the type of the soils and weathered part of core formation are causes of this phenomenon. The body of road is at the middle part of the valley and it is exposed to this phenomenon and negative action of the erosion. For this we recommended not only remove the water by means of ditches, but during excavation, the road must protected in the upper and bottom part, to not allow erode of the slope's material, small surface slides and detaching of the mass rock.

2.2. Weathering Phenomenon

This phenomenon is visible at the rock formation that are composed by sedimentary rocks(mudstone, sandstone, conglomerates), which are new deposits with weak clay cementation. Under the action of the atmospheric agents they are transformed from weak rock to soils. When the road passes in cutting in the zone with clay rocks we will be attention and we will take the engineering measures to protect the stability of the environment.

2.3. The movement and sliding of the weathered mass rocks

From the beginning of the new road we have identified some zones with limited area landslide. The kind of the instability are:
Slide of the colluviums
Slide of the upper part of the weathered rocks
Rock landslides
Debris flow
We thing that , the design of this road to show maximal care for the stability of the slopes during and after the construction of the road and a special attention must to paid for the protection of the foundations of the bridges that are on the slopes prone to slide.

2.4. Activity of the tectonic movements(tectonic faults)

In Albania there are a developed regional tectonics, which is mainly horizontal with a
,low angle over thrust and others secondary tectonic movement.[5] The eastern areas have moved with a low angle over thrust towards west. This phenomenon has caused a total destruction of the rock mass in 7 km length of the road, and it is associated with a lot of other local tectonics. These zones are founded in the contact between different rocks, or inside the same rock. As result of this phenomenon in the hills side many rocky mass have moved toward the relieve fall and have created a rocky bent relieve. We must be very attention to not destruct the existing brittle, or frail equilibrium.

2.5Seismic Hazard

After Albanian Seismic Code [4] the zone to be studied is classify (by MKS-64) with intensity 8 ball and the soils in the second category [ ]. For calculation of the slope stability, by [2] we can use a_{max} = 0,2g, and the deep of epicentrum 25-30 km. For these conditions some of the observed slides can to reactivate caused the destruction of the road.

3. GEOLOGY AND HYDROGEOLOGY

The geological structure of the studied area[1] is composed by sedimentary deposits, limestone rocks, and granular rocks as below:

3.1 Limestone rock (Pg_2, Cr_2, Cr_1, J_1, J_{2-3} up T_3).

They have white to grey color, little cracks, in some part karst phenomenon, very resistible against atmospheric agents, very good characteristics for the foundations of the bridges, stabilized slopes and for the embankment.

3.2 Paleogene's deposits (Pg_1, Pg_3^I).

They are flysch deposits, brown to beige color, medium to weak cementation, in superficial part weathered, they form unstable slopes and at Radhima is very active sliding zone.

3.3. Neogene's deposits (N_I^{2h}, N_I^{2t}, N_I^3).

They are composed by mudstone, sandstone and rare conglomerates, conglobreccias, brown to beige color, good to weak cementation with superficial part weathered. In the mudstone layer and colluviums drposits can observed landslide.

3.4. Quaternary deposits (Q_4),

Are alluvial, torrent and colluviums deposits. Alluviums of the Dukati and Shushica rivers are consolidated gravel, sands, silty- sands, silty- clay, with 20-25m thickness. Elluviums or torrent deposits are moderate consolidate silty- clay, silty- sands with 8-15 m thickness. Colluviums are presented by silty- clays and gravely-silty-clays, moderate consolidated, unstable and with 2-4,5m thickness.
The level of the underground water is deep and the water is not aggressive to concrete and steel.

4. FIELD AND LABORATORY INVESTIGATIONS

For the part of the road that passes in cutting or over embankments, we have made trial pits which passes by viaducts and bridges, we have made bore-holes until 10-40m depth. At the same time we have realized SPT-tests and laboratory tests in ALTEA laboratory from samples taken by BH. From laboratory test[1] we have determined physical and mechanical properties for the soils, some characteristics for the rocks, and LA, soundnes, Proctor, CBR etc for the disturbed soils and rocks which will be serve as building material for the road and embankment.

4.1. Results of the site investigations.

From BH we have discover some different layers and we have compile the geological profile.

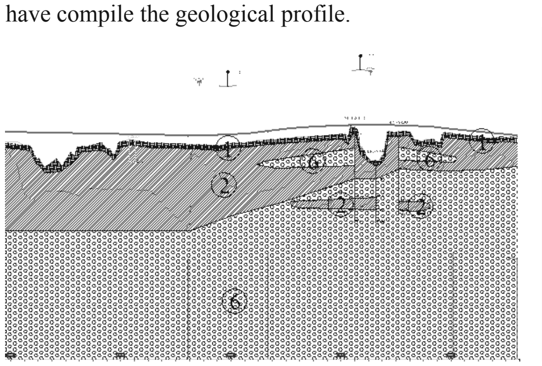


Fig. 1 Geological Profile

4.1.1 *By description of layers and SPT-tests we have evidence six layers (Table 1)*

