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SLOPE STABILITY ANALYSIS OF THE WORKING LEVEL AND FINAL SLOPE IN THE SURFACE MINE OF MARLS NEAR 'HANI I ELEZIT'

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ABSTRACT

The future of Kosovo's economic development relies on the exploration of natural resources, particularly, mining. Great importance has been placed on the exploitation of these resources via the surface utilization of marls. Marls being the prevalent raw material for cement production. Since the beginning of 20thcentury, great achievements have been made in the geo-techniques field, leading to the remarkable progress in the art of mining.This paper through the limit equilibrium solution examines the optimization of parameters for slope stability and presents the findings of the on-site research and lab workings conducted on the open-pit mines of marls near the cement plant "SHARR CEM" Hani i Elezit.

Expansion of the mine to the south-eastern boundary will require significant stability analysis.Therefore in order to determine represented parameters as realistically as possible, physic-mechanical parameters were drawn from the material on the slope. The lab results were processed from astatistical perspective their reduction were conducted under geotechnical conditions for safety. This parameters where adopted so that slope stability calculations could take place. Two analytic methods were used for geostatic analyses,The Bishop'smethod and Janbu's method.

INTRODUCTION

The continued economic development of Kosova is primerly dependent on mineral resouces with mining being a significant industry and main contributor to the economy. Of particular importance is the extrations of marls from open-pit mines. This paper presents development of research techniques in the laboratory as well as in the field for the open-pit marls mines locations. In these locations marls is found in abundance and is main raw material in production of cement.The proposed expansion of the mine on south-eastern boundary requires an assessment of the stability of the slopes for this part of the mine.In order to find out the exact parameters of lithological strata for which the research has been conducted, some physico-mechanical parameters have been concluded.For parameters gained in the laboratory, statistical calculations have been employed, resulted in reduction of parameters on geotechnical conditions required for safety.For geostatic analysis in this paper two analytical methods have been used: The Bishops' method and Janbus' method

To-date a wide range of research has been published on the methodology of determining optimal parameters for slope stability in resource utilization. Therefore in this paper the application of 'limit equlibrium solution' (methods of potencial sliding surfaces) has been applied, to reveal optimization of parameters for slope stability

1.0 CURRENT DEVELOPMENTS IN SURFACE MINES OF MARLS.

Marls reserves are found in the vicinity of town 'Hani i Elezit'. Strata of marls are laid out on the eastern side of the town and along the road (mororway) Prishtiné (Prishtina – Shkup (Skopje). Research has been conducted to include the terain which extends into the munipciality of Kaçaniku(*read - Kachaniku).*Transportation of marls from the open-pit mine to the factory is carried out with conveyor belts constracted over the bridge which crosses the motorway (Prishtiné – Shkup). The factory is situated on the western side of the raod. For this reason the factory has a desierd posision and good transportation links.

2.0. AXIOM OF THE GEOMECHANIC PARAMETERS NEEDED FOR GEOSTATICE ANALYSIS

To achieve a realistic ananlysis of the slope stability, the manner of selection of the representative geomechanical parameters is of paramount importance. The assumptions of geomichanic parameters was achieved based on the results gained with lab ananlysis, statistical workings:

- For Marls: φ =30.83 [^{0}], Cr = 31.84[KN/m^2], γ = 20.34[KN/m^3]
-For Sand: φ =26.00 [^{0}], Cr = 15.00[KN/m^2], γ = 22.00[KN/m^3]
-For formations: φ =36.00 [^{0}], Cr = 125 [KN/m^2], γ = 28.00[KN/m^3]

Fig.1. The situation map of the marls mine "Hani i Elezit"

3.0. ANALISYS OF THE SLOPE STABILITY

Based on the geological and hydrogeological results obtained in the field as well as calculated geomecanic parameters in the laboratory, appropriete geomechanic profiles have been constracted for analysis of the slope stability.The laboratory analysis and the litology from the samples of test drills have indicated that profil 5-5, is more important for analysis of the stability of the slopes.

Based on profile mentioned above the following has been analyzed.

