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The Exploitation of the Coal in the Mine of Sibovc Basing on the Drilling Done by Geotechnical Aspect

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Abstract: Considering great demands for the energy as inside also outside Kosovo, it is very necessary to open the mine of Sibovc for coal exploitation, for existing thermo-plants, as well as for those which will be built in future in order to have a stable economic development. The exploitation of the coal in surface mines especially in our mines it is a problem that requires professional and scientific approach, since not recognizing this problem often has resulted with sequences in the term of material. In this context, thankfully to the technological revolution, today is possible to use a range of methods for the slope stability calculations. We use these methods, too, mainly for the purpose of defining geotechnical safety at the border slope systems as well as at the advance slope systems. Taking into account all geological-engineering data, including tectonic movements, surface and underground water, seismic factors etc. Today there are a lot of contemporary approaches, development and improvement of which enable input of all geological-engineering data (geo mechanical parameters) in order to analyze and design slopes in generally.

***Key words**: exploitation, methods, drillings, geotechnical security*

Introduction

Kosovo territory is very rich with natural resources that have a particular strategically importance for the development of different branches of industry and economy of Kosovo. One very important place within these resources takes place also the areas with resources of coal particularly those in the puddle of Kosovo and Dukagjin wherein we should also include the puddle of Coal in Drenica. In this period the researching are done according to the distances 250x250, 750x750 and 1000x1000 whereas in years 2004, 2005 and 2006 there are done and complementary drillings in basin of SW Sibovc (Figure 1) according to the necessity of the coal exploitation, which are shown in the figure below not avoiding the completing of laboratory analysis in order to determine physical-mechanical parameters for the clay and coal. 3D drilling presentation of with drillings and izohipset of the areas are given in Figure 2 and map of working area in Figure 3.

Figure 1. A general view of Sibovc mine

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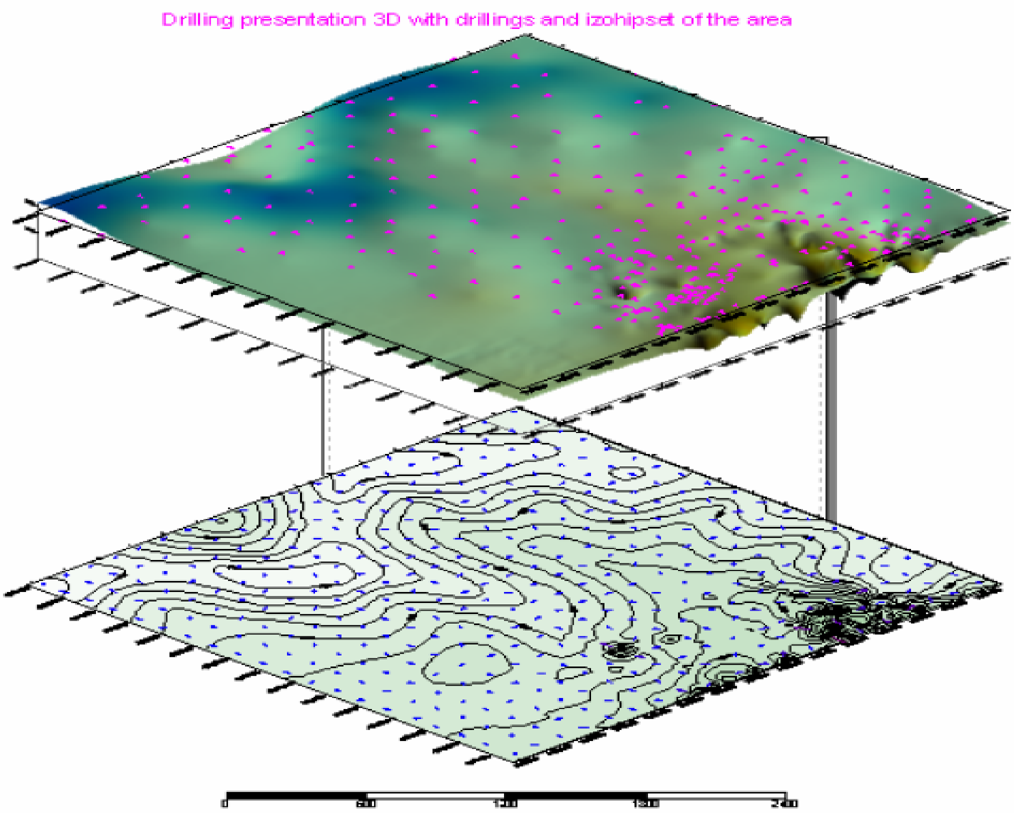


Figure 2. 3D drilling presentation of with drillings and izohipset of the areas

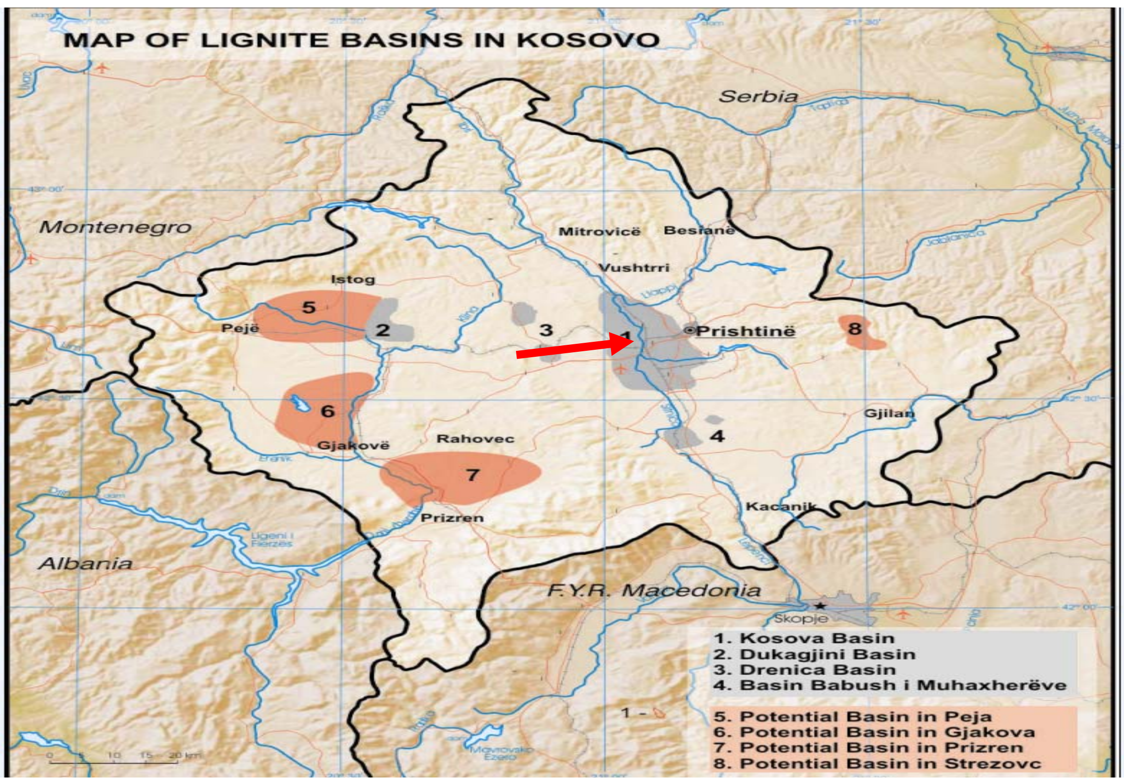


Figure 3. Map of the investigation area.

