Structures under Shock & Impact VI, C.A. Brebbia & N. Jones (Editors)

Fissuring of rocks under explosive charges

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Abstract

The process of the demolition of the rock with explosives is important in managing the quality of the extracted minerals. Improvement in the fragmentation can be obtained by variation of the following parameters: the specific consumption of explosives, the distribution, the inclination of the holes in the rock, the use of micro delays, the way the charges are built and the understanding of the géological properties of the massif.

Practical results in the open pit mineral mines show that changes in the charges lead to a large variation in the fragmentation. This allowed some authors to state that "all the fragmentation problems are solved vraying the consumption of the explosives". The authors think that this hypothesis is not true for all kinds of rocks.

The hole diameter influences the explosive's concentration. An increase in diameter generates an increase in the concentrated charge and often leads to an increase in the number of large pieces resulting after the explosion.

Inclined holes result in an increase in the fragmentation of the rocks through the decrease of the regulated fragmentation region and charge energy losses.

The optimal interval of the delay must be determined exactly since main differences can decrease its effect. In addition to the working security, the use of micro delay has a great influence on the quality of the fragmentation.

In this paper, field results related to many tests, taking into account these different parameters are presented.

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1. Introduction

A major step in the exploitation of open pits mineral mines is the rocks preparation for extraction. This preparation predetermines the process efficiency, the work's security, and in general the efficiency of the open pit mining operations. In most cases, the preparation for extraction includes the demolition of the rock massif to obtaining pieces of the dimensions needed for the normal process of extraction and transport.
It must also insure a minimal degree of mixing of sterile and mineral rocks in order to have the smallest dilution possible. The process of demolition of the rocks with explosives is essential in the management of the extracted minerals. The improvement of the quality of the fragmentation can be obtained by:
- specific comsumption of the explosives
- distribution pattern
- inclination of the holes
- use of micro-delays
- building of the charges
- understanding the technological properties of the massif.

table.1 Catégories of fissuration of rocks

categories	Rocks	Distances between fissures, m	Number of fissuration by linear meter
I	Highly fissured	< 0,1	> 20
II	Very fissured	0,1 - 0,5	10 - 2,0
III	Average fissure	0,5 - 1,0	2,0 - 1,0
IV	Less fissured	1,0 - 1,50	1,0 - 0,65
V	no fissured	> 1,50	< 0,65

The data shown in the tables and figures have been obtained through different experiments made in many quarries of construction materials /1/, /2/.

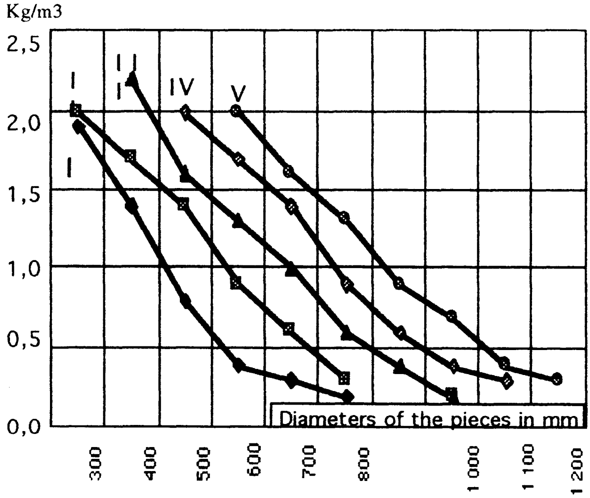
2. Specific consumption of explosives

The practice of charges in many open cast mineral mines shows that changes in the specific consumption lead to large variations in the fragmentation. This has allowed some autors to state that "All fragmentation problems can be solved by the specific consumption of the explosives". We think that this statement is not true for all kinds of rocks. We have carried out a set of experiments showing that, in the case of monolithic rocks, the increase of the charge by 2.3 times induces a proportional decrease of the large blocks. This decrease is only 1.3 times in the cases of fissured modules.

Table 2 Specific consumption of explosives

diameter of the pieces mm	Types of fissures I	II	III	IV	V
	Specific consumption of explosives Kg/m^3				
300	1,9	2,0	-	-	-
400	1,4	1,7	2,2	-	-
500	0,8	1,4	1,6	2,0	-
600	0,4	0,9	1,3	1,7	2,0
700	0,3	0,6	1,0	1,4	1,6
800	0,20	0,3	0,6	0,9	1,3
900	-	-	0,4	0,6	0,9
1000	-	-	0,2	0,4	0,7
1100	-	-	-	0,3	0,4
1200	-	-	-	-	0,3

Fig.1 The fragmentation and the specific consumption of the explosives in fissures rocks



It is noticed that the increase of the specific consumption could not solve the problem of the very large blocks when the rock is fissured. The energy of explosion is alloted unequally across the system of fissuration

The granulometric analysis carried out for several explosions show that the average size K50 is proportional to the surface of a AxB mesh on one hand and to the relationship E/B mesh ratio on the other hand.

