Analysis of Collapse Load and Open Hole Evaluation Based on Rock Mass Ratting (RMR) Method in Underground Mining

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Abstract. The excavation of a underground rock mass resulting a change in the balance of rock conditions such as the occurrence of rock collapse and changes in the dimensions of tunnel as a result of the displacement of the voltage distribution. It is desirable to have a good geotechnical analysis to provide an appropriate treatment of rocks excavated. This research was conducted to determine rock mass class, rock strength. Classification of rocks mass with RMR system And Q-System FK potential of wedge using unwedge software. From the measurement of several parameters of RMR method, RMR value of 48 (Coal) and 60 (Sillstone) is obtained where as rock mass class III (fair rock), based on the Q-System obtained a value of 14 in class II for coal and 4 Class III for Sillstone. Based on the RMR-system classification, the value for span maximum is 3 m with a collapse time of 110 hours and the value of the load collapses is 1,56 tons / m2. Based on the Undwedge Software processing, there was an increase in FK values for both methods, Based on Support RMR Ground from 1,907 to 2,939 and Based on Ground Support Q-System from 1,907 to 2,078.

Introduction

Mineral and coal sediment mining methods are broadly divided into two methods, namely open pit mining methods and underground mining methods. The coal mine in Sawahlunto is carried out by open pit and underground mining. underground mining as found in the CV. Bara Mitra Kencana. Bara Mitra Kencana is in the Eocene-aged Sawahlunto formation in the Ombilin basin consisting of cover soil of carbonan flakes, siltstone, sandstones, conglomerate inserts and coal. In the research location rocks that are found are siltstone (siltstone) and coal. Whereas for the support that is applied by the company that is using wood support and concrete support in the canopy. The potential for instability that occurs in rocks around the underground pit opening requires special handling, especially buffer design to guarantee. Therefore, it is necessary to observe the conditions of the opening holes and various laboratory tests on rock mass samples as compilers of the opening holes. This analysis can be used to determine the rock mass class and the groundsupport type that will be used to strengthen the rock so it does not collapse.

Literature Review

1.1. Rock Mass Rating System

In classifying rock mass based on the RMR classification system, Bieniawski uses six main parameters which are summed to obtain the total RMR value.
1.1.1. Compressive Strength (UCS) and Point Load Test (PLI). Compressed rock compressive strength can be obtained from uniaxial compressive strength test, Uniaxial Compressive Strength (UCS) and point load test, Point Load Test (PLI).

1.1.2. Rock Quality Design (RQD). In 1967 D. U. Deere introduced Rock Quality Design (RQD) as a guide to quantifying the quality of rock masses quantitatively. RQD is defined as the percentage of the intact core with a length of more than 100 mm against the core run depth [3]. Whereas Priest and Hudson (1976) provide a relationship between the value of RQD and the distance between discontinuous fields in the rock mass or joint spacing (Js).

1.1.3. Discontinuities. Discontinuity field spacing is defined as the perpendicular distance between two consecutive discontinuities along a measurement line made arbitrarily.

1.1.4. Discontinuous Conditions. There are several parameters used by Beniawski in estimating the surface conditions of discontinuous fields, namely: persistence, fracture (roughness) of surface discontinuity (roughness), filling material (infilling), weathering (weathering).

1.1.5. Groundwater Conditions. Groundwater conditions are determined by observing the roof and walls of the tunnel visually. Then the ground water conditions found can be expressed as general conditions such as dry, damp, wet, there are water droplets, or there is a flow of water.

1.1.6. Discontinuous Orientation. Subsequent RMR correction was performed based on the direction of excavation of the tunnel and the orientation of the discontinuous fields at that location. Discontinuous orientation is considered advantageous if it is directed perpendicular to the axis of the tunnel and will be detrimental if it is in line with the axis of the tunnel. General directions are usually stated in strike / dip or dip / dip direction. Both of these values are obtained by measurement using a geological compass [5].

1.2. Stand Up Time
Tunnel stability analysis criteria can be stated in the form of a graph of the relationship between the RMR to the roof span to find out the stand-up time value and determine the stability condition of the tunnel. The stand-up time parameters in rock mechanics and tunnel design influence decisions in selecting rock reinforcement methods, and the time to install rock support. Stand up time is not a function of rock weighting and can be determined by plotting the value of the RMR and the span on the graphical interpolation stand up time geomechanics of the graph.

Based on the results of the RMR system geomechanical classification, the collapse height (Ht) and collapse load (Prmr) to be received by the buffer can be determined by the following formula [6]:

\[ Ht = \frac{(100 - RMR)}{100} \times B \]  
\[ P_{RMR} = \frac{(100 - RMR)}{100} \times \gamma \times B \]

1.3. Stability Analysis of Openings
Stability hole analysis is done to get the safety factor (FK) value from the opening hole. In the FK underground mine is determined by calculating the ratio between the strength of the load to hold from a reinforcement to the load of rock that it is supporting. Analytical methods are one of the approaches to the stability of openings or tunnels using computer programs as tools or tools to facilitate data processing. In this study the computer programs used were Dips and Unwedge.