Geological Construction

The zone where the research is done in the surface mine of Sibovc SW, as well as in the peripheral zones around, are constructed by Paleozoic, Mesozoic and Cenozoic formations (Quaternary and tertiary)

Paleozoic-the formation of Paleozoic is presented with crystal and limestone thickness .The crystal thickness (layer) take an important place in the sides construction of Kosovo basin and they are spread as in West as well in East.

Mesozoic- The formations of Mesozoic are presented by serendipities, periodicities, the above cretac and limestone fleshes.

Serendipities and periodicities in the siding part of the basin come into surface; some zones lay in the direction of NNW-SSE

Cenozoic- The formations of Cenozoic are presented with tertiary and quaternary deposits. The tertiary is represented by andezit-dacit rocks as well as the tufts of Neogen of Kosovo basin.

Quaternary in the greatest part of Kosovo is represented with sand and gravel, alluvial deposits.

In Figure 3 is shown the map of site with drillings and profiles (Figure 4), wherein are calculated general and partial slopes beginning from Figure.8.to.19.

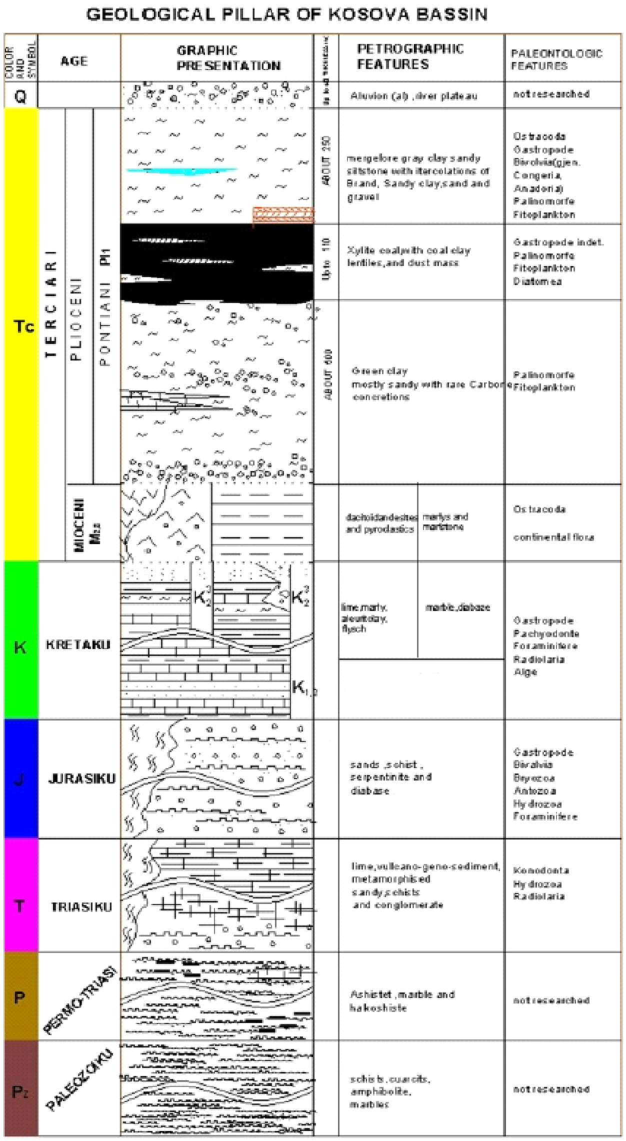


Figure 4 The map of the site with drillings and profiles

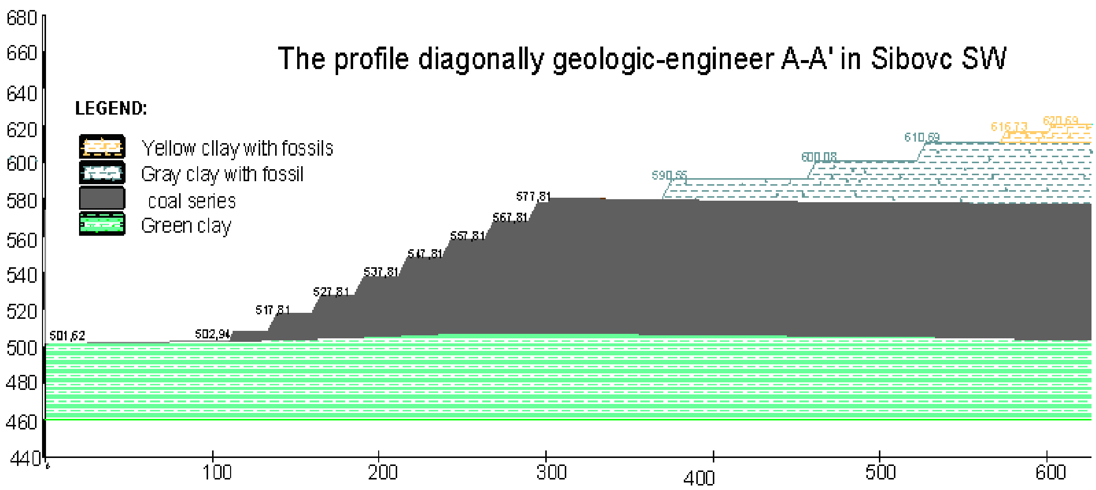


Figure 5 The profile diagonally geologic-engineer A-Ain Sibovc SW

Basing on the data of the drillings that are shown in the Figure 2 and the map of the site in Figure 3 by the geologic-engineer, the mine of Sibovc SW is composed by these formations: Yellow clay with an average thickness of 10-12 m, Grey clay with an average thickness of 30 m, coal with an average thickness of 70 m and at the end the green clay ,all these are shown in the cutting A-A' in Figure 5, as well the pulling out of core which is shown in Figure 6. There are realized 100 champions for geo mechanical analyses by using the test (TRIAXIAL), direct test (DIRECTSHEAR) the (ring Shear) test in the base of these analyses are gained the ultimate parameters for calculation that are shown on Table 1,whereas the calculations for clay are shown on table 2&3

