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Excavation method in Goushfill mine

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Abstract

This research tries to investigate the geomechanical parameters of rock mass in Goushfill mine. Using available cores, and studying existing methods, logs, and careful assessment of samples, four types of rock mass in Goushfill mine, shale, mineralized shale, dolomite and mineralized dolomite are classified, on the basis of GSI, RMR and Q-system. The physical parameters, friction angle and cohesion of rock mass are measured in the rock mechanics lab of Isfahan University of Technology. The excavation method is defined according to the results of the study and thus parameters of the excavation are specified.

Keywords: *Cut and fill, Exploitation methods, Goushfill, Nicolas, UBC method*.

1 Introduction

Irankuh mine is located in Irankuh mountains 20 km southeast of Isfahan, central Iran. The area is 25 km long and 3 km wide. The climate is moderate and average rainfall is 50 mm in a year. The most important work done is excavation of two exploration tunnels in Goushfill deposit. Based on mine plan the open pit mine is excavated with 8 to 14 m benches from 1728m. Considering that the exploitation of Goushfill mine is an open pit method, with increasing depth underground mining method needs great attention.

2 Geology of Goushfill mine

The main zone of mine is covered with carbonate sediments which is located on lower Jurrassic sediments as unconformity. The sediments consist of continuous periodic age (low Cretaceous). The total thickness of these rocks is over 800 m. This alternation consists of more limestone and dolomite with less shale and marl. The carbonate sediments are specified as a source rock for Goushfill mine deposit.

3 Laboratory tests

Physical properties of rock mass at Goushfill mine are investigated and the results are included in Table 1. To examine cohesion and friction, four types of rocks which are of the main part of underground activities are chosen to do triaxial compression test. The results obtained from these tests are shown in Figs 1, 2, 3, 4. Based on available borehole, RQD [1] of four types is defined in Table 2.
In this project discontinuities are studied with scanlines. Normally the base of division of an area with different sections are the average discontinuities, which affect quality of rock mass.

Table 1: Densities of different rocks

Type of rock	Shale	Mineralized shale	Dolomite	Mineralized dolomite
Density, dry (gr/cm^3)	2.693	2.719	2.856	2.699
Density, saturated (gr/cm^3)	2.708	2.735	2.859	2.702

