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Full Length Research Paper

Determination of physical mechanical parameters for the exploitation of coal in regard to geotechnical Safety

Hysen Ahmeti[1]

[1]University for Business and Technology; Faculty of Civil Engineering and Infrastructure; Republic of Kosovo, Pristina.E-mail: hysen.ahmeti@ubt-uni.net; ORCID: 0000-0001-9348-6238.

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Abstract

Based on the ever-increasing demands for electricity production in the Republic of Kosovo and beyond, within a year, 7 to 8 million ton of coal are needed. Coal exploitation is a very urgent requirement in order to meet the needs of the community for electricity production. Upon request, it is foreseen to perform additional drilling to define the layers of coal cover from the Geological Geo-mechanical and Hydro-geological aspect. This should happen to have a more realistic overview of coal exploitation in order to supply existing power plants, also those that are planned to be built in Kosovo, respecting the Standards of the European Union. In order to have a clearer idea, additional drilling are realized in the period 2017/2020, which is presented in the situation map Figure no.1 and which is the purpose of this research. Taking samples from drilling to extract physical-mechanical parameters was the focus of the research. To calculate the mechanical parameters such as hardness, φ^{o} angle and the cohesion C, three tests are applied; triaxial test, direct test and torsion test, which were performed in the laboratory of mechanics at INKOSË Institute-according to ISOO 9001 standards. To calculate the slope angles and height, designed according to the profile II-II 'Fig.15, to have a long-term safety factor during technological operations for coal mining in the surface mine and for calculation of existing slopes and those planed, in this research are applied geotechnical Euro-codes EC- 7. For the realization of the safety factor, two forms of calculation are used, according to the geological layers, the circular shape and the polygonal one. The circular shape is applied to the coal cover, while the polygonal one to the coal seam. The calculations of height and α angle in the slopes geometry with the safety factor are presented in Table.9,10,11

Key work: Physico-mechanical parameters, coal geotechnical safety.

INTRODUCTION

Exploration in the coal basin of Kosovo, defined as large coal reserves, began in the 50's of last century. Initially with some underground works, and later with the advancement of technology, it became possible to open a mine in the southwestern part is part of the municipality of Kastriot previously known as Obiliq.

Based on the increasing demands for coal, in 2006 was approved the discovery/excavation of the source in the southwestern part of the city, which will be used at full capacity according to the requirements of the existing power plants of the Kosovo A and the Kosova B power plant.

These works have also served as an information sample of geological-engineering character on which the technology should be designed according to geo-mechanical parameters. The lignite reserves in Kosovo are estimated to be around 10 billion tons, which are concentrated in the Kosovo Coal Basin. Kosovo is ranked in Europe in terms of lignite reserves. The exploitation of coal, with its geographical position, is favorable for the construction of a new power plant that is expected to be built soon in Kosovo, in order to supply energy to the community in general with the help of the European Union.

1.2 Potential research objectives

Geological assessment and interpretation was performed for an area of four km². This includes the part of the active mining area where coal is being exploited to generate electricity for the citizens of Kosovo and beyond. In this area, 28 drillings were carried out according to the situation map Fig.1 with a depth of 150m - 170m up to the contact with the green clay, including the coal cover for a more accurate identification of the geological / geo-mechanical layers according to Fig.4. The parameters that should be considered are: tectonic cracks, geo-mechanical parameters, groundwater level, as well as any feature of the presence of fires that would negatively affect the process of coal mining both from the technological point of view and from the aspect of geotechnical safety ref [1,2]

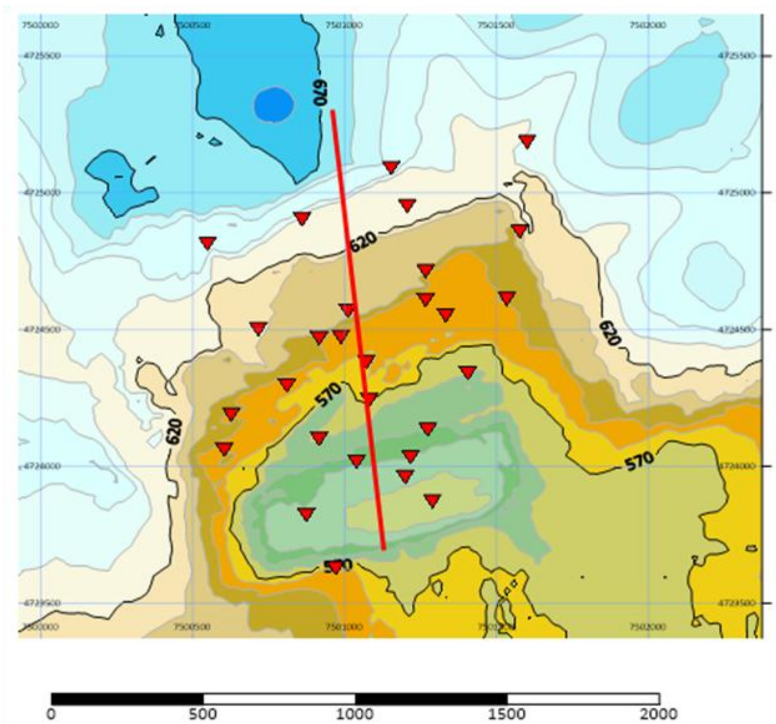


Fig. 1. Geodetic map of the mine with drilling position.

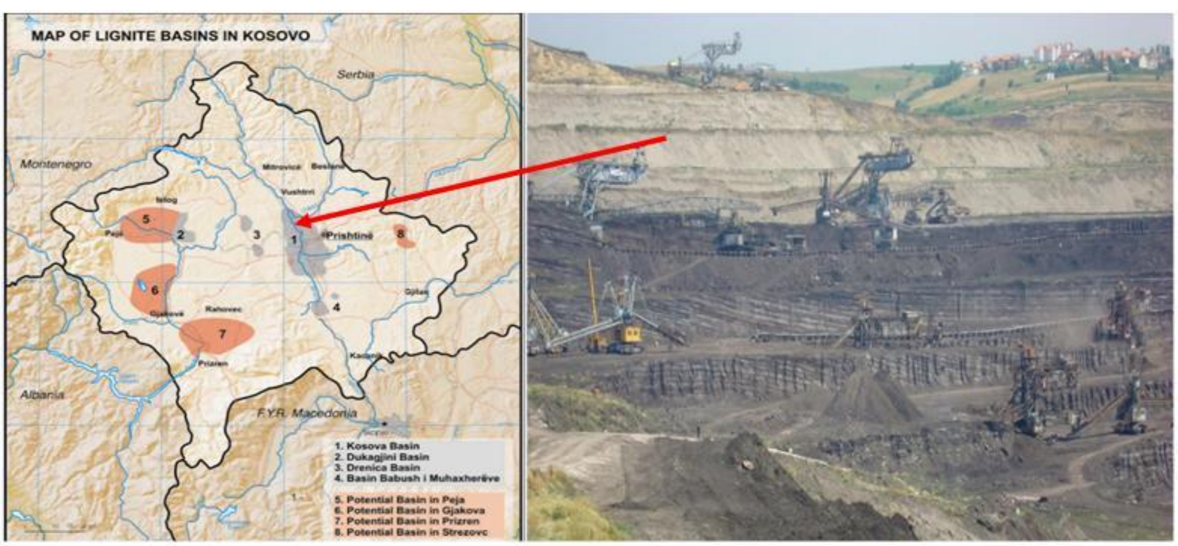


Fig.2. Geological map of Kosovo with drilling position.

