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A PROBABILITY METHOD FOR DEFINING THE BOUNDARIES OF AN OPENCAST MINE

S CHRISTOV
University of Mining and Geology, Sofia, Bulgaria

ABSTRACT: The initial information for designing an opencast mine has a probability character. That is why the paper offers a method for defining the boundaries of the mine on the basis of probability statistics decisions. From the cumulative schedule of the regime of mining operations we define the values of: the average overburden ratio, the initial overburden ratio, the most unfavourable exploitation overburden ratio, the irregularity coefficient of the overburden removal operations and the portion of overburden during the construction period for slope angles 30, 4C and 50 and slope height H=15G m and H-10C m (tabl.1). The dependencies between the average overburden ratio and the degree of risk from increasing the slope's angle are also defined. The mine boundaries are determined by the method of permissible average overburden ratio. The results of the calculations are shown in tables and graphs. The method makes possible the use of a probability approach to defining the boundaries of the opencast mine and considering the degree of risk when assessing the angle of the unworkable slope. The method allows to define more precisely the optimal boundaries of the mine. It is applicable in designing and exploiting steeply-inclined deposits such as Medet, Elatzite, Assarel, etc. in Bulgaria.

One of the important strategical problems in designing and construction of opencast mines is the determination of their boundaries in plan and profile. The efficient work of the mines depends to a great extend the correct solution of this problem. As the starting design information of an opencast mine has a probability character there exists a certain risk in taking final decision about its boundaries« When defining the mine boundaries and the reliability estimation of the taken decision it is necessary to apply probability methods. The present paper suggests a method for defining the mine boundaries on the basis of probability statistics decisions (Ghristov, 1994).

The probability character of the values of the strength parameters of rocks brings to the unclearness in determining the final situation of the slope. The permissible interval of its change depends on the changing scope of the relative mistake of the calculated strength rock characteristics. It will bring to changing the mine boundaries - from Oi to CX2 at depth H (Figure 1) In our case œ. changes from 30^{e} to 50°, while the depth is H-153 m.

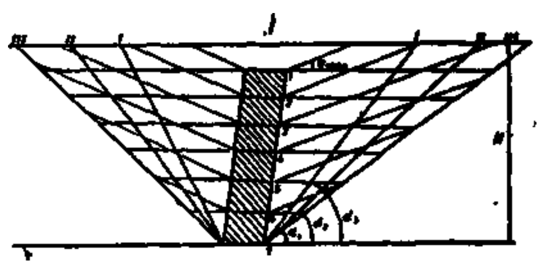

Figure 1. Depending the boundaries of an opencast mine exploiting steeply-inclined deposits considering the probability character of the angle of the «workable slope.

For a chosen direction of development of mining works and angle of the working slope tltoax-'S^{0} the stage volumes of the overburden and the mineral have been consequently defined (Figure 1). On the basis of these data the increasing values of the overburden and the mineral P have been calculated from the exploitation H and the cumulative graphs V-f(P), P=f(H) and V=f(H).

On the basis of the method of I.A. Arsenov (Arsenov, 1970) from the cumulative schedule the values of the average overburden ratio n,.p , the initial overburden ratio no i the most unfavourable exploitation overburden ratio n£, the irregularity coefficient of the overburden removal operation

$$\lambda = \frac{n_i}{n_{cp} - n_o} \qquad (1)$$

and the portion of the overburden during the construction period

$$\mu = \frac{n_o}{n_{cp}} \qquad (2)$$

have been defined. The values of these parametra it scope angle of the unworkable slope 30", 40° and 50° are shown in Table 1.

and other specialists show that the strength rock parameters have a distribution close to the normal one. Therefore, we can use the low of normal -distribution of error in the strength rock parameters, while the error in the calculation of the average overburden ratio will be commensurable with the error of the calculation of the stability of the slope.

At a respective possible error of the calculated strength rock parameters 6=0.36 the root-mean-square a=0.12 and the possible deviation E=0.674 o=0.08 can be defined the degree of risk in various slope angles (Christov, 1994; Christov, 1989).