- Geometric parameters of the working level [**α and h]** and
- Overall gradient of the slope[**β**]

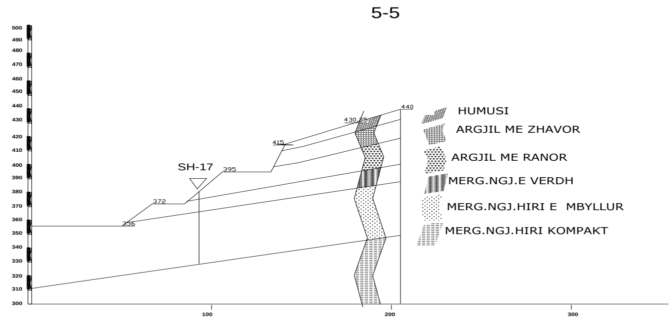
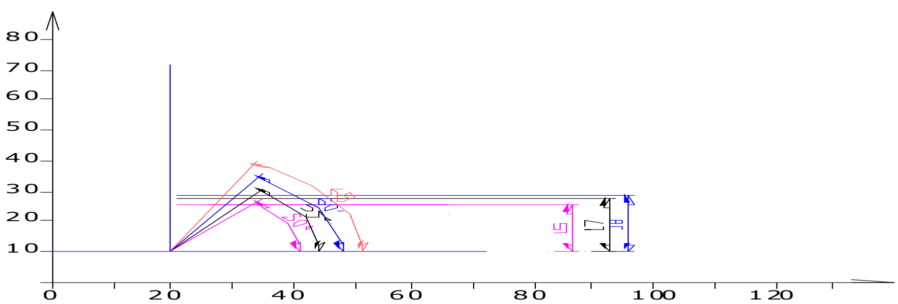


Fig.2. Profile of the working level 5-5.

4.0. ASSUMPTION OF OPTIMAL PARAMITERS OF THE GEOMTRIC WORKING LEVEL (hight of the bench [h], angle of the working bench [α] and Overall angle [β]

To acheave realistic analysis of slope stability the method used to determin optimal geometric parameters of the working level (the hight and angle of the bench) is of atmost importance.

Height of the working level	Angles of the working level	Overall angle of the slope
h=15 [m]	$\alpha=50^0$; $\alpha=55^0$; $\alpha=60^0$	$\beta=25^0$
h=17 [m]	$\alpha=50^0$; $\alpha=55^0$; $\alpha=60^0$	$\beta=30^0$
h=18 [m]	$\alpha=50^0$; $\alpha=55^0$; $\alpha=60^0$	$\beta=35^0$



Diag.1. Presents angles of the working level [**α**] and height of the working level [h] which are being ascertained for geostatic analysis with: BISHOP'S AND JANBU'S methods on profile 5-5'.

4.1. ASSUMPTION OF PORE WATER PRESSURE

This Ratio is usually obtained from the existing tables with given values.

r_u= 0.00 , r_u= 0.10 ,r_u= 0.20 and r_u= 0.3

4.2. DETERMINATION OF THE SAFTY FACTOR.

Befor we can start analysing the stability of the slopes we have to obtain the safety factor depending on the weight of the object and time span of the stability of the slope.In this instance, since the wroking level has a short time span, minimal safety factor. $\mathbf{F_{min}}$**= 1.10**, has been adopted.Whereas steepnes of the final slope on the eastern side of the mine where there are no objects of any siginificanse, safety factor $\mathbf{F_{min}}$**= 1.30.** has been adopted. And on western side, there are objects of capital value, like the motorway Prishtiné – Shkup, Ball mill and Petrol station; for the angle of the bench and angle of the final slope, safety factor $\mathbf{F_{min}}$**=1.50.** has been adopted.

5.0. METHODS USED FOR CALCULATION OF SAFTY OF THE SLOPE.

Methods for calculating safty of slopes are:

- Sircular slip surfaces – Bishops' method.
- Non-sircular slip surfaces– Janbus' method.