Geographical position of the mine

Lignite deposits in Kosovo are located between the city of Mitrovica in the north and Kaçanik in the south. The Kosovo Coal Basin covers about 85 km from north to south with an average East - West extension of 10 km. In this way, the deposit is about 850 km². Morphologically, the Kosovo Basin forms an expanded valley where height differences do not exceed 80 m. In the banks of Sitnica river lies the central flat part with a more hilly terrain approaching the Çicavica, Golesh and Sharr mountains according to Fig.2

Geological characteristics

From a closer look of the geological map Fig, no.3 Kosovo Basin is mainly a tectonic zone filled with tertiary sediments. The Basin area is represented by Paleozoic rocks and to the east Upper Cretaceous sediments. In the coal basin of Kosovo are developed, in addition to tertiary sediments, quaternary sediments that have a hydrogeological character

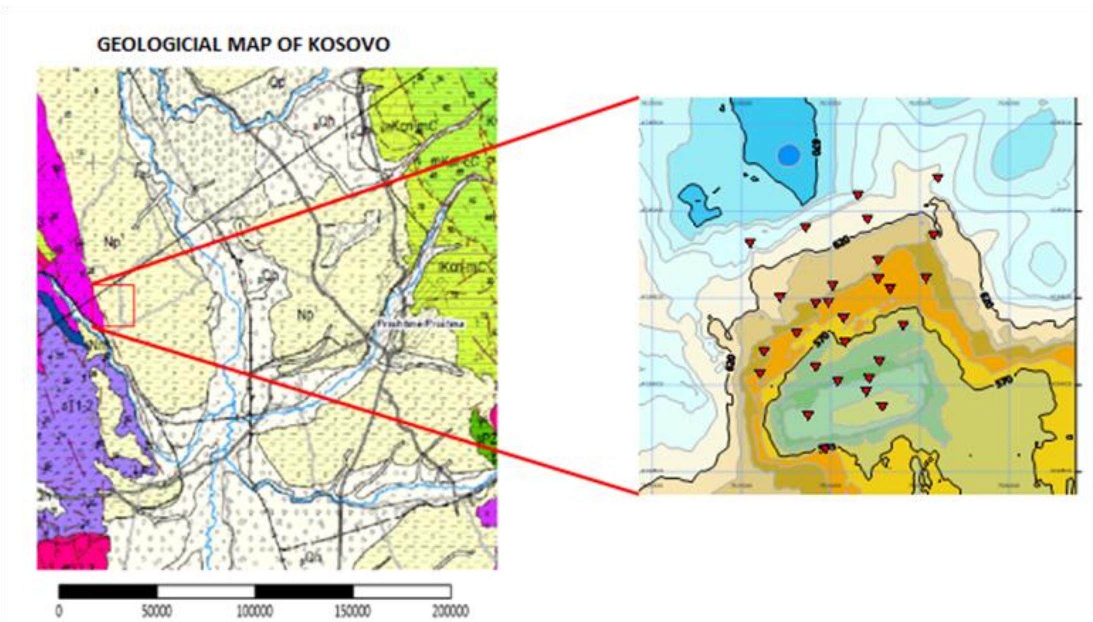


Fig.3. Geological map of Kosovo with drilling position

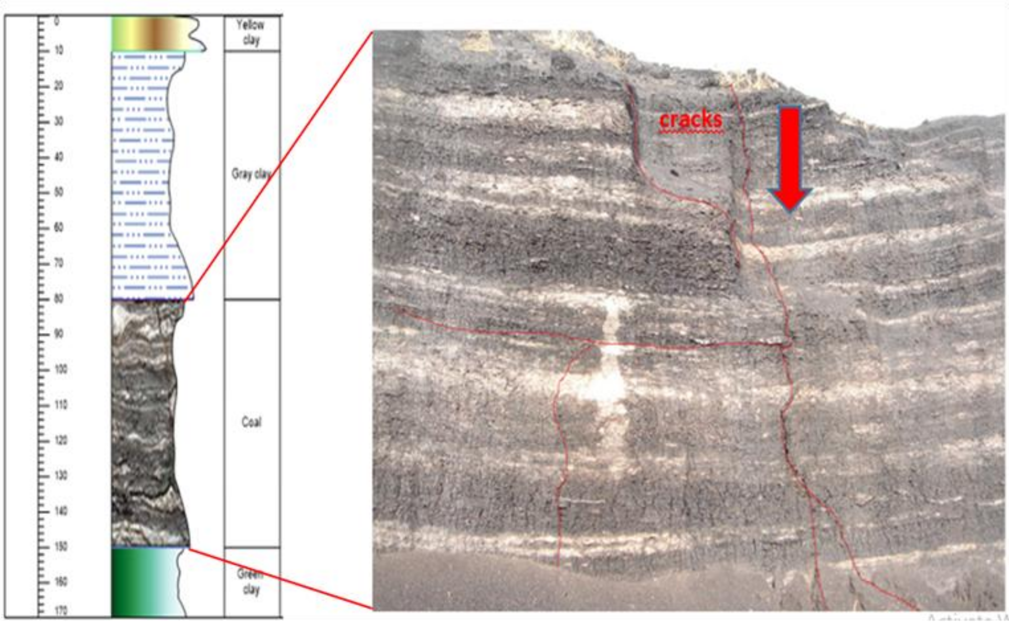


Fig.4, Geological description of drilling.

In the mine area, in the south-west mine, from the drilling and research process, it was found that in the coal layer is present a small layer of clay with dimensions 0.20 m-0.50m. This would reduce the quality of coal in terms of calorific value according to Fig 4.5 and at the same time, it will negatively affect the stability of the slopes that can lead to the detachment of coal in the form of blocks during mining activity. Then, with the data collection and implementation, we will have a more productive approach to finding the permissible safety factor according to geotechnical standards in the mine. ref [2,9]

Basin tectonics

In the western direction, the coal is tectonically associated with series of slips mainly in the N-NW / S-SE direction. The eastern boundary is characterized by sedimentary straits. Kosovo basin tectonics is complex. This complication is characterized by frequent changes of the geological formations.

Fig. 5. Presentation of cracks in the coal layer.

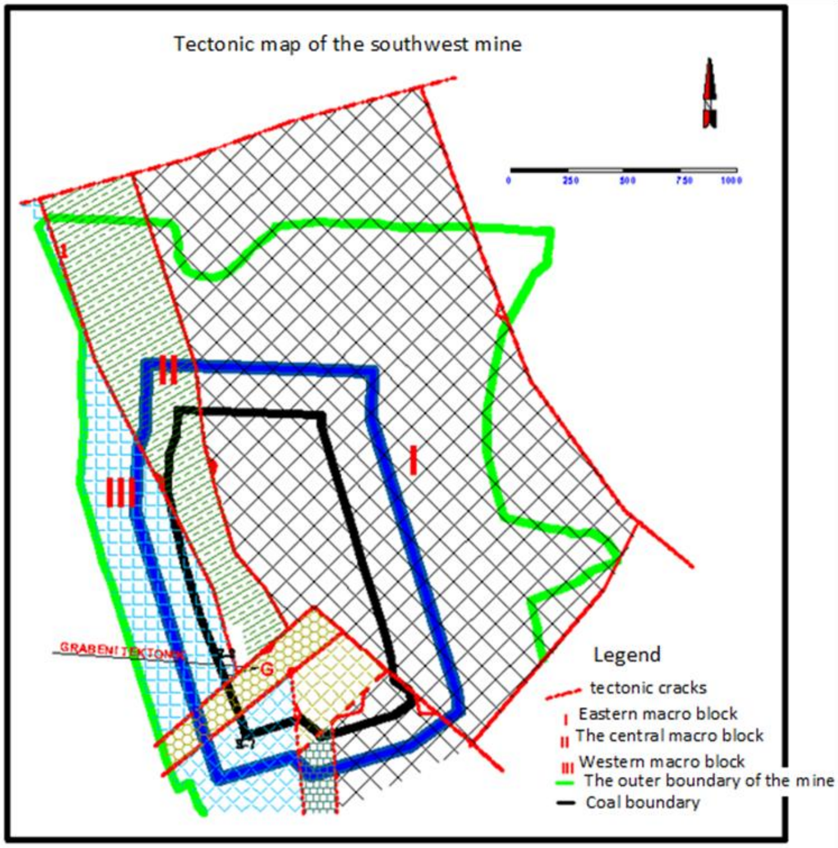


Fig. 6. Tectonics of the coal mine in the southwest.