Table 1. Soil-mechanical Parameters

Geological Layers	**φ[°]**	**C[KN/m^2]**	**γ[KN/m^3]**
Yellow clay	12.8	5.8	17.7
gray clay	10.5	9.3	17.8
coal seam	22.0	30.0	12.2
green clay	16.1	16.7	19.5

Figure 6. The pulling out of core

Figure 7. Cutting-A-A'

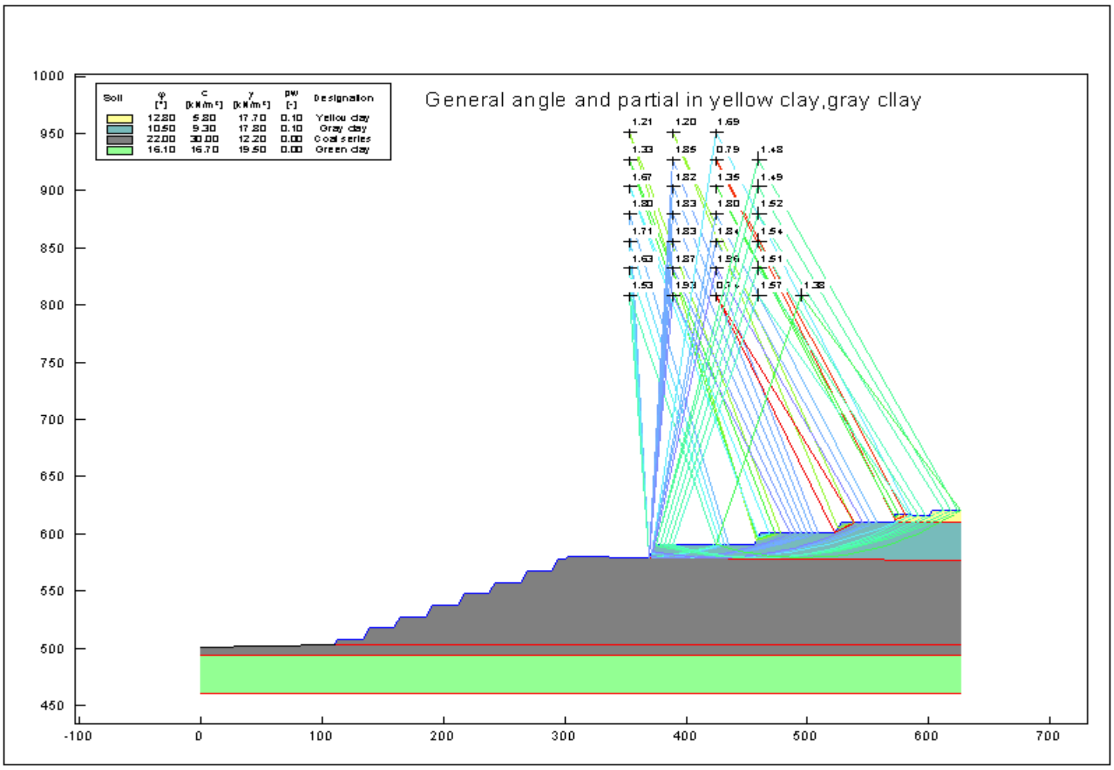


Figure 8 General angle in yelow clay,gray cllay Method-Bishop

$$T = \frac{[Gi - (ui + \Delta ui]*bi]*\tan\varphi + ci*b}{\cos\vartheta i + \frac{1}{\eta}\tan\varphi i*\sin\vartheta i} \qquad \eta = \frac{r\sum Ti + \sum Ms}{r\sum Gi*\sin\vartheta i + \sum M}$$

M(Ti) = 13945.6 / M(s) = 0.0 / M(Gi) = 9311.9 / M = 0.0

	Xm	Ym	radius	slices	FOS
Circle	445.2330	976.4872	397.1872	20	1.5117

Numerator = 4777022.231 Denominator = 3160053.555

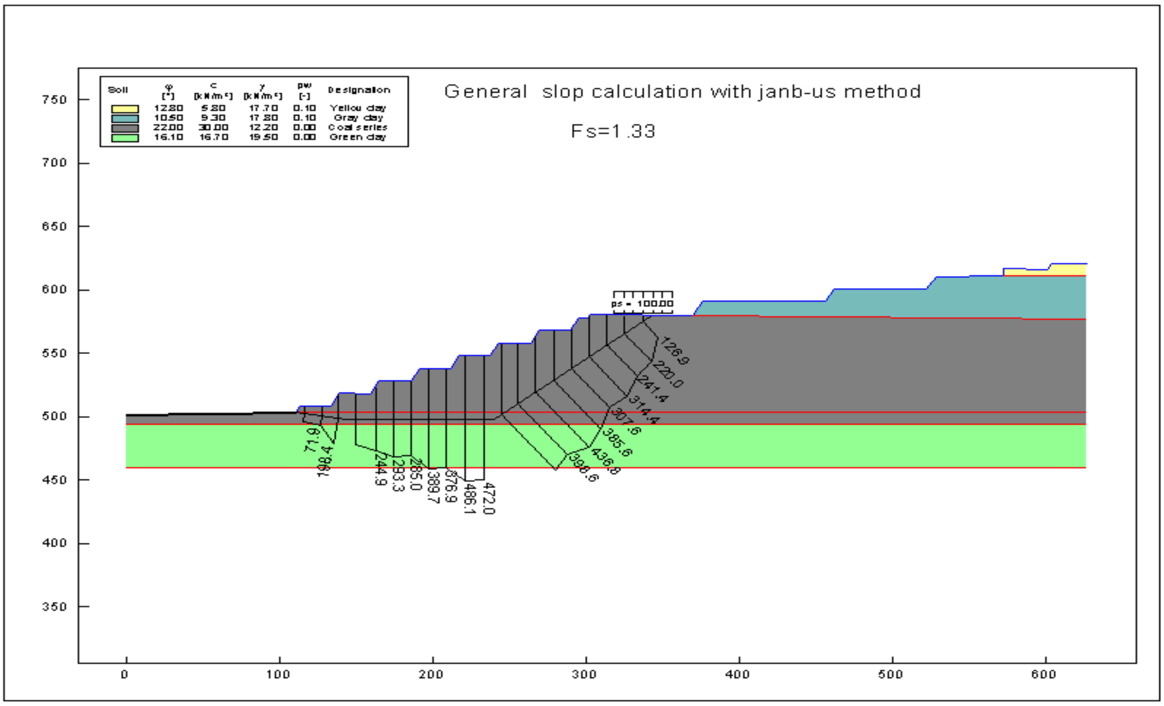


Figure 9. General slope calculation in coal.