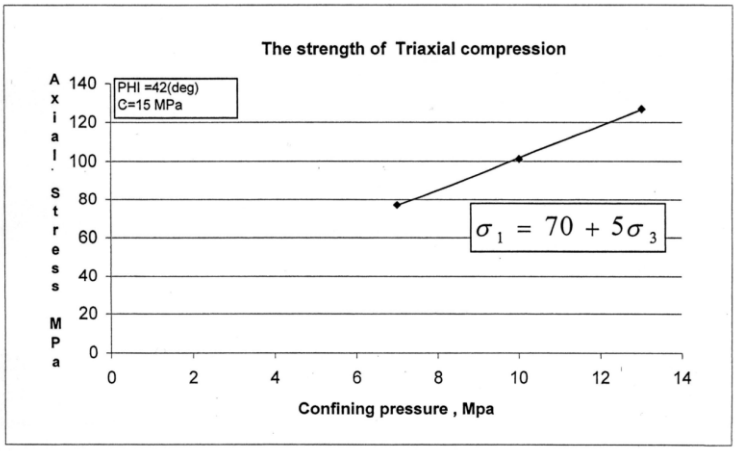

Fig . 1: Triaxail test for shale

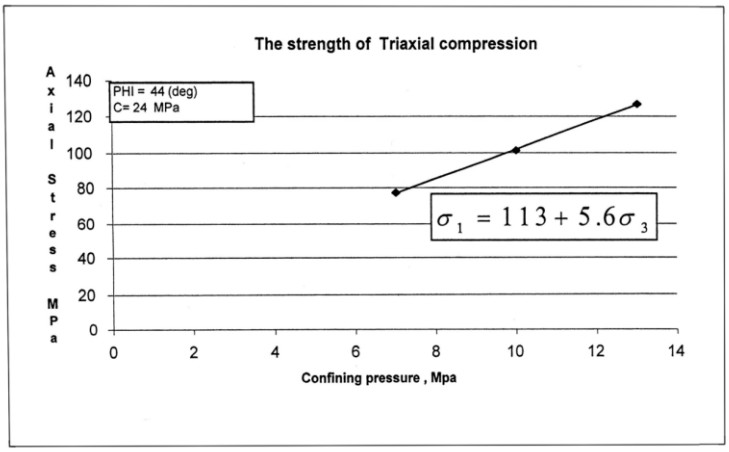

Fig. 2: Triaxial test for mineralized shale

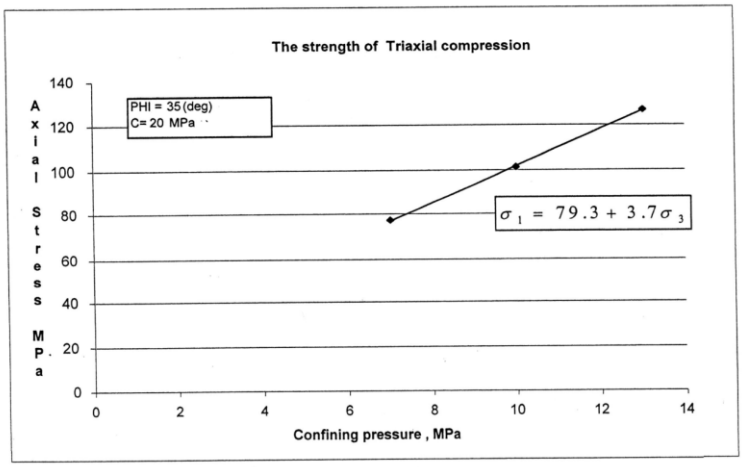

Fig. 3: Triaxial test for dolomite

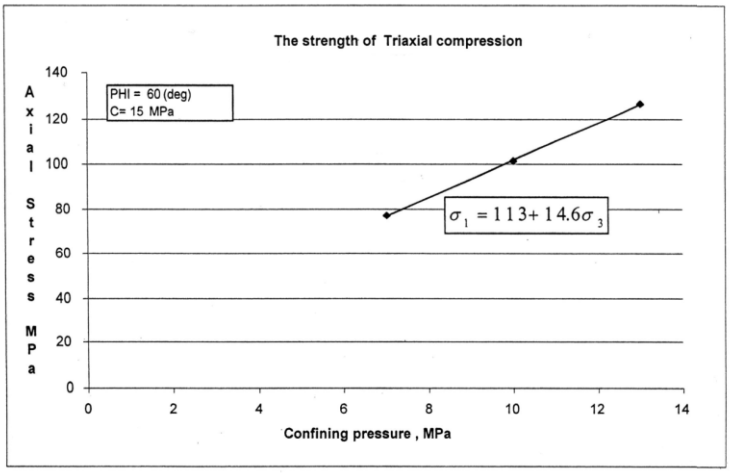

Fig. 4: Triaxial test for minerlized dolomite

Table 2: RQD of different rocks

Type of rock	Shale	Mineralized shale	Dolomite	Mineralized dolomite
RQD (%)	27	43	46	46.5

4 Definition of geomechanical parameters in Goushfill mine

In order to specify geotechnical characteristics of rock mass, a series of special studies are done in this research. The rock mass is obtained as engineering classification to define Q[2], RMR [3], GSI [4] as specified in Table 3.

Table 3: Rock mass classification

Type of rock	Shale	Mineralized shale	Dolomite	Mineralized dolomite
Q	0.37	0.59	2.53	2.56
RMR	35	39	52	52
GSI	35-40	35-40	55-60	55-60

5 The selection of suitable exploitation methods

Generally for the recognition of applicable mining methods, it is desirable to compare characteristics of deposit with exploitation methods. The next step is to assess suitable exploitation method with economical aspects. There are two important parameters to define exploitation methods, 1-physical and geological characteristics of deposit. 2- the conditions of footwall, hanging wall and ore. Selection techniques of the methods depend on assessing mining methods specified based on previous experiences and with their own direct achievements. The aim of these presented layouts is to discuss the best mining methods including surface, underground, hydraulic or other available methods. The process of selection method must first define feasibility of exploitation for surface, underground or mining method. The next step in the case of rejection of old mining methods from technical or economical aspects, is considering the new exploitation methods. The techniques of selection methods are divided into two groups: qualitative and quantitative models. Hence, quantitative models consider effective parameters in the selection of the methods and they are more reliable than qualitative models. Therefore in this part quantitative models are studied.

6 Quantitative models

In this method based on ratings of effective parameters in selection of the exploitation parameter methods, the suitable methods are chosen.

7 Nicolas method

The first computed method is suggested by Nicolas [5]. The method shows new route to choose suitable exploitation method. This method is desirable for the projects for which exploration drillings define mineral deposit without preparation of underground openings. The selection of exploitation method with the use of this procedure is achieved by two steps. In the first step different exploitation methods are arranged with different characteristics and based on maximum ratings. In the second step, in order to reduce the suitable methods and to decrease selection domain, with detailed studies based on mining expenses, required investment, extraction amount, available man power, environmental conditions and other special local conditions, the most suitable exploitation method is specified. The selection of the methods depends on high ratings with accurate analysis. The effective parameters on exploitation plan of Nicolas method can be introduced as follows : thickness of deposit, inclination of deposit, slope of deposit, distribution of fineness in deposit, uniaxial compressive strength (UCS), joint distance, shear resistance of joints. These characteristics for the ore, footwall, hanging wall, are investigated separately, and the ratings related to any mining methods are determined.