The Kosovo Basin is tectonically a continuation of the Vardar area ref. [9] and specifically belongs to the belt of internal Dinariteshales. In the formation of the tectonics of the Kosovo basin we can distinguish three phases
:

Pre-lake phase - belongs to the time of tectonic formation of Kosovo pits. According to many authors, this phase belongs to the Oligocene-Miocene period, which is characterized by large detachments, affecting all formations surrounded by the occasional impact of volcanic activity, especially in the northeastern sector, in Janjeve and Shushica.

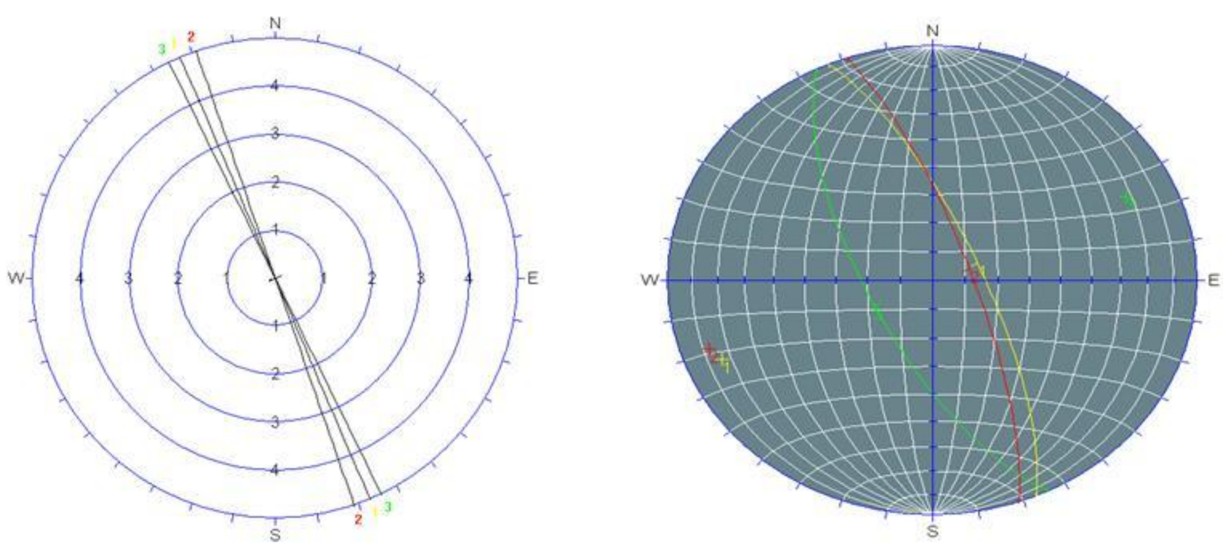
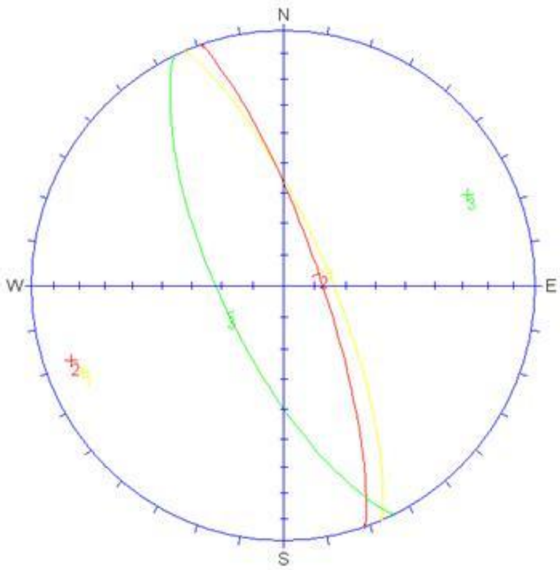
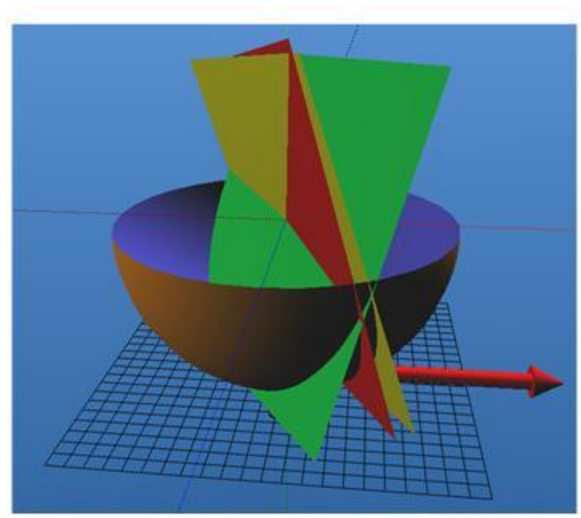


Fig.7. (a) Alignment direction b) Schmid grid for stereographic projection of areas.





c) Hemosphere projection d) 3D plan view

Fig.7 (c, d) Tectonic interpretation of cracks according to the schmid network (a, b, c, d).

Large tectonic faults have occurred along the western part that are also shown on the tectonic map of the basin. The contacts between the basin and the lateral formations are clearer due to the strong tectonics during which the basin is lowered.

Lake phase: relates to the relatively quiet phase of basin formation and coincides with the sedimentation time of the Pliocene series. Looking at the whole basin, it can be concluded that a wide asymmetric syncline has developed in it. The main longitudinal axis of which is close to the western boundary and approximately parallel to the longitudinal axis of the basin. Longitudinal tectonic faults, transverse and diagonal detachments are shown in the tectonic map in Fig.6, while direct field measurements were performed in the part belonging to the active area of the mine. in Fig.2.

Long tectonic rifts. - Longitudinal tectonic faults. - They have a parallel extension direction with the longitudinal axis in the N-NW / S-SE direction. One of them is the tectonic fault of Qyqavica, which lies in the western part of the basin, along which occurred the deepest sinking of the coal series.

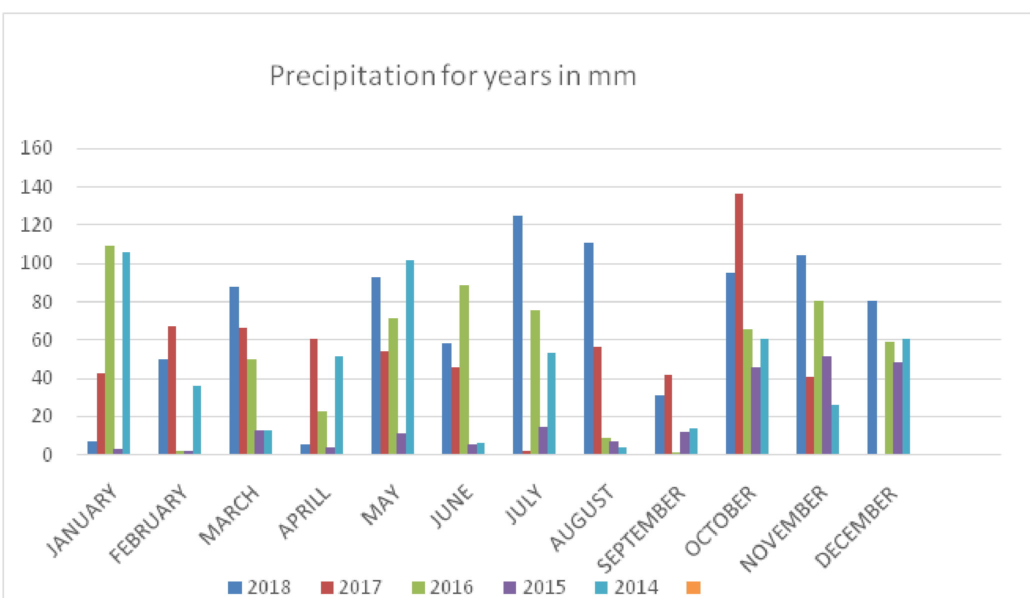


Fig.8. Appearance of rainfall in years.

Fig.9. Field sampling for determination of physico-mechanical parameters.