Table 1. Description of the different layers

Nr.of layer	Description	Thickness(m)	Classification	N_{SP}
1	soft brown silty-clay	3-4	CL	9-12
2	medium dense silty-clay-gravel	3,5-4	GC	24-28
3	clayey's elluvium	6-8	ML-CL	60-80
4	sand's elluvium	4-6	SM	50-60
5	gravel and sandy-silty-gravel	7-14	GM	35-50
6	moderately weak mudstone and sandston	7-30	-	80-12

4.2. Results of laboratory investigations

From laboratory tests we have determined the following parameters :
Grain size distribution

Moisture content W = (5-29)% mean 15%
Specific gravity γ_0 = (26-27,2) kN/m^3 mean 26,5 kN/m^3
Bulk density γ = (18,8-23) kN/m^3 mean 19,5 KN/m^3
Limits of plasticity (liquid) LL= (18-50)% (plastic) PL = (13-28)% mean 34% and 25%
Void ratio e = 0,355-0,743 mean 0,62
Resistive parameters of soils by direct shear test : C = 22-25 kPa mean 23 kPa ϕ = 22^o-24^o mean23^o
Bearing capacity R = 150-300 Kpa mean 200kpa
Modulus of deformation E = (0,4-0,7).10^4 kPa mean 0,55.10^4 kPa etc.

4.3. Correlation between different soil parameters.

After elaboration of the results from laboratory tests and in situ tests we have take the following correlations :
Correlation between bearing capacity of each layer "R" and percentage of gravel.

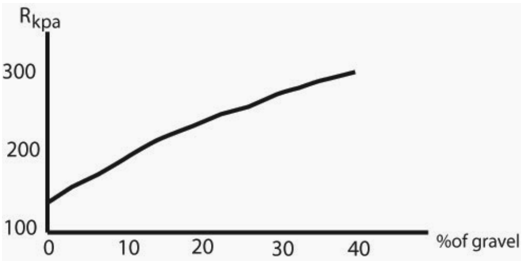


Fig.2 Correlation between R and percentage of gravel

Correlation between bearing capacity "R" and percentage of silty grains

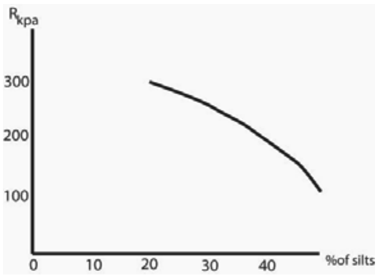


Fig.3 Correlation between R and percentage of silty grains

Correlation between bearing capacity "R" and modulus of deformation "E"(fig.4)

.

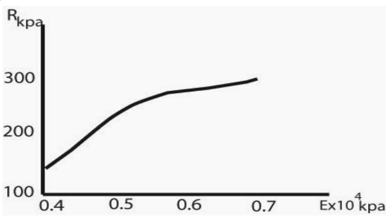


Fig.4 Correlation between R and E

Correlation between N_{SPT} and void ratio "e"

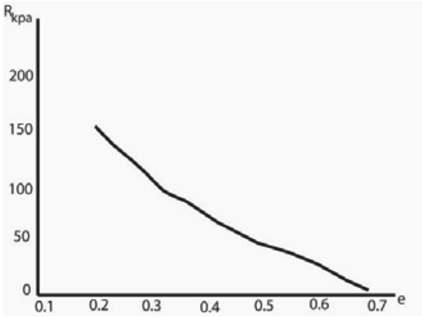


Fig.5 Correlation N_{SPT}-e

Correlation between N_{SPT} and percentage of gravel grains

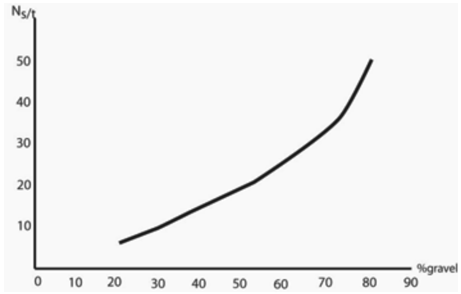


Fig.6 Correlation N_{SPT} and percentage of gravel grains

By the results of the test in direct shear apparatus we have the following values :
In the upper layers (3-5 m depth), which are "UCS" classification are silty-clay, maximum shear strength is 0,88, that to say the soils are with low sensibility.
The "pic" value and the "residual" value of the resistive parameters of this layer are : ϕ_p = 23^o-24^o ϕ_{res}= 20^o; C_p = 20-25KPa, C_{res} = 10KPa
From static loading test, for the upper layer (3m depth) they are suitable for the construction of the road because they have R>150KPa and E> 40MPa.