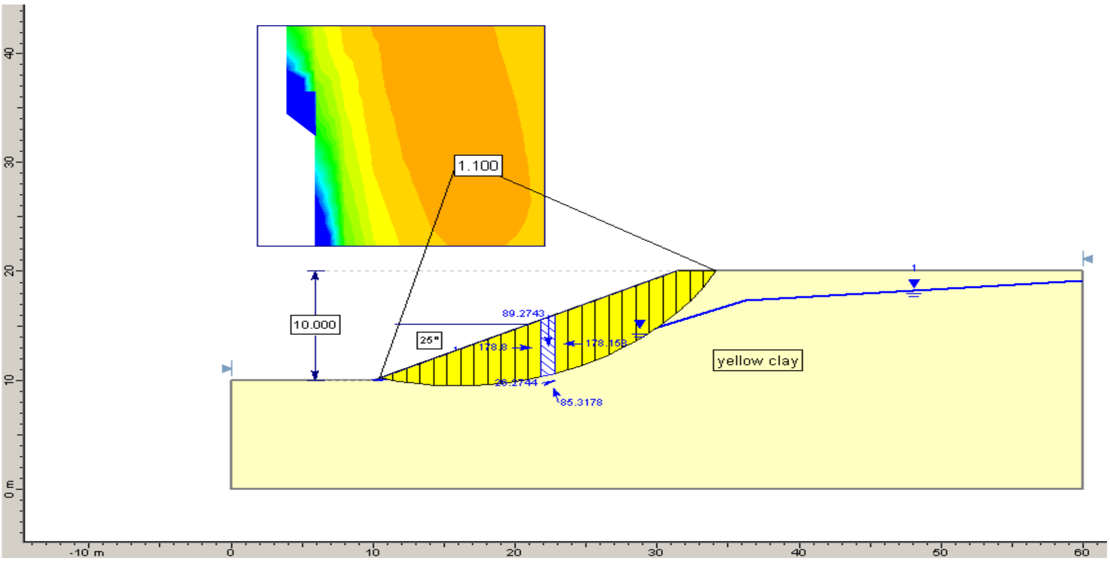


Figure 10. Partial angle in yellow clay

FOS = 1.3274 = [H(Ti) + H(s)] / [H(Gi) + H]
Numerator = 44460.6957
Denominator = 33492.0735
H(Ti) = 44460.6957
H(s) = 0.0000
H(Gi) = 33492.0735
H = 0.0000
Slice values
x = x (slice toe)
y = y (slice toe)
b = slice width
phi = friction angle
c = cohesion

PWP = porewater press. coeff
tet = inclination of slice
g = weight
t = tangential force
pw = porewater pressure
pw(con) = excess pwp due to consolidation
wv = vertical water pressure
pst = permanent loads and foundation
pv = live loads
fakpv = factor for live loads

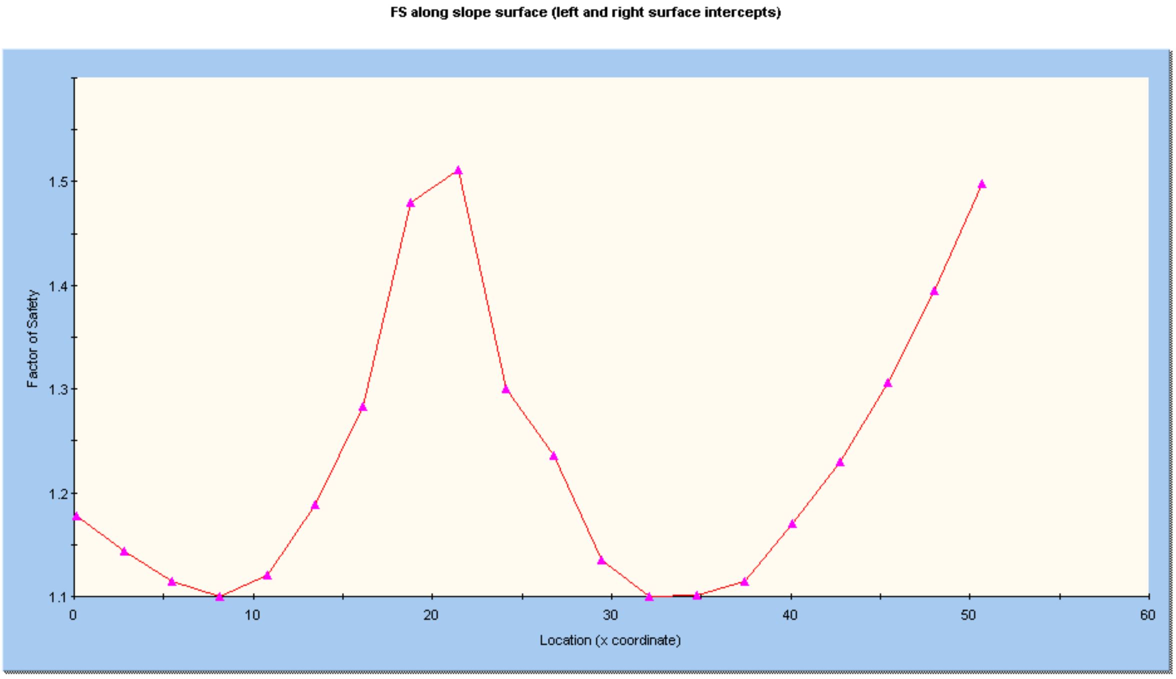


Figure 11. Factor of Safety-with location (x coordinate)

