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CONSTRUCTION OF HORIZONTAL MINING FACILITIES THROUGH SCHIST`S MASSIVE

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ABSTRACT

This paper presents cost analysis for horizontal mining facilities through schist's massive. Two variables, headings cross section and rock-quality designation (RQD) were considered. Based on a real data analyses we were able to define two parameters functional relation between costs and cross-section. Examples and clasifications are elaborated in details.

KEY WORDS

Cross-section, Scientific research, Rocks.

1. INTRODUCTION

Mining practice were found that within the same type of rock material exist zones with different structural features, such is the schist. Various features create different stability of rock material during different operations, such as the exploitation and the construction of underground facilities.

The determination of structural features means assessment of all weakening and damage planes, given that cracks and their sets have significant impact on the physical, mechanical, technological, hydrological properties and deformability of the rock mass.

The impact of jointed underground facilities on its stability, depends of the orientation on jointed planes in terms of the excavation direction, the cross-sectional size, the degree of rock material separateness with cracks and cracks sets and stability of each block adjacent to the underground facilities.

Most disadvantaged case in terms of underground facilities contours stability is that the direction of the cracks and cracks sets is parallel to the advancement of underground facilities direction [1]. While the blocks instability around underground facilities is proportional to the mining facilities cross-section.

2. ANALYSIS OF THE HORIZONTAL MINING FACILITIES CONSTRUCTION

As already discussed, in this paper horizontal mining facilities constriction with different cross-section, in schist's massive with varying degrees of jointed is analyzed.

Table 1 shown physical and mechanical properties obtained by laboratory tests that are required for this survey as follows: bulk density γ [MN/m^3], uniaxial compressive strength σ_c [MPa], tensile strength σ_t [MPa], cohesion C [MPa], angle of internal friction φ [°], Poisson`s coefficient ν and modul of elasticity E [MPa].

Table 1. Physical and mechanical properties of the anticipated rocks type

DESCRIPTION	γ [MN/m^3]	σ_c [MPa]	σ_t [MPa]	C [MPa]	φ [°]	ν	E [MPa]
schist	0,0270	98	6,10	14,00	32,0	0,120	32000

Three sizes of the mining facility cross-section and three degrees of jointed in schist's massive is anticipated (Table 2).

Table 2. Variants of horizontal mining facilities in model

Rock type	Uniax. compr. strength of intact rock σ_c[MPa]	Spacing of joints l [m]	Number of joints per 1m' J_n[br./m']	Factor of joints J_f	Uniax. compr. strength of rock mass σ_{cm}[MPa]	Anticipated cross-section [m^2]	Tag in model
schist	98	0,40	2,50	80,07	52	10,10	A1
						13,73	A2
						16,68	A3
		0,30	3,33	106,75	42	10,10	B1
						13,73	B2
						16,68	B3
		0,25	4,00	128,11	35	10,10	C1
						13,73	C2
						16,68	C3

To obtain data that can be compared, other influential parameters in the mining construction system is needed to be the same in all mining facilities [3].

Construction system includes these fixed parameters:

- cross-sectional shape of the mining facilities – horse – shoe shaped;
- the average depth of the same route - 500 m;
- usage of the mining facility - a relatively long;
- mechanization level of the production process - relatively equally;
- method for excavation the mining facilities – drilling and blasting operations;
- capability of working personnel - relatively well trained;
- one shift duration and number of shifts per day - in the calculations 6 effective hours per shift and 3 shifts per day were applied.

3. PARAMETERS OF INDIVIDUAL WORKING OPERATIONS

In all variants, holes with diameter of 45 mm, except central, with a diameter of 64 mm were applied.

Prismatic cut type with empty central hole were applied. Explosive AMONEKS-3, produced by "Trayal" Corporation of Krusevac, Serbia were used for blasting. Cartridge with diameter of 38 mm are used for auxiliary and cut holes, while cartridge with diameter of 28 mm are used for flanking blast holes. Calculations for required drilling and blasting parameters are performed by the same formulas and reviewed by experienced data (for all working operations) for all variants.

After drilling and blasting, a break of 30 minutes follows (adopted time for all variants) when compression LVS are used for released of the workplace from dust and noxious gases from blasting.

At the loading and transportation as input data the quantity of material from one blasting are used.

Elastic support will be apply (sprayed concrete + steel mech + bolts + steel ribs) [2]. The share of individual support elements depends of calculations for required support loads, bearing in mind rock type features.

