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Statistical Processing of Drillings Done in Surface Mine of Kosovo for Exploitation of Coal 2008-2024

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Abstract : Knowing that the Republic of Kosovo even though with a small surface of territory in economical aspect there are concentrated energetic resources of the Balkan and European rang. he surface exploitation of the minerals which are useful, without any doubt represent an easy way of the exploitation with a lower cost in report to the underground exploitation but very often during the mineral activity exercise as a result of low scale of the studying by geotechnical aspect of source spot or by non respect of physical-mechanical parameters that may cause problems with consequences in human beings and technological equipments. In this context this work deals with problems of this nature which appeared as a consequence of mineral activity exercises in the case of joint of two mines as the one of Mirash and Bardh in coal basin of Kosovo as well as the opening of the new mine of South-West Sibovc that are necessary additional researches in the geology-engineering-geotechnical aspect by basing on lit logic description of drilling and taking samples for lab oratorical analyses which should be done with technological devices of the recent technology with four tests: starting with Triaxial test , Direct shear test, Module of sustainability and that with Ring shear test , considering statistical processing for issuing more accurate parameters for coal exploitation by geotechnical aspect for the needs of the country and further.

***Key-words:** , Drillings ,Statistical Elaboration, exploitation*

Introduction

The territory of Kosovo is quite rich with natural resources that have an extraordinary strategically for development of various sectors of industry and economy of Kosovo. Therefore knowing the large amounts of coal and their economical importance for their exploitation up to power plants wherein is produced the electrical energy for economic development of the country in order to extract it in more rational way and without consequences, but in order to avoid these consequences are done additional research drillings about 25 drillings with the depth up to the green layer which are shown in Figure 2. (Buβ,J September 2008), (Bresnahan & Dickenson 2009) Software program surfer 8 by getting above 100 samples for physical-mechanical feature analyses according to different depths that are shown billow with symbols SB and Sh. The location wherein the research is done is shown in the zone nearby the surface mine Bardh and Mirash on the map Figure.1

The purpose and importance of studying in this work is the statistical processing of over 100 samples by issuing the physical-mechanical parameters for three layers beginning from yellow clay, grey clay and green clay. Statistical processing for three layers are shown on tables 1,2,3,whereas according to Achtenberg's limits are shown in Tables 4-6 , as well as the main parameters of mechanical soils which are internal friction angle (φ) and cohesion (C) by using four methods, Triaxial test, Direct shear test, Module of sustainability and that with ring shear test all of them are shown in Figures 6-9; whereas statistical work is shown on Tables 7-11 according to Ahmeti H,(2008), for issuing the accurate parameters for coal exploitation until 2024

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Figure.1 The map where is situated the research coal basin of Kosovo

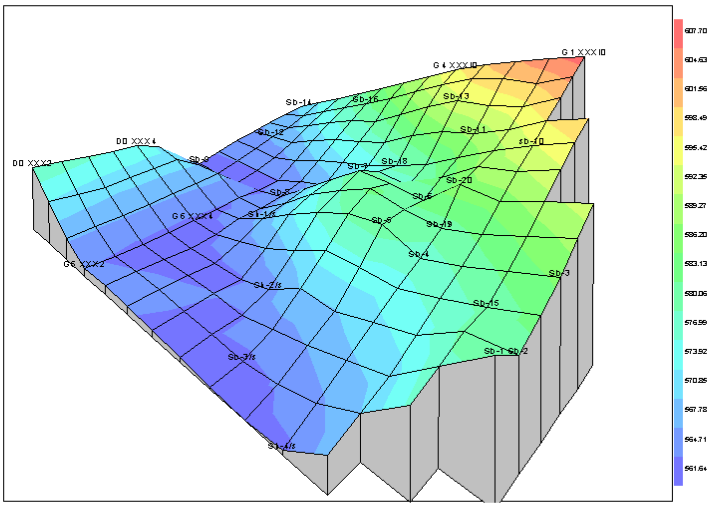

Figure.2 The locations wherein are done drillings for physical-mechanical feature analyses

