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Modeling and optimizing the drilling and blasting pattern of the Boghde-Kandi quarry rubble mine of Saghez

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Abstract

In most surface mines, the convention empirical methods are used to design the blasting pattern that leads to the undesirable results and increasing the production costs. In this research, the Delpat software package was utilized to simulate and optimize the blasting pattern of Boghde-Kandi quarry rubble mine. For this purpose, mine information was firstly collected and essential rock geomechanical parameters were measured. Then using the above-mentioned software, simulation of blasting pattern was conducted for hole diameters i.e., 76, 89, 102 and 115 mm. Comparison of the costs related to selection of each of the above hole diameters showed that overall costs were decreased by increasing in hole diameter. However, higher hole diameter required the greater volume of explosives which causes further ground vibration and flyrock. By utilizing the greater hole diameters, official buildings and; crushing and grading equipment sites will be located in the flyrock and ground vibration area and may be damaged. On the other hand, applying the hole diameter of 102 mm leads to the considerable cost decreasing (0.08 $/m^3) compared to the 76 mm hole diameter that currently is used in mine. Therefore, hole diameter of 102 mm was proposed as an optimum one. According to this hole diameter, other parameters related to drilling and blasting pattern were calculated and proposed to perform in practice. Practical implementation of the blasting operation based on the suggested pattern leads to improve fragmentation and minimizing costs and side effects compared to the previous pattern.

Keywords: *Quarry rubble mine, Drilling and blasting pattern, Rock fragmentation, Delpat software*

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Extended Abstract:

1. Introduction

Drilling and blasting is the common method for large scale production in the surface mines such as open-pit and quarry mines. Therefore, optimization of the blasting operation could be a best approach to increase the income and decrease the production costs. Generally, the overall objective of the drilling and blasting operation in surface mines such as rubble quarries is the rock fragmentation which is the first stage of mine extraction process. So rock fragmentation can play a critical rule lifetime and economic conditions of the mine. Suitable rock fragmentation due to desired blasting can cause decreasing the total cost of the blasting operation, improvement the efficiency of the drilling, loading, hauling, crushing and grinding operations. These lead to maximize the overall costs of the mine production. Therefore, development of a systematic approach is necessary to optimize the drilling and blasting process in surface mines. For this purpose, identifying all of the effective parameters on the drilling and blasting operation and incorporating in the modeling process is required (Lownery et al., 2001). To do that, different efforts were initiated by various researchers to achieve more reliable and scientific methods to optimize the drilling and blasting design. These presented methods include of empirical formulae based on field measurement, simplified analytical equation, numerical modeling, prevention hazard of blasting operation, artificial intelligence and computer-aided design (Liu et al., 2014).
In the empirical formulae, empirical equations between design variables and blast outputs were developed using the statistical analysis on the basis of field measurements data. However, large amount of field data are required in this method. Moreover, these methods have poor applicability in practice (Yang and Rai, 2011). On the other hand in the simplified analytical equations, the simplified theoretical relations between the effective parameters and blasting results were constructed based on simplification and assumptions of rock mass and explosives characteristics. Due to more assumptions and neglecting some influencing factors, these equations can only reflect approximate relationships (Yang et al., 1989). In the numerical methods, the blast design would be customized on the basis of feedback from the simulated results. However, only one or several factors instead of the complete blast design has considered in the optimization of blasting pattern. Moreover, numerical method is a time consuming method and some of the modeling required parameters are difficult to determine (Zhu, 2009). In the prevention hazard of blasting operation, optimization of the drilling and blasting pattern is performed in these methods only from the standpoint of hazard prevention whereas; the equilibrium should be established between the lowest side effects and the best blast results (Liu et al., 2014). Finally, One of the main problems in the application of artificial intelligence methods is their dependency to the availability of a large number of datasets in the form of input(s)-output(s). However, an inaccuracy in the datasets leads to invalid results of these methods (Monjezi et al., 2009, 2010; Rezaei et al., 2011).
In order to overcome the above-mentioned limitations and the shortages, an attempt was made in this paper to develop a new method with considering all of the possible effective technical and economical parameters for optimum designing the blasting pattern.

