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The Analysis of Rock Slope Rock Mass Structure Research Methods

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Abstract: Firstly, the characteristics of rock slope are discussed,then to describe the rock slope rock mass structure research methods from three aspects. The first aspect, the research methods of strength and deformation characteristics of rock slope are discussed from the point of view of field test and laboratory test; the second aspect is the introduction of the research on the engineering properties of rock mass structure surface; the third aspect is the discussion of the rock slope stability analysis methods and ideas , for example, rock mass structure control theory, the red flat polar projection and solid proportion projection, block theory, the key block, the theory of the dominant surface of rock slope, etc.

Keywords: Rock slope; Rock mass structure; Research method

1. Introduction

Before the introduction of the rock slope, the concept of soil slope is introduced first to highlight the characteristics of the rock slope. Soil slope, generally has the characteristics of homogeneous and isotropic, there is no obvious structure, the soil itself cohesion, slope and water are the key factors affecting its stability. Rock slope is different. Rock slope contains a lot of cracks, faults and other structural surfaces, there are structurals. On the one hand, the stability of rock slope is related to the lithology itself, on the other hand, it is affected by the structure of rock mass, the rock mass structure includes two parts of the structural plane and the structural body[1-2].

2. Research Methods of Rock Mass Strength and Deformation Characteristics of Rock Slope

The test of rock slope rock mass strength and deformation characteristics occupies a very important position in the stability analysis of the slope rock mass. Rock slope, under normal circumstances, must be carried out in the following three kinds of tests: one is the strength and deformation characteristics of the main rock mass which are formed in the direction of the possible failure of the slope; the second is the strength characteristic of the weak structural plane, which may be the main component of the sliding surface; the third kind is the strength and deformation characteristics of broken rock mass which can produce large compressive deformation under the action of external force[2].

The above experimental researches can be divided into field test and laboratory test[2]:

2.1. Field tests

1) Experimental study on shear strength of rock mass

Basic content: The load at the start of the test is graded by applying normal stress to a predetermined value, and the stress on the predetermined shear plane is σ .In the vertical direction of the deformation to achieve stability, then push the thrust force T in a hierarchical manner. The application method of thrust should ensure that the relation curve between shear stress τ and shear displacement δ as far as possible. Bymeasuring δ_u ,the relative displacement of the upper and lower rocks in the shear plane, and δ_a ,the absolute shear displacement of bedrock under shear plane displacement, the characteristic points of different stages of the curve of τ-δ are determined by comparing with different directions and displacement curves. At the end of the experiment, the actual shear section shall be surveyed and described, then to determine the actual cutting area and shear surface fluctuation etc. in order to calculate and evaluate the test results more accurately when finishing the test data. Finishing of test results,In addition to finishing the curve of τ-δ ,includes determination of the relation curve between shear stress τ and normal stress σ in shear strength equation $\tau = \sigma \cdot tg\varphi + c$.

2) Experimental study on mechanical characteristics of rock mass structural plane

Basic content: Take the structural plane with high dip angle as an example. During the test, the vertical stress and horizontal stress are applied to the initial stress σ_2 , then to maintain the horizontal stress σ_2 , and then the vertical stress, σ_1 , is applied to in a hierarchical manner until the failure of the specimen. When applying a predetermined initial stress σ_2 , the vertical stress must be synchronized with the horizontal stress, and the whole

process of the relationship between stress and displacement can be mapped. Lastly, the shear strength of a certain set of tests corresponding to the different stages of the stress displacement curve, can be obtained from Moore circles with the coordinate axes of τ and σ .

3) Experimental study on long term strength of rock mass structural plane

Basic content: The long-term strength studied here refers to the strength of the project during the period of the project, which is at most the time range of decades to hundreds of years.Standard test method for determination of long term strength of rock mass structural planes, includes preparation of a group test body (6 - 5 blocks), its shear area of 3000- 10000 square centimeters. The content of the test is basically the same as the shear strength test of rock mass structural plane, and the difference lies in the rheological test to use a special voltage stabilizing device in order to remain the applied stress unchanged within the prescribed time of observation. The relation curves between shear displacement and time are obtainedby recording the change of shear displacement every time interval Δt in the experiment .In the stress-strain curve of the graded shear stress tests, it becomes a linear relationship when the shear stress is relatively small.But it is upward when the specimen is close to failure, and at this time, τ_o can be considered to be corresponding to the long-term shear strength of the shear plane of the positive stress σ_o .