Physical situation of samples for

Analyses

SB-1/ 4.00-5.00 .	SB-8/ 23.00-24.00	SB-16/ 5.00-6.00.
SB-1/ 12.00-13.00 .	SB-8/ 26.00-27.00 .	SB-16/ 10.00-11.00
SB-1/ 25.00-26.00	SB-8/ 107.00-108.00	SB-16/ 30.00-31.00 .
SB-2/ 4.00-5.00 .	SB8/ 111.0-112.00	SB-16/ 41.00-42.00
SB-2/ 11.00-12.00 .	SB-9/ 4.00-5.00	SB-16/ 124.00-125.00
SB-2/ 20.00-21.00 .	SB-9/ 11.00-12.00	SB-17/ 9.50 – 10.00
SB-2/ 41.00-42.00	SB-9/ 20.00 -21.00.	SB-17/ 14.50-15.00
SB-2/ 49.00-50.00	SB-9/ 27.00-28.00 .	SB-17/ 19.50-20.00 .
SB-2/ 71.00-72.00	SB-9/ 105.00-106.00	SB-17/ 24.50-25.00
SB-2/ 74.00-75.00	SB-9/ 113.00-114.00	SB-17/ 55.40-56.00 .
SB-3/ 3.00-4.00	SB-10/ 3.00-4.00 .	SB-18/ 5.50-6.00
SB-3/ 11.00-12.00	SB-10/ 9.00-10.00	SB-18/ 20.50-21.00
SB-3/ 20.00-21.00	SB-10/ 21.00-22.00	SB-18/ 40.50-41.00 .
SB-3/ 29.00-30.00 .	SB-10/ 31.00-32.00	SB-18/ 59.50-60.00 .
SB-3/ 75.00-76.00	SB-10/ 36.50-37.50	SB-18/ 117.50-118.30 .
SB-3/ 81.00-82.00	SB-11/ 5.00-6.00	Sh- 1/ 6.00 – 7.00
SB-4/ 5.00-6.00	SB-11/ 14.00-15.00	Sh- 1/ 11.00 – 12.00.

SB-4/ 11.00-12.00	SB-11/ 18.00-19.00	Sh- 1/ 18.00-19.00.
SB-4/ 20.00-21.00	SB-11/ 29.00-30.00.	Sh- 1/ 29.00 – 30.00
SB-4/ 28.00-29.00 .	SB-11/ 44.00-45.00	Sh- 1/ 35.00 – 36.00 .
SB-4/ 114.00-115.00	SB-11/ 53.00-54.00	Sh- 1/ 120.40 – 121.40
SB-4/ 119.00-120.00	SB-11/ 65.00-66.00	Sh- 1/ 130.00 – 131.0 .
SB-5/ 4.00-5.00	SB-11/ 69.00-70.00	Sh-2/ 5.00 – 6.00 .
SB-5/ 14.00-15.00 .	SB-12/ 6.00-7.00	Sh-2/ 11.00 – 12.00
SB-5/ 26.00-27.00 .	SB-12/ 16.30-17.30	Sh-2/ 20.00 – 21.00
SB-5/ 35.00-36.00 .	SB-12/ 26.00-27.00	Sh-2/ 30.00 – 31.00
SB-5/ 42.00-43.0	SB-12/ 29.00-30.00	Sh-2/ 33.00 – 34.00
SB-6/ 5.00-6.00 .	SB-13/ 5.00-6.00 .	Sh-2/ 124.00 – 125.00 .
SB-6/ 10.00-11.00	SB-13/ 17.00-18.00	Sh-2/ 136.00 – 137.00 .
SB-6/ 22.00-23.00 .	SB-13/ 26.00-27.00	Sh-3/ 19.10 – 19.60
SB-6/ 32.00-33.00	SB-13/ 39.00-40.00	Sh-3/ 29.30 – 29.80 .
SB-6/ 41.00-42.00 .	SB-13/ 47.00-48.00	Sh-3/ 124.00 – 125.00 .
SB-6/ 50.00-51.00	SB-13/ 56.00-57.00 .	Sh-3/ 132.00 – 133.00.
SB-6/ 62.00-63.00	SB-13/ 69.00-70.00	Sh-4/ 5.00 – 6.00 .
SB-6/ 64.30-65.30	SB-13/ 77.00-78.00	Sh-4/ 11.00 – 12.00 .
SB-6/ 120.00-121.00	SB-14/ 3.00-4.00.	Sh-4/ 19.50 – 20.50
SB-7/ 3.00-4.00	SB-14/ 11.00-12.00.	Sh-4/ 98.50 – 99.50.
SB-7/ 17.00-18.00 .	SB-14/ 20.00-21.00.	Sh-4/ 135.00 – 136.00.
SB-7/ 23.00-24.00 .	SB-14/ 31.00-32.00	
SB-7/ 34.50-35.50 .	SB-15/3.50-4.00	
SB-7/ 43.00-44.00 .	SB-15/ 11.20-11.60	
SB-8/ 8.00-9.00	SB-15/ 15.00-15.40	
SB-8/ 14.00-15.00	SB-15/ 18.00-18.40	
	SB-15/ 20.60-21.00	
	SB-15/ 90.50-91.00	

