Numerical Analysis of the Durability of Retaining Wall with Anchor

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Abstract: Based on the practical engineering, durability of retaining wall with anchor had been calculated by a FLAC 3D program. Through simulation test, the earth pressure, displacement, and anchor stress of this new type of retaining wall under conditions such as attenuation of soil strength, loose of anchor and influence of water were analyzed. The simulation results of the numerical simulations showed that the retaining wall with anchor has good durability under different operating conditions. Necessary long-term supervision of anchor stress should be adopted during the operation process of retaining wall and reinforced after the loss in time. Erosion of water should be taken into account, and necessary waterproof and drainage measures should be adopted as well.
Keywords: retaining wall with anchor; numerical simulation; lateral earth pressure; displacement.

1. Introduction

The typical structure of retaining wall with anchor is connected by reinforced concrete cantilever retaining wall symmetric arranged on both sides of subgrade and opposite pull anchor penetrated the whole roadbed width. Its wall body section is small, self-weight is light and can be hierarchically constructed, at the same time, it can make full use of the both sides of panel as anchor plate and avoid overlapped waste while arranged reinforcement on both sides, as shown in figure 1. It's suitable for soft foundation section of low bearing capacity or high filled embankment reinforcement, which can save the land effectively.

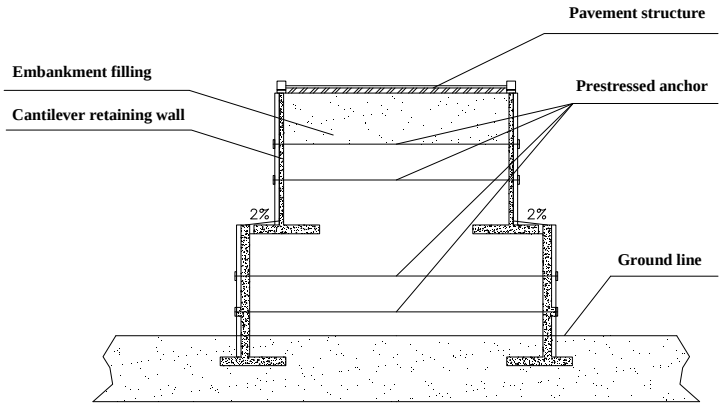


Fig.1 The structure of retaining wall with anchor

Currently, studies of this type of retaining wall were few, the deformation and mechanical characteristic of reinforced earth retaining wall was analyzed and it revealed that the earth pressure was in a curve distribution behind the retaining wall [1]. Retaining wall with new type anchor plate had been designed, which had been used in the practical engineering [2-3].

At the same time, numerical simulation had been widely used in the related analysis of this type of retaining wall. Houmin Li analyzed the influence factors of mutual anchoring thin retaining wall [4]. Jianqing Wu analyzed the factors which influence the earth pressure distribution of retaining wall with anchor through FLAC 3D program [5]. Guanbao Song studied the mechanical characteristic of retaining wall with anchor through ANSYS program and drawn the conclusion that the lateral earth pressure was in a tendency of nonlinear [6].

Based on the above research, relied on pressure-dispersed anchor cantilever retaining wall of QingLin expressway practical engineering, this paper established finite difference numerical model by FLAC3D, and simulated analyzed the effect mechanism of this new type of retaining wall.

2. Numerical simulation model

2.1. Fundamental assumption of the model

To actually reflect the mechanical and deformation characteristics of retaining wall in the engineering, and convenient to study the effect mechanism of retaining wall, the following assumptions were made to the numerical calculation model:

(1) There is no longitudinal deformation occur along the way of the model;

(2) The surface material of the road is elastic, the soil and the basement gravel chose Mohr-Coulomb elastic-plastic model, the deformation between the layers' filler is successive and without slip or separation;

(3) The material of retaining wall is elastic and there may be slip or separation among retaining wall, filling earth behind retaining wall and foundation soil;

(4) Subgrade filling construction is completed in one time, and imposes equal prestress to each anchor cable.

2.2. Establish of the numerical simulation model

In practical engineering, the design elevation of the retaining wall was 6m, therefore, based on the similarity theory and 3 was chosen as the geometry similarity constant, in this numerical simulation model, the wall height was 2.0 m, the anchor position was 1.3 m high, the length of wall heel plate is 0.6 m; the length of wall heel toes is 0.3 m and the wall thickness is 0.02 m. The size of the soil was 2.4 m * 1.8 m * 1.8 m (length * width * height). In order to improve the calculation accuracy and reduce the computing time, the rectangular grid and mesh encryption on the retaining wall was chosen as shown in figure 2.