Transverse and diagonal tectonic faults are less pronounced compared to longitudinal ones, but also along them there were relative movements of coal blocks. Analyzing research drilling and data collection, it was found that this basin is also affected by disjunctive tectonic movements, which have divided the coal seam into several micro and macro blocks arranged in the shape of parallel triangles forming a laminate-shaped structure. This shape is calculated when in taking into account three main elements: alignment, azimuth and angle, which are represented by Schmidt grid in Figs. 7 (a, b, c, d). The lower and upper boundary of the coal seam is taken as the main element of the tectonic interpretation. [2,4,5]. Due to tectonic complications that have occurred in this narrow sector and the formation of disconnection phenomena, we can notice the presence of methane gas (CH_4).

Post-lake phase- characterized by new tectonic activity

Hydrological Characteristics

The most important area or segment of the hydrographic network in the plain of Kosovo belongs to the river Sitnica, but this river has little impact on the surface of the mine in the Southwest. While on the western side is the river Drenica, which also has little impact on the mine and mainly water flows from the mine into this river.

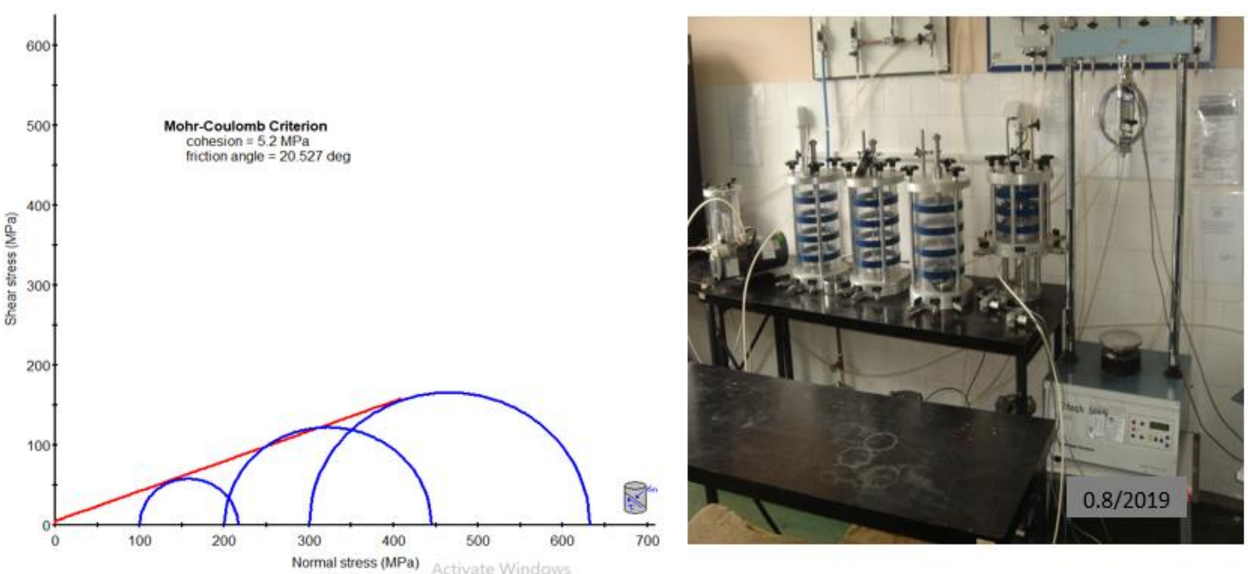


Fig.10. Assignment of angle φ and cohesion C with triaxial test.

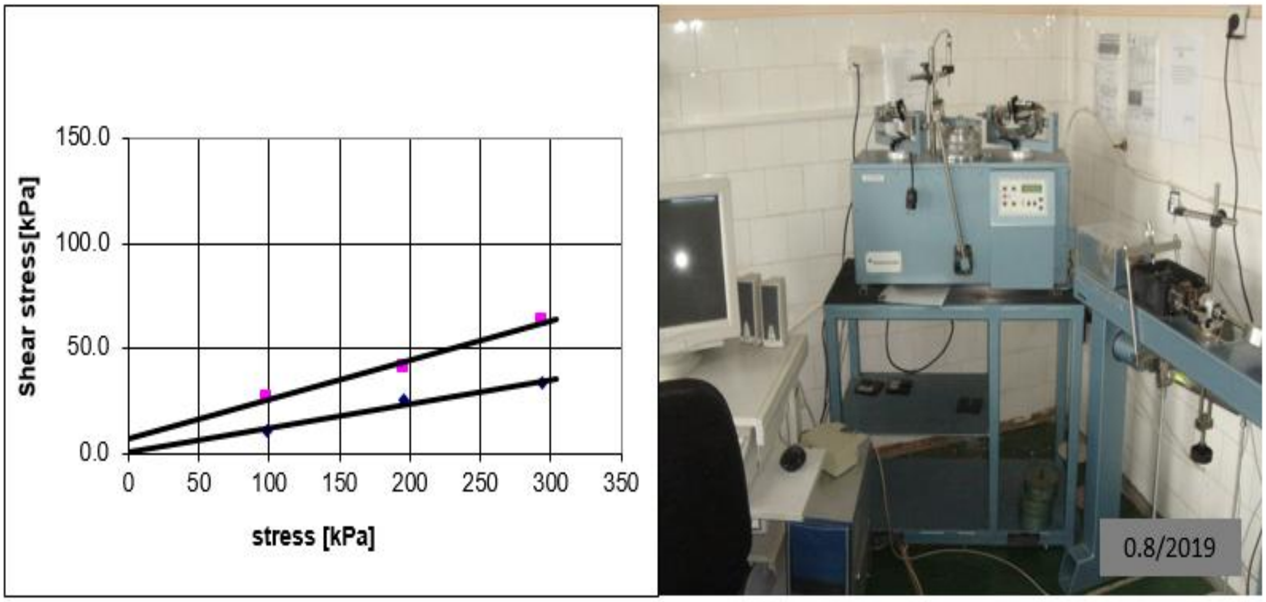


Fig.11. Configuration of angle φand cohesion C with twisting test.

These rivers flow from the south to the north, which then flows into the Ibar River in the city of Mitrovica. However, although it is a considerable area of water basins, around the coalmine in the Southwest we can conclude that these rivers flow in areas that are considered poor in water in except the flood periods. In Figure8 we can see the rainfall precipitation according to the Hydro-meteorological Institute of Kosovo ref. [10]]

Climate features

The Kosovo Basin is characterized by a continental climate with drier and hotter summers and moderately cold winter temperatures. These temperatures depend on the impact of high-pressure areas from Siberia and low-pressure areas from the Atlantic Ocean

The average annual temperatures of the coalmine area in the southwestern part of Obiliq, is around +10.2 ^{0}C. The coldest month is January with an average temperature of -1.5 ^{0}C, while the warmest is August with an average temperature of +20.4 ^{0}CAutumn is warmer than spring by +1.5 ^{0}C. The average winter temperature (December-February) is +0.2 ^{0}C, spring (March-May) +9.7 ^{0}C, summer (July-August) 19.5 ^{0}C, and autumn (September-November)+11.2^{0}C, the average temperature in February reaches +5.9 ^{0}C while the coldest reaches -5.4 ^{0}C.ref. [10]