Figure.3 change of yellow clay in grey clay

Figure.4 the extraction of coal core

Figure.5 green clay in depth of 129m

1.2 Lab oratorical analyse

Main parameters of physical state of soils are
Natural humidity W[%]
Volume weight γ [kN/m^3]
Specific weight γ_s [kN/m^3].
Granule metric content
Atterberg' s borders in consistence W_r, Wp, Ip, Ic and I_r.
porosity (n) and porosity coefficient (e)

1.3 main parameters of mechanical state of soils are
Internal friction angle (φ) and cohesion (C)
Triaxial test
Direct shear test
Ring shear test
Module of sustainability E_N [kN/m^2]

Figure.6 Triaxial test

Figure.7 Direct shear test


Figure.8 Ring shear test


Figure.9 Module of sustainability

Statistical Processing Analyses and Results

Statistic processing is done by calculating:

Average value $$\bar{X} = \frac{\sum Xi}{n}$$

Standard deviation $$S = \sqrt{\frac{\sum (Xi - \bar{X})^2}{n-1}}$$

Coefficient of variation $$v = \frac{S}{\bar{X}} \times 100\%$$

Statistical processing of physical parameters of soils for three layers are shown in Tables 1- 6

Table 1. Obtained results from statistical of physical parameters for yellow clay

Statistical indexes	V.weight γ[kN/m^2]	V.dried weight γ_t[kN/m^2]	Specific weight γ_s[kN/m^2]	humidity W[%]	porosity n	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. samples	20	20	19	20	19	19
S	0.867	1.077	0.27	6.6	3.18	0.14
V	4.901	8.3	1.0	18	6.2	13.4

Table 2. Obtained results from statistical of physical parameters for grey clay

Statistical indexes	V.weight γ[kN/m^2]	V.dried weight γ_t[kN/m^2]	Specific weight γ_s[kN/m^2]	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. samples	75	75	64	75	55	55
S	0.697	1.07	0.20	0.48	21.98	0.132
V	3.92	8.162	0.7	12.6	43.5	12.9

Table 3. Obtained results from statistical of physical parameters for green clay

Statistical indexes	V.weight γ[kN/m^2]	V.dried weight γ_t[kN/m^2]	Specific weight γ_s[kN/m^2]	humidity W[%]	Porosity n	Porosity coefficient e
X max	20.83	18.46	26.8	33.83	49.2	0.97
X min	17.92	13.5	25.89	12.69	30.59	0.441
X mean	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	4.2	7.4	0.9	20.1	11.5	19.8

Table 4. Obtained results from statistical processing according to Atterberg's borders for yellow clay

