Original Research Article

Slope stability analysis of open-pit mining

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Abstract: This paper aims to explore the influence factors of open-pit mining slope stability, and put forward the corresponding analysis methods and measures to improve the stability. Through the comprehensive analysis of geological conditions, slope structure characteristics, mining activities and environmental factors, the limit equilibrium method and finite element method are used to quantitatively evaluate the slope stability, and the actual case is analyzed. Finally, a series of measures to improve the stability of the slope are put forward in order to provide reference for the safe mining of open-pit mines.

Keywords: Open-pit mining; Slope stability; Analysis method; Safety measures

1. Introduction

As an efficient way to obtain mineral resources, the slope stability of open-pit mining is directly related to the production safety and economic benefits of the mine. Slope instability may lead to serious casualties and property losses. Therefore, it is particularly important to analyze and evaluate its stability. This paper first analyzes the main factors affecting the stability of the slope, then introduces several commonly used slope stability analysis methods, and takes an open-pit coal mine as an example for case analysis, and finally puts forward measures to improve the stability of the slope.

2. Influencing factors of slope stability

2.1. Geological condition

Geological conditions are the basic factors affecting slope stability. The type, strength, fracture development degree, bedding and joint distribution of the rock will have an impact on the slope stability. For example, the existence of weak rock strata will reduce the overall stability of the slope.

2.2. Slope structure characteristics

The height, slope, shape of the slope, the bedding of the rock and soil, the inclination and inclination of the joints and other structural features have a direct impact on the stability of the slope. The higher the slope and the steeper the slope, the worse the stability.

2.3. Mining activities

The blasting, excavation, loading and other activities in the mining process will change the stress state and groundwater conditions of the slope, thus affecting the stability of the slope. Unreasonable mining sequence and method may lead to slope instability.

2.4. Environmental factor

Natural environmental factors such as rainfall, earthquake and temperature change will also affect the stability of the slope. For example, long-term rainfall may lead to saturation of slope soil and increase the risk of

instability.

3. Slope stability analysis

3.1. Qualitative analysis

Through geological survey and field observation, the stability of the slope is preliminarily judged. Qualitative analysis can quickly identify the potential problems of the slope and provide direction for further quantitative analysis.

3.2. Quantitative analysis

3.2.1. Limit equilibrium method

The limit equilibrium method is an analysis method based on the limit equilibrium condition. The stability of the slope is evaluated by establishing the slip surface and calculating the safety factor. This method is suitable for simple shape slopes, such as circular slip surface and linear slip surface.

3.2.2. Finite element method

The finite element method is a numerical analysis method. By establishing a numerical model of the slope, the stress and deformation of the slope under different working conditions are simulated to evaluate its stability. This method is suitable for slopes with complex shapes and complex geological conditions.

3.3. Monitoring technique

Using modern monitoring techniques, such as GPS, tiltmeter, stress meter, etc., real-time monitoring of slope displacement and stress changes, to provide data support for stability analysis.

4. Case analysis

Taking an open-pit coal mine as an example, the analysis process of slope stability is introduced in detail. Firstly, through geological survey and field observation, the geological conditions and structural characteristics of the slope are determined. Then, the limit equilibrium method and the finite element method are used to quantitatively analyze the slope stability. Finally, combined with the monitoring data, the stability of the slope is evaluated, and the corresponding safety measures are put forward.

4.1. Analysis of geological conditions

The open-pit coal mine is located in a certain place in North China. The geological conditions are complex. The main rock strata are sandstone and mudstone, and there are multiple sets of cracks and joints. Through drilling sampling and geological exploration, the physical and mechanical properties of rock strata are determined.

4.2. Analysis of slope structure characteristics

The height of the slope is 60 meters, the slope is 45 degrees, and the shape is irregular trapezoid. Through field measurement and UAV aerial photography, the specific shape and size of the slope are determined.

4.3. Quantitative analysis

Using the limit equilibrium method, a circular slip surface model is established, and the safety factor of the slope is calculated to be 1.2, which is in a critical stable state. The finite element method is used to simulate the stress and deformation of the slope under different working conditions. It is found that the stability of the slope is

reduced under rainfall and blasting conditions.

4.4. Monitoring data analysis

By installing GPS monitoring equipment, the displacement of the slope is monitored in real time. The monitoring data show that the slope has a large displacement during the rainfall, and the maximum displacement reaches 5 cm.

5. Measures to improve slope stability

5.1. Optimized mining plan

Reasonable design of mining scheme to reduce the adverse effects on slope stability. For example, step-by-step mining is used to reduce the height of the slope and reduce the disturbance of blasting to the slope.

5.2. Slope reinforcement

The stability of the slope is improved by means of anchoring, shotcrete, geogrid and other engineering techniques. These measures can increase the shear strength of the slope and reduce the possibility of slip.

5.3. Drainage system

Establish an effective drainage system to reduce the impact of groundwater on slope stability. For example, set up drainage ditches, blind ditches, etc., in a timely manner to eliminate the slope of the water.

5.4. Monitoring and early warning system

Establish a slope monitoring and early warning system to detect slope stability problems in a timely manner and take preventive measures. The monitoring system can include displacement monitoring, stress monitoring and crack monitoring.

6. Conclusion

Slope stability analysis and control of open-pit mining is an important part of mine safety production and environmental protection. Through the scientific analysis and effective control of the stability of the open-pit mining slope, it can effectively improve the safety production level of the mine, protect the environment and realize the sustainable development of the mine.

The analysis and control of slope stability in open-pit mining is a complex system engineering. It is necessary to comprehensively consider various factors such as geological conditions, mining methods, mining depth, slope shape and size, and adopt a combination of preventive control and governance control to achieve slope stability.

In practical application, it is necessary to formulate a scientific and reasonable mining plan and slope stability control measures according to the specific mine conditions to ensure the safe production and environmental protection of the mine.

In general, the slope stability analysis and control of open-pit mining is an important task for mine safety production and environmental protection. It requires the joint efforts of mining enterprises, scientific research institutions and government departments to continuously improve the theoretical level and technical level of slope stability analysis and control of open-pit mining, and provide scientific basis and technical support for mine safety production and environmental protection.

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