New Drilling Design by Doubled Holes in Surface Mines

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Abstract

Drilling of holes in mines is a very important factor that generally has a great influence on the operability, productivity and especially the cost of a ton of ore extracted. Therefore, in this paper, we will see a technique that helps us to optimize the drilling-blasting ring by making doubled holes in each position in the block to be fragmented at the company of CGMSG (quarry of aggregates).

Keywords: *quarrying and mining, design of drilling, blasting*

Introduction

Drilling and blasting are seen as sub-systems of the size reducing operations in mining. To have better design parameters for economical excavation of mineral production and good fragmentation, the drilling and blasting operations needs to be optimized to improve fragmentation, which in turn will have a positive impact on the diggability of the material, reducing the time and energy to load. Better fragmentation sizes, meaning producing more fines, will reduce the energy required to crush and grind the material hence increasing crusher and mill throughput. Other benefits include improving the conditions of the bench floor, reducing flyrock, reducing ground vibrations and reduce secondary blasting.(Joel Edem Kwaku Gadikor. 2018). Most previous works have focused on drilling and blasting just in terms of costs reduction by different means. Afeni and Afum et al. tried to investigate the cost effects of different drilling equipment and blasting patterns respectively in two open pit mines through experimental and onsite observations (T.B. Afeni. 2009), (B.O. Afum, V.A. Temeng. 2015). Some other researchers made attempts to optimize drilling and blasting operations from the technical point of view; Sontamino and Drebenstedt addressed a dynamic model for a bench blasting design (Sontamino P, Drebenstedt C. A. 2012). Bowa introduced a practical method in an open pit mine to optimize blasting design parameters such as bench height, drill hole diameter, spacing, etc. (V.M. Bowa. 2015). Tosun and Konak determined a particular charge for blasting operation to reduce operating costs through an experimental method (A. Tosun, G. Konak. 2015). In addition, some other researchers tried to study the environmental aspect of drilling and blasting operations; Lashgari et al. and Attalla et al. investigated the emission of NOx from blasting elements in a surface coal mine through data gathering and mathematical equations (M.I. Attalla, and al. 2008), (E. Pruyt. 2013).

In recent years, Algeria has known a rapid dynamic in the construction projects such as; buildings, roads, and infrastructure, which increase the demand of the aggregates production in quarries.(Remli. S et al, 2019). To do this, it is necessary to find solutions to optimize the mining process to meet the requirements of the mining industry. The objective of this work is to optimize the drilling in mines and quarries by using a technique consist by doubling of holes in each location in the block to be fell that directly due to the relative change of blast plan such as the distance between holes and that between rows.

Materials and methods

Geographical location of Sarl CGMSG

The study area is part of wilaya of Bouira which is located in central part of northern Algeria. The Sfail El Faidja quarry is located at 8 km as the crow flies from el hachimia and 18 km as the crow flies to south of capital of Bouira wilaya.

Geology of the deposit

The deposit consists of Cenomanian formations, represented by alternating limestone, marl and predominantly marly clay. The limestones are gray to platinum and dark gray to the break, they are very compact and massive with centimeter calcite vein or slits. The latter represent two structural directions oriented N 020 and N 140 which cut the limestone banks in paving stones or lozenges, and after alteration gives an appearance of beads(CGMSG, 2013).

The strength of this formation is much reduced east of the deposit, where it does not exceed 20 m and greater westward or reaches 40 m. The east-west transition from deposit is marked by a loophole of NW-SE direction. The limestone and marly formations extend in a dip of 15 to 20 ° towards the SSW and direction N100 to N110.

Role of drilling

Drilling is the process of making a hole into a hard surface where the length of hole is very large compared to the diameter (Pathak, 2014). Drilling and Blasting is the most common method for breaking and loosening solid rock in surface mines. The general objective is to produce the broken material that can be excavated and loaded.

Surface mining requires drilling for different purposes that include (Pathak, 2014):

- Production drilling i.e. for making holes for placement of explosives for blasting.

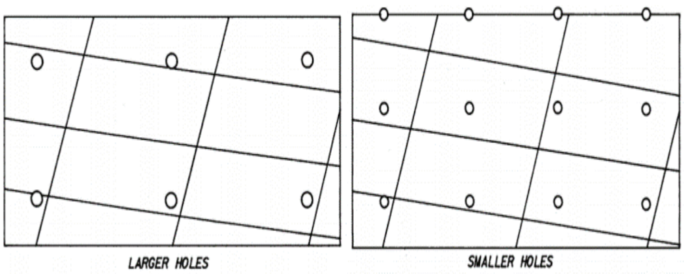

Fig. 1. Two different meshs of drilling confronted with the same grid of discontinuities. Illustration according of U.S. Bureau of Reclamation, 2001
Rys. 1. Dwie różne siatki wiercenia skonfrontowane z tą samą siatką nieciągłości. Ilustracja według US Bureau of Reclamation, 2001