5.1. BISHOPS' METHOD

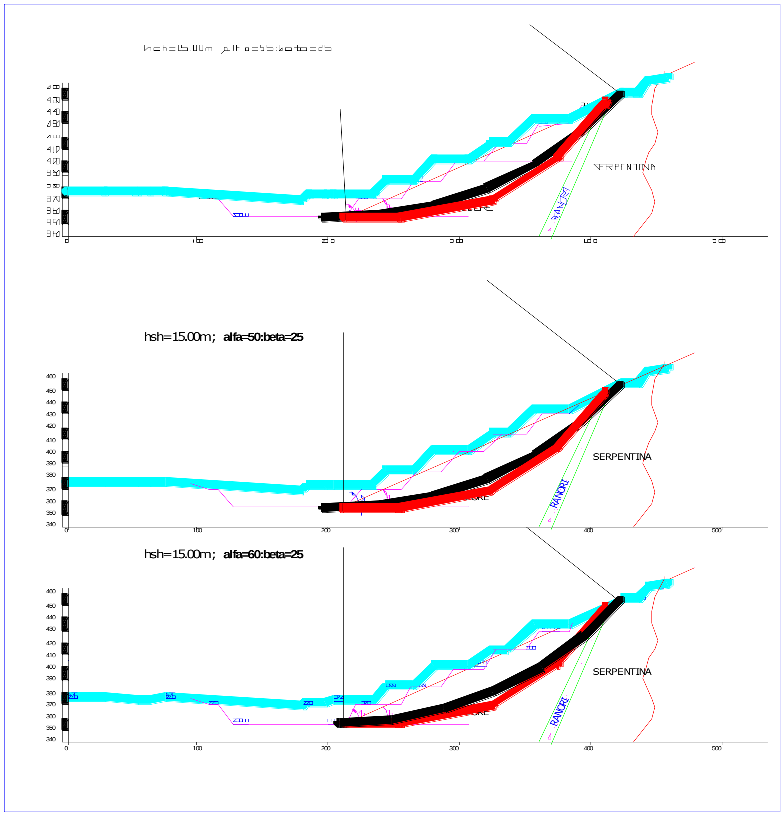
5.1.1. SAFTY ANALYSIS OF WORKING LEVEL

for the height of the bench h=15 [m], and for angle [α] and [β] with veriable vlaues

Note: *Due to the limited number of pages for this paper, only tables 1, 4, 6 and 9, are shown, for the other tables only the results are shown.*

Tab.1. Analysis of determination of safety factor, according to Bishop

Bishops' Method									
	ru	**F**	**ru**	**F**	**ru**	**F**	**ru**	**F**	Circular
h=15m	0,00		0,10		0,20		0,30		
$\beta=25^0$	0,00	1,71	0,10	1,54	0,20	1,37	0,30	1,2	
$\alpha=50^0$	0,00		0,00		0,00		0,00		
h=15m	0,00		0,10		0,20		0,30		X=209m
$\beta=25^0$	0,00	1,69	0,10	1,52	0,20	1,35	0,30	1,18	Y=636m
$\alpha=55^0$	0,00		0,00		0,00		0,00		R=281m
h=15m	0,00		0,10		0,20		0,30		
$\beta=25^0$	0,00	1,67	0,10	1,5	0,20	1,33	0,30	1.16	
$\alpha=60^0$	0,00		0,00		0,00		0,00		
	ru	**F**	**ru**	**F**	**ru**	**F**	**ru**	**F**	
h=15m	0,00		0,10		0,20		0,30		
$\beta=30^0$	0,00	1,40	0,10	1,25	0,20	1,10	0,30	0,95	
$\alpha=50^0$	0,00		0,00		0,00		0,00		
h=15m	0,00		0,10		0,20		0,30		X=254m
$\beta=30^0$	0,00	1,39	0,10	1,24	0,20	1,09	0,30	0,94	Y=556m
$\alpha=55^0$	0,00		0,00		0,00		0,00		R=201m
h=15m	0,00		0,10		0,20		0,30		
$\beta=30^0$	0,00	1,38	0,10	1,23	0,20	1,08	0,30	0,93	
$\alpha=60^0$	0,00		0,00		0,00		0,00		
	ru	**F**	**ru**	**F**	**ru**	**F**	**ru**	**F**	
h=15m	0,00		0,10		0,20		0,30		
$\beta=35^0$	0,00	1,25	0,10	1,11	0,20	0,96	0,30	0,83	
$\alpha=50^0$	0,00		0,00		0,00		0,00		
h=15m	0,00		0,10		0,20		0,30		X=200m
$\beta=35^0$	0,00	1,23	0,10	1,09	0,20	0,95	0,30	0,82	Y=632m
$\alpha=55^0$	0,00		0,00		0,00		0,00		R=285m
h=15m	0,00		0,10		0,20		0,30		
$\beta=35^0$	0,00	1,2	0,10	1,07	0,20	0,93	0,30	0,80	
$\alpha=60^0$	0,00		0,00		0,00		0,00		



Diag.2. Cross-section profile of the working level

For working level, [Fs] optimal parameters will be:

From table.1 for parameters:
h=15[m], $\beta=25^0$and $\alpha=60°$ if ru =0.20. Fs=1.50
h=15[m], $\beta=30^0$ and $\alpha=55°$ if ru =0.10. Fs=1.24
h=15[m],$\beta=35^0$ and $\alpha=50°$ if ru =0.10. Fs=1.11