Ord. Nr.	Sample .(m)	Natural humidity W[%]	Plasticity indexes				
			Wrr	Wp	Ip	I_r	Ic
1	Sb-1/4.00-5.00	37.83	65	34.5	30.5	0.109	0.89
2	Sb-2/4.00-5.00	30.3	51	26	25	0.18	0.82
3	Sb-5/4.00-5.00	30.42	55	22.6	32.4	0.23	0.77
4	Sb-7/3.00-4.00	33.9	55.2	27.7	27.5	0.23	0.77
5	Sb-10/3.00-4.00	35.04	49	29.6	19.4	0.28	0.72
6	Sb-17/9.50-10.00	37.2	58	31	27	0.23	0.77
7	Sb-18/5.50-6.00	40.1	47	26.4	20.6	0.665	0.33
8	Sb-18/20.50-21.00	41.2	50	30.3	17.7	0.553	0.44
9	Sh-1/6.00-7.00	41.83	58	32.3	25.7	0.37	0.62
10	Sh-2/5.00-6.00	37.51	53	28.4	24.6	0.35	0.63
11	Sh-4/5.00-6.00	38.4	63	36.8	26.2	0.06	0.93

Table 5 Obtained results from statistical processing according to Achtenberg's borders for grey clay

Ord nr.	Sample .(m)	Natural humidity W[%]	Plasticity indexes				
			Wrr	Wp	Ip	I_r	Ic
12	Sb-1/12.00-13.00	39.88	61	37.2	23.8	0.113	0.88
13	Sb-1/25.00-26.00	39.07	69	38.5	30.5	0.019	0.98
14	Sb-2/20.00-21.00	36.14	59	31.4	27.6	0.172	0.82
15	Sb-3/11.00-12.00	35.7	65	34.2	30.8	0.049	0.95
16	Sb-4/28.00-29.00	37.16	62	36	26	0.045	0.95
17	Sb-5/14.00-15.00	33.63	48	28.8	19	0.25	0.75
18	Sb-5/26.00-27.00	33.21	57	24.2	32.8	0.46	0.54
19	Sb-6/50.00-51.00	33.53	62.0	40.6	21.4	-0.33	1.33
20	Sb-7/17.00-18.00	36.9	64.0	22.07	41.9	0.35	0.65
21	Sb-9/11.00-12.00	36.15	44	26.9	17.1	0.54	0.46
22	Sb-9/20.00-21.00	31.7	56	32.5	23	-0.034	1.03
23	Sb-10/9.00-10.00	35.06	63	36.8	36.2	-0.066	1.06
24	Sb-10/21.00-22.00	38.68	51	22.9	28.1	0.56	0.46
25	Sb.16/10.00-11.00	32.44	56	25.3	25.7	0.24	0.76
26	Sb-16/30.00-31.00	35.42	51	36	15	-0.4	1.40
27	Sb-16/41.00-42.00	34.56	54.7	33.6	21.1	0.045	0.95
28	Sb-17/19.50-20.00	34.7	63	36.3	26.7	0.041	0.95
29	Sb-17/24.50-25.00	37.1	61	36	25	0.044	0.95
30	Sb-18/40.50-41.00	38.4	64	34.2	29.8	0.14	0.86
31	Sh-1/11.00-12.0	37.13	71	36	35	0.032	0.98
32	Sh-1/29.00-30.00	36	69	33.5	35.5	0.070	0.93
33	Sh-2/11.00-12.00	37.5	75	38.4	36.6	-0.02	1.02
34	Sh-2/30.00-31.00	36.3	66	37.1	28.9	-0.02	1.02
35	Sh-3/19.1-19.6	28.72	54	27.5	26.5	0.04	0.95

Table.6 Obtained results from statistical processing according to Atterberg's borders for green clay