4) Experimental study on deformation characteristics of rock mass

Basic content: Under certain conditions, the test body can be regarded as a semi infinite elastic body, which can be approximately regarded as homogeneous anisotropic or orthotropic. In the study on the stability of slope rock mass, the half plane or plane loading icon is generally used with static method in the hole , and at this time, the wall or bottom of the cavern chamber is regarded as the surface of a semi infinite body. When the surface of the linear size is about three times more than the size of the corresponding linear of loading area, it is considered that the boundary requirement of the elastic theory formula for calculating the deformation constant is satisfied. According to the specific boundary conditions, the formula is used to calculate the modulus of deformation[2].The chamber water pressure and borehole deformation method can be used to study the deformation characteristics of the rock mass. The two methods are the same. In the case of applying the radial load, the corresponding radial displacement is measured, and then the deformation modulus of rock mass is obtained.

5) Field experimental study on strength and deformation characteristics of rock mass under three directions stress state

Basic content: There is at the foot of the slope rock mass in the area of stress concentration, then the stress state is often three dimensional stress state. Therefore, it is very necessary to carry out the experimental research on the three stress state in the study of slope rock mass stability. Loading equipment capability is often limited due to the test of large size specimens of hard rock mass. Therefore, the field large-scale three axis compression tests are carried out in a relatively easily deformed fault zone or weak rock mass. Under the field conditions, the general can only be carried out under the three axis compression test ($\sigma_1 \neq \sigma_2 = \sigma_3$). The loading method begins with applying stress in all directions to a predetermined stress($\sigma_2 = \sigma_3$) in a synchronous hierarchical manner, and remains $\sigma_2 = \sigma_3$ unchanged, and then hierarchically to apply σ_1 to the test body until its damage. The anisotropic micrometer readings should be read after each level of applied stress. The stress-strain curves are sorted out, and then each stage of the whole process of stress - strain can be judged. The stress-strain relationship curve before the yield limit is approximately regarded as a linear relationship. Hooke's law can be used to calculate the deformation parameters(ε_1 , ε_2 , ε_3), then the shear modulus(G) and bulk modulus (K) of the three axial compression are calculated by the formula, and the deformation modulus (D) and Poisson ratio(μ) are calculated to describe the stress-strain properties of isotropic elastic bodies. The strength of the three axis compression test conditions can be determined by the generalized form of Coulomb's law and the corresponding Moore envelope.

2.2. Laboratory tests

1) General three axes test

Basic content: There will be a set of impervious specimen, installed in the pressure chamber gradually applied pressure to a predetermined initial stress state. Uniform compression of the three directions of the specimen, then gradually apply the vertical pressure. At the same time, the corresponding longitudinal and transverse deformations of the specimen are measured at every several loads until the specimen is broken. The stress state of specimen failure is $\sigma_1 > \sigma_2 = \sigma_3$ .With different initial stress state applied, the different ultimate strength under lateral pressure can be obtained. Measured moire envelope and envelope equation of rock and stress-strain curve of rock can be obtained by calculating and arranging the measured data of three - axis shear test, and then to analyse failure mode of specimen.

2) Three directions three axes test

Basic content: General three axes design is based on the theory of Moore. The theory considers that the effect of the second principal stress (σ_2) on the strength can be neglected in the three direction stress state.According to

this view, it does not matter with $\sigma_2 = \sigma_1$, $\sigma_2 = \sigma_3$. However, the relevant researches show that even for small samples with good uniformity, the load is not the same, its strength is not the same. This shows that the failure strength is affected by the second principal stress. There are two ways to apply pressure in three directions. The first is that the sample is a cube,with solid loading piston in three directions. The second is that the sample is a rectangular body, and the two direction is pressed by the solid piston, and the other direction is pressed by the liquid.

3) Study on the time factor of rock mass slope – indoor rheological test

Basic content: Experimental analysis of rock rheology is an attempt to understand the rheological properties of rock mass from the macroscopic aspect, as the scope of the rock mass to study the mechanical properties of the medium. It is necessary to strengthen the research indoor because the field tests are always carried out in a very limited time and a small number of subjects. Indoor test can strictly control the experimental conditions and eliminate the secondary factors. The test involves rock torsion rheometer. The test shows that the rock block and other rheological bodies are subject to the general rheological law[2]. Although the physical properties and structure of the rock mass make the form and parameters of the equation in great differences, the strain of rock mass is changed with time under a certain stress. Relevant tests show that in addition to the instantaneous strain, the later parts can be divided into three stages: transient rheology, constant velocity rheology, accelerated rheology, and finally reach the damage[2]. This type is not unique. Due to the different stress states and different lithology, there will be other types.

