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Determination of optimal extraction direction in order to increasing of the cuboid productivity of dimension stone quarries using discontinuity modeling (Case study of Travertine Kapyol Mine)

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Abstract

Rock mass contains intact rock and discontinuity network. The intersection between discontinuities create rock blocks with various geometry. Determination of rock blocks geometry is necessary to evaluate the economics of stone reserves. Besides, the extraction of stone blocks is performed by cutting planes, and the optimization of cutting pattern leads to increasing quarrying efficiency and decreasing production of waste in quarries. This procedure results less environmental damages and more economical beneficiations. Also, will reduce environmental impacts and increase economic interests. In this research, first, important features of discontinuities such as persistence, spacing, orientation, etc. have been extracted in the Kapyol quarry stone mine. Then, using 3DEC simulation of the block model and using block modeling, different joint azimuth rotation is investigated in four classes. Analyzing the results obtained from the modeling showed that in order to obtain maximum value, the direction of the current extraction should change 70 degrees to the west, as a result of its variation, an average in-situ block is 287.45m^3 and the amount of saleable cuboid in four classes is 65826.27 m^3, which according to the current rate will generate about 115 billion and 98 million Rials for this mine.

Keywords**:** *Quarries mines, 3DEC modeling, Cuboid optimization, Discontinuities analysis*

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Extended Abstract:

1. Introduction

Decorative stone is one of the three high value minerals in the country. According to the Statistics Center of Iran, 5353 mines were operating in Iran in 2017, the total value of their products was 250485 billion rials. On the other hand, only about 25 percent of the stone produced in Iran is sold in the market, and about 55 percent in mines and 20 percent in quarries mines turn into waste. Although tectonic status is effective in the performance of stone mines, in general there should not be much difference between the average yields in different countries. It can be concluded that stone mining in Iran is not followed scientifically in Iran. The main factors in the low efficiency of mines in the country can be the lack of study and investment before mining, low technology and lack of skilled labor.

One practical way to increase the efficiency of quarries mine is considered discontinuities analysis in the perform extraction and cutting operations. Numerous studies have been conducted on the analysis of discontinuities in quarries stone mines. Mosch et al. used an algorithm to optimize extraction of dimension stone blocks (Mosch et al., 2011). Elmouttie and Poropat, presents a new technique for estimating the in-situ block size distribution in a jointed rock mass. The technique is based on Monte Carlo simulations using more realistic fracture geometry as its input compared to other block size estimation methods (Elmouttie and Poropat, 2012). Yarahmadi et al., developed a computer program to determine geometry of rock mass blocks in two dimensional spaces. In this article, the geometry of jointed rock mass is programmed in MATLAB™ (Yarahmadi et al., 2014). Yarahmadi et al., reviews various methods for discontinuity and rock block survey. The variety of techniques to determine the shape and size distribution of the rock blocks were divided into index and modeling methods. Based on the various reviews, a new approach is proposed to determine suitable methods for use in the evaluation of dimension stones. This new methodology was applied in a limestone quarry in Joshqan, Iran, to verify the applicability of the different methods in dimension stone quarries (Yarahmadi et al., 2015). Yarahmadi et al., used numerical algorithm was selected from various algorithms and was developed for in situ block identification. The optimization approach was adopted to increase quarry productivity and to investigate quarrying direction on a large scale (Yarahmadi et al., 2018). Azarafza et al., estimate the shape and block dimension utilized, by the algorithm based on the AI image processing technique for rock mass structural detection and for rock block definition in 2D and 3D space obtained with the Mathematica software package. The algorithm, by categorizing the discontinuities in two groups (opened and closed), which represents the main and the secondary discontinuities, can identify the emplacement and shape of rock blocks (Azarafza et al., 2019).

The purpose of this paper is to analyze the discontinuities in the Kapyol mine front in order to provide a suitable solution to increase the efficiency of extraction and increase coupling.

2. Methodology

In this research, first, important features of discontinuities such as persistence, spacing, orientation, etc. have been extracted in the Kapyol quarry stone mine. then, using 3DEC simulation of the block model and using block modeling, different joint azimuth rotation was investigated in four classes.

3. Conclusion

The presence of discontinuities in quarry mines not only affects the quality of the extracted rock block it also reduces the mining efficiency. Therefore, it is vital to study the general condition of discontinuities in quarry mines. In this research, first, important features of discontinuities such as persistence, spacing, orientation, etc. have been extracted in the Kapyol quarry stone mine. Then, using 3DEC simulation of the block model and using block modeling, different joint azimuth rotation is investigated in four classes. Analyzing the results obtained from the modeling showed that in order to obtain maximum value, the direction of the current extraction should change 70 degrees to the west, as a result of its variation, an average in-situ block is 287.45m3 and the amount of saleable cuboid in four classes is 65826.27 m3, which according to the current rate will generate about 115 billion and 98 million Rials for this mine.

4. Reference

Azarafza, M., Ghazifard, A., Akgün, H., & Asghari-Kaljahi, E. (2019). Development of a 2D and 3D computational algorithm for discontinuity structural geometry identification by artificial intelligence based on image processing techniques. *Bulletin of Engineering Geology and the Environment*, *78*(5), 3371–3383.

Elmouttie, M. K., & Poropat, G. V. (2012). A method to estimate in situ block size distribution. *Rock Mechanics and Rock Engineering*, *45*(3), 401–407.

Mosch, S., Nikolayew, D., Ewiak, O., & Siegesmund, S. (2011). Optimized extraction of dimension stone blocks. Environmental Earth Sciences, 63(7–8), 1911–1924.

Yarahmadi, R, Bagherpour, R., Khademian, A., Mirzaie, H., & Kakaie, R. (2015). Developing a MatLab code for determine geometry of rock mass blocks and its applications in mining and rock mechanic engineering. *Journal of Mining and Metallurgy A: Mining*, *51*(1), 41–49.

Yarahmadi, Reza, Bagherpour, R., Kakaie, R., Mirzaie, N. H., & Yari, M. (2014). Development of 2D computer program to determine geometry of rock mass blocks. *International Journal of Mining Science and Technology*, *24*(2), 191–194.

Yarahmadi, Reza, Bagherpour, R., Taherian, S.-G., & Sousa, L. M. O. (2018). Discontinuity modelling and rock block geometry identification to optimize production in dimension stone quarries. *Engineering Geology*, *232*, 22–33.