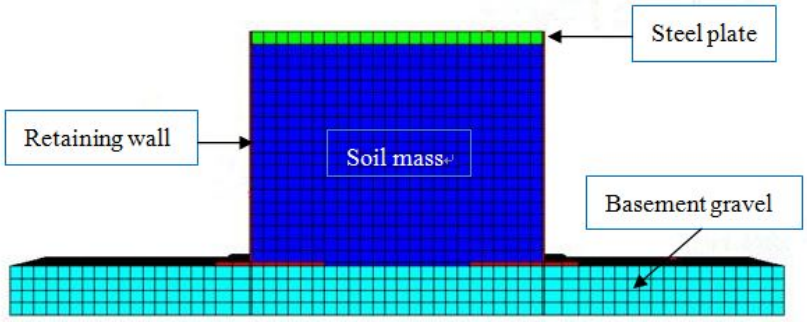


Fig.2 Calculation model of the numerical simulation of the retaining wall

There is rich structure units in FLAC3D program, which can simulate beam, anchor cable, pile, shell, geogrid and lining, among these units, shell unit is composed of 3 nodes equal thickness limited unit, it can be regarded as isotropic linear elastic material without failure limit, cable unit is composed of 2 nodes equal section linear unit and yield in the tensile and compressive, could not resist bending moment. According to the basic assumption and the related research of this paper [7], the shell unit was adopt to simulate the subgrade surface and base, the cable unit was employed to simulate anchor of retaining wall with anchor.

2.3. Model parameter

The retaining wall of this numerical model chose elastic model and the soil and the basement gravel chose Mohr-Coulomb elastic-plastic model. To in accord with the actual situation better, interface was set up between the soil and the retaining wall, the soil and steel plate, steel plate and retaining wall, retaining wall and basement gravel. Interface position was shown in figure 3.

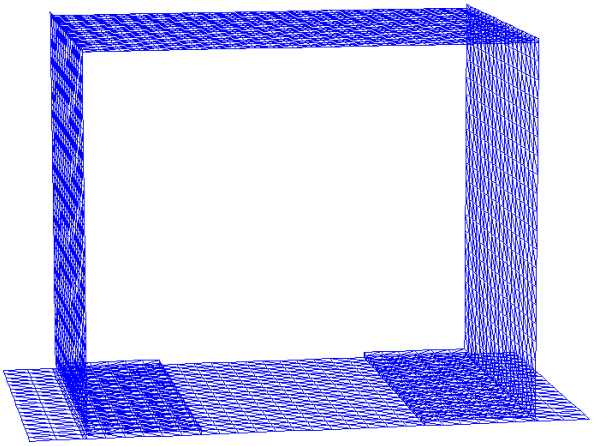


Fig.3 Position of interface

Among them, the interface was controlled by four main parameters such as cohesive, friction angle, normal stiffness and shear stiffness. All these parameters were found from the literature and model test results and the value of these parameters of this numerical simulation model of retaining wall were shown in table 1.

Tab.1 Main parameters value of this numerical simulation model of retaining wall

Elasticity modulus of retaining wall （MPa）	Elasticity modulus of soil （MPa）	Poisson ratio of soil	Density of soil （kg/m^3）	Cohesive of soil （kPa）	Internal friction Angle of soil （°）
210000	20	0.32	1900	0	38

Constraint condition of this numerical model was confirmed based on the indoor model test, the Y direction on the cross-sectional of the lengthways subgrade was constrained to promise the strain was flat. The constraint condition was shown in figure 4.

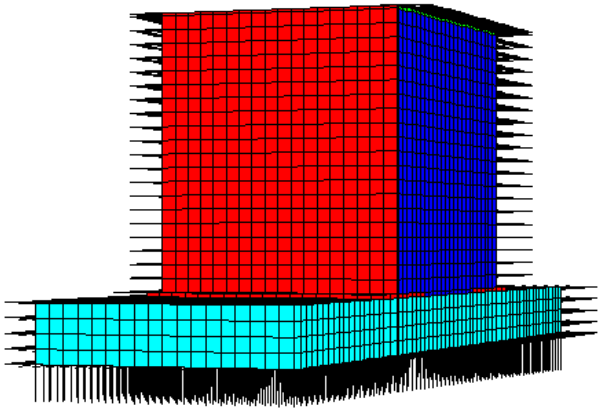


Fig.4 Constraint condition of the calculation model

3. Calculating results and analysis

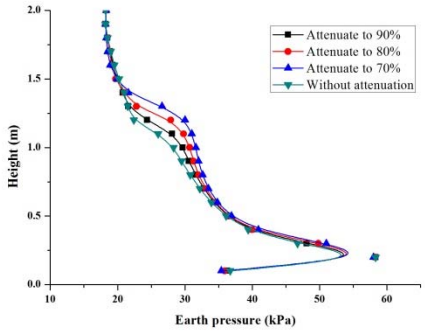
Calculation