8 The modified Nicolas method

Through the modifications done in Nicolas method [6], the important parameters were applied in different exploitation methods. According to Table 4, each group of weight factors which is more suitable due to conditions of deposit, is considered in previous ratings. The weight factors considered in this project are 1, 0.8, 0.6 and 0.4, so as to reduce the effect of footwall. The ratings of modified Nicolas method in Goushfill mine are presented in Table 5.

Table 4: Weight factors of selection methods

Parameter		Ratings		
Shape, Dip, Thickness, Distribution, Grade		1	1	1
Mechanical properties of rocks	Ore	1	0.8	1.3
	Hanging wall	0.8	0.6	1.3
	Foot wall	0.5	0.4	1.3

Table 5: Modified Nicolas method

		Thickness	Dip	Shape	Grade	UCS			RQD			Shear strength of joints			Ratings
						Ore	Hanging wall	Foot wall	Ore	Hanging wall	Foot wall	Ore	Hanging wall	Foot wall	
1	Open pit	3	4	2	3	3.2	1.8	1.6	2.4	2.4	1.2	2.4	1.2	1.2	29.2
2	Block caving	0	4	2	2	0.8	2.4	1.2	3.2	1.8	1.2	2.4	2.4	1.2	24.6
3	Sublevel stoping	2	4	2	3	2.4	-32.6	0.8	0	0.6	0	1.6	0	0.4	-15.8
4	Sublevel caving	0	4	4	2	2.4	1.8	0.8	1.6	1.8	0.4	1.6	2.4	0.8	23.6
5	Longwall mining	0	-49	4	2	0.8	2.4	1.2	3.2	1.8	0.8	2.4	2.4	1.2	-26.8
6	Room and pillar	2	0	4	3	2.4	0	0.8	0.8	1.2	0.4	1.6	0	1.2	17.4
7	Shrinkage stoping	2	4	2	2	2.4	2.4	1.2	0.8	1.8	1.2	1.6	2.4	0.8	24.6
8	Cut and fill	4	4	4	3	1.6	1.8	0.8	2.4	1.2	1.4	2.4	2.4	1.6	30.8
9	Top slicing	0	2	3	2	2.4	2.4	1.2	0.8	1.8	1.2	1.6	2.4	0.8	21.6
10	Supported mining	1	3	2	3	0.8	1.8	0.8	3.2	1.2	1.6	2.4	2.4	1.6	24.8

9 UBC method

Because of disadvantages of Nicolas method, UBC method [7] is introduced. In Table 6, rating of UBC is shown for Goushfill mine. The suggested exploitation method of quantitative techniques, modified Nicolas method and UBC are mentioned in Table 7 with priority. According to hanging wall UCS, Sublevel stoping is omitted in modified Nicolas

method; therefore, the priorities are suggested for decimal and economical assessment, exploitation systems as follow: 1-cut and fill 2-sublevel stoping 3-open pit mine.

Table 6: UBC method

						UCS			RQD				
		Thickness	Dip	Shape	Grade	Ore	Hanging wall	Foot wall	Ore	Hanging wall	Foot wall	Depth	Ratings
1	Open pit	3	1	2	3	3	3	4	3	3	4	0	29
2	Block caving	0	4	2	2	1	3	2	2	3	3	3	25
3	Sublevel stoping	3	4	2	4	4	1	3	4	0	2	4	33
4	Sublevel caving	0	4	4	2	3	3	2	3	4	3	2	30
5	Longwall mining	0	-49	4	1	2	5	--	4	5	--	2	reject
6	Room and pillar	1	-49	4	2	3	0	--	3	0	--	3	reject
7	Shrinkage stoping	0	4	4	2	3	1	2	3	0	3	3	25
8	Cut and fill	4	4	4	3	3	5	3	2	5	2	3	38
9	Top slicing	0	0	2	1	1	2	2	1	0	2	1	12
10	Supported mining	2	2	1	1	1	2	2	1	4	0	1	17

Table 7: Comparison of different methods

Method	Modified Nicolas	UBC method
First	Cut and fill	Cut and fill
Second	Open pit mine	Sublevel stoping
Third	Supported mining	Sublevel caving

10 Cut and fill method

This method is too expensive; therefore, the cost of fill may reach 50 % of total amount. The filling operations can make the cycle of operation complex and need skilled workers. Also compaction of filling materials can cause instability and subsidence risk. Due to the high cost of ore, the grade can be high. This method is not economical in Goushfill mine, and it loses its importance. Due to high advantages of sublevel stoping and coping with the deposit this method is applicable in Goushfill mine.

11 Conclusion

1-the rock mass of Goushfill mine is classified based on GSI, RMR and Q system. 2-the geomechanical indexes of Goushfill rock mass are determined according to laboratory tests and field study. 3-the underground mining method is investigated quantitatively and the sublevel stoping is chosen.

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