4. COSTS FOR CONSTRUCTION OF 1 M' HORIZONTAL MINING FACILITIES

Based on established parameters, individual prices for operating supplies, purchase prices of mechanization and the cost of wages, in all variants of horizontal mining facility, costs of individual working operations are determined (Table 3).

The cost analysis, given in Table 3 for individual working operations shows that the supporting has greatest percentage in the total construction costs and it ranges from 54 to 55.6%, at the very strength rock type, variant A and from 57.7 to 58. 4% in the highly broken rock mass, variant C. The percentage increase because in the poor rock, this working operation requirements are larger. Within the rock mass by the same degree of jointed, the costs are increase with the cross section increase, so the costs of supporting at the largest cross-section "3" are 22% higher than the same smallest cross-section "1".

Next in percentage share of total costs are drilling and blasting costs. In the most compact rock type they range from 17.2 to 17.7% of total costs, to reduce at the heavily jointed environment from 15,5 to 16%. Within the rock type with the same degree of jointed, costs of drilling and blasting grow up with the room profile growth, so at the largest profile drilling and blasting costs are larger about 17% than that of the lowest profile.

Loading and transportation costs have roughly the same percentage of the total costs as costs of drilling and blasting.

Ventilation costs grow up with the facilities profile growth and in total construction costs accounted of 3% at the smallest profile, and 5.7% for the largest one.

Given the foregoing it can be concluded that at the schist's massive, supporting costs present the biggest costs, about 56% of total costs of 1m' horizontal mining facilities constructed.

Table 3. Total construction costs of 1 m’ horizontal mining facilities

Ord. num.	Construction costs [€/m’]			Variants								
				A			B			C		
				Sub-variants			Sub-variants			Sub-variants		
				A1	A2	A3	B1	B2	B3	C1	C2	C3
1	Drilling and blasting costs	Costs for materials and energy		80,05	84,69	89,63	78,86	82,05	87,95	76,76	80,14	85,47
		Costs for wages		26,17	27,65	32,52	26,17	27,65	32,52	26,17	27,65	32,52
		Equipment costs	Costs for maintenance	0,44	0,54	0,62	0,44	0,54	0,62	0,44	0,54	0,62
			Cost for amortization	8,76	10,73	12,34	8,76	10,73	12,34	8,76	10,73	12,34
			Costs for insurance	0,09	0,11	0,12	0,09	0,11	0,12	0,09	0,11	0,12
		Total		115,57	123,71	135,23	114,32	121,08	133,55	112,22	119,16	131,06
2	Ventilation costs	Costs for materials and energy		18,91	24,52	41,25	19,09	24,71	41,66	19,44	25,10	42,49
		Costs for wages		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Equipment costs	Costs for maintenance	0,08	0,09	0,17	0,08	0,09	0,18	0,09	0,09	0,18
			Cost for amortization	1,62	1,71	3,47	1,65	1,74	3,54	1,71	1,80	3,68
			Costs for insurance	0,02	0,02	0,03	0,02	0,02	0,04	0,02	0,02	0,04
		Total		20,63	26,33	44,93	20,84	26,56	45,41	21,26	27,01	46,40
3	Loading and transport. costs	Costs for materials and energy		77,24	77,24	77,24	77,24	77,24	77,24	77,24	77,24	77,24
		Costs for wages		13,72	14,37	10,55	13,72	14,37	10,55	13,72	14,37	10,55
		Equipment costs	Costs for maintenance	0,44	0,61	0,53	0,44	0,61	0,53	0,44	0,61	0,53
			Cost for amortization	8,85	12,27	10,53	8,85	12,27	10,53	8,85	12,27	10,53
			Costs for insurance	0,09	0,12	0,11	0,09	0,12	0,11	0,09	0,12	0,11
		Total		100,33	104,62	98,96	100,33	104,62	98,96	100,33	104,62	98,96
4	Supporting costs	Costs for materials and energy		240,74	276,11	304,40	251,06	288,04	317,57	275,00	315,71	348,13
		Costs for wages		94,35	99,53	103,53	97,26	102,64	106,81	102,90	108,89	113,52
		Equipment costs	Costs for maintenance	1,06	1,20	1,31	1,10	1,25	1,36	1,22	1,39	1,51
			Cost for amortization	21,20	24,00	26,16	22,04	24,97	27,24	24,42	27,72	30,27
			Costs for insurance	0,21	0,24	0,26	0,22	0,25	0,27	0,24	0,28	0,30
		Total		357,57	401,08	435,67	371,68	417,15	453,26	403,79	453,98	493,74
Total costs for the main work operations				594,09	655,73	714,78	607,18	669,41	731,18	637,60	704,78	770,16
5	Costs of auxiliary work operations			57,65	63,58	68,50	59,03	65,01	70,24	62,33	68,90	74,49
Total construction costs of 1 m’ horizontal mining facilities in rock type schist				651,74	719,31	783,27	666,21	734,42	801,42	699,93	773,68	844,64

