IOP Conf. Series: Materials Science and Engineering **250** (2017) 012038 doi:10.1088/1757-899X/250/1/012038

The Effect of Freeze - thaw Cycles on Slope Anchorage and Preventive Measures of Research

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Abstract. Freeze-thaw cycles have great harm to slope anchorage structure, and the theoretical system has not been formed because there are too many constraints and interrelations. This paper analyzes the failure principle and appearance of the slope under the freeze-thaw cycles and puts forward the prevention and control measures. On the whole, at this stage there is no way to raise the anchoring technology as a system to do the whole study. It is urgent to establish a complete concept and overall evaluation mechanism of rock and soil anchoring system, because it can give full play to the function of the favorable elements in the anchoring system and weaken the harm of the unfavorable elements so that the system can achieve the best working condition.

1. Introduction

Slope is a natural or artificial formation of the slope and it is one of the most basic geological environment of human engineering activities as well as the construction of the most common form of engineering [1]. The anchoring technology is a reinforcement technology to reinforce the rock and soil by using the anchor (cable). It is widely used in rock and soil reinforcement, which has the advantages of improving the stability of the rock and soil itself, faster, economical and reliable and so on. No matter what kind of anchoring system, theoretically the way of transmission of force is from the anchor to the grouting body, and then by the slurry into the surrounding rock and soil.

There are many factors that affect the durability of slope engineering; a factor that can not be ignored is the freeze-thaw cycles. In the area where the temperature is affected by the freeze-thaw cycles, the slope engineering is prone to freeze-thaw damage, and the stability of the slope is greatly affected, even the instability of the slope is caused.

2. Analysis of Axial Force of Bolt

Yang Shuangkuo etal.[2] proposed the concept of the first and second critical deformation of the anchor and revealed the three-stage characteristics of the anchoring force of the anchor with the deformation of the anchor - the anchoring force strengthened and deformed, and the anchoring force remained constant stage and anchoring force weakening deformation stage. And the characteristics of three kinds of anchoring forces with the variation of deformation are introduced in detail. The numerical simulation of the whole of the anchor is carried out by Luo Yiping[3] through using FLAC3D. It is confirmed that the above conclusions are different, but their essence is the same.

3. Analysis of Shear Stress at the Interface between Bolt and Mortar

Micro-wrinkle in the anchor body surface plays an important role in the anchoring force. The cohesive force between the anchor body and the grouting material is the main way of transmitting force, but if the drawing force is continued to be increased, the displacement between the anchor body and the grouting material will destroy the cohesive force. The main form of force transmission is the friction [4-5].

Results of research at home and abroad [6-9] show that the shear stress distribution is not immutable, and it gradually changes with the increase of drawing force. When the drawing force is small and the anchoring interface is in the elastic bond state, the shear stress at the interface of the bolt-grouting material is the largest at the end and decreases gradually in the shape, and its shape is roughly distributed according to the hyperbolic function or exponential function. As the drawing force continued to increase, bolt-grouting material interface shear stress in the end reduced and its maximum value to the lower part of mobile, big in the middle and small at both ends of distribution; When drawing force continues to increase, the end of the anchored body interface damage occurs, if the design on the interface end of bolt and grouting material, the friction resistance between the interfaces of the depths of the maximum shear stress to pass to anchor solid stability to provide the required pulling force; As the drawing force increases again, bolt-grouting material interface maximum shear stress to the anchor still deep solid, until the bolt-grouting material interface is broken.

4. Analysis of Interface Shear Stress of Mortar-rock Mass

It's generally believed that the friction between the anchor and the hole wall determines the effective anchorage length [10], the average surface friction decreases with the increase of bolt length. When vertical drawing force effect on anchoring body, anchoring body and rock mass around the friction on the contact interface, due to the friction resistance is from top to the bottom of the anchored body development gradually, the friction resistance at different anchorage depth is different. The upper end of the anchor first reaches the limit value. When the drawing force is greater than the extreme value of the friction resistance, the interface between the anchor and the surrounding rock mass softens into the partial slip state. With the increase of drawing force, the softening of the interface between the anchor and the surrounding rock mass will develop toward the bottom of the anchor until the interface between the anchor and the surrounding rock mass is all in the slip state and the anchoring structure is destroyed[11,12]. The destruction process is shown in Figure 1.