Ord.nr.	Sample .(m)	Natural humidity W[%]	Plasticity indexes				
			Wrr	Wp	Ip	I_r	Ic
36	Sb-8/107.00-108.00	22.01	45	26	19	-0.21	1.21
37	Sb-8/111.00-112.00	20.0	49	22.5	26.5	-.094	1.09
38	Sb-18/117.50-118.00	22.9	53	25.1	27.9	-0.079	1.07
39	Sh-1/130.00-131.00	25.92	52	23.3	28.7	0.09	0.90
40	Sh-4/ 135.00-136.00	20.7	60	23.6	36.4	-0.07	1.07

3. Calculation of total value for the toughness parameters determined with Direct shearing test

The determination of these parameters is done by joining of all resistance parameters in shearing τ and normal specific pressure in sample σ according to expression:

$$\tau = \sigma\, tg\varphi + C$$

So that the total value for tgφ and C is calculated according to expressions:

$$C = \frac{1}{\Delta}\left[\sum_{i=1}^{n}\tau_i \sum_{i=1}^{n}\sigma_i^2 - \sum_{i-1}^{n}\sigma_i \sum_{i=1}^{n}\sigma_i\tau_i\right] \quad tg\varphi = \frac{1}{\Delta}\left[n\sum_{i=1}^{n}\tau_i\sigma_i - \sum_{i=1}^{n}\tau_i \sum_{i=1}^{n}\sigma_i\right] \quad \Delta = n\sum_{i=1}^{n}\sigma_i^2 - (\sum_{i=1}^{n}\sigma_i)^2$$

Standard deviation of cohesion $Sc = S_\sigma \sqrt{\frac{1}{\Delta}\sum \sigma_i^2}$

Coefficient of variant for cohesion $v_c = \frac{Sc}{\bar{C}}$

Statistical processing of toughness obtained by triaxial test
is done according to the expressions:

$$tg\varphi = \frac{a-1}{2\sqrt{a}}, \left[{}^{0}\right]$$

$$C = \frac{b}{2\sqrt{a}}, \left[\frac{kN}{m^2}\right]$$

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

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

$$\Delta = n\sum\sigma_3^2 - \left(\sum\sigma_3\right)^2$$

Results

Table.7 Obtained results by triaxial direct shear test for yellow clay

Triaxial test			**Direct shear test**		
Statistical indexes	C [kN/m^2]	φ [^{0}]	Statistical indexes	C [kN/m^2]	φ [^{0}]
X max	16.0	23.45	X max	13.0	18.0
X min	2.0	10.06	X min	0.0	7.22
X mean	11.57	14.17	X mean	5.94	12.51
∑Xi	81	102.9	∑Xi	101	212.68
n	7.0	7.0	n	17.0	17.0

Table.8. Obtained results from the ring shear test and direct shear test for grey clay

Ring shear test			**Direct shear test**		
Statistical indexes	C [kN/m^2]	φ [^{0}]	Statistical indexes	C [kN/m^2]	φ [^{0}]
X max	18.0	14.0	X max	50.0	17.9
X min	9.0	9.0	X min	0.0	6.1
X mean	12.4	12.0	X mean	9.05	12.8
∑Xi	87.0	84.0	∑Xi	220.9	463.09
n	7.0	7.0	n	43	43

Table.9 Obtained results from direct shear test for green clay

Statistical indexes	C [kN/m^2]	φ [^{0}]
X max	26.0	19.0
X min	6.0	12.8
X mean	16.7	16.1
∑Xi	251	241.6
n	15.0	15.0

Table.10. Obtained results from sustainability module for yellow clay

Statistical indexes	**σ=100[kN/m²]**	**σ=200[kN/m²]**	**σ=400[kN/m²]**
X max	5556	8000	10520
X min	888.9	1250	2899
X mean	2886	3407	5181
∑Xi	37516	44286	67348
n	13	13	13

Table.11 Obtained results from sustainability module for grey clay

Statistical indexes	**σ=100[kN/m²]**	**σ=200[kN/m²]**	**σ=400[kN/m²]**
X max	1250	14280	20000
X min	1086.95	1639.34	3100.77
X mean	4451.54	5975.93	8037.88
∑Xi	191416.2	256965.2	345628.6
n	43	43	43

