Study on Stability Theoretical of Bank Slope under Coupled Conditions

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Abstract: In view of the factors affecting the soil bank slope of inland waterway and its analysis characteristics, the method of stability analysis of soil bank slope in inland waterway are put forward in the paper. On the basis of that, the soil slope under the influence of water level change, rainfall and ship traveling wave are analyzed, and the stability of the ecological slope after planting is analyzed. In order to consider the soil slope with multi factors, the finite element method should be adopted in the analysis of the stability of the soil bank slope under the combined action of many factors.

1. Preface
From the point of view of geotechnical stability, such as slope stability, foundation bearing capacity, soil pressure calculation, the theoretical basis is the limit analysis theory. The limit analysis theory of soil has been developed for the last 100 years, and the limit analysis method is gradually mature. With the development of numerical methods of rock and soil mechanics, numerical limit analysis method has been developed gradually. It has a wide range of applicability and good practicability[1]. In this paper, according to the factors affecting the soil bank slope and its analysis characteristics in inland waterways, a method for analyzing the stability of soil bank slopes in inland waterways is proposed.

On this basis, it is a good method to analyze and study the soil slope of the inland waterway and the stability of the ecological slope after planting. In practical application, the following conditions must be satisfied:

(1) It can carry out general and ecological bank slope analysis by mature and reliable commercial finite element program;(2)The accuracy requirement of finite element calculation can be satisfied;(3)There are constitutive model and strength criterion of rock and soil materials for practical choosing;(4)Reliable criteria are selected to prepare for judging whether the bank slope can be reached critical failure. Therefore, based on the analysis of the stability of the ecological slope of the inland waterway under multi factors[2], it studies the above conditions and presents the numerical analysis method of the soil or ecological slope stability that meets the actual needs in this paper.

2. The stability analysis principle of soil bank slope
Method for stability analysis of soil slope are geotechnical plasticity based on the theory of solid material stress after the general first entered the elastic condition, as the load increasing, some points in material yield into the plastic stage. Then the failure is achieved by plastic state. If the damage is limited to local points, it will occur some cracks in the soil, but not the failure of the whole rock mass; if the expansion point of damage to the rock and soil of a whole is through the surface, the surface becomes the failure surface, the overall damage will occur in the rock mass, the rock and soil
3. Determination of stability analysis method of channel soil bank slope

For river soil bank slope, due to the particularity of the environment, the influence of the rainfall and water level changes, ship waves and other factors, there are many slope in stability phenomenon. It will detailed analysis of damage characteristics of soil slope in the influence of various factors on the method to provide the basis for river soil slope stability analysis in the following paper.

3.1. Variation in water level

The change of water level will cause seepage, and the seepage of water is one of the important factors affecting slope stability. As long as there is water seepage, seepage not only contact surface and particle skeleton itself have pressure, buoyancy and drag effect, and the existence of seepage water will make the soil shear strength decreased, affecting the stability of soil slope. The slope seepage field and stress field interaction can be expressed as follows: the water head difference in the slope under the action of internal water flow will occur, resulting in rock and soil medium seepage volume force, so that the slope stress field and displacement field changing, which prompted the volumetric strain and void ratio (ratio) change. The soil permeability coefficient and void ratio are necessarily linked, changes will lead to the change of void ratio in slope soil permeability coefficient, permeability coefficient change influences on seepage field, because water head distribution of slope seepage field and stress field. The cycle of interaction of seepage field, the mutual restriction relations called coupling, and the coupling relationship will eventually reach a stable equilibrium stable seepage field and stress field. And the coupling effect of stress field on the stability of the slope will affect the seepage field.

In the calculation of the finite element method, the finite element program ABAQUS has good coupling of seepage and deformation field analysis function, which can be directly coupled seepage field and stress. It can simulate the complex boundary conditions and various soil layers to analyze the seepage field in the landslide area, and take into account the effect of seepage on the landslide in the way of seepage force.