3. Research Ideas on Engineering Properties of Rock Mass Structural Plane

Shigui Du thinks that the engineering properties of rock mass structural plane can be classified by the engineering classification of rock mass structure[3]. And then this is divided into two aspects: the geometrical description of the structural plane and the mechanical effect of the structural plane. The geometric description of the structural plane includes the spatial orientation effect of the structural plane and the effect of the rock mass integrity of the structural plane. Based on the above analysis, the engineering properties of rock mass structural plane are studied at last.

4. Method and Thought of Stability Analysis of Slope Rock Mass

1) Control theory of rock mass structure

Guangzhong Sun puts forward the theory of rock mass structure control[4-5]. And it is considered that there are two levels in the control theory of rock mass structure. The first level is the control of rock mass structure, which includes three aspects, namely, the deformation mechanism of rock mass, the mechanism of rock mass failure, and the mechanical properties of rock mass. The second level is the application, including four aspects, that is, guiding the rock mechanics test, guiding the rock mass mechanics analysis, guiding the transformation of the rock mass, guiding the design of the rock mass engineering.

2) Red flat polar projection and solid proportional projection

Yuke Sun etc. applied the red flat projection method and the solid proportion projection method to the slope engineering[6-7].On the one hand, the red flat projection exhibits the angular distance and spatial geometric elements with the method of using two dimensional plan, and does not show their absolute size. On the other hand, the entity proportion projection is based on the red flat projection. The structure of the point, line length, the size proportionally are displayed on the two-dimensional plane by vertical projection ,according to the actual size of the structure surface exposed to a certain location of the rock mass. By using the combined application of the red flat projection and the solid proportion projection, the analysis of the slope rock mass structure and the stability of the rock mass can be easily analyzed. Mainly in order to make clear the combination of the situation of the slope rock mass structure stability, that is, the structure of the form, analyse slope rock mass structure by using red flat projection and solid proportion projection. In particular, the form, size, position and distribution of unstable structures should be clearly defined, which is the basis of the stability analysis of rockmass.

3) Block theory of key block

Genhua Shi puts forward the key block theory[8-10],and block theory can effectively analyze the stability of rock mass under structural plane cutting. Block theory is used to analyze the block cut by the production of various structural surface and the morphological characteristics of the block, the pattern of instability and so on. Analyse the mechanical of block stability according to the limit equilibrium analysis, solving block stability coefficient, searching and identifying key blocks. The key blocks have different geometric shapes and forms of motion, which can reflect the damage and influence on the stability of the slope. The whole stability of the slope is determined by the identification of the key block geometry and the stability coefficient. Because of the block theory in the analysis of rock mass stability cleverly using the geometric topology, the block has made discrimination problem etc solved. So the block theory has considerable application value in the stability analysis of slope rock mass.

4) The dominant surface of rock slope

Guoyu Luo professor etc. put forward the theory of the dominant surface of rock slope[11-12]. It is indicated that the side slope is the main function of the slope deformation and failure. In this side slope, the plane of the geological advantage reflects the advantage of the nature, the plane of the statistical advantage reflects the advantages of the number. Comprehensive consideration of the two, can get the real advantage plane. According to this aspect, it is clear that the dominant side can reflect the specific time, quantity, yield and quality, so the dominant surface is not completely consistent with the normal slope of weak structure.

The dominant surface of rock slope is mainly in the form of A, B line working principle. A line begins with analysing the regional tectonic line ,then researching field compression structure, measuring the three essential factors of measurement of fracture, and the old, new, three types of structural are classified and analyzed, and analyse geological advantages surface and red flat projection. B line begins with detailed measurements of the space, and then making the pole figure, according to the pole figure for equal density map, analysing the advantages of the center, and then counting red flat projection of the statistical dominant surface. Combine the results of A line and B line, study on the failure mode of slope, and comprehensively analyse regional stability and slope stability. Finally, stability zoning and detailed calculation are carried out.

5. Conclusions

1) Rock slope has the structure, and the stability of rock slope is mainly affected by the lithology and rock structure, it is necessary to study them.

2) Rock slope has rock mass strength and deformation characteristics, and the experimental study can be divided into field tests and laboratory tests. Experimental research should be carried out as far as possible in the field, but it is sometimes necessary to be in laboratory tests because of field limitations.

3) Research ideas on engineering properties of rock mass structural plane, can begin with engineering classification of rock mass structure, then to analyse two aspects: geometry description and mechanical effect of structural plane. At last, the engineering properties of rock mass structural plane are studied.

4) Ideas and methods of control theory of rock mass structure, block theory of key block, the dominant surface of rock slope etc. can be taken into account for the stability analysis of slope rock mass.

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