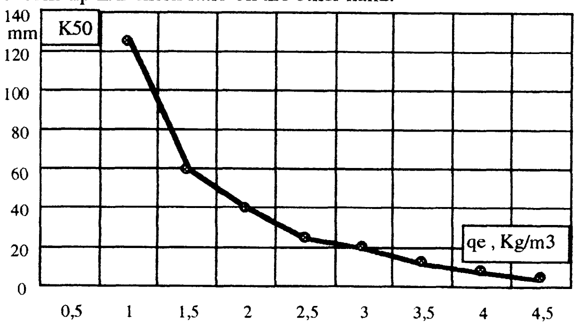


Fig.2 Average size according the specific charge.

K50 is the average size of a square mesh allowing through 50% of the load, AxB is the surface of mesh, E/B is the mesh ratio

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3. Distribution regularite of the explosive

The hole diameter influences the explosive concentration in the rock. The increase in the diameter generates an increase of the concentrated charge and often leads to an increase in the number of large pieces. Experiments held in the quarry show that a decrease in the number of large pieces from seven to twelve per cent. The specific concentration decerases from eight to fourteen per cent. These same experiments show that the influence of the charge's diameter on the fragmentation depends on the fissure's pattern of the rock.

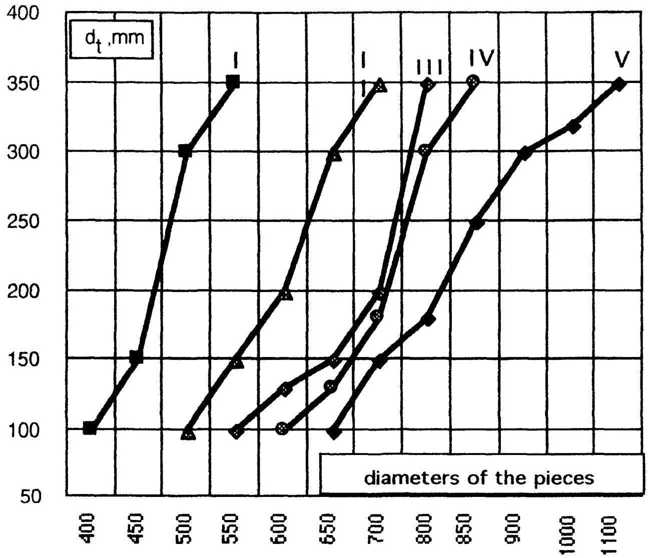

Fig 3 Diameter of the holes versus fragmentation of fissured rocks (dt, diameter of the hole in mm)

For the case of fissured rocks, it is recomended according to the results of the Fig.3 small holes. As the tests were carried out in limestones quarries of one notices that for these latter, the diameters 104-150 mm give good results for all types of fissuration. The utilization of large diameter holes will produce on the other hand very large blocks in the categories IV and V.

4. Inclination of the holes

Inclined holes favour the efficiency of the fragmentation of the rocks and this is produced by a reduction of :

- the regular fragmentation region
- the loss of the charge's energy in the massif
- the loss of energy employed in the destruction of the bottom of the baes /3/.

The practice shows that the use of inclined holes decreases the large blocks from 8 - 10 % to 15 - 25 % and increases the efficiency of the excavators by 1.5 times (Fig.4).

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Table 4 Hole inclinations in degrees

	Types of fissures				
	I	II	III	IV	V
diameters of pieces mm	Hole inclinations in degrees				
400	60	-	-	-	-
450	70	-	-	-	-
500	80	-	-	-	-
550	-	60	-	-	-
600	-	70	50	-	-
650	-	80	60	-	-
700	-	90	75	50	-
750	-	-	80	60	50
800	-	-	90	80	60
850	-	-	-	80	70
900	-	-	-	90	80
1000	-	-	-	-	90

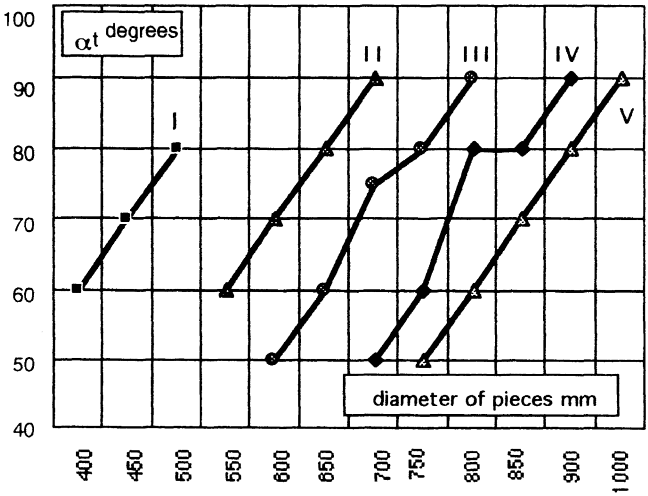

Fig 4 Holes diameter and fragmentations in fissured rocks (α_t: hole inclination).

The local constraints of the quarry result in the experiments being carried out on holes at 40 to 90 degrees (Fig.4). The size of the pieces for all the types of fissuration increases as are approched the 90° angle.

