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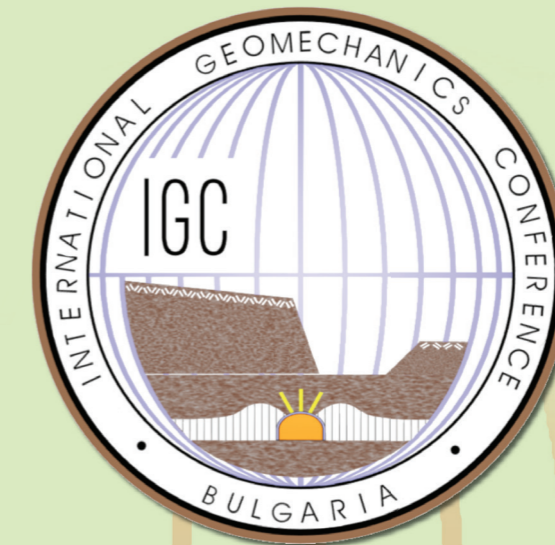
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*Устойчиво развитие – стандарт за качествен живот*  
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PROCEEDINGS OF THE VII INTERNATIONAL GEOMECHANICS CONFERENCE



# PROCEEDINGS

of the

## VII INTERNATIONAL GEOMECHANICS CONFERENCE

27 June – 01 July 2016

International House of Scientists "Fr. J. Curie"  
Resort "St. St. Constantine and Elena", Varna, Bulgaria

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- A. Physical and mechanical rock properties. Methods and means of identification.**
- B. Stressed and deformed state of the rock mass. Technological solutions and systems for management of the rock pressure.**
- C. Stability of flanks and slopes.**
- D. Geodynamic impacts on underground and surface excavation equipment. Geomechanical securing of rock falls and landslides.**
- E. Mine-surveying methods and computer systems for monitoring and management.**
- F. Ecology and environment protection.**





## ASSESSMENT OF SLOPE STABILITY OF EXTERNAL DUMP - SETTING THE MAXIMUM HEIGHT OF ELEVATION

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### ABSTRACT

*An external dump in open pit "Bucim" already exceeds the defined heights and volumes according to the existing mining projects. It imposes the need for finding possible solutions for alternative delay in the formation of internal dump, which has already become a reality. In this paper we shall analyse the current situation, will make projection of redefine possible slopes and benches and will be a conclusion and proposal for future activities related to the further use of dump.*

**Keywords:** slope stability, maximum, external dump, open pit.

### INTRODUCTION

Waste dump from the open pits of the mine "Bucim" already exceeds the defined heights and volumes according to the existing mining projects. It imposes the need for finding possible solutions for alternative delay with form of internal dump, which has already become a reality.

Will define and project the basic elements of the waste dump elevation we shall made an analysis of the current state, will make a design of redefine possible slopes and benches and will be given a conclusion and proposal for future activities related to the further use of waste dump. External dump will serve further for permanent disposal and storage of waste rock from the primary exploitation of the remaining amounts of the deepening of the Central ore body, the expansion in the Northeast and amounts of future surface mine "Vrsnik". Will be reserved geotechnical characteristics of the work environment and the waste. For assessment of slope stability of the waste dump we use: ordinary method, Bishop method, Spencer method and Junbu method.

### ANALYSIS OF GEOTECHNICAL STABILITY OF WASTE DUMP

It predicts bench elevation of the working planum in two stages, i.e. two bench levels by 20 meters, i.e. for a total elevation of 40 meters, with a bench flats from 25 to 30 meters, i.e. new planums will be the initial level 680 m (I phase) and a final level of 700 m (II phase).

With the transition to frontal delay operating space increases.

Analysis of geotechnical stability of the waste dump is made of the three possible cases:

- current state of waste dump,
- current state according I phases (elevation 680),
- current state according II phases (elevation 700).