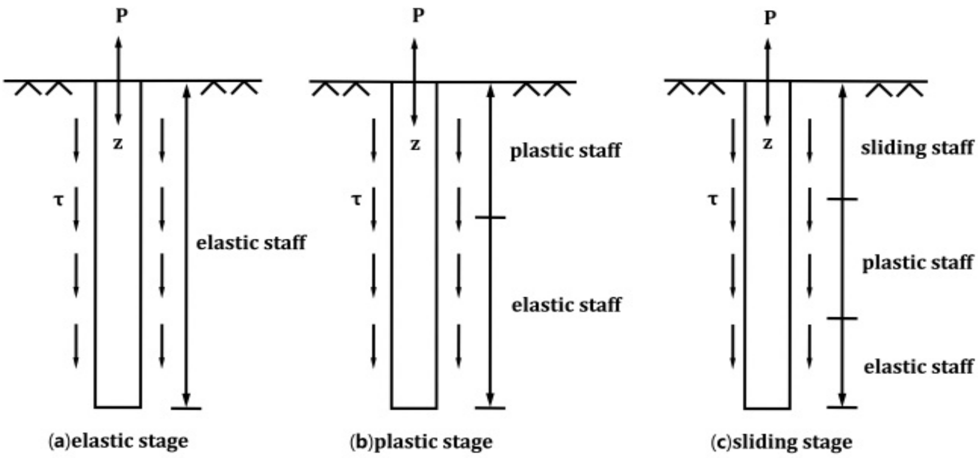

Figure.1 Interaction of mortar and rock mass

5. Influence of Freeze-thaw Cycling on Slope Anchorage Structure

Affected by ambient temperature change, water saturated rock mass and supporting structure in the transition between solid and liquid. The volume of water caused by changes of internal crack and the change of pore size, and the anchoring structure stress state changes so that produce frost heaving and

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thawing settlement. When the rock mass structure is subjected to frost heave, the structure will have frost heave deformation, so that the internal cracks and pores of the structure to further develop. And the deformation caused by frost heave is not fully recovered during the melting process of the rock mass. The rock mass structure is subjected to repeated frost heaving or melting by the external temperature. Because the influence mechanism of the rock mass and the supporting structure is different, the influence degree is different, so it will be in the rock mass and support. The interaction of the structure will be the surface of the stress distribution changes, which induced the interaction surface cracking, dislocation or even off the phenomenon seriously affected the slope protection engineering safety [13, 14].

6. Protective Measures for Freezing and Thawing of Slope Supported by Anchorage

For non-support of the natural slope, in order to prevent the occurrence of landslides and other disasters under the action of freeze-thaw cycles, it must take reinforcement support measures.
For example: ①retaining wall; ②anti-slide pile; ③soil nails;
④prestressed anchor (cable); ⑤anti-slip plug; ⑥slope protection;
⑦shot anchor support; ⑧cutting slope lightening; ⑨drainage and seepage and so on.

The anchoring section can increase the bond strength of the interface at the interface of the anchor and increase the anchoring length of the bolt. The increase of the anchorage length can also improve its ultimate pull force. However, beyond the limit anchorage length, the tensile capacity of the bolt can not be improved. In addition to increasing the length of anchoring, the following methods can be used in the project, such as single-hole composite anchoring (a)and post-high pressure grouting anchoring(b). The expansion of the anchorage(c) can also improve the pull-out force of the anchor in the weak or complex rock and soil layer, but also increase the shear strength of the rock mass around the anchor and improve the overall stability of the slope.

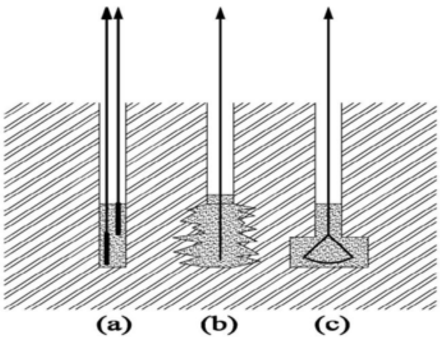

Figure.2 Method to improve the capacity of anchor rods

7. Conclusion

Freeze-thaw cycles have an adverse effect on the slope anchoring structure, and this effect can not be avoided. This effect can only take favorable measures to minimize its harm. The anchorage works can obviously improve the rock and soil properties, and the lattice structure can enhance the slope protection. The plant slope has many advantages and the effect of the above method can not be neglected. Slope protection measures can take the combination of prestressed anchored lattice beam and vegetation slope protection, which can reinforce the slope and green the environment. But it still needs a complete theoretical system. It is urgent to establish a complete concept and overall evaluation mechanism of rock mass anchoring system so that the function of each favorable element in the anchoring system can be fully exploited, thus weakening the harm of the unfavorable elements so that the system can achieve the best working condition.

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