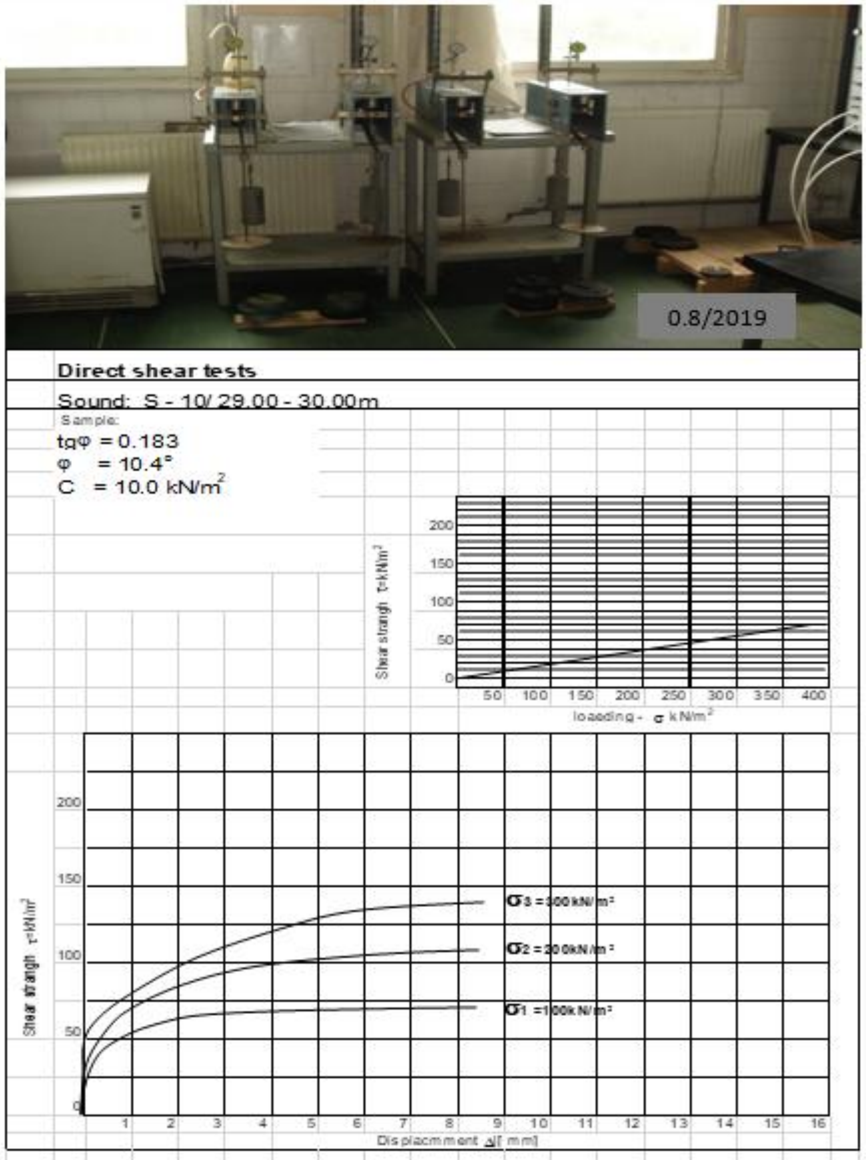


Fig. 12. Configuration of angle φand cohesion C with direct test.

Wind

Of all types of winds, the most pronounced is North-East with 20.3%, north with 19.4%, and westerly winds with 50%. Northeast winds are most often reported in spring and are most pronounced in winter. The largest resting areas of these winds are in August and April. The average measured wind temperature is in March and is around 3.2 ^{0}C, while the lowest in August and September reaches 1.8 ^{0}C. data from ref. [10]

METHODOLOGY

In this research are used Insi-tu methods. Drillings are conducted and are presented in the situation map Fig.1 with Drilling set type EK-650, diameter 145 / 101mm according to Fig.9

The sample was brought to the laboratory of geo-mechanics and was subjected to analysis to derive physical-mechanical parameters according to the standard ISOO 9001 at the Inkos Institute ref. [1]Since we have a large number of drillings, where geo-mechanical analyzes were performed according to depth, then we had a change of values according to geological layers. For each layer, statistical processing was done to extract the most realistic values that was applied to the equation (1,2,3) and the results are presented in table.1 and.2 according to ref. [6]. While the mechanical (hardness) parameters were performed with three tests, the three-axis test, the torsion test the direct test according to Fig.10,11,12. The statistical processing was done according to equation (4,5,6,7,8) which are presented in table.3 and the final parameters for the calculation of slopes are presented in table.4, according to equation (9,10) .ref. [7]

Table 1. Results obtained from statistical processing of geomechanical parameters for yellow clay.

Indicators statistics	Volumetric weight **γ**[kN/m^2]	Volume dry weight γd[kN/m^2]	Specific weight Gs[kN/m^2]	the humidity W[%]	porosityn%	porosity coefficient.e
Xmax	19.75	14.7	26.6	55.2	59.6	1.478
Xmin	16.28	10.49	25.49	22.6	44.59	0.805
Xmean	17.692	12.86	26.106	36.9	50.97	1.048
∑Xi	353.4	257.1	496.02	739.2	968.4	19.913
n	20	20	19	20	19	19
S	0.867	1.077	0.27	6.6	3.18	0.14
V	0.04901	0.083	0.01	0.18	0.062	0.134

Table 2. Results obtained from statistical processing of geomechanical parameters for ash clay.

Indicators statistics	Volumetric weight γ[kN/m^2]	Volume dry weight γd[kN/m^2]	Specific weight G_s[kN/m^2]	the humidity W[%]	porosity n%	porosity coefficient e
Xmax	19.81	18.83	26.7	54.88	61.2	1.57
Xmin	15.88	10.25	25.7	23.56	42.92	0.752
Xmean	17.77	13.217	26.20	35.13	50.461	1.021
∑Xi	1333.1	991.29	1676.9	2634.9	2775.4	56.2
n	75	75	64	75	55	55
S	0.697	1.07	0.20	0.48	21.98	0.132
V	0.0392	0.0816	0.007	0.126	0.435	0.129

Arithmetic mean value

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{N} x_i \qquad (1)$$

Where are: n - number of champions
Xi- characteristic values of a test
Sample Variance

$$S^2 = \frac{1}{(n-1)}\sum_{i=1}^{N}(x_i - \bar{x})^2 \qquad (2)$$

Sample Coefficient of Variation

$$V = \frac{S}{\overline{X}} \qquad (3)$$

The acquired results of the physical parameters for each lithological slope layer are indicated in Table 1 and Table 2.

Soil consistency

In this case, three limits of consistency are used and they are: Liquide limit in the between the liquid and plastic stage, Plastic limit between the plastic and semi-solid state) and Shrinkage between the semi-solid and solid state. Evidence for setting consistency limits is standardized; experience has shown that consistency limits characterize very well the properties of clay materials. [3,12,13]

Table 3. Results obtained from statistical processing for green clay.

Indicators statistics	Volumetric weight γ[kN/m^2]	Volume dry weight $γ_d$[kN/m^2]	Specific weight G_s[kN/m^2]	the humidity W[%]	Porosity n%	porosity coefficient e
Xmax	20.83	18.46	26.8	33.83	49.2	0.97
Xmin	17.92	13.5	25.89	12.69	30.59	0.441
Xmean	19.44	15.658	26.496	24.27	39.78	0.670
∑Xi	427.71	344.47	423.94	534.04	517.22	8.714
n	22	22	16	22	13	13
S	0.825	1.16	0.23	4.91	4.61	0.133
V	0.042	0.074	0.009	0.201	0.115	0.198

Table 4. Atterberg boundaries in consistency.