$tg\alpha_0 = tg\alpha_m(1-3\sigma) = 0.576$	3υ°	0
$tg\alpha_1 = tg\alpha_m(1-2\sigma) = 0.680$	34°10'	2.3
$tg\alpha_2 = tg\alpha_m(1-\sigma) = 0.790$	38°10'	15.9
$tg\alpha_3 = tg\alpha_m(1-E) = 0.827$	39°50'	25.0
$tg\alpha_m = tg\alpha_o \frac{1}{1-3e} = 0.827$	42°	50.0
$tg\alpha_4 = tg\alpha_m(1+E) = 0.970$	44°	75.0

Table 1. Parameters of **the** mine with slone heieht 150 and 100 m and various angles of **the unworkable slope.**

Angle of the slope	Height of the slope, m									
	H 15u m					H = 1C0 m				
	ucp	u1			"cpa	"cp	ni	U1	Al	ncpa
	m^J/m^1	m^3/m^3	m^3/m^3	m^3/m^3	m^5/m^3	m^3/m^3	m^3/m^3	m^3/m^3	m^3/m^3	m^3/m^3
30°	7.55	0.055	13.20	1.85	2.80	5.63	0.125	7.83	1.58	3.33
40°	5.32*	0.081	7.20	1.47	3.52	3.90	0.179	4.33	**1.53**	3.89
50°	**3.85**	0.112	2.34	1.3C	5.17	2.86	**C.245**	2.67	1.24	4.25

From the cumula schedules in Figure 2 can be seen that to the increase of the production with P and the depending of the mining works with h corresponds respective certain increase of the overburden volume. For example, at B"150 m, P » 1.0 million m^3, h « 20 m and angles of the unworkable slope 30°, 40^s and 50^s these increases are respectively V* » 7.8 million m^3, Y^{1*0} • - 4.40 million m^J and V* = 2.73 million m^3. The Figure 2 shows with dattes line V-f(H) for ot » 30° at an average overburden ratio. From this diagram the volumes of the overburden can be defined which are additionaly taken out or concervated in separate stages.

The studies carried out by the author

where OJJ is the mathematical expectation of the slope angle.

The diagrams of the relationships between the average overburden ratio and the degree of risk created by the angle increase of the unworkable slope are given on Figure 3.a. The same figure shows the production change of the mine at various slope angles.

Defining the boundaries of the opencast mine is done by the method of the addmissible average overburden ratio (Arsenov, 1970)

$$n_{cp} = \frac{n_b}{\lambda - \mu(\lambda - 1)} \qquad (3)$$

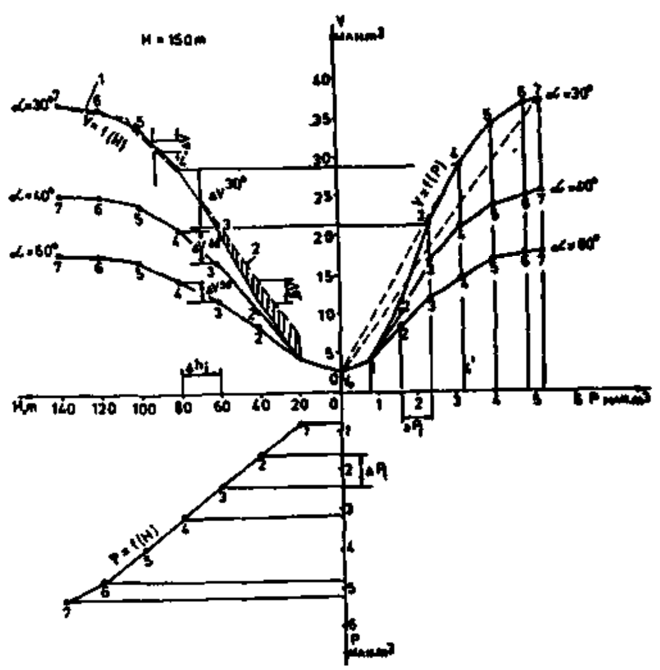

Figure 2. Graph schedule of the regime of mining works of the mine at H-150 m; 1 - before making the overburden ratio average, 2 - after making the overburden ratio average.

where % is boundary overburden ratio (in aur case ribi-s accepted as 5 rnVm,).

In Table t are given the aobtained results in the calculation of Ticpd' The crossing point B in Figure 3.a. satisfies the equation TVp^cpd• The slope angle is a=44°, the production of mine mass AİL = =7.0 million m³, while the risk degree - R=75% which is practically unacceptable, for normal work in the mine. Similar conclusions were made at H"tC0 m. The obtained results are given in Table 1 and Figure 3.b and Figure 4,

At H=100 m the condition T i " 1 , is fullfilled for point B_1 (Figufe 3?DJ. In this case the mine is formed under the slope angle of the unworkable slope tx=40° A_{WM}8=6.5 million m³ and risk R=25%.