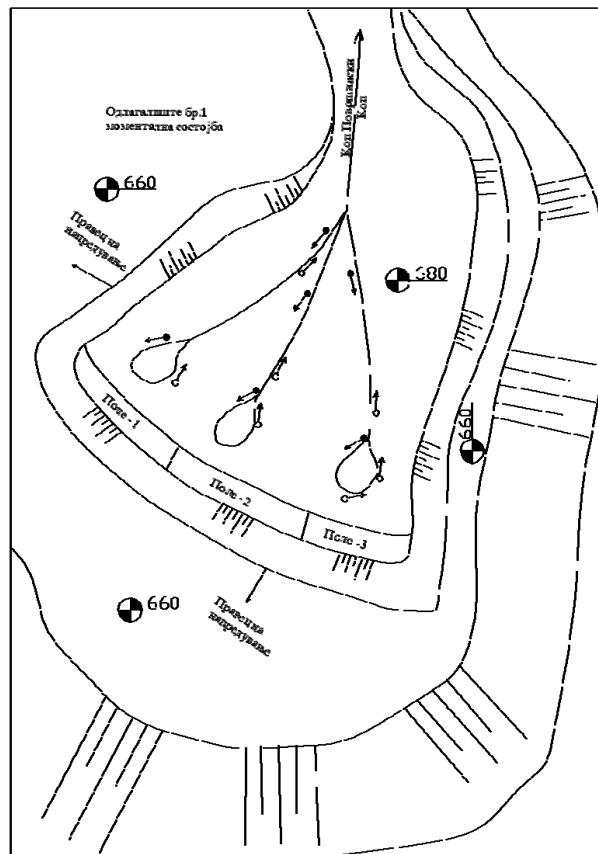


Fig. 1 Crossing from front to of frontally advancing

It was analyzed 4 characteristic sections that are oriented in the main 4 and secondary 4 surveying routes, namely:

- section 5-5' with orientation W-I,
- section A-A' with orientation N-S,
- section B-B' with orientation NI-SW and
- section C-C' with orientation NW - SII

In addition it was given the analyzes of stability of section C-C' orientation NW - SE

Geotechnical analyzes of stability on this section, according four characteristic methods: ordinary method, Bishop method, Janbu method and Spenser gives this results:

Table 1 Planned condition of waste dump  $R_u = 0$

Predicted sliding surfaces with predicted piezometric line and $R_u = 0.0$	Minimal safety factor									
	S-1		S-2		S-3		S-4		S-5	
	F	M	F	M	F	M	F	M	F	M
Lamella	1.903		1.437		2.056		1.781		1.327	
Bishop	1.951		1.425		2.164		1.817		1.407	
Janbu		1.887		1.337		2.025		1.719		1.404
Spencer	1.926	1.926	1.436	1.436	2.091	2.089	1.777	1.775	1.496	1.464
Minimal value (Fs)	1.887		1.377		2.025		1.719		1.327	
Average value	1.919		1.422		2.085		1.774		1.420	
Stability condition (Fs > 1.3)	YES		YES		YES		YES		YES	



*Table 2 Planned condition of waste dump with  $R_u = 0.1$*

Predicted sliding surfaces with predicted piezometric line and $R_u = 0.1$	Minimal safety factor									
	S-1		S-2		S-3		S-4		S-5	
	F	M	F	M	F	M	F	M	F	M
Lamella	1.680		1.309		1.816		1.567		1.307	
Bishop	1.729		1.339		1.922		1.605		1.326	
Janbu		1.670		1.396		1.795		1.515		1.303
Spencer	1.706	1.706	1.335	1.356	1.856	1.855	1.596	1.568	1.324	1.325
Minimal value ( $F_s$ )	1.670		1.309		1.795		1.515		1.303	
Average value	1.698		1.351		1.849		1.565		1.317	
Stability condition ( $F_s > 1.3$ )	YES		YES		YES		YES		YES	

There was 2 analyses done of slope stability of waste dump with current condition – II phases for this section with  $R_u=0$  and with  $R_u = 0.1$ .

Analyses show:

1. According current condition with  $R_u = 0$  (Table 1), geotechnical analysis of the current state of the slope of the excavated blocks is stable with minimum value of the safety factor for all 5 superiors sliding surfaces and is above 1.3.

2. According current condition with  $R_u = 0.1$  (Table 2), geotechnical analysis of the current state of the slope of the excavated blocks is stable with minimum value of the safety factor for all 5 superiors sliding surfaces and is above 1.3.

### **GROUND LOADS CALCULATION OF THE WASTE DUMP**

This waste dump according current condition have working slope of  $36^\circ$  (1:1,38), and its horizontal projection is cca 200 meters and the greatest height of 145 meters (vertical projection). Dumps with slope have a critical position in the burden of the fracture surface in the slope.