Nr.	Sample in [m]	layers	W%	**LL%**	**PL**	**PI**	**LI**	**CI**
1	S - 1 / 13.30 - 14.00	Yellow clay	22.96	78	23.62	54.38	-0.012	1.012
2	S - 2 / 29.00 - 30.00	Gray clay	15.21	47	21.73	25.27	-0.258	1.258
3	S- 3 / 7.00 - 8.00	Yellow clay	21.6	56	21.35	34.65	0.007	0.993
4	S - 4 / 17.00 - 18.00	Gray clay	21.8	45.3	14.2	31.1	0.244	0.756
5	S - 5 / 26.50 - 27.00	Gray clay	19.06	67	22	45	-0.065	1.065
6	S - 6 / 36.00 - 37.00	Green clay	17.61	59	17.6	41.4	0.02	0.998
7	S - 7 /52.20 - 62.20	Green clay	27.1	57	26.9	30.1	0.07	0.993
8	S - 8 / 62.00 - 63.00	Green clay	16.24	57	22.29	34.71	-0.174	1.174
9	S - 9 / 7.00 - 8.00	Yellow clay	29.1	79	23.12	55.8	0.106	0.894
10	S - 10/ 29.00 - 30.00	Gray clay	12.6	40	21.44	18.6	-0.473	1.473
11	S - 11/ 17.00 - 18.00	Gray clay	38.53	64	21.7	42.3	0.397	0.603
12	S - 12 /23.00 - 24.00	Gray clay	40.24	34	57.14	23	0.27	0.73
13	S - 13/ 50.00 - 51.00	Green clay	29.79	52	17.4	34.6	0.357	0.643
14	S - 14/ 7.00 - 8.00	Yellow clay	27.81	69	22.45	46.55	0.115	0.885
15	S - 15/ 17.00 - 18.00	Gray clay	12.7	33	13	20	-0.015	1.015
16	S - 16/ 27.00 - 28.00	Gray clay	12.6	40	21.44	18.6	-0.473	1.473
17	S - 17/ 49.00 - 50.00	Green clay	10.62	32	21.11	14.47	0.485	1.485
18	S - 18/ 2.50 - 3.00	Yellow clay	32.27	58	30	28	0.08	0.92
19	S - 19/ 11.50 - 12.00	Yellow clay	39.66	66	31.3	35.7	0.242	0.738
20	S - 20/ 24.00 - 24.50	Gray clay	19.6	58	22.7	35.3	-0.09	1.09
21	S - 21/ 24.20 - 25.20	Gray clay	23.2	72	22.5	49.5	0.014	0.986
22	S- 22/ 36.50 - 37.00	Green clay	16.19	59	20.6	38.4	-0.115	1.115
23	S - 23/ 11.00 - 11.50	Yellow clay	21	57	18.92	38.08	0.055	0.945
24	S - 24/ 39.00 - 39.50	Green clay	23.2	60	21.35	38.65	0.048	0.952
25	S - 25/ 7.80 - 8.30	Yellow clay	33.75	57	32.6	24.4	0.047	0.953
26	S - 26/ 21.00 - 21.50	Gray clay	26.59	53	34	19	-0.389	1.389
27	S - 27/ 35.00 - 35.50	Green clay	14.57	56	32	24	-0.725	1.725
28	S - 28/ 44.00 - 44.50	Green clay	21.95	59	22.3	36.7	-0.009	1.009

For this purpose, the consistency index is used. This shows the ratio of the natural water content in the soil to the consistency limits. The consistency index is defined by the following equation (4,5) endthe Table 4

$$CI = \frac{LL-w}{LL-PI} \qquad \text{ek. (4)}$$

Similar to the consistency index is the use of the flow index. The flow index is defined by the equation

Table 5. Results obtained from triaxial test and direct test for yellow clay.

Triaxial proof Indicators statistics	C [kN/m^2]	φ [^{0}]	***Direct shear tests*** Indicators statistics	C [kN/m^2]	φ [^{0}]
Xmax	16.0	23.45	Xmax	13.0	18.0
Xmin	2.0	10.06	Xmin	0.0	7.22
Xmean	11.57	14.17	Xmean	5.94	12.51
∑Xi	81	102.9	∑Xi	101	212.68
n	7.0	7.0	n	17.0	17.0

Table 6. Results obtained from the twisting test and the cutting test for gray clay.

Twisting test Indicators statistics	C [kN/m^2]	φ [^{0}]	***Direct shear tests*** Indicators statistics	C [kN/m^2]	φ [^{0}]
Xmax	18.0	14.0	Xmax	50.0	17.9
Xmin	9.0	9.0	Xmin	0.0	6.1
Xmean	12.4	12.0	Xmean	9.05	12.8
∑Xi	87.0	84.0	∑Xi	220.9	463.09
n	7.0	7.0	n	43	43

$$\mathrm{Ll} = \frac{\mathrm{w}-\mathrm{PL}}{\mathrm{LL}-\mathrm{PL}} \qquad (5)$$

Statistical processing of hardness parameters with three-axis test

Statistical processing of hardness parameters obtained with the triaxial test was done according to equation (6,7,8,9,10)

$$tg_{\varphi} = \frac{\alpha-1}{2\sqrt{\alpha}}, [°] \qquad (6)$$

$$C = \frac{b}{2\sqrt{\alpha}}, \left[\frac{kN}{m^2}\right] \qquad (7)$$

$$a = \frac{1}{\Delta}\left(n\sum\sigma_1\,\sigma_3 - \sum\sigma_1\sum\sigma_3\right) \qquad (8)$$

$$b = \frac{1}{\Delta}\left(\sum\sigma_3^2\sum\sigma_1 - \sum\sigma_3\sum\sigma_1\,\sigma_3\right) \qquad (9)$$

$$\Delta = n(\sigma_3)^2 - (\sigma_3)^2 \qquad (10)$$

σ_1, σ_3– maximum principal strain [kN/m^2]
The results obtained from statistical processing are presented in Tables 5, 6 and 7

Determining the calculation parameters

For the determination of mechanical parameters (hardness) are mainly used three apparatus which have given different results, then applying equation (11) and equation (12) for calculation it is necessary to make correction, unification of mechanical strength parameters according to equation (13,14).

$$\varphi_{\mathrm{overal}} = \frac{\varphi^{\mathrm{N}}_{\mathrm{pd}}\cdot\mathrm{npd} + \varphi^{\mathrm{N}}_{\mathrm{trea}}\cdot\mathrm{ntrea}}{\mathrm{npd}+\mathrm{ntrea}}, [°] \qquad (11)$$

$$\mathrm{C}_{\mathrm{overal}} = \frac{\mathrm{C}^{\mathrm{N}}_{\mathrm{pd}}\cdot\mathrm{npd} + \mathrm{C}^{\mathrm{N}}_{\mathrm{trea}}\cdot\mathrm{ntrea}}{\mathrm{npd}+\mathrm{ntrea}}, \left[\frac{\mathrm{KN}}{\mathrm{m}^2}\right] \qquad (12)$$

npd - number of samples with the direct shear test
ntrea- the number of samples with three - axial test
npp - the number of samples with the torsion test.

Table 7. Results obtained from direct-cut test on green clay.

	Direct shear tests	

Indicators statistics	C [kN/m^2]	φ [^{0}]
Xmax	26.0	19.0
Xmin	6.0	12.8
Xmean	16.7	16.1
∑Xi	251	241.6
n	15.0	15.0

Table 8. Final geomechanical parameters for calculation (15-16).

Lithological layers	Physical - mechanical parameters		
	φ [^{0}]	C [kN/m^2]	γ[kN/m^3]
Yellow clay	12.4	7.8	18.7
Gray clay	13.2	10	17.86
Coal	25	30	12.2
Green clay	16.2	16.8	16.5

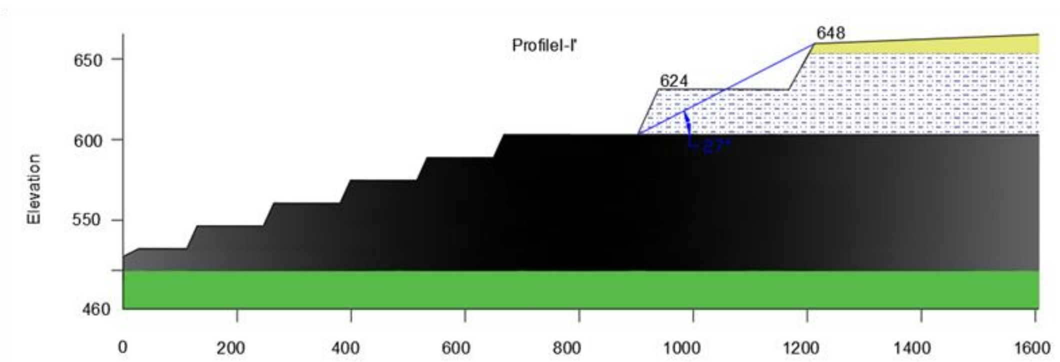


Fig.13. Profile I-I' Existing state according to the map of situations.