Thus, at H= 125 m and «=42° the risk degree is R"=50%. (Figure 5).

The reverse problem can also be solved at a given risk degree to define the boundary depth of the opencast mine. Considering the possible negative and positive error when defining the strength rock parameters, the boundaries of the opencast mine in designing scould be calculated at two values of its depth - the first with a risk smaller than 50%, i.e. H<125 m and the second with R>50 %, H>125 m. At the final decision of the boundaries of the opencast mine it is necessary to have in mind as well the financial factors with the help of the function of efficiency (Christov, 1989).

The suggested method allows to use the probability method for defining the boundaries of the opencast mine and for calculating the risk degree estimating the angle of the unworkable slope. The method allows to obtain more real optimal boundaries of the mine. It can be applied in designing and exploiting of steep running depositions of the type "Medet", "Elataite", "Asarel", "Burd^e" etc.

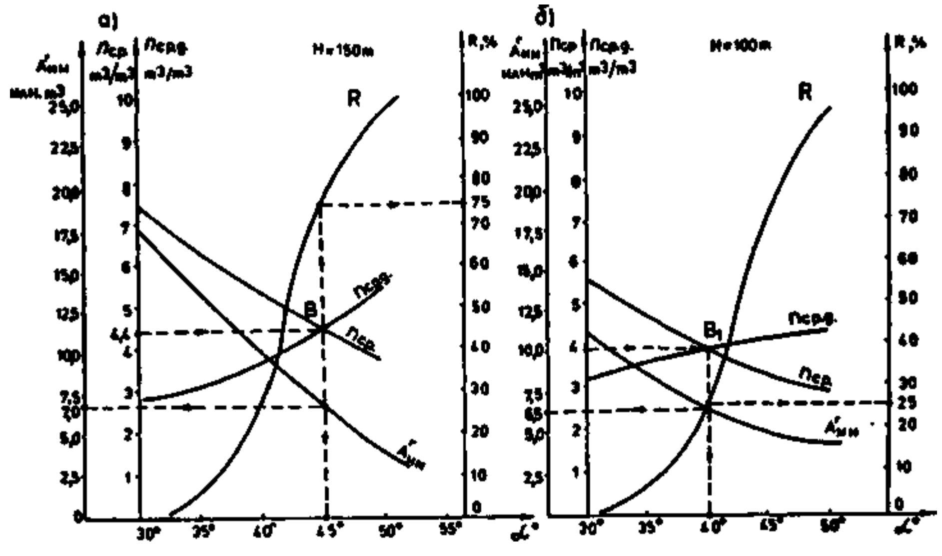

Fig. 3. Diagrams of the relationships between the average overburden ratio r i , the «ddmissible overburden ratio n_{cp}<j, the production power of the mine AMM? and the pit •**lope angle** et considering the resk degree R. a) at mine depth H-100 m; b) at mine depth H-tOO Ä.

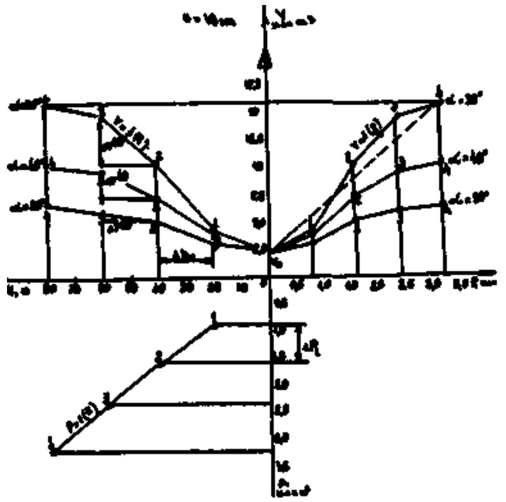

Fig. 4.Graph schedule of mining works in an opencast mine at H-100 m

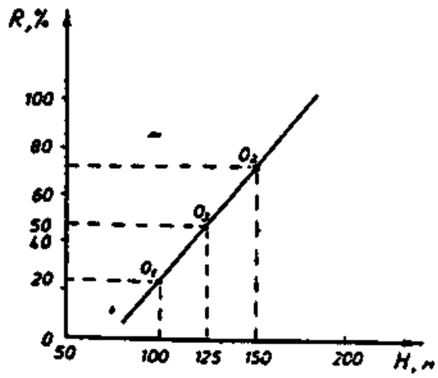

Fig. 5. Defining the limit depth of an opencast mine at a definite risk degree

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