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A Model For Prediction Of Unplanned Dilution In Underground Metal Mines Considering Rock Engineering Systems

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Abstract: The over-break and slough of walls and roof of stopes in underground mines leads to an unplanned dilution and ore grade reduction. The complex mechanism of unplanned dilution resulting from the effect of different parameters and interaction between them makes it impossible to provide an unplanned dilution model with sufficient accuracy through non-system methods. In this paper, a high-precision model in which interactions between parameters are considered is presented using the rock engineering systems approach. For this purpose, after selecting 8 parameters, as the most important parameters for unplanned dilution, the interaction matrix has been formed, matrix was coded and the ranking table was made and finally the index of unplanned dilution of 24 stopes from the Venarch Manganese mines has been calculated. Subsequently, using the cavity monitoring system, the actual values of unplanned dilution of each stope were measured and from there the unplanned dilution prediction model was obtained based on the unplanned dilution index. The model, which is a power relationship, has a coefficient of 0.89, root mean square error of 0.034, mean absolute error of 0.089 and a percentage of variance of 87. At the end, using this model, unplanned dilution of 9 new stopes (other than the 24 workshops) was predicted and compared with the actual values measured. The coefficient of this prediction is equal to 0.95, which indicates the high efficiency of the model and system approach in predicting the unplanned dilution of underground mining stopes.

Keywords: Underground stope, Over-break and slough, Unplanned dilution modeling, Rock engineering systems.

INTRODUCTION

The contamination of ore with wastes or materials of lower than cut-off grade is referred to dilution. In underground stopping methods, dilution happens as a result of falling of roof and walls, cutting of roof and floor, and loading of waste materials. In general categorization, dilution can be classified into two groups: planned (internal) dilution and unplanned (external) dilution. Planned dilution refers to a situation where, considering the deposit characteristics and in order to design the stope, some rock materials are removed from hanging wall and footwall. Unplanned dilution, however, happens outside stope design premise as a result of over break of the hanging wall by undesired fractures. Final dilution can be defined as the sum of planned and unplanned dilutions [1].

The complex mechanism of unplanned dilution resulting from the effect of different parameters and interaction between them makes it impossible to provide an unplanned dilution model with sufficient accuracy through non-system methods. In this paper, a high-precision model in which interactions between parameters are considered is presented using the rock engineering systems (RES) approach. The concept of RES, introduced by Hudson [2], is a method of structuring all the ways in which rock mechanics parameters and variables can affect the rock mechanics interactions. The key element in RES is the interaction matrix. The interaction matrix is both a basic analytical and a presentational technique for characterizing the important parameters and the interaction mechanisms in the rock engineering system. The generation of the interaction matrix can help in the weighting of parameters within the rock mass system as a whole.

In recent years, it has been made possible to measure accurate area of mining stopes using automatic laser rangefinders. Cavity monitoring system (CMS) was first introduced by Miller et al [3]. That system consisted of reflector less laser rangefinder, which is extended up to 5 meters into the stope cavity at the end of a boom support. Later on, other researchers used CMS data in their studies on dilution being able to calculate volume of cavity; this system can be used to calculate dilution directly with known values of design and actual stope volumes.

From the CMS data, the unplanned dilution prediction model was obtained based on the unplanned dilution index. The model, which is a power relationship, has a coefficient of 0.89, root mean square error of 0.034, mean absolute error of 0.089 and a percentage of variance of 87. In the end, using this model, unplanned dilution of 9 new stopes (other than the 24 stopes) was predicted and compared with the actual values measured. The coefficient of this prediction is equal to 0.95, which indicates the high efficiency of the model and system approach in predicting the unplanned dilution of underground mining stopes.

METHODS

After selecting 8 parameters, as the most important parameters for unplanned dilution, the steps of RES, including the formation of interaction matrix, matrix coding and formation of the ranking table and indexing the unplanned dilution of 24 stopes from the Venarch Manganese mines were conducted. Then, using the CMS, the actual values of unplanned dilution of each stope were measured. In this study, CMS was implemented defining the linear equivalent of over break and slough (ELOS) for dilution.

In order to calculate actual stope volume, cross-sectional profile of the stope was acquired at equal spacing and then integrated into a continuous volume. A laser rangefinder with an effective range of 200 m at 1 mm tolerance equipped with a digital goniometer of an operating angle range of 360 degrees at 0.1 degrees tolerance was used to acquire the profiles.

In order to acquire each section, first, the rangefinder was mounted on a tripod at the center of the lower side of the section on stope floor. Then, the distance from that to points on stope walls and roof at different angles were read until a section was recorded. Next, the tripod was shifted to the center of the lower side of the next section and the procedure was repeated to record the second section. The procedure was repeated until required numbers of sections were captured. Following with the investigations, acquired data was fed into AutoCAD.14 Software where actual stope was modeled three-dimensionally and the stope volume was determined. Specifying design and actual volumes of the stope, ELOS was calculated.

FINDINGS AND ARGUMENT

Using the RES approach, to a large extent, reduces the difficulty of analyzes and the presentation of the unplanned dilution model as a process with many complexities. The feature of the new model is the consideration the interaction between the effective parameters which has not been seen in any of the experimental and numerical past models of this issue. Another feature of this new model is the simultaneous presence of parameters related to drilling and blasting with geological parameters. Also, the use of CMS has led to an increase in the precision in calculating unplanned dilution values, and ultimately all of these increase the accuracy of the proposed model in anticipation of unplanned dilution.

CONCLUSIONS

Using RES and CMS technics for presentation a model for prediction unplanned dilution in underground stopes has been very successful. The coefficient of this prediction model that used other stopes equal to 0.95 indicates the high efficiency of the model in predicting the unplanned dilution of underground stopes.

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