So with the strength reduction technique for analysis of slope stability under seepage by using ABAQUS finite element program, it can get the overall stability coefficient of slope, and the procedures for the use of powerful post processing function. It also can reveal the slope seepage and the most dangerous sliding surface shape and position.

3.2. Rainfall

The rainfall infiltration is a very complex process, which include slope infiltration, slope infiltration, infiltration along the fissures, cracks to various forms of soil seepage and seepage in soil under the condition of gravity. In general, in the rainfall process, the basic parameters of soil and the strength index of slope in the space and time are changing. Considering the effect of rainfall on the soil slope of inland waterway, it is necessary to consider the changes of soil saturation and seepage field with time. The rainfall infiltration is being changed with time of a saturated unsaturated seepage flow, finite element strength reduction of soil saturation in the slope of this complex process a very good simulation, stress and deformation, so the method should be selected to calculate.

3.3. Ship wave

The ship wave is a kind of waves when ship is sailing in water due to the waves of the hull and the water interaction. It's a long-term scouring effect under destruction of soil bank slope by waves. The wave in the shoreline near is broken, then which forms a forward surge of scour on vertical ridge root, reflux formed in the scour surface wave down when it will take away the soil erosion and accumulation in the slope. Because it has a certain bond strength for the clay itself, after a longer
period of time, toe hole concave will be formed along the lines of slope. When it reaches a certain depth, soil ender empty upper hanging empty will collapse down, then it formed complete the soil slope erosion. The empty soil body collapsed again and again, eventually it will show the collapse and destruction of the whole soil bank slope.

3.4. Multi factor interaction
In the past, the analysis of influencing factors of bank slope stability was carried out purely for one or two influencing factors. But for inland waterway bank slope, because of the particularity of its environment, it often be undergo the simultaneous effects of water level change, rainfall and ship waves. Therefore, a very special point in the stability analysis of inland waterway is that we must consider the situation under the influence of multiple factors at the same time\[^6\], so as to be closer to the reality, which can provide guidance for the slope protection project of inland waterway.

Due to the finite element method fully meeting the static permission, strain compatibility and constitutive relation between stress strains, and is suitable for dealing with nonlinear, heterogeneous and complex boundary problems, so it is an ideal analysis method of soil stress, deformation and stability. In order to comprehensively consider many factors influence on the stability of soil slope that should use the finite element method.

4. Ecological effect of bank slope stability
One of the most important parts of the implementation of project management is the ecological slope protection plants and its ecological effect is reflected in the interaction between the root and soil plants, plant roots for strengthening mechanism of soil strength parameters in River riparian soil depth changed with root soil, the strength has been increased. The research direction is to reflect the variation in soil the parameters and related mechanical models. Therefore, for the methods and models of vegetation slope stability analysis, it is necessary to consider the general slope stability analysis based on the combination of characteristics of vegetation, the vegetation root (root of herb and woody plants root overseas) technology processing, and which can reflect the real physical and mechanical state (such as some research, as a flexible fiber, containing the root soil as a kind of reinforced soil, combined with the shear test results of reinforced soil with root research). Combined with indoor soil test to carry out research. Simulation of plant ecological effect, using the finite element method is more than the limit equilibrium conditions meet, such as considering soil vegetation, because the root spatial distribution is more complex, in all directions were using limit equilibrium method to calculate the soil, a division. The artificial soil strips all belong to different root, both the root and soil stress or root, soil or coordination among the two deformation, the simplified are difficult to reach with the actual stress and deformation. The finite element can well simulate this ecological effect.

5. Conclusion
For inland waterway soil bank slope, first of all, it will be affected by various factors.

They are uncertain for failure mode and scope. Limit equilibrium method can not be used to analyze the stability of soil bank slope of inland waterway under the influence of many factors. The finite element strength reduction method is more rigorous in theoretical system than the limit equilibrium method. Compared with the traditional limit equilibrium method, the finite element strength reduction method is more suitable for slope stability analysis.

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