Tab. 1. Characteristics of limestone quarry
Tab. 1. Charakterystyka kamieniołomu wapienia

uniaxial compression resistance	113 Mpa
Los Angeles test	23
Micro Devaltest	27
Limestonerate (calcite and / or organic)	77.42 %

Tab. 2. Blasting plan parameter for doubled and simples holes
Tab. 1. Charakterystyka kamieniołomu wapienia

Parameters	**Simple hole**	doubled holes
Holes number	100	100
Holes length	16 m	16 m
Bench Height	15 m	15 m
Burden	4 m	5.65 m
Spacing	4 m	5.65 m
Holes diameter	102 mm	102 mm
Holes Inclination (β)	85°	85°
Number of rows	03	02
Sub-drill	1 m	1 m
Stemming	2.4 m	2.4
Charge of explosive in a hole	111.5 kg	111.5 kg
Total amount of explosives (Temex + Anfo)	11150 kg	11150 kg
number of electric detonators	100 pieces	50 pieces
Specific Consumption of explosives	464 g/m^3	464 g/m^3

	Simples holes	**Doubled holes**	**Optimization rate**
drilling machine displacement time to drill holes	1 h and 20 min	1 h and 2 min	22%
Blasting operation time	2 h and 30 min	2 h	20 %

- Exploration drilling i.e. for sample collections to estimate the quality and quantity of a mineral reserve.
- Technical drilling i.e. during development of a mine for drainage, slope stability and foundation testing purposes.

In conditions where the spatial frequency of one or more sets of discontinuities is large, it is notoriously preferable to blast the benches with a reduced hole diameter; this allows for a tighter drilling pattern with equivalent specific consumption. A loose mesh of drilling in this type of situation can lead to whole portions of the bench that are little or not fragmented (see Figure 01). This remark also applies to blasting in conglomerate rocks.

Experimentation

The experience of the doubled holes was made at CGMSG quarry for aggregates (Fig. 02), so some data on limestone are mentioned in Table 01 where the rock is characterized by an average hardness with a value of uniaxial compression resistance of 113 MPa. In addition, the rock mass is slightl cracked.

Drilling procedure involves to drill two adjacent holes instead of a single hole in each location, the distance between them is 0.5m to 0.7m depending on the hardness and stability of rock mass. This distance is intended to avoid the convergence between holes at certain depth. During the process of loading explosives into holes, priming is done by connecting a single pair of holes by a single electric detonator (Figures 02 and 03).

Parameter of blast plan

In this experiment, both tests are done using the doubled and single holes (Figure 04). The blasting plan parameters in both cases are shown in Table 02.

The determination of the mesh of doubled holes is by the following relation:

$A' = B' = \sqrt{(A*B)}$ or

– A and B represent the distance between the holes and that between the rows successively.

– A' and B' represent the distance between the doubled holes and that between the rows successively.

Results and discussion

After having the same blasting results in both cases (well-defined grain size, good inclination of the bench face,

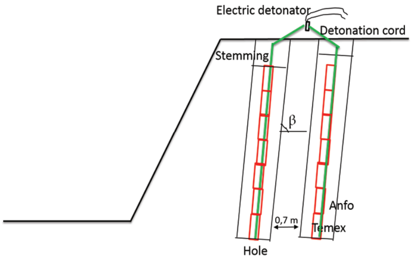

Fig. 2. Schema of doubled holes in the bench
Rys. 2. Schemat podwójnych otworów

Fig. 3. Photographies of doubled holes test
Rys. 3. Fotografie testu podwójnych otworów

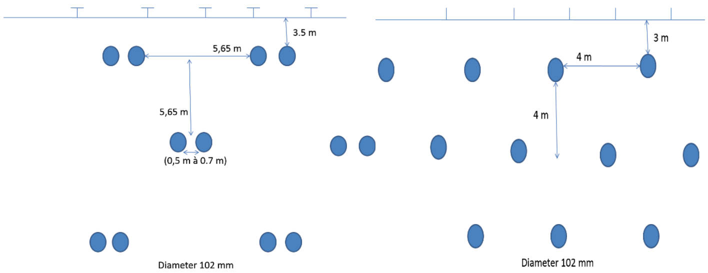

Fig. 4. Drilling plan for simple and doubled holes
Rys. 4. Plan wiercenia otworów prostych i podwójnych

Fig. 5. Blasting results for doubled and simples holes
Rys. 5. Wyniki strzelania otworami pojedynczymi i podwójnymi

good shape of broken rock pile and good shape of the bench) figure 05. So we can conclude that the use of the technique of doubled holes (table 03) has actually allowed us to benefit the blast operation time with a rate of 20% and especially in the necessary quantity distribution time of the explosive material in each hole (manual loading), so the benefit of the connection time of two cords coming from the doubled holes by a single electric detonator. So the latter also allowed us to minimize the cost of felling that will positively affect the cost price of a ton of rock felled. Also thanks to this technique, distance of moving of drilling machine to drill all holes is decreased, so an optimized displacement rate of 22% which due practically to the increase of drilling yield.

