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Zonation of Rock-Slope Failure Potential of Sungun Copper Mine Based on SMR and Analytic Hierarchy Process (AHP)

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Abstract

Zonation of potential of geological hazards in open pit mines gives us the opportunity to prediction and make conter measures for stablization of hazardous areas befor occurance of any incident. Sungun copper mine is located in the East Azerbaijan province, 45 km north of Varzaqan County.
In this research, in order to zonation of potentially unstable areas, slope mass rating (SMR), kinematical analysis and analytic hierarchy process (AHP) methods by using of Dips 6.0, Expert Choice and ArcGIS softwares were accomplished. In the study by using Analytical Hierarchy Process method, the effective general criterias on the failure of rock slopes and extraction benches including structural geology, geomechanics, groundwater condition of joints, morphology and degree of alteration were selected and ranked by forming a pairwise comparison matrix. Then the sub-criterias and alternatives are wheighted by using of overall row wheight method on the basis of their importance. Finally, by integration of obtained data layers in the ArcGIS system, the studied mine area was zoned in low, medium and higth category in terms of failure potentially. According to the results, the western, southern, southeast and scattered parts of the north area of the studied mine specially in mining benchs are more likely to rock slope failurs, which is in good agreement with field observations. The results showed that there is a fairly good agreement between the results of the methods used in this research. But due to the fact that in the hierarchical analysis method, other criteria involved in the failure are considered, and the result is more reliable.

***Key words**: Rock-slope Failure; SMR; AHP; ArcGIS; Sungun Copper Mine*

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Extended Abstract:

1. Introduction

Zonation of potential of geological hazards in open pit mines gives us the opportunity to prediction and make conter measures for stablization of hazardous areas befor occurance of any incident. Sungun copper mine is located in the East Azerbaijan province, 45 km north of Varzaqan County. The study of failure potential on rock-slopes and mining benches in the studied mine due to tectonization of the area and daily extraction by using of blasting method is of particular importance.

2. Methodology

In this research, in order to zonation of potentially unstable areas in the studied mine, at first, slope mass rating (SMR) was considered based on Romana (1985) equ. 1.

$$SMR = RMR_{basic} - (F1.F2.F3) + F4 \quad (1)$$

where RMR_{basic} is basic gemechanical rock mass classification after Bieniawski (1989). The coefficients of F1 depends on the difference between joints and rock face orientation and F2 relates to the slope face angle.While for slope angle less than 20 degree, the F2 value is equal to 0.15 and for slopes greater than 45 degree, this factor will be equal to one. The value of the coefficient of F3 varies between 0 to -60 depending on the failure mechanism, rock face and joints slopes. The coefficient of F4 is depending to the drilling method and varies between 8 to 15. According to SMR classification, slopes with rating more than 60 percents are stable. Based on geomechanical data obtained from drilled cores, the average of basic rock mass rating in the studied area various from less than 40 up to 80, the least and most amount of RMR_{basic} is belonging to the altered argillaceous and the sirisitic alteration zone respectivelly**.**

In order to evaluation of rock slope failure by using analytic hierarchy process (AHP), five general criteria including alteration, structural geology, geomechans, morphology, groundwater condition of joints are selected. Some of these criteria categorized in sub-criterion and alternatives.

The geological setting and alteration of Sungun copper mine rock mass can be classified in two portions of porphyric monzonite with dominant phillic alteration and dioritic and granodiorite dyks with dominant **s**irisitic alteration. The general rock face slope value in the area is in the range of 10 to 30 degree and in some places between 50 and 60 degree. In the analysis general slope for rock face and extracton benched are considered equal to 37 and 67 degrees repectivelly. For consideration of joints impacts, detailed joint study operation carried out in 10 different blocks of mining area and kinematical analysis accomplished by using of Dips 6.0 software for identifing the type and possiblity of failure in each block. The results of laboratory experiments on drill core samples indicates that the uniaxial compressive strength of rock is in the range of 100 to 250 MPa and only in the central part of the mine is slightly more than 250 MPa.

The hierarchical analysis process involves the following steps (Lee et al., 2008; Bogdanovic et al., 2012):

A) Definition of hierarchical analysis structure (including purpose, criteria, sub-criteria and alternatives)

B) Formation of pair comparison matrix and determining the intensity of importance of criteria, sub-criteria and options.
C) Calculating the weights and determine the final score
D) Calculating the Inconsistency ratio
Figure 1 shows a schematic representation of analytic hierarchy process (AHP). In this method, after definition of the criteria involved in the studied phenomena, the importance of each criterion to other criteria is determined by the formation of a pairwise matrix using special numbers depending on its intensity of importance. This number starts from 1 for the same importance criteria and ends with the absolute value of 9 (Saaty, 1980).