5. Charges with micro delays

The optimal interval of the delay must be determined exactly since any difference reduces the effect of its use. The use of the micro delay has a great influence on the quality of the fragmentation. The period of the micro delay is not important for the rocks with fissuration types of I to III. However, for the rocks with types III to V, the use of charges with micro delays increases 1.6 to 2 times the efficiency.

The evolution of the size of largest blocks as a function of the mesh ratio E/B is different according to that the mines are initiated without delay.

Table.4 size of largest blocks as a function of the mesh ratio E/B

mesh ratio	% of large blocks	
E/B	delay	without delay
01	22	39
02	17	32
03	12	18
08	10	11

It appears (table.4) that the use of micro delays improve the fragmentation. It is important to note that for the mesh ratio E/B=8, the two case give the same size (in %) of large blocks.

6. Building of the charges

Practice and research in this field show that the quality of the fragmentation depend considerably on the building of the charges. This latter is related to the rocks properties and determines the quality of the fragmentation. Any building charge in quarry can be divided into three groups depending on the energy index of the charge :

- Cylindrical charges correspond to vertical inclined continuous charges and using the same explosive.
- Charges with different explosives and using two or many starting points.
- Charges of different forms and with pockets allowing to modify the density of the explosive.

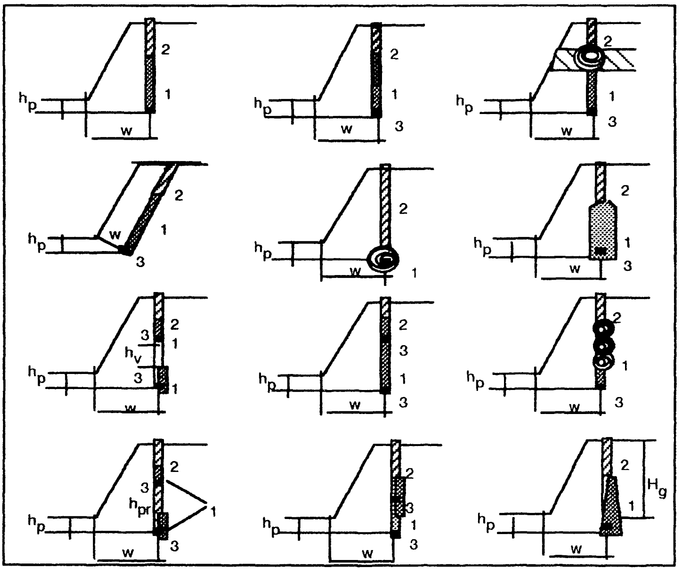

Fig.5 Construction of charges by Y.I Anistratov./5/

1. Explosive, 2. Filling, 3. Starting points, Hg. Hight of the base, hp.Excess length, hv. Empty space, hpr. Filling intermediate.

The use of charges disrupted by air chamber, improves considerably the fragmentation of the rocks and allows to decrease the consumption of the explosive by up to 10 % without changing the fragmentation. The length of the space of the air is generally related to the category of the fissure of the rocks.

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Finally, from the model Kuz-Ram [7,1], some interesting behaviors of the different parameters can be studied. Preserving the average size K50 constant and increasing the diameter of the holes 100 mm to 350 mm, one finds that the faulty parametrs increase :
- the specific load
- the size of the largest block
- the rate of explosions

In the same way, when the diameter of the holes increases for 100 to 350 mm for a specific constant energy, one notices that :
- the average size K50 increases by more than 60%
- the rate of the blocks larger than 100 cm reaches 5 to 25%
- the rate of the explosion doesn't vary much and it is minimal for the intermediate diameters.

We can conclude that the diameter of the hole has great influence on the size of the blocks. The model of Kuz-Ram [7] has some limitations however regarding the mesh ratio and the condition of homogeneity of the rock.
We must also point out that the quality of the fragmentation has a important influence on the efficiency of the transport and loading operations [6]. The smallest is the average size of the pieces, the most efficient are machines such as excavators and trucks.

7. References

[1] D. MERABET , Gestion de la qualité des minerais de fer dans les mines à ciel ouvert . Thèse de Doctorat d'état, Université d'Annaba, 1991.
[2] MERABET .D , Principes de l'élaboration des projets des mines à ciel ouvert, Office des Publications Universitaires (O.P.U), Septembre 1989, Alger.
[3] H. HERAUD et J.L. MEYER, Qualité de la foration, R.I.M. Les techniques, Avril 1993, pages 86-98.
[4] UTLER J.M, FOUTS R.K, Optimizing open pit operation with computer simulation, American Mining Congress Journal, March 1975, CERCHAR B73 80 581
[5] Y. ANISTRATOV, Technologie d'exploitation des mines à ciel ouvert, Nedra, Moscou 1988, pages 49-82.
[6] BASTIDE, DEYINE, Exemple de determination d'un parc d'engins miniers à ciel ouvert, Revue de l'industrie minérales , les techniques, Janvier 1983.
[7] BLAZY. P, JDID E.A, Théorie de la fragmentation, Techniques de l'ingénieur, A5069,5070, 11-1992.