5. FUNCTIONAL DEPENDENCY

Based on the calculated construstion cost of horizontal mining facilities, using a computer program OM Explorer, upgrade on the Excel program, a functional dependence at the construction costs from the rock type and the profile size are established in the following form:

$$z=c+ax+by \quad (1)$$

Where as:

x – uniaxial compressive strength of rock mass [MPa];

y – profile size of facility [m^2],

are independent variables,

while

z – construction cost of horizontal mining facility [€/m'],

is dependent variable

c – constant;

a, b – constants before independent variables.

Following values of coefficients are obtained:

c = 594,346

a = - 3,103

b = 20,789

$$z = 594{,}346 - 3{,}103x + 20{,}789y \quad (2)$$

This functional dependence is graphically presents on Figure 1.

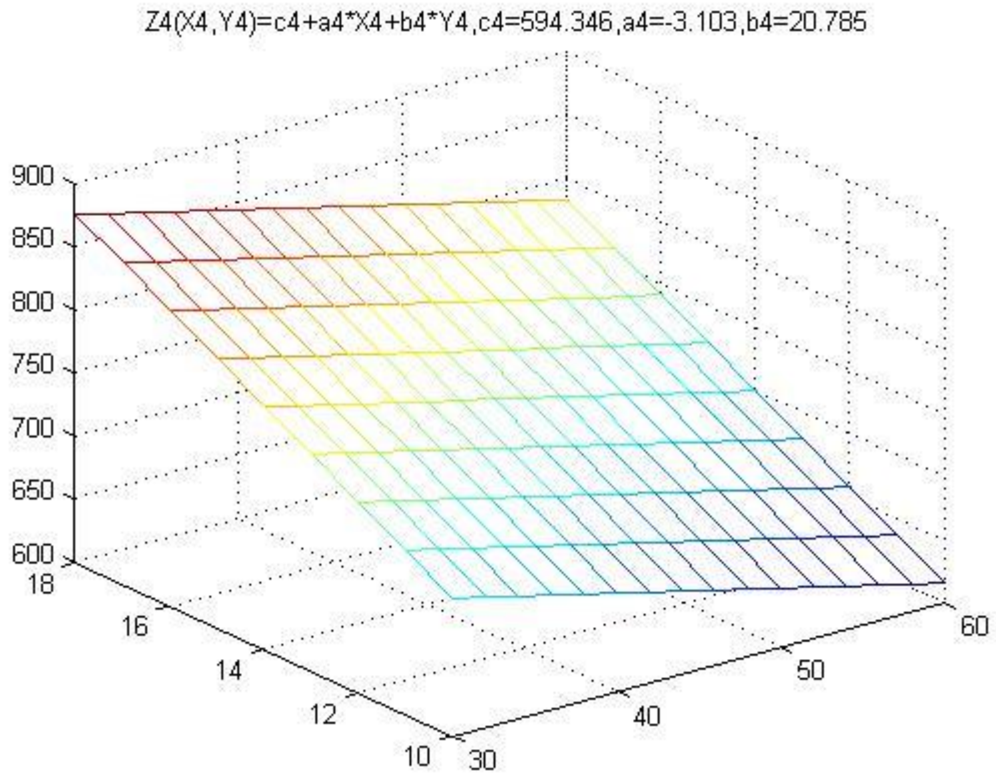

Figure 1. Functional dependence of the construction costs of horizontal mining facilities depending from the rock type and profile size in the schist`s massive

From Table 3 and Figure 1 can be observed that for same-cross section size, with an increase of schist`s massive uniaxial compressive strength, construction costs are reduce. The percentage of reduction between the weakest and strongest schist`s massive at all profiles given in the table ranges from 14.4 to 17.8%. While at the schist`s massive with the same strength, costs rising with the profile growth among the smallest and largest profile, the percentage of increase ranges from 23.8 to 29% [3].

6. CONCLUSION

From scientific research results can be concluded that different structural features at the same rock material type, as different profile size, leads to differences in the construction costs of 1 m' horizontal mining facilities.

Therefore, during construction of mining facilities is necessary to choose optimal route and optimal cross-section size, which means if exploitative conditions allow, the route is going through stronger rock type, and the cross-section size to match on the mine capacity.

Any deviation in terms of these two crucial factors leads to unnecessarily increase of construction costs.

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