5. THE CHOICE OF THE CUTTING'S TYPE

The choice we base in our calculations about the stability of the cohesive slopes that have :
γ = 19-20 KN/m^3, ϕ = 23^o-$24^{o,}$ C = 20-25 KPa. In the zones where are visible slides we have determined the depth of the sliding surface (4-5)m and residual resistive parameters of the soil ϕ = 20^o, C = 10 Kpa. For the seismic zone with magnitude M = 5,5, depth of epicentrum of the earthquake 25- 30 km, second category of soils and a_{max} = 0,2g, by [3] we have take the coefficient K_s = 0,07 for the calculation of the supplement earth inertial force. The factor of safety "FS", in general, is FS = 1,5-1,8 but we have the cases when FS,1,3. The types of cutting choice by us satisfied three conditions:
Preservation of existing equilibrium of natural slopes
Unloading of the part of the slopes when they are in limit state (FS,1,3).
Harmonization of the cuttings with environment to create beautiful landscape.
5.1Classification of the cuttings
For the road with length 29 km, where 80% passes in cutting, by our study we have made some classification:
5.1.*1Classification by relief*

The hills when passes the new road have the slopes with inclination 10^o-35^o and more.
Regarding this relief we have use four categories of cuttings

Table 2 Classification by relief

Category	Slope inclination	Nr.of escalations	Schema H_1 H_2
1	$(8\text{-}14)^o$	1 and 2	3-8 2-4
2	$(15\text{-}22)^o$	2 and 3	8-15 1,5-3
3	$(23\text{-}30)^o$	2 and 3 in	8-14 3-14
4	$(31\text{-}35)^o$	5 and 6	18-24 10-28

5.1.2*Classification by geological conditions*
In the unstable slopes we have choice two categories of cuttings:
Construction of the cuttings by excavation of the part of the sliding mass

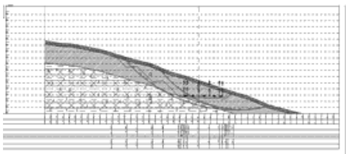
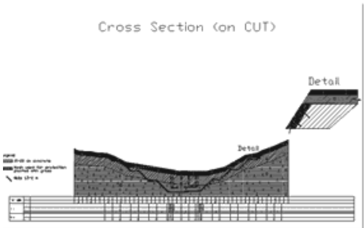


Fig7 Cutting by exavation in the sliding mass

Construction of the cuttings based in the stable rock mass and preservation of slopes by nails protection mesh and concrete slab.



5.1.3*Classification by geotechnical properties of the slope's soils*
Regarding the resistive soils parameters of the slopes and characteristics of the rock mass of the slopes also the inclination and fault direction of the layers in slopes, we have design three categories of slopes (Table 3)

5.1.4. *Classification by geotechnical properties*

Table 3

Geotechnical characteristics)	High(H),width(b),inclination(α
Rock mas R_c = (50- 60)Mpa	H = (3-6) b = (2-3)m α=60^0-65^0 m=2:1
Medium cemented soils ϕ= 25^o C = 50KPa	α= (60-65 $)^o$ m = 2:1 H = (3-5)m b= (2-3)mα= 45^o m = 1:1
Silty-clay soils ϕ = $(20\text{-}23)^o$ C = 20KPa	H = (3-5)m b = (2-3)m α= $(33\text{-}35)^o$ m = 1:1,5

5.1.5. *Classification by dangerous phenomena's.*

Regarding the more dangerous phenomena's which can appear during the construction and exploitation period of the new road, we have made the following classification.
In the colluviums zones ,which are in limit state of equilibrium, we can predict the protective geotechnical structures as piles, sheet piles and retaining walls
In more weathering zones we have predict protective geo-synthetic covertures combined with different vegetable
In the rock zones with intensive erosion phenomena's or weathering phenomena's we can use protective metallic mesh combined with metallic construction

6. CONCLUSIONS

For the new road "By-pass Vlora"that passes in cutting we have take the following conclusions:
By geometry we have classify three types of cuttings:
With big cut in left side
With big cut in right side
With two big cuts in both sides
By cutting's height we have three classifications:
Shallow cutting H = 5m - 6m
Middle cutting H = 6m – 15m
Deep cutting H > 15m
By intersect layers the cuttings are classify:
Cutting which intersects 1 layer
Cutting which intersects two or more layers
Regarding the dangerous zones we have classify:
Cutting without the sliding plane
Cutting with presence of the sliding plane
Regarding the base of the road in cutting we have classify:
Cutting based completely in the same layer
Cutting based in two layers
Cutting based in core formation
partially in embankment
Escalations we have made regarding the inclination of the terrain to secure esthetical harmonization with environment, not damage of the environment and security for the road.
In the sliding zones we must undertake (predict) the following engineering measures:
Excavation of the soils over sliding surface to unload the slope
Construction of the retaining walls, anchorage walls etc
Enforcement of the slopes by piles, micro-piles etc
In the zones that have evidence the rolling rock mass must take the following engineering measures:
Horizontal drainage
Enforcement by metallic nyle mesh combined with metallic profiles
Use vegetable revetment
Enforcement by geo-synthetics, concrete revetment etc

7. REFERENCES

Altea & Geostudio 2000 Shpk 2011 Report on the geological and geotechnical conditions of "*Vlora by-pass" Tirana*
Bozo L. *1989 Behaviour of the basements and foundations under seismic action-*
Ph.D. Thesis Tirana
Bozo L. 2004 *Soil Dynamics – Vol. 1,2,3 Press "Natyra" Tirana*
KTP-Antisizmic (Albanian Seismic Code for construction design) 1989 Tirana
Landslide and Geo-environment 2011 Proceedings of the International Symposium Press "Natyra" Tirana