2. Materials and methods

The Boghde-Kandi quarry rubble mine was considered as the case study in the current research. For designing the drilling and blasting pattern of this mine, Delpat software package was utilized which is one of the powerful package programs to design of drilling and blasting pattern (Kalayci et al., 2015). To do that, mine data and information were collected and undetermined required parameters measured in the first stage. Then, gathered data was proceed in Excel environment and prepared to perform the drilling and blasting modeling. In the next stage, Delpat software was applied to optimum design of the drilling and blasting pattern. Finally, the results of blasting operation for different hole diameters were compared in terms of desired fragmentation, minimum production cost and side effects. On this basis, optimum hole diameter and other blasting pattern variables proposed for practical implementation in the mine.

3. Tests results

By using the Delpat software for the blasting operation of the Boghde-Kandi quarry rubble mine on the basis of the mine information and its rock characteristics, the results were achieved for four hole diameters including 76, 89, 102 and 115 mm. The results of blasting operation calculations are shown in Figure 1. Moreover, cumulative and size distribution curve of the rock fragments due to blasting is demonstrated in Figure 2. As can be seen in Figure 1, 115 mm hole diameter leads to minimum blasting and total production costs. According to this, this hole diameter can be suggested as the optimum ones provided that it does not cause any safety problems such as flyrock, back break and ground vibration.

Design of drilling and blasting pattern was conventionally conducted on the basis of the personnel experts in the Boghde-Kandi quarry mine. Utilized hole diameter was 76 mm in which total production cost was estimated 0.66 $/m^3. Furthermore, application of this hole diameter caused the side effects such as ground vibration and flyrock. On this basis, mentioned side effect can be expected at a much large scale while the utilization of 102 and 115 mm hole diameters. So these hole diameters could not be suggested in practice despite their lower total production cost. On the other hand, by using the 102 mm hole diameter, the total production cost is decreased as much as 0.08 $/m^3 compared to the conventional applied hole diameter (76 mm) as shown in Table 1. Therefore, the hole diameter of 102 mm is suggested as an optimum one for practical implementation in the Boghde-Kandi quarry mine. On the basis of this hole diameter, other variables of the drilling and blasting pattern were proposed according to Table 1.

Table 1. Modeling results for different drilling and blasting pattenrs using Delpat software

Parameter	**Hole diameter**			
	76	**89**	**102**	**115**
Bench height (m)	9	9	9	9
Burden (m)	2.36	2.5	2.61	2.84
Spacing (m)	2.37	2.74	3.17	3.43
Subdrilling (m)	0.86	0.98	1.12	1.2
Stemming (m)	2.06	2.46	2.65	2.91
The amount of primer (Kg/hole)	1.5	1.5	1.5	1.5
Bottom charge (Kg/hole)	10.73	17.56	24.91	34.75
Column charge (Kg/hole)	19.26	22.69	27.47	30.8
Hole lemgth (m)	9.92	10.08	10.16	10.27
Drilling cost ($/m^3)	0/5	0.5	0.49	0.49
Blasting cost ($/m^3)	0.33	0.3	0.27	0.25
Total cost ($/m^3)	0.66	0.61	0.58	0.51

4. Conclusion

In the current study, Delpat software was used to design of the optimum drilling and blasting pattern in the Boghde-Kandi quarry mine. For this purpose, required data for the modelling and optimization of the blasting pattern of this mine was gathered and prepared. After that, drilling and blasting patterns were designed using the Delpat software for hole diameters of 76, 89, 102 and 115 mm. Comparison the blasting and production total costs revealed that the costs would be decreased by increasing in the hole diameter. Considering the blasting side effects of holes with 115 mm, the 102 mm hole diameter was proposed as the optimum one for the Boghde-Kandi quarry w leads to significant reduction in production total cost (0.08 $\$/m^3$) compared to the current used hole diameter (76 mm) in the mine.

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