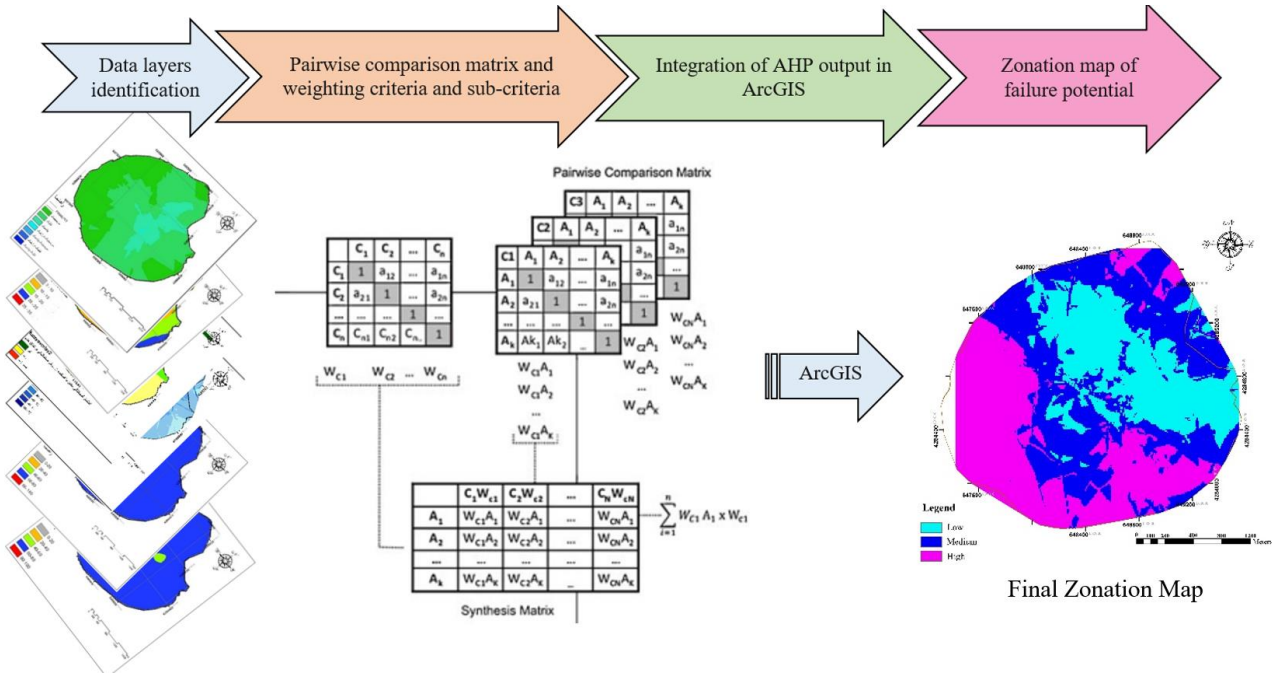

Figure 1. Shematical illustration of analytic hierarchy process (AHP)

3. Discussion

The value of the rock mass rating (SMR) in the studied area is various from less than 60 up to more than 80, which according to Romana (1989), the major part of the mine is classified as a stable rock and the only in western and south-western part of the mine the occurance of failure is possible.

The results of kinematical analysis by Dips 6.0 showed that the occurrence of plane and wedge failure in the western and wedging and and toppling failure in southern part of the mine is possible. In the north and other parts, the toppling failure is probable. The zonation of mine area based on this analysis classified into five different sections based on the probability of occurrence of each type of failure and considered in AHP analysis.
In order to zonation by AHP, at first the criteria were selected and then, using the paired comparison matrix, the intensity of importance of each criteria, sub-criteria and aletrnatives weighted by using expert choice software and classified as layers of information in ArcGIS techniques. Ultimately, the integration of the obtained data layers has resulted in a zoning map for the entire study area into three classified zone based on failure potential (low, medium and high).

4. Conclusion

According to the results, the western, southern, southeast and scattered parts of the north area of the studied mine specially in mining benchs are more likely to rock slope failurs, which is in good agreement with field observations. The results showed that there is a fairly good agreement between the results of the methods used in this research. But due to the fact that in the hierarchical analysis method, other criteria involved in the failure are considered, and the result is more reliable.

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