From table.2 for parameters:
h=17[m], $\beta=25^0$and $\alpha=60°$ if ru =0.10. Fs=1.42
h=17[m], $\beta=30^0$and $\alpha=55°$if ru =0.10 Fs=1.20
h=17[m], $\beta=35^0$and $\alpha=50°$ if ru =0.00. Fs=1.21

From table.3 for parameters:
h=18[m], $\beta=25^0$and $\alpha=60°$ if ru =0.10. Fs=1.40
h=18[m], $\beta=30^0$and $\alpha=55°$ if ru =0.10. Fs=1.18
h=18[m], $\beta=35^0$ and $\alpha=50°$ if ru =0.00. Fs=1.10

5.1.2. ANALYSIS OF THE STABILITY OF THE OVERALL SLOPE FOR GRADIANT: $\beta=25^0\beta=30^0$and$\beta=35^0$

Table 4. Presents the depencence of the safety factor [Fs] from these parameters [ru],[h], and [α] Overall angle $\beta=25^0$

$\beta=25^0$												
	ru =0.00			**ru** =0.10			**ru** =0.20			**ru** =0.30		
h(m)	α=50	α=55	α=60	α=50	α=55	α=60	α=50	α=55	α=60	α=50	α=55	α=60
	F_s			**F_s**			**F_s**			**F_s**		
15	1,7	1,69	1,67	1,54	1,52	1,5	1,37	1,35	1,33	1,2	1,18	1,17
17	1,6	1,59	1,57	1,46	1,44	1,42	1,34	1,32	1,31	1,18	1,16	1,15
18	1,6	1,53	1,51	1,44	1,42	1,4	1,32	1,3	1,29	1,16	1,15	1,13

From table 4
h=15[m], $\beta=25^0$and $\alpha=60°$ if r_u =0.10. Fs=1.50
h=17[m], $\beta=25^0$ and $\alpha=55°$ if r_u =0.10. Fs=1.44
h=18[m] ,$\beta=25^0$ and $\alpha=50°$ if r_u =0.10. Fs=1.44

From table 5
h=15[m], $\beta=30^0$ and $\alpha=60°$if r_u =0.10. Fs=1.38
h=17[m], $\beta=30^0$ and $\alpha=55°$ if r_u =0.10. Fs=1.35

h=18[m], β=30^0andα=50° if r_u =0.00.   Fs=1.34

From table 6

h=15[m], β=$35^0$and α=60° if r_u =0.10.
h=17[m], β=$35^0$and α=55° if r_u =0.10.   Fs<Fmin
h=18[m], β=$35^0$and α=50° if r_u =0.00

5.2.0 ANALYSIS OF STABILITY OF THE WORKING LEVEL:
For the hight of step h=15 [m], for angles [α] and [β] with variable values.

Tab. 6. Analysis of determination of the safety factor [F_s] according to Janbus' method

Janbus' method.										
	ru	**F**	**ru**	**F**	**ru**	**F**	**ru**	**F**	**Non-sircular**	
h=15m	0,00		0,10		0,20		0,30			
β=25^0	0,00	1,69	0,10	1,53	0,20	1,37	0,30	1.21		
α=50^0	0,00		0,00		0,00		0,00			
h=15m	0,00		0,10		0,20		0,30		x	y
β=25^0	0,00	1,68	0,10	1,51	0,20	1,35	0,30	1,19	254	355
α=55^0	0,00		0,00		0,00		0,00		326	370
h=15m	0,00		0,10		0,20		0,30		375	403
β=25^0	0,00	1,66	0,10	1,50	0,20	1,34	0,30	1,17	410	445
α=60^0	0,00		0,00		0,00		0,00			
	ru	**F**	**ru**	**F**	**ru**	**F**	**ru**	**F**		
h=15m	0,00		0,10		0,20		0,30			
β=30^0	0,00	1,36	0,10	1,22	0,20	1,08	0,30	0,92		
α=50^0	0,00		0,00		0,00		0,00		x	y
h=15m	0,00		0,10		0,20		0,30		254	355
β=30^0	0,00	1,35	0,10	1,20	0,20	1,06	0,30	0,90	326	370
α=55^0	0,00		0,00		0,00		0,00		375	403
h=15m	0,00		0,10		0,20		0,30		410	445
β=30^0	0,00	1,34	0,10	1,19	0,20	1,05	0,30	0,89		
α=60^0	0,00		0,00		0,00		0,00			
	ru	**F**	**ru**	**F**	**ru**	**F**	**ru**	**F**		
h=15m	0,00		0,10		0,20		0,30			
β=35^0	0,00	1,24	0,10	1,10	0,20	0,95	0,30	0,81	x	y
α=50^0	0,00		0,00		0,00		0,00		268	355
h=15m	0,00		0,10		0,20		0,30		333	375
β=35^0	0,00	1,21	0,10	1,08	0,20	0,93	0,30	0,79	388	421
α=55^0	0,00		0,00		0,00		0,00		415	446
h=15m	0,00		0,10		0,20		0,30			
β=35^0	0,00	1,19	0,10	1,06	0,20	0,91	0,30	0,78		
α=60^0	0,00		0,00		0,00		0,00			

