

A Study of the Instability Failure Mechanism and Treatment Technology of High Slope of Broken Rock Mass

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Abstract: With the development of highway construction in China, the Guizhou region has ushered in a new wave of road construction, which has brought great convenience to people's travel. At the same time, due to the instability of the high slope of the broken rock mass, a series of disasters have caused great troubles for people's travel safety. The formation of the slope changes the original stress state inside the rock mass, the stress of the slope body is redistributed, the direction of the principal stress changes, and stress concentration occurs. Moreover, under the influence of various natural forces and engineering, the stress state changes continuously with the evolution of the slope, causing different forms of deformation and destruction of the slope rock mass. Unstable natural slopes and artificial slopes, under the influence of rock and soil weight, water and vibration, and other factors, often cause harmful deformation and destruction, resulting in traffic disruption and causing huge disasters. On the basis of summarizing the previous research results, this paper mainly studies the stability analysis of the high slope of the fractured rock mass and the research of engineering protection and reinforcement technology, and proposes a targeted slope treatment plan.

Keywords: High Slope of Fractured Rock Mass; Stability Analysis; Numerical Analysis; Slope Treatment

Introduction

A slope is a geological body with a laterally facing surface, including a general term for slopes, slope tops, and lower slopes with a certain height. The high slope of the fractured rock mass refers to the temporary surface with a certain slope formed by natural gravity or artificial action in the loess area. The fractured rock high-steep slope rock mass is a geological body with certain mineral composition and structure formed after being subjected to multiple geological processes and undergoing deformation and destruction and occurring in a certain geological environment. The deformation and failure of the high slope of the fractured rock mass is a complex, irreversible and dynamic dissipation process. The factors affecting the stability of the high slope of the fractured rock mass include topography and geological structure. At the same time, the stress redistribution during the formation of the high slope of the fractured rock mass causes the dynamic tensile stress zone and the shear stress concentration zone to appear in the slope. When the value is greater than or equal to the mechanical index of the rock mass, it will lead to the destruction of the local rock mass structure, which will become the cause of the instability or criticality of the rocky high steep slope. The remote automatic monitoring system is used to monitor the stability of the loess high slope after support. Through the analysis of various monitoring data, the stability status of the slope after support and the trend of geological disasters can be obtained. The analysis results show that the slope structure after support is stable, and the support structure has a good reinforcement effect to meet the stability requirements of the structure. The monitoring results on site can guide the slope with similar geological conditions.

I. Characteristics of Fractured Rock's High and Steep Slope

In the analysis of tall rock slopes, the geological factors such as various discontinuities in the

rock mass should be measured in detail, that is, the geological features such as rock mass categories and rock mass structures of the engineering slope should be known in detail. The rock mass is an integral part of the geological body and is composed of rock and geological structure. There are many types of rocks. According to their genesis, there are sedimentary rocks, magmatic rocks and metamorphic rocks according to their strength. There are soft rock, medium hard rock and hard rock. During the formation of the slope, the original stress state inside the slope changes and causes stress redistribution and stress concentration. In order to adapt to the new stress state, the slope body also undergoes deformation and destruction of different forms and scales. Stress distribution after high steep rock slopes are formed. Due to the redistribution of stress in the slope body, the main stress trace around the slope is obviously deflected, which is close to the air surface. The closer the maximum principal stress is to the parallel free surface, the smallest principal stress is nearly orthogonal to the immediate surface. As the slope height increases, the distribution range of the maximum principal compressive stress from the vertical direction increases, and the deviatoric stress in the slope decreases. The maximum principal stress near the foot of the slope is equivalent to the tangential stress of the air surface, and the closer the surface is, the higher the minimum principal stress is equivalent to the significant reduction of the radial stress, which decreases to zero at the surface and even to the tensile stress. Therefore, this zone is the highest stress or maximum shear stress in the slope, forming a maximum shear stress increase zone. It is usually the part of the slope that is most prone to deformation and damage, and thus the pressure-induced fracture surface parallel to the slope or the bottom surface of the slope is often produced. The slopes formed during construction are also collectively referred to as slopes, as shown in Figure 1.



Figure 1 Diagram of Roadside Slope

The slope is divided into a natural slope and an artificial slope. Due to the dry climate and lack of vegetation protection, summer is the season of concentrated rainfall, which is prone to large-scale continuous rainfall and weaken the slope. Under the influence of natural factors or human factors on the slope, the slope will slip and become unstable. As one of the most common countries in the world for geological disasters, the geological problems of slopes are extremely serious, including landslides and collapses.

II. Slope Instability Mechanism and Numerical Analysis

The outstanding advantage of the finite element method is that it is suitable for dealing with nonlinear, heterogeneous and complex boundaries. However, the analysis of soil stress and deformation is just such a difficult problem. The application of the finite element method can solve these problems better and open up a new way in the analysis of slope stability analysis. The

finite element method is to analyze the stress and strain of the soil by using the discretized structure composed of a finite number of unit bodies instead of the original continuum structure. These unit bodies are only strongly connected at the joints. The general material stress-strain relationship or constitutive relationship can be expressed as:

$$\{\sigma\} = [D]\{\varepsilon\} \quad (1)$$

The relationship between the joint force of the unit body and the displacement of the joint can be established by the principle of virtual displacement, and then the overall equilibrium equation is written.

$$[K]\{\delta\} = \{R\} \quad (2)$$

Using the finite element method, the nonlinear stress-strain relationship of the soil can be considered. After the stress and deformation of each calculation unit are obtained, the position of the damage zone and the expansion of the damage range can be determined according to different strength indexes. If you try to link the local damage with the overall damage, find the appropriate critical slip surface position, and then push the safety factor according to the balance of forces. In this way, stability issues can be combined with stress analysis. Or determine the stress distribution inside the slope under various working conditions, and determine the damage standard by the nature of the slope soil to measure the safety degree of the slope.

