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The role of structural joint studies in design of economic extraction and stability analysis of rock face of decorative stone mines

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Abstract

Profitable production of decorative stone depends on the dimensions of the extractable block. One of the important parameters in determining the dimensions of blocks is identifying and modeling discontinuities and their role in mining optimization and the instability and sliding of blocks. The shape and volume of sub-blocks obtained from mine exploitation are challenging issues in mining operations, which are controlled by the three-dimensional model of the discontinuity system. Failure to pay attention to this issue in decorative stone mines leads to many problems such as severe crushing of stone blocks and low extraction efficiency. In this research, an extraction optimization approach has been used for decorative stone mines. By discontinuities survey in the rock mass and choosing different directions for the extraction working face, a 3D block model was made. For each of the alignment, the number and volume of sub-blocks were calculated. Blocks with a volume of less than one cubic meter were considered as waste and based on that, the percentage of recovery was calculated for each of work front direction. Based on the results obtained from the modeling, one of the models that led to the largest volume blocks production was suggested as the optimal face direction. Also, for the optimal alignment, the analysis of the stability of the mine faces was done according to the spatial position of the structural joints. In this alignment, there was no possibility of plane and toppling sliding, but there was a possibility of wedge sliding. The stability analysis showed that there is a possibility of wedge slide in other stretches as well, which was expected due to the jointing of the rock mass. Therefore, the line with the highest percentage of recovery, considering the safety of wedge faliure, was suggested for the mine extraction plan.

Keywords: *Structural joint, Decorative stone, Optimal extraction, Working face alignment, Slope stability*

Extended Abstract:

1. Introduction

Decorative stone mining is the art of collecting huge stone pieces without crushing and cracking in such a way that the least amount of damage is done to the extracted stone block. The main factors of increasing the profitability of a decorative stone mine are optimizing the block size and focusing on the production of high-quality raw blocks with suitable dimensions. Montani (Montani, 2003) has stated that considering the global average of decorative stone mining, only one third of the extracted raw stone is consumed as a final product in the market.

The formation of separate blocks in the rock mass is the result of the collision between the discontinuity planes and the working front plane. Discontinuity plates in the rock mass divide the mining block into smaller sub-blocks. Lu (1999) has used the term in situ blocks for these blocks. The smaller the size of the mining sub-blocks, the lower the ability to cut and produce large slab from the mining block. Given that structural fracture planes will separate the rock mass, any geological feature that limits the size of the block will reduce the value of the final product.

2. Methods

In this research, based on identifying joints in the rock mass of a decorative stone mine, it has been tried to analyse the sub-blocks formed in terms of volume and number in different hypothetical directions for the work front. And then, according to the volume of the created sub-blocks, the most optimal extension for the mining work front is determined. In order to design optimal extraction and consider the effect of the existence of rock mass joints on the recovery percentage of mining blocks and to control the stability of the mine working front, an attempt was made with the help of three-dimensional geometric modelling of mining blocks to design mining in such a way that selected work front produce sub-blocks with larger dimensions.

For this purpose, structural geological studies were carried out and three joint sets were identified in the area. In the geometric model, four directions with azimuth of 0, 15, 30 and 45 degrees were chosen for the extraction work front and the simulation of the mine rock mass. After the implementation of the joints, the information including the number, frequency, and volume of the sub-blocks in each model was extracted and separated into classes of one cubic meter. Based on the results of the number and volume of sub-blocks, the optimal alignment of the mining work front with 15 degrees azimuth.

In addition to considering the highest recovery coefficient, the stability of the selected extraction work front was also checked. Planar sliding, wedge and toppling analysis was also done for the selected alignment.

3. Results

Based on the results of the number and volume of sub-blocks, the optimal alignment of the mining work front with 15 degrees azimuth. There is no planar slide and toppling in the selected direction. But there is a possibility of wedge failure, which according to the studies done in other directions, there is also the possibility of this sliding, so the direction with azimuth of 15 degrees was chosen for the extraction operation.

4. Conclusion

By modeling the joint sets and examining the four directions of the extraction work front with azimuths of 0, 15, 30 and 45 degrees, it was found that the largest volume of blocks can be extracted economically with the angles of 15, 0, 30 and 45 degrees, respectively.

Based on the results of slope stability analysis of the selected directions, there is no possibility of sliding and toppling along the azimuth of 15 degrees; But there is a possibility of wedge sliding. On the other hand, there is a possibility of wedge sliding in other alignments, so the alignment with 15 degrees azimuth was chosen as the optimal extraction direction.

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