2.3.1. Dips Program. Dips program is widely used to help identify the direction of the joints or joints, of all existing joint joints. This data joint will be grouped into family based on the similarity of the direction of the emphasis [7]
2.3.2. Unwedge Analysis. The shape and size of the wedge in the mass of the rock and around its opening depends on the size, shape and orientation of the opening (azimuth tunnel) and on the significant joint set orientation. The three-dimensional geometry of wedge modeling problems requires efficient calculation by utilizing a computer program that is already available. One example of such a computer program is that UNWEDGE was developed specifically for use in underground mining. Taking into account the rock mass where there are several sets of discontinuous fields (joint sets) will produce the possibility of a combination of joint sets that have the potential to form a wedge. Data needed is dip and dip direction from each joint set that has been measured.

2.3.3. Recommendations for rock support systems. Recommendations for rock support systems / reinforcement can determine how long the tunnel is safe without supporting the self-supporting time. In addition, Bieniewski also determines the type, diameter, and length of the rock bolt (ironbolt), iron network (steel set), shotcrete, and cast (concrete) concrete as described in Table 3 [8]

Data Analysis Technique
In conducting this research, it combines theory and reality found in the field. From these two things, an approach can be drawn towards solving problems that arise.

3.1. Types of Research
Based on the type of data that will be obtained, this research is classified into quantitative research. Quantitative research method is one type of research whose specifications are systematic, planned, and structured clearly from the beginning to the making of the research design [9].

3.2. Data Collection Techniques
The method of data collection techniques used in this study is the observation method, namely the method of data collection carried out by systematically observing and recording the symptoms under investigation [10]. Observation is carried out according to certain procedures and rules so that it can be repeated by research and observation results provide the possibility to be interpreted scientifically

- Data Processing
- Data Analysis
- Conclusion

Research Result

4.1. Test of Physical and Mechanical Properties of Rocks

| No | Parameter                          | Silstone | Coal  |
|----|------------------------------------|----------|-------|
| 1  | Natural density (gr/cm³)           | 1.98     | 1.1   |
| 2  | Dry density (gr/cm³)               | 2.03     | 1.19  |
| 3  | Saturated Density (gr/cm³)         | 2.48     | 1.01  |
| 4  | Apparent Specific density          | 1.82     | 1.01  |
| 5  | True Specific gravity              | 2.3      | 1.18  |
| 6  | Natural water content (%)          | 9.4      | 18    |
| 7  | Saturated water content (%)        | 10.8     | 22    |
| 8  | Degree of saturation (%)           | 86.3     | 94.03 |
| 9  | Porosity (%)                       | 19.6     | 16.13 |
| 10 | Void ratio                         | 0.5      | 0.51  |
4.2. RMR-System

4.2.1. Parameters of Roofing System RMR Classification Sillstone

| Parameters of Roofing System RMR Classification Sillstone | Condition | Value |
|-----------------------------------------------------------|-----------|-------|
| Rock Quality Design (RQD)                                | 90.97 %   | 20    |
| Spacing of Discontinuities                               | (0.15 m)  | 8     |
| Persistence                                              | (< 1 m)   | 6     |
| Aperture                                                 | (0.1-1 mm)| 4     |
| Roughness                                                 | slighty rough | 3   |
| Infilling                                                 | <5mm      | 4     |
| Weathering                                               | Highly Weathered | 1 |
| Groundwater                                              | Dry       | 15    |
| Strike and dips of Joint set                             | unfavorable| -10  |

| Total Rating | 60 |
|--------------|----|
| Mass Class Of Rock | Rock Class III |

4.2.2. Parameters of Roofing System RMR Classification Sillstone

| Parameters of Roofing System RMR Classification Sillstone | Condition | Value |
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| Spacing of Discontinuities                               | (0.15 m)  | 8     |
| Persistence                                              | (< 1 m)   | 6     |
| Aperture                                                 | (0.1-1 mm)| 4     |
| Roughness                                                 | slighty rough | 3   |
| Infilling                                                 | none      | 6     |
| Weathering                                               | Highly Weathered | 1  |
| Groundwater                                              | Drop by drop | -10 |
| Strike and dips of Joint set                             | unfavorable| -10  |

| Total Rating | 48 |
|--------------|----|
| Mass Class Of Rock | Rock Class III |

Based on the weighting according to the Bieniawski parameter it was concluded that for coal in BMK 34 it belongs to class III rocks with a total weight of 48. Value 48 is located in range 41-60 which are included in medium-class rocks. While the measured siltstone belongs to class II rocks with a weight of 60. Value 60 is located in the range 41-60 which is included in the medium grade rock.
Prediction of Load Collapse Using Undwedge Software

Figure 1. Wedge result from undwege processing

Table 4. Undwedge Result

| Location         | Safety Factor | Volume     | Weight       |
|------------------|---------------|------------|--------------|
| Upper Right wedge| 2.442         | 441.192 m³| 926.504 tonnes|
| Lower Left wedge | Stable        | 237.746 m³| 499.267 tonnes|

The wedge formed at the Research site has the lowest safety factor of 2.442 on the right wall and is stable so it does not need to be given more reinforcement because it is in a safe condition where the value of safety of factors is greater than 1.

Value of Span Maximum and Stand Up Time

Figure 2. Value of Span Maximum and Stand Up Time

Based on the value of the relationship between the stand up time and span maximum in Table 46, the maximum span value of the study location is 3 meters with a collapse time of 170 hours, this value is taken from the width of the predetermined opening hole is 3 meters.

5. Conclusion

Based on the system RMR method, the rock mass at the study location is in class III (fair rock) with a coal RMR value of 48, and Silstone with a value of 60. Based on Q-System, the value is 14 in class II for coal and 4 Class III.
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