The landslide body is a steep slope formed by artificial excavation. The composition materials are artificially filled soil, silty clay, cloud limestone fragments and strongly weathered carbonaceous shale. The upper silty clay is plastic-soft plastic, with high compressibility and micro-permeable water. It is easy to soften when exposed to water and has poor stability. The strong weathering layer has joint fissure development, strong water permeability and easy muddy. Weathered carbonaceous shale mud is a water-permeable layer, which is a micro-permeable layer, which provides a rich material source and favorable topographic conditions for the formation of landslides.

The indoor test results of 13 soil samples taken from the upper soil layer of the landslide body were counted, and the standard values were determined to be cohesive force $c=19$ kPa and internal friction angle $\varphi=11.83^\circ$. According to the results of geotechnical tests, the natural gravity average of the upper fragmented rocky soil is 18.2kN/m^3 , and the natural gravity of the strongly weathered carbonaceous shale is 21.0kN/m^3 . Taking into account the geological conditions of the landslide area, the upper silty clay containing more broken stones and the characteristics of the highly weathered carbonaceous shale, the natural weight of the upper sliding body is determined to be 19.8kN/m^3 and the saturation weight is 20.50kN/m^3 . The finite difference method is used to analyze the numerical model of fractured rock slope. The relationship between collapse and slope is shown in Figure 2.

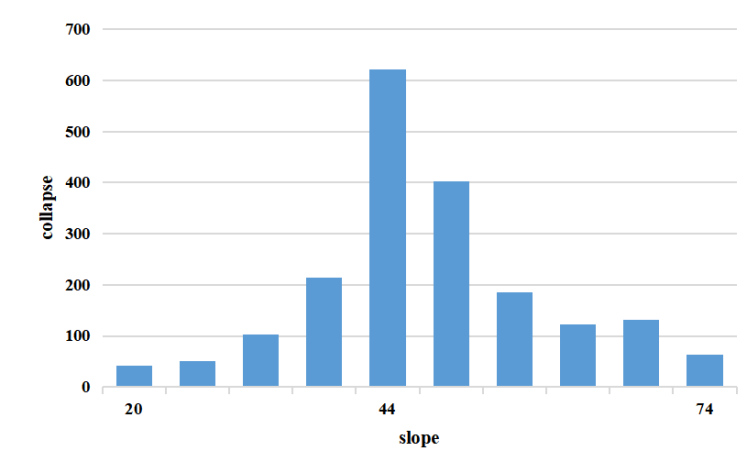


Figure 2 Relationship between Fractured Rock Mass Collapse and Slope

According to the calculation results of landslide topography and landslide thrust, it is considered to use anchor cable anti-slide pile plus retaining wall or lattice anchoring for support. Anchor cable anti-slide pile is the joint work of anchor cable and pile. Its advantage is to change the cantilever force condition of the pile and the mechanism that the pile completely relies on the lateral foundation reaction force to resist the landslide thrust, so that the stress state of the pile body and the pile top is greatly improved. Therefore, it is a reasonable and economical active anti-sliding structure, which is extremely beneficial for controlling landslide deformation.

III. Slope Treatment Effect Monitoring

Construction safety monitoring is to monitor the displacement, stress and groundwater of the slope during the construction period. The monitoring results are an important basis for guiding construction and feedback design, and are an important part of implementing information construction. The construction safety monitoring will monitor the slope body in real time to understand the impact of the engineering disturbance and other factors on the slope body, timely guide the project implementation, adjust the project deployment, and arrange the construction progress. When carrying out the construction safety monitoring side, the measuring points are arranged in the area where the slope stability is poor, or the engineering disturbance is large, and strive to form a complete section, which is mutually verified and supplemented by various means.

The monitoring time of the slope treatment effect is generally required to be no less than one year. The data collection time interval is generally one day. When the external disturbance is large, such as during heavy rain, the number of observations can be encrypted. Long-term monitoring of the slope will be carried out after the completion of the prevention and control project, and the slope body will be dynamically tracked to understand the characteristics of the stability of the slope. Long-term monitoring is mainly carried out for the important slope prevention and control project. Long-term monitoring of slopes is generally carried out along the main section of the slope. The arrangement of monitoring points is less than the construction safety monitoring and prevention effect monitoring. The monitoring content mainly includes the deep displacement monitoring of the sliding belt, the groundwater level monitoring and the ground deformation monitoring.

Conclusion

From the point of view of geotechnical mechanics, the slope treatment is to exert an external

force on the slope rock and soil body through a certain structure or to improve the original slope environment by a certain structure, and finally reach a certain mechanical equilibrium state. However, due to the complexity of geotechnical dynamics inside the slope, it is impossible to completely consider the real mechanical effects inside the slope from geological exploration to treatment design. Most of the design is carried out on a large degree of simplified calculation. The ecological protection technology of highway slope and the analysis of plant slope stability have been applied in developed countries for a long time. At present, most engineering builders still use relatively mature engineering protection, and ecological protection technology is still in the exploration and application stage. This paper discusses the application of ecological protection technology in detail with the structural characteristics of the high-slope of the broken rock mass of the expressway, which has a good guiding significance for improving the application of highway slope protection technology in China.

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