Joining of parameters

$$C_{pergj} = \frac{C_{pd}^{N} \times npd + C_{t}^{N} \times ntr}{n_{pd} + n_{trer}}, \left[\frac{kN}{m^2}\right] \quad (1)$$

$$\varphi_{pergj} = \frac{\varphi_{pd}^{N} \times n_{pd} + \varphi_{t}^{N} \times n_{trer}}{n_{pd} + n_{trer}}, \left[{}^{0}\right] \quad (2)$$

n_{pd}- number of samples with shearing test
n_{ter}- number of samples with triaxial test

Since is done the joining of parameters, these values are exposed statistical processing by doing the correction according to the expressions:

$$\Delta C = \sqrt{\frac{(C_{pergj} - C_{pd})^2 n_{pd} + (C_{pergj} - C_{t})^2 n_{t}}{n_{pd} + n_{t}}}, \left[\frac{kN}{m^2}\right] \quad (3)$$

$$\Delta \varphi = \sqrt{\frac{(\varphi_{pergj} - \varphi_{pd})^2 n_{pd} + (\varphi_{pergj} - \varphi_{t})^2 n_{t}}{n_{pd} + n_{t}}}, \left[{}^{0}\right] \quad (4)$$

Finalization of geo mechanical parameters

Finalization of parameters is done for determined reliability from B=90%. For the concrete case parameters Qc and Qφ for reliability 90%, for values of which are accepted from tables t_a= 1.35 for K= n -2 Bozo, L(2007), Đukić, D (1984) whereas the calculation is done according to formulas:

$$Qc = \frac{t_a \times \Delta C}{\sqrt{n}} \quad (5) \qquad Q\varphi = \frac{t_a \times \Delta \varphi}{\sqrt{n}} \quad (6)$$

From these are calculated the reduced values of cohesion and internal friction angle , whereas parameters for coal are taken from processed elaborates by *INSTITUTE INKOS* (2003) North slope in surface mine Bardh.

Table.12 final results

Lit logical Member	**Physical-mechanical parameters** φ' [°]	c' [kN/m²]	γ [kN/m³]
Yellow clay	13.1	7.5	17.72
Grey clay	12.6	9.5	17.81
Coal layer	40.0	50.0	12.2
Green clay	16.1	16.7	18.5