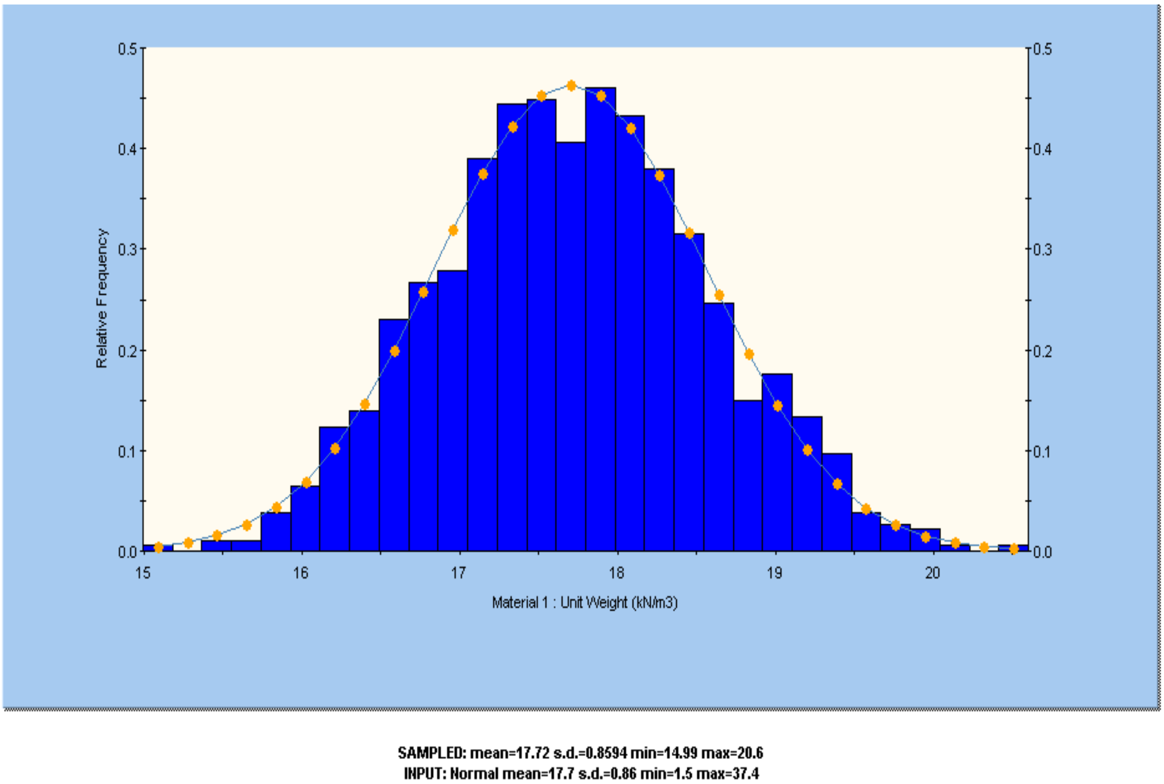
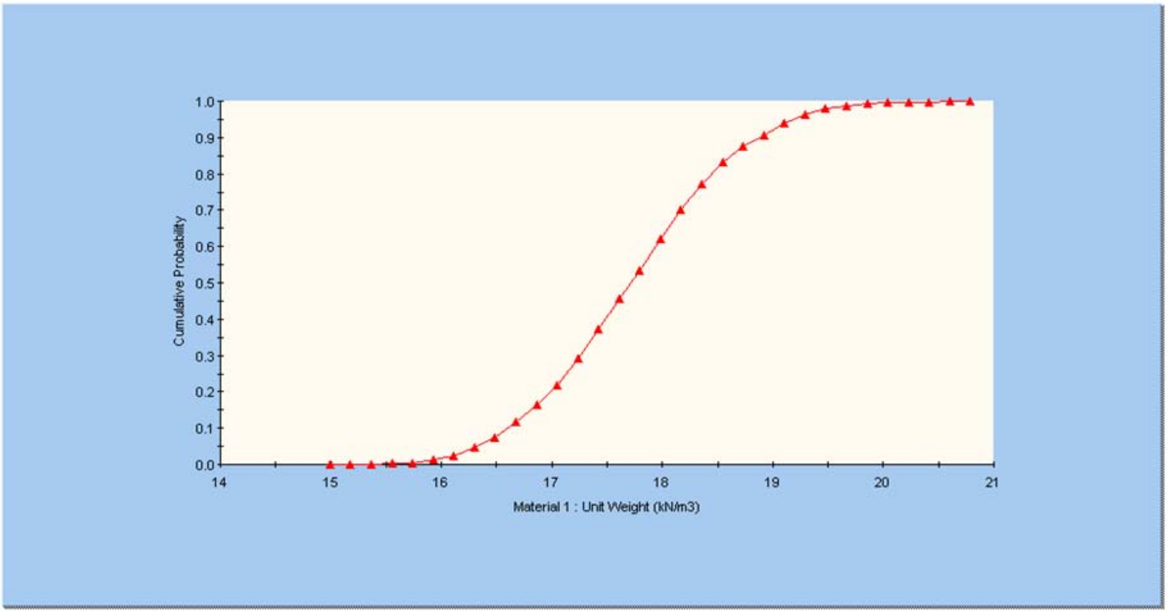


Figure 12. Histogram by Monte-Carlo



SAMPLED: mean=17.72 s.d.=0.8594 min=14.99 max=20.6

Figure 13. Cumulative Probability & Unit Weigh (kN/m^3)

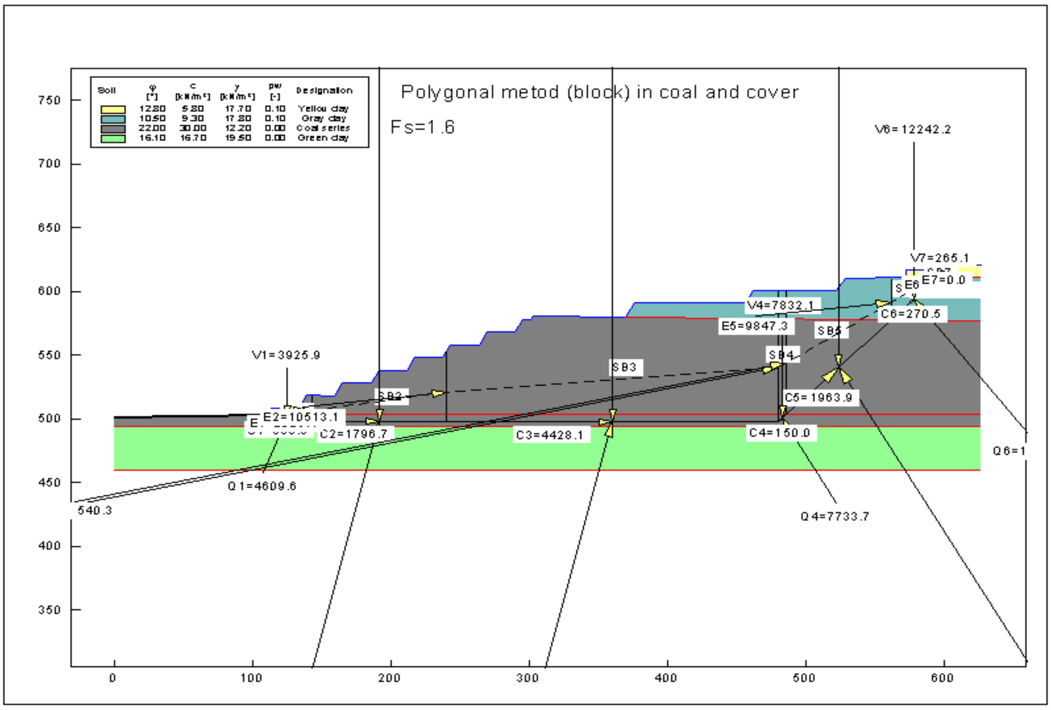


Figure 14. Polygonal method (blocks) in coal and cover

Slic e values

SB = slip body	H = horizontal loads
x, y = slip body base	C = cohesion
phi = friction angle (mean)	U = porewater pressure
V = weights, loads, water forces	Q = friction force