All these optimizations quoted above in the time of the operation of blasting due automatically to the reduction of cost price of the drill-blast ring.

On the other hand, the use of doubled holes technique causes an excess of the shock wave due to increase of seismic and acoustic waves generated from the instantaneous charge elevation; and this, for quarries that are using the sequential exploder. So it is not recommended to use this technique in quarries near to habitats.

Knowing that the choice of drilling machine depends essentially on the geometry of deposit, the physicomechanical properties of the rocks and the planned production. So there are companies already bought drills for such a reason but after that, it knows an increase of the production according to demand of the market, therefore to satisfy business needs,, it is necessary to carry out this technique to avoid the purchase of other drilling machine that affect the cost price and even the national economy (reduction of the number of drilling machine import).

Conclusion

Doubled holes drilling design has allowed us to virtually reduce drilling and blasting times as well as increase felling production, so all of these optimizations actually due to the cost reduction of a ton of rock extracted. On the other hand, the use of this technique of preference is avoidable when the mine is located in the neighborhood of habitats because the doubled holes drilling due to increase of instantaneous charge which causes the damage of houses and infrastructures caused by the intensity of seismic wave. In addition, this technique is not effective in the case of very cracked rock mass, because the majority of explosive energy escapes through the cracks so we will get a bad blast result (high rate of Out-sized).

Literatura – References

1. U.S. Bureau of Reclamation. Engineering Geology Field Manual. 2001.
2. Joel Edem Kwaku Gadikor. 2018. Optimization of drilling and blasting practices at a western us open pit copper mine. thesis for Master of Science in Mining Engineering. 88 p.
3. CGMSG, 2013. Rapport inédit. Plan géologique de la carrière CGMSG 2014.
4. Pathak, K. 2014. Introduction to drilling technology for surface mining. Department of Mining Engineering, IIT, kharagpur-721302.
5. T.B. Afeni. 2009. Optimization of drilling and blasting operations in an open pit mine-the SOMAIR experience. Mining Sci Technol, pp. 736-739
6. B.O. Afum, V.A. Temeng. (2015). Reducing drill and blast cost through blast optimisation-a case sudyGhana Mining J, 15 (2) , pp. 50-57
7. Sontamino P, Drebenstedt C. A. prototype dynamics model of bench blasting design. The 10th international conference on mining, materials and petroleum engineering. Songkhla: Sciences and Technologies Towards; 2012.
8. V.M. Bowa. 2015. Optimization of blasting design parameters on open pit bench a case study of Nchanga open pits. Int J Sci Technol Res, pp. 45-51
9. A. Tosun, G. Konak. 2015. Determination of specific charge minimizing total unit cost of open pit quarry blasting operations. Saudi Soc Geosciences, pp. 6409-6423
10. E. Pruyt. 2013. Small system dynamics models for big issues. TU Delft Library, Delf.
11. M.I. Attalla, S.J. Day, T. Lange, W. Lilley, S. Morgan2008. NOx emissions from blasting operations in open-cut coal mining. Atmos Environ, 42, pp. 7874-7883
12. S. REMLI, A. BENSELHOUBand I. ROUAIGUIA. 2019 .Optimization Of Blasting Parametrs In Open Cast Quarries Of El Hassa-Bouira (Northern Algeria). GeoScience Engineering .ISSN 1802-5420. Volume LXV. p. 53 – 62

Nowy projekt wiercenia przez podwójne otwory w kopalniach odkrywkowych

Wiercenie otworów w kopalniach jest bardzo ważnym czynnikiem, który generalnie ma duży wpływ na funkcjonalność, produktywność, a zwłaszcza na koszt tony wydobytej rudy. Dlatego w tym artykule przedstawiono technikę, która pomaga zoptymalizować prace wiertniczo-strzałowe poprzez wykonanie podwójnych otworów w każdym miejscu w bloku do rozdrobnienia. Badania przeprowadzono w firmie CGMSG (kamieniołom kruszyw).

Słowa kluczowe: *wydobycie, górnictwo, projektowanie odwiertów, prace strzałowe*