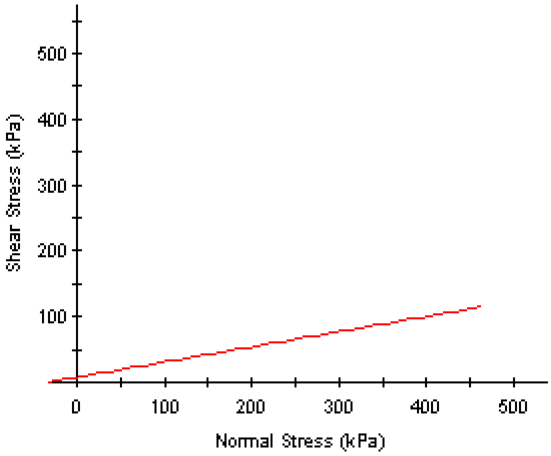

Fig.10 Direct shear diagram of yellow clay

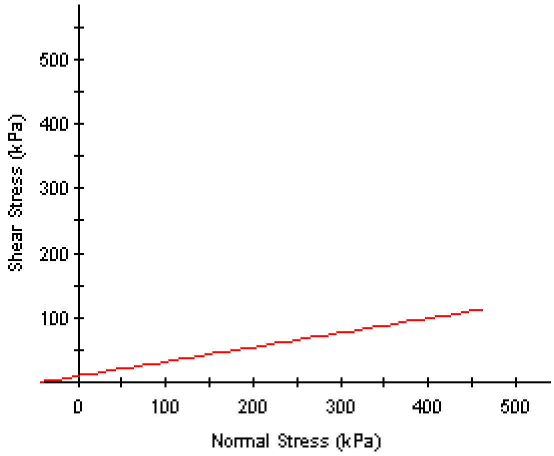

Fig. 11 Direct shear diagram of grey clay

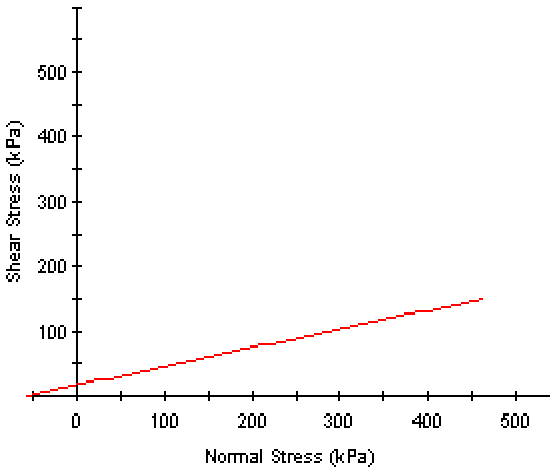

Figure 12. Diagram of direct shearing, coal

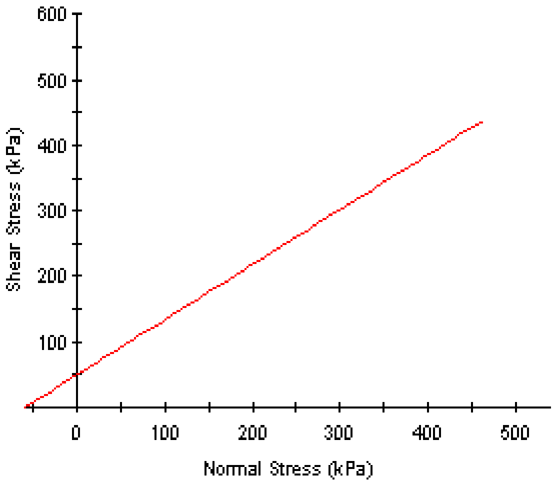

Figure 13. Diagram of direct shearing, green clay

Conclusions

From the concrete data during the opening of samples for analyzing a number of samples were damaged, for the reason of lit logical layers damages, such a phenomenon is noticed during the extraction of core as in fig 3,4,5 whereas the other group is noticed even during the opening of samples for lab oratorical analyses.

As a damage of these lit logical layers is supposed had happened because of tectonic movements of coal that basing in the drillings achieve a plunging up to 20m as well the presence of surface and underground water that influenced in the weakness of physical-mechanical parameters and in meantime deposition of clay materials that is necessary at least 80 years for their consolidation.

According to the obtained results from geo mechanical lab oratorical tests and obtained results during the drilling, it is concluded that this part is very complicated for exploitation as it is a zone with quiet evident tectonic movements because of the presence of humidity as well as non continual extension of lit logical layers.

For this reason geo mechanical parameters especially those of toughness evidently differ in the same lit logical layer. Regarding to this, the determination of these parameters is done with four methods; with the method of triaxial test, with the method of direct shear test, with Ring shear test and with sustainability module that are shown in fig. 6,7,8,9 wherein are prepared the samples for analyse, since in the cracked samples are obtained unreal values, whereas for healthy samples (without damages) are obtained real values. Basing on that that the majority of samples were cracked then these parameters are determined with the method of Ring shear test. For this reason is done statistical processing for three layers that according to different results is done the joining of three methods pursuant to formula 1, 2, 3, 4 in order to approach to issuing of the real parameters for slope calculation in order to create optimal conditions as by geotechnical aspect also technological aspect whereas the finalization of parameters is realized according to Formulas 5 & 6.

In calculation of slopes should be considered the parameters done from statistical processing that are shown on Table 12, and in diagram with figure 10-13 Slide.V5.0 (1989-2006)

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