Slope stability analysis to DIN 4084

Parameter list

FOS = safety

Coordinates of layers and soil numbers

No.	x(left) [-]	y(left) [m]	x(right) [m]	y(right) [m]	Soil no [m]
1	572.300	610.690	626.800	610.600	
2	369.200	579.300	626.800	576.900	
3	110.400	502.900	626.800	502.900	
4	0.000	493.600	626.800	493.600	
5	0.000	460.000	626.800	460.000	

Coordinates

No.	x [m]	y [m]
1	107.080	502.882
2	142.800	497.700
3	240.100	497.700
4	479.900	497.200
5	600.606	616.017

FOS = 1.6246
dTh (FOS = 1.0) = 67054.4377

CRITICAL SLIP SURFACES (Part 1)

SB	x [m]	y [m]	phi [°]	Vx [kN/m]	Vy [kN/m]	Hx [kN/m]	Hy [kN/m]	Cx [kN/m]	Cy [kN/m]
0	107.080	502.882							
1	142.800	497.700	22.0	0.0	-3925.9	-392.6	0.0	659.6	-95.7
2	240.100	497.700	22.0	0.0	-43058.5	-4305.8	0.0	1796.7	0.0
3	479.900	497.200	22.0	0.0	-254808.2	-25480.8	0.0	4428.1	-9.2
4	485.691	502.900	22.0	0.0	-7832.1	-783.2	0.0	106.9	105.3
5	561.485	577.509	22.0	0.0	-71772.8	-7177.3	0.0	1399.6	1377.7
6	595.156	610.652	10.5	0.0	-12242.2	-1224.2	0.0	192.7	189.7
7	600.606	616.017	12.8	0.0	-265.1	-26.5	0.0	19.5	19.2
Sum				0.0	-393904.7	-39390.5	0.0	8603.2	1586.9

CRITICAL SLIP SURFACES (Part 2)

SB	x [m]	y [m]	Ux [kN/m]	Uy [kN/m]	Fx [kN/m]	Fy [kN/m]	Qx [kN/m]	Qy [kN/m]
0	107.080	502.882						
1	142.800	497.700	0.0	0.0	0.0	0.0	1743.2	4267.3
2	240.100	497.700	0.0	0.0	0.0	0.0	10943.8	44005.8
3	479.900	497.200	0.0	0.0	0.0	0.0	66626.4	265543.1
4	485.691	502.900	0.0	0.0	0.0	0.0	-3934.7	6657.9
5	561.485	577.509	0.0	0.0	0.0	0.0	-35845.5	60653.7
6	595.156	610.652	0.0	0.0	0.0	0.0	-8581.3	10967.8
7	600.606	616.017	0.0	0.0	0.0	0.0	-164.9	222.1
Sum			0.0	0.0	0.0	0.0	30787.0	392317.8

SB = slip body no.
x, y = intersection between intermediate slip line and surface
det = 'Wall friction angle' (mean)
F = anchors, nails, dowels, geosynthetics
Q = friction force

INTERMEDIATE SLIP SURFACES

SB	x [m]	y [m]	det [°]	Fx [kN/m]	Fy [kN/m]	Qx [kN/m]	Qy [kN/m]
1	142.800	497.700	7.0	0.0	0.0	2010.4	245.7
2	240.100	497.700	6.5	0.0	0.0	10445.2	1193.1
3	479.900	497.200	12.0	0.0	0.0	56018.8	11918.7
4	485.691	502.900	11.9	0.0	0.0	51407.8	10849.8
5	561.485	577.509	6.5	0.0	0.0	9784.7	1108.4
6	595.156	610.652	7.9	0.0	0.0	171.9	23.8
Sum				0.0	0.0	129838.9	25339.6