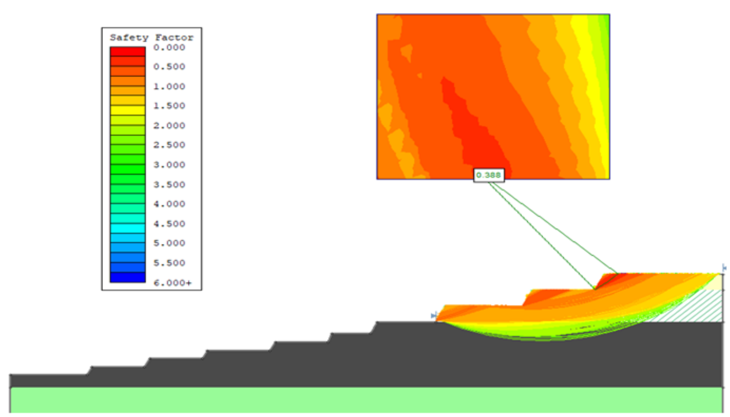


Fig. 14. Calculation of existing condition with safety factorFs<1.

The values obtained by doubling the parameters obtained from the above tests, have a large difference, therefore the values obtained are subject to correction according to the expressions:

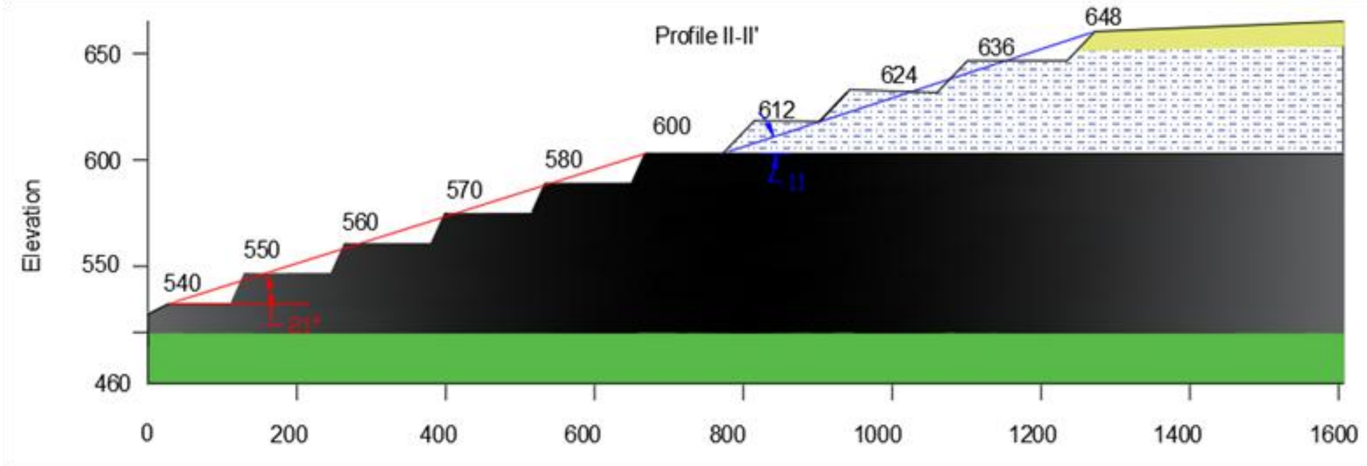


Fig.15. Condition designed from the aspect Technological –Geotechnics.

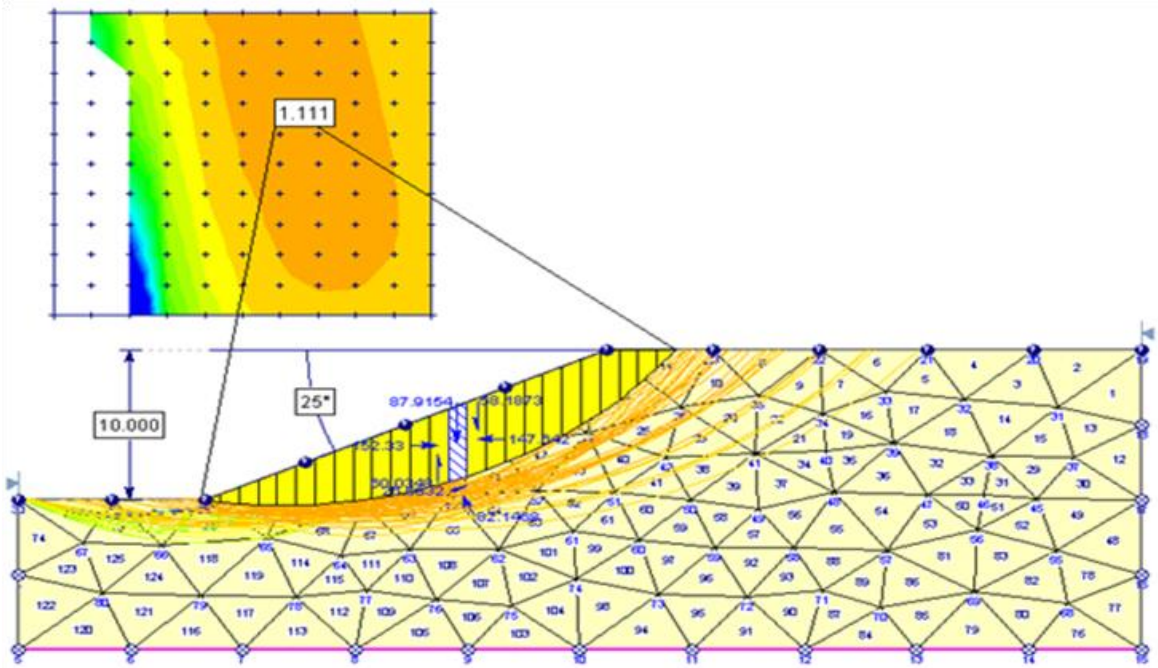


Fig.16. Calculation of partial slope according to the scale designed for yellow clay.

$$\Delta_C = \sqrt{\frac{(C_{përgj} - C_{pd})^2 n_{pd} + (C_{përgj} - C_t)^2 n_t + (C_{përgj} - C_{pp})^2 n_{pp}}{n_{pd} + n_t + n_{pp}}} \quad (13)$$

$$\Delta\varphi = \sqrt{\frac{(\varphi_{përgj} - \varphi_{pd})^2 n_{pd} + (C_{përgj} - \varphi_t)^2 n_t + (\varphi_{përgj} - \varphi_{pp})^2 n_{pp}}{n_{pd} + n_t + n_{pp}}} \quad (14)$$

For the specific case the parameters Qc and Qφ are calculated for the reliability B = 90.0%, for the value of which are taken from table no.8 depending on the number of samples analyzed where tα = 1.3, for the yellow clay, gray clay , while for green clay tα = 1.4, for K = n - 2, while the calculations are made according to eq. (15,16)

$$Q_c = \frac{t_\alpha \cdot \Delta c}{\sqrt{n}} \quad (15)$$

$$Q_\varphi = \frac{t_\alpha \cdot \Delta\varphi}{\sqrt{n}} \quad (16)$$

Calculation of slopes from a geotechnical perspective

In figure 13 is calculated the existing condition according to profile **I-I'** by applying the geo-mechanical parameters according to table no.8. For the height of the slope, in the quota 600-648, for the yellow clay and the gray clay, that are very present in the part of the coal covering, by applying the methods according to [4,5,8,11], we derived a safety factor Fs<1 which is presented in Fig.13. Based on the calculation according to Fig.14, it is proved that the geotechnical and technological condition is not met. Then in profile **II-II** 'Fig.15, is designed and calculated the geometry of the slop according to the allowed safety factor which is Fs> 1

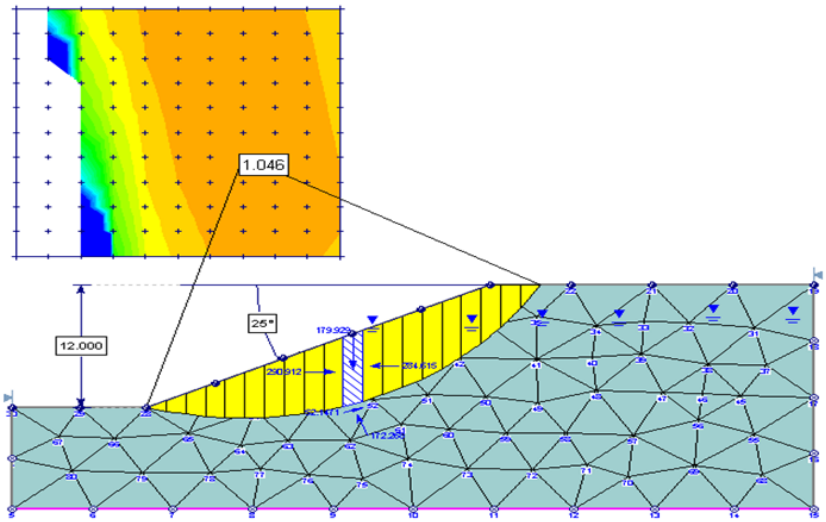


Fig.17. Calculation of partial slope according to the scale designed for gray clay.