For working level, [F_s] optimal parameters will be

From table 6. For parameters:
h=15[m],β=25^0 and α=60° if r_u =0.10.   Fs=1.50
h=15[m],β=30^0 and α=55° if r_u =0.10.   Fs=1.20
h=15[m],β=35^0andα=50° if r_u =0.10.   Fs=1.10

From table 7. For parameters:
h=17[m],β=25^0 and α=60° if r_u =0.10.   Fs=1.43
h=17[m],β=30^0 and α=55° if r_u =0.10.   Fs=1.17
h=17[m],β=35^0 and α=50° if r_u =0.00.   Fs=1.20

From table 8. For parameters:
h=18[m],β=25^0 and α=60° ifr_u =0.10.   Fs=1.38
h=18[m],β=30^0 and α=55° if r_u =0.10.   Fs=1.15
h=18[m],β=35^0 and α=50° if r_u =0.00.   Fs=1.00

5.2.1. ANALYSIS FOR STABILITY OF THE FINAL STEP FOR GRADIANT β=25^0β=30^0andβ=35^0

Table 9. Represents dependence of the safety factor [Fs] for these parameters [ru], [h], and [α] for overall angleβ=25^0

Janbu's -$\beta=25^0$												
	ru =0.00			**ru** =0.10			**ru** =0.20			**ru** =0.30		
h(m)	α=50	α=55	α=60	α=50	α=55	α=60	α=50	α=55	α=60	α=50	α=55	α=60
	$\mathbf{F_s}$			$\mathbf{F_s}$			$\mathbf{F_s}$			$\mathbf{F_s}$		
15	1,69	1,68	1,66	1,5	1,51	1,5	1,37	1,35	1,34	1,2	1,19	1,17
17	1,59	1,57	1,53	1,5	1,45	1,43	1,34	1,32	1,3	1,17	1,15	1,13
18	1,53	1,51	1,49	1,4	1,4	1,38	1,31	1,29	1,28	1,14	1,12	1,11

For the final slope [Fs] optimal parameters will be:

From table 9
h=15[m],$\beta=25^0$ and α=60° if r_u =0.10. Fs=1.50
h=17[m],$\beta=25^0$ and α=55° if r_u =0.10. Fs=1.45
h=18[m],$\beta=25^0$ and α=50° if r_u=0.10. Fs=1.40

From table 10
h=15[m],$\beta=30^0$ and α=60° if r_u =0.10. Fs=1.35
h=17[m],$\beta=30^0$ and α=55° if r_u =0.10. Fs=1.32
h=18[m],$\beta=30^0$ and α=50° if r_u =0.00. Fs=1.30

From table 11
h=15[m],$\beta=35^0$ and α=60° if r_u =0.10.
h=17[m],$\beta=35^0$ and α=55° if r_u =0.10. Fs<Fmin.
h=18[m],$\beta=35^0$ and α=50° if r_u =0.00

CONCLUSION

In this paper we've assessed the stability of the slope in the south-eastern side of the mine, which include profiles 5-5, 6-6 and 7-7 of the open-pit mine near 'Hani i Elezit'. From the existing data of the current state and results obtained from calculations of the slope stability for given geometric parameters for the bench, assumed optimal parameters for geostatic analysis have been addopted.

h=15(m); α=50°; β=25°;
h=17(m); α=55°; β=30°;
h=18(m); α=60°; β=35°;

Results gained of the safety factor for geometric parameters of level, height (h) and angle of the working level (α) and pore water pressure (r_u) obtained with Bishop's method, can be found on tables; 1, and with Janbu's method are presented on table 6.
Results from both methods, match, with some small error rate which is insignificat and poses no safety risk.

Assumed, geometric optimal parameters and research results from above mentioned methods lend estimates which give enough stability for optimal and rational exploitation of marls. In conclusion, expansion of the mine on the south-estern boundary si feasable.

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