Characteristics	Size
Bench slope of the waste dump	1:1,38 ( $\beta=36^\circ$ )
height of the waste dump	$h=155$ m (max)
Waste characteristics	$\gamma_1 = 17.9$ kN/m <sup>3</sup>
	$\varphi_1=36^\circ$ ,
	$c_1=0$
ground	$\gamma_2 = 26$ kN/m <sup>3</sup>
	$\varphi_2=37^\circ$ ,
	$c_2=200$ kPa, $c_2 = 200$ kN/m <sup>2</sup>

Occasion for this is the active pressure of delayed waste whose oblique resultant force  $R$  acting on the ground of the waste. For this reason the position of force  $R$  is adopted as a feature to calculate the limit loads and permissible load of the ground. This dump is burdened with oblique force  $R$  which is the resultant of the load



W and the pressure in a section that conditions delayed material as an external force  $E_a$ , which is calculated according to Rankin. In ground loads appearing sliding surface with angle to the horizon which is not according to Rankin but smaller for angle  $v$ . This angle  $\delta$  depends on the resultant R. The angle  $v$  decreases with increasing  $\delta$ .

If the angle  $v$  is lower, sliding lines are shallower and shorter, and ground loads is lower.  $v$  angle is obtained from the ratio of stress in ellipse according Kreyu and Ohden, and the equation:

$$v = \beta' - \left(45^\circ - \frac{\varphi_2}{2}\right),$$

Value of angle  $\beta'$  is:

$$\operatorname{tg}\beta' = \mu_a + \sqrt{\mu_a^2 - \operatorname{tg}^2 \left(45^\circ - \frac{\varphi_2}{2}\right)}$$

$$\mu_a = \frac{1 - \operatorname{tg}\left(45^\circ - \frac{\varphi_2}{2}\right)}{2 \operatorname{tg}\delta} = \frac{1 - \operatorname{tg}\left(45^\circ - \frac{37}{2}\right)}{2 \operatorname{tg}20,61} = 0,667$$

$$\operatorname{tg}\delta = \frac{0,5\gamma_1 \cdot h_2 \cdot \operatorname{tg}^2 \left(45^\circ - \frac{\varphi_1}{2}\right)}{\gamma_1 \cdot h + b} = 0,5 \cdot \frac{h}{b} \cdot \operatorname{tg}^2 \left(45^\circ - \frac{\varphi_1}{2}\right)$$

$$\operatorname{tg}\beta' = 0,667 + \sqrt{0,667^2 - \operatorname{tg}^2 \left(45^\circ - \frac{37}{2}\right)} = 1,110$$

$$\beta' = 47,99^\circ$$

$$v = \beta' - \left(45^\circ - \frac{\varphi_2}{2}\right) = 47,99 - 26,5 = 21,49^\circ$$

By increasing the angle  $v$  is decreases prism of passive resistance A'DE and will not be enough resistance that opposes the resultant R. From this reasons max  $\delta$  should be smaller from  $\varphi_2$  according next relation.

$$\delta \leq \frac{2}{3} \varphi_2$$

In the case of dump

$$\delta_{\text{doz}} \leq \frac{2}{3} \varphi_2 = 24,67^\circ$$

According to the calculation of the most critical section, requirement is content.

$$\delta = 20,61^\circ < \delta_{\text{doz}} = 24,67^\circ$$

The condition of the bearing a capacity of the ground at a height of 155 meters delay and bulk angle of 360 satisfied the criterion.

$$\frac{\operatorname{tg}\delta}{\operatorname{tg}\varphi_2} \leq 0,70$$

In the case of a dump that is:

$$\frac{0,376}{0,754} = 0,499$$

Since  $0,499 < 0,500$  and according to this criterion safety satisfied.



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With this criterion for safety can perform its elevation of two benches with a height of 20 m, and leaving the bench skirts of 25 - 30 m, to level 660 m and 680 m, with a final plateau level 700 m .

### **CONCLUSION**

With the geotechnical analysis of the slope stability and check the bearing capacity of the ground showed that the planned future state of external dump will be completely stable. With this analysis for elevation of external dump were created conditions to define all necessary and legally prescribed activities relating to:

- Design capacity of delay in waste dump accordance with the development plan of the mine "Bucim",
- analyzing the geotechnical stability of the slopes of current and planned state of waste dump,
- Design of access roads to the two new benches,
- calculation of quantities currently suspended waste,
- design of complete process of loading, transport and disposal of the waste,
- review of security measures and technical protection on waste disposal working on disposal, etc.

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