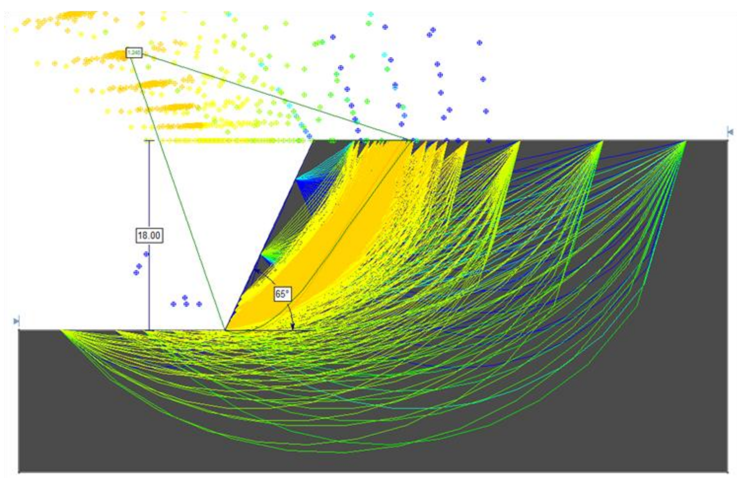


Fig.18. Calculation of partial slope according to the scale designed for the coal layer.

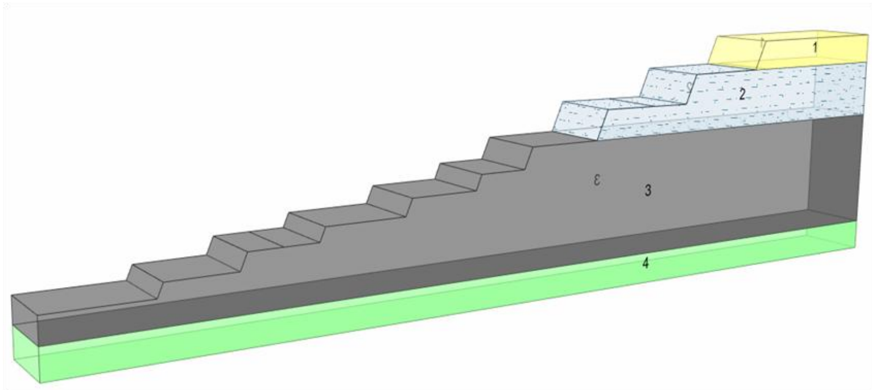


Fig. 19. Technologically-geotechnically designed 3D state of the art scale with Fs>1.2.

Table 9. Results for yellow clay with height H = 10m & angle φ = 25^0.

Methods	hight H(m)	angle. α^o	Center (x,y)	Radiusi	Fs
Bishopi	10	25	(16.01,30.4)	20.39	1.10
Janbu	10	25	(16.01,28.38)	20.16	1.07
Corps of Engineers #1	10	25	(13.99,36.45)	26.79	11.11
Corps of Engineers #2	10	25	(13.99,36.45)	26.79	1.12
GLE/Morgensten-Price	10	25	(13.99,36.45)	26.79	1.09
Lowe-Karafiath	10	25	(13.99,36.45)	26.79	1.10
Spancer	10	25	16.01,28.38)	19.24	1.09

Table10. Results for ash clay with height H = 12m & angle φ = 25^0.

Methods	hight H(m)	angle. α^o	Center (x,y)	Radiusi	Fs
Bishopi	12	25	(17.23,34.48)	25.509	1.044
Janbu	12	25	(17.23,32.06)	23.46	1.027
Corps of Engineers #1	12	25	(17.23,36.91)	27.56	1.067
Corps of Engineers #2	12	25	(17.23,34.48)	25.509	1.079
GLE/Morgensten-Price	12	25	(17.23,34.48)	25.509	1.47
Lowe-Karafiath	12	25	(17.23,23.46)	25.509	1.058
Spancer	12	25	17.26,34.48)	25.509	1.046

Table 11. Results for Coal layer with height H = 18m & angle φ = 65^0.

Metodat	Lartësia H(m)	Këndi. α^o	Fs
Janbu Simplified	18	65	1.189
Janbu Corrected	18	65	1.245
Corps of Engineers #1	18	65	1.325
Corps of Engineers #2	18	65	1.331
GLE/Morgensten-Price	18	65	1.327
Lowe-Karafiath	18	65	1.292
Spancer	18	65	1.325

In profile II-II', according to Figure 15, are calculated the heights and angles of partial escalation, that are presented according to the drilling lithology according to Figures 16. The height of the stable stair, for yellow clay, from the geo-mechanical parameters according to table no.8, should be H = 10m and angle α = 25^0, while for gray clay the height of the stable stair, according to geo-mechanical parameters, should be H = 12m and the angle α = 25^0 as in Figure While the height of the partial escalation in coal according to the technology designed with the allowed safety factor according to Figure 18, is calculated height H = 18m and angle α = 65^0

The final general angle according to profile II-II 'in coal, according to the designed technology, should be the height H = 60m with the angle α = 21^0, while the final general angle in the coal cover according to the designed technology, according to Figure 15, based on the processing parameters final statistical height should be H = 48m and angle α = 11^0

The final state with safety factor Fs ≥1.2 is shown in Figure 19 according to [5]

RESULTS

Based on laboratory analyzes, the geometry of the slopes (stairs) designed according to the technology, with the safety factor for yellow clay and gray clay has been calculated. The results are presented as follows in Table 9 and Table 10 according to [4, 5]

While for Coal the calculations for the height H = 18m and the angle α = 65^0 are presented according to table 11 based on [4.11]

CONCLUSIONS

Based on the geological drilling, according to the situation map with the drilling position Figure no.1, the most accurate identification of the coal cover layers was done. Sampling was done directly in the field according to Figure .9 and at the same time the mechanical parameters were derived applying the apparatus as in Fig.10,11,12. While for the calculation of the slopes, the final values of the geological layers derived from the statistical processing [7]. According to table no.8, the safety factors of the slopes, from the geotechnical aspect, have been calculated by applying two forms of calculation: the circular shape in the coal cover and the polygonal one in the coal layer according to [3,4,5,8,11]. The results are presented in Table 9,10,11.

RECOMMENDATIONS

In order to have a long-term safety in the surface coal mine for the needs of power plants, in order to supply electricity to the community in general, the designed technology according to Figure 15.19 must be respected:

To be taken into consideration and respected the height of the slopes and the angle α according to the results in table .7 and table .8

The height of the partial slopes in coal should be H = 18m and the angle α = 65^0 according to table 11 and Figures.18

The general angle in the coal should be α = 21^0 and the height H = 60m according to Fig.15

The general angle in the cover (wasteland) should be H = 48m and the angle α = 11^0 according to Fig.15

Channels should be opened in the side part of the mine so that the atmospheric waters do not enter the mine which would hinder the technological process during the mining activity and at the same time the physical-mechanical parameters will be weakened, which can cause slip of clay masses in the coal cover or collapse of the side slopes of the coal blocks due to the existing cracks that are presented according to Fig.4, and 5 while their presentation is made in the plan according to the Schmid grid Fig.7 (a, b, c, d)

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