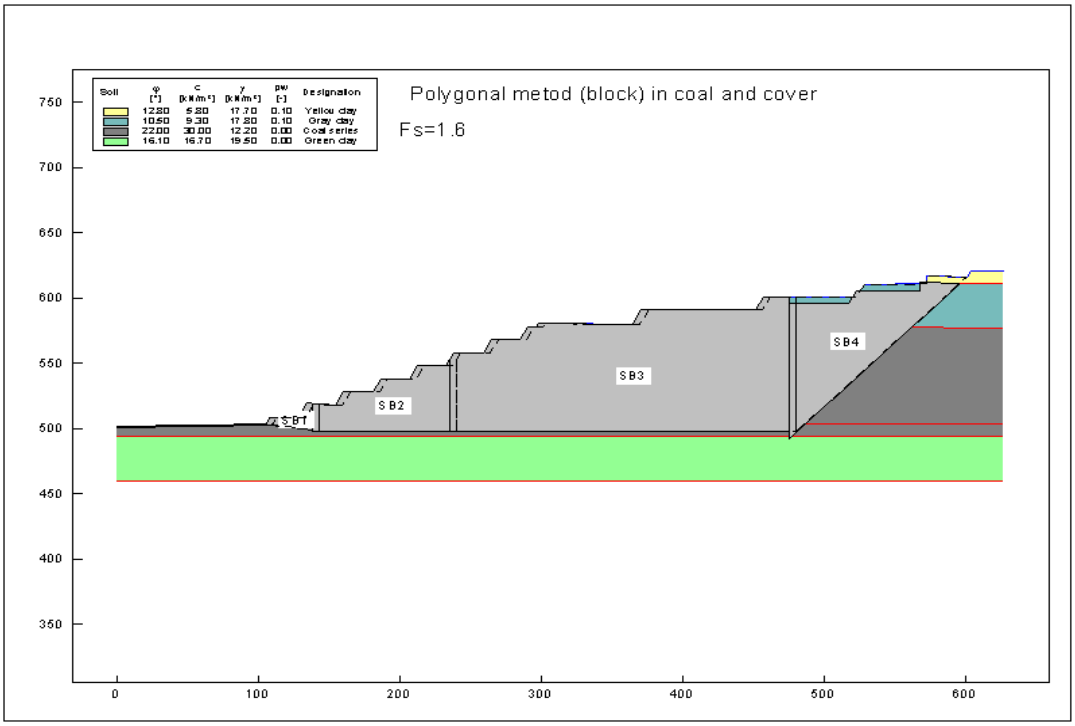


Figure 15. Blocs possible movements

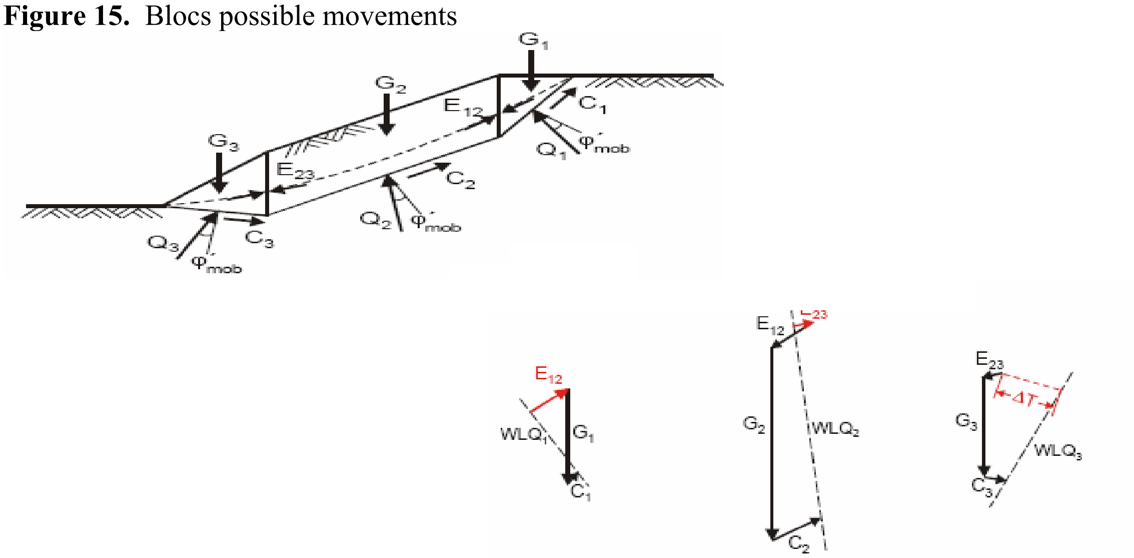


Figure 16. Vertical slice method

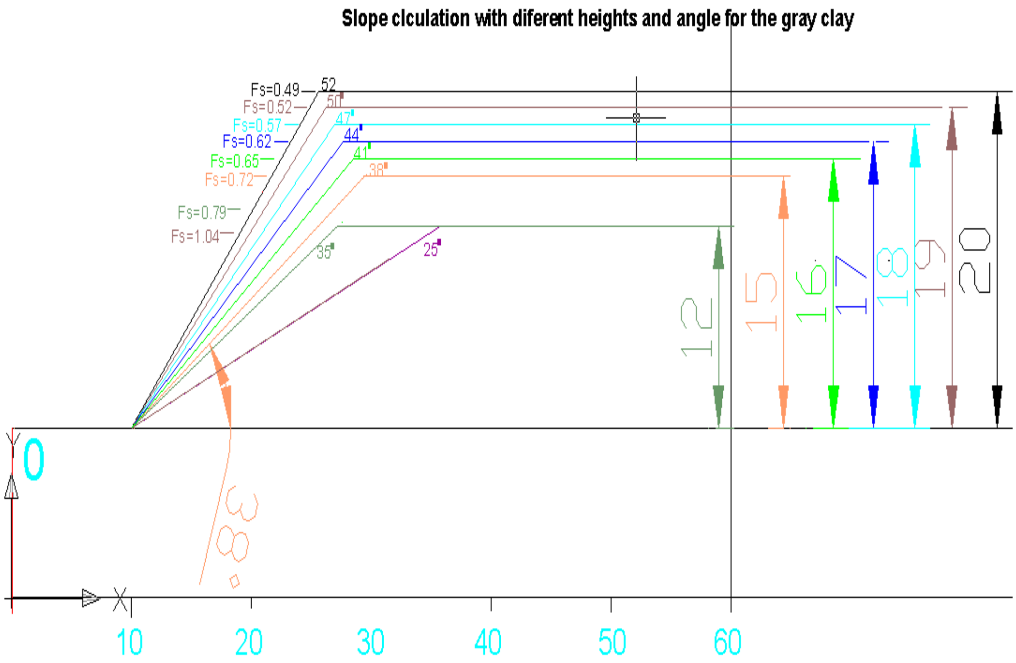


Figure 17. Slopes calculation with different heights and angles for the gray clay

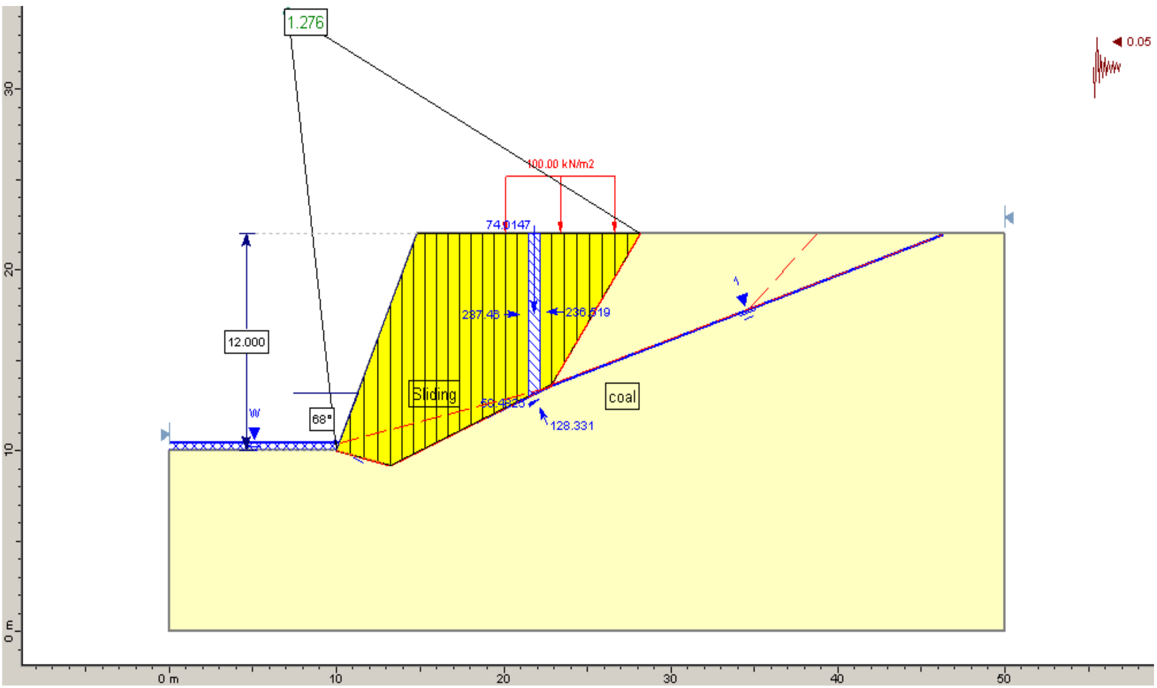


Figure 18. Partial Angle in Coal

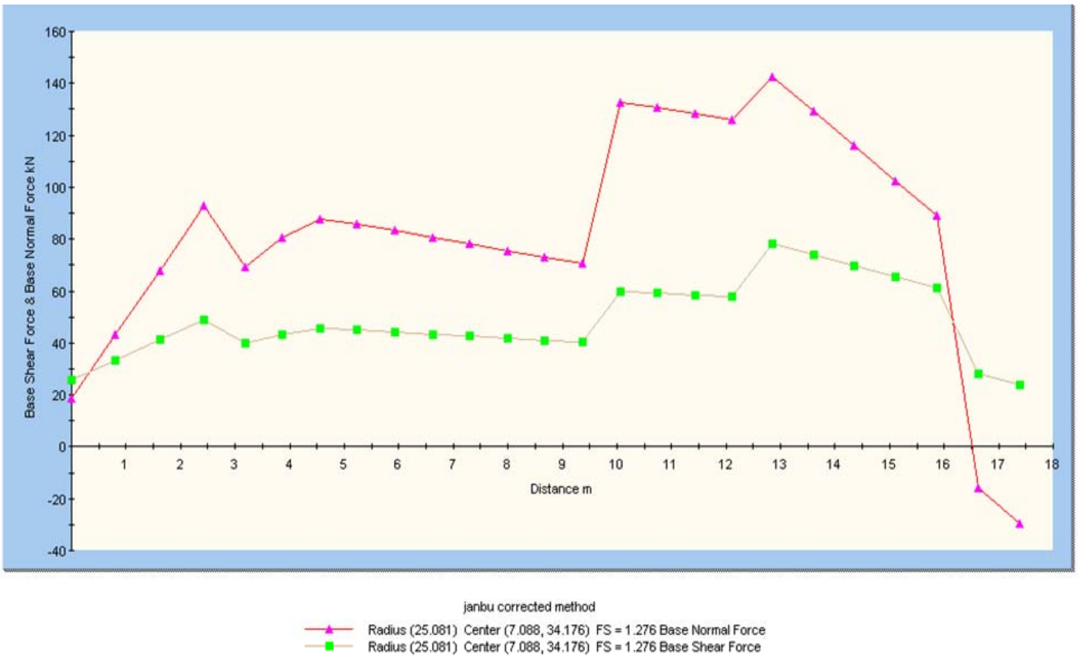


Figure 19. Base shear force &Base Normal Force [KN]

Table 2. Slopes calculation partial with Seismic coefficient

Method	Heigh (m)	Angle ß°	Center (x,y)	Radius	Seismic coeff.	Load q[KN/m^2]	Porewater. pressure. ru	Fs.
Bishop-it	20	52	4.32 46.75	36.50	0.05	110	0.0	0.44
Janbu	19	50	5.23 45.56	35.48	0.05	110	0.0	0.462
Corps of Engineers #1	18	47	6.20 47.07	37.12	0.05	110	0.0	0.496
Corps of Engineers #2	17	44	9.78 43.25	33.18	0.05	110	0.0	0.530
GLE/Morgensten-Price	16	41	8.24 47.20	36.86	0.05	110	0.0	0.568
Lowe-Karafiath	15	38	9.41 48.52	38.42	0.05	110	0.0	0.592
Ordinary/Fellenius	12	35	16.48 35.58	26.20	0.05	110	0.0	0.664
Spancer	12	25	15.53 40.0	30.43	0.05	110	0.0	0.70

Table 3. Slopes calculation partial with pore water pressure

Method	Heigh (m)	Angle ß^o	Centre (x, y)	Radius	Seismic coeff.	Load q[KN/m^2][	Porewater. pressure. ru	Fs.
Bishop-it	20	52	4.32 38.37	28.35	0.0	0.0	0.10	0.494
Janbu	19	50	5.23 37.38	27.55	0.0	0.0	0.10	0.52
Corps of Engineers #1	18	47	6.20 39.04	28.74	0.0	0.0	0.10	0.57
Corps of Engineers #2	17	44	7.18 35.45	25.58	0.0	0.0	0.10	0.62
GLE/ Morgensten-Price	16	41	10.77 31.99	21.80	0.0	0.0	0.10	0.65
Lowe-Karafiath	15	38	9.41 38.6	28.48	0.0	0.0	0.10	0.72
Ordinary/ Fellenius	12	35	12.37 29.41	19.54	0.0	0.0	0.10	0.79
Spancer	12	25	17.23 34.48	25.509	0.0	0.0	0.10	1.046

Conclusion

The coal basin of Kosovo is one of the largest basins in Balkan with the exploitation in the surface mine in the open sky with exploitation reserves more than 100 years. The average thickness of the coal lay is 70m and covered with deposits of Quaternary, alluvion with an average thickness of 8-10 m. In other sectors the coal lay is (65% of the surface covers) by the yellow clay with an average thickness of 10-12m and grey clay with an average thickness of 30m

Therefore this report coal cover-layer in ratio 3:1 is conditioned the exploitation of surface mine. In geological composition of the basin and peripheral zone take place many formations, as those of Paleozoic (with crystal limestone snow slip), Mesozoic (limestone and cretaceous fleshes), Cenozoic that is represented by the depositions of Neogene and those of Quaternary mainly with gravel and alluvion sand.

In geological composition the basin of Kosovo is characterized with diversity lit logy, as in horizontal as well in vertical extension.

In the structural side the basin of Kosovo has a developed tectonics it is represented graded of grebe type, covered with deposits of Neogene and Quaternary.

Within this synclinal, in the lays of coal are developed many separations tectonically systems with parallel and diagonal directions with lengthwise ax of the basin

Recommendation

Basing on geo -mechanical parameters that are processed and realized in the laboratory according to the drillings done, without trying to avoid the tectonic introduced, the presence of surface water, underground there are calculated the partial and general slopes with different heights and angles as in coal as well in clay, up to the time the minimal and maximal possible factor was found for exploitation of coal.

As a conclusion it should be said for exploitation of coal should be considered the height of covered slopes which should be $h \leq 10$m and the angle $\alpha \leq 25^0$ for yellow clay as partial angles, whereas for the grey clay the height of slope is:

$h \leq 12$m and the angle $\alpha \leq 25^0$ that are shown in a tabular form and Figure 17, whereas in coal the partial angle should be $\alpha \leq 65^0$ with a height $h \leq 12$m, that is shown in Figure 18 and the general one in coal $\alpha \leq 22^0$ that is shown in figure 9 , that in any way should be the removal of water through protected canals in order not to deal with any weakness of physic-mechanical parameters.

Temporary greening is recommended to counteract erosion in the area of the head slopes. If necessary, use of geo textiles has to be checked

Furthermore specific geotechnical features like underground cavities resulting from coal first and past mining activities, formation of fissures in fault zones or sliding masses have to bi considerate

According to the gained results, all methods have given satisfactory results but we should distinguish:

Bishop's methods, give 90% results in ductile rocks (clays) in report of tough formations (coals). The reason is in the fact that the circle cylinder form is difficult to realize in coals except of any sliding in the same form.

Whereas the form of Janb-us (polygonal) and that of blocks (polygonal) in tough rocks (coals) have given more satisfactory results in report with those of circle cylindrical forms, because the tectonic in coal is expressed in the form of blocks, that suits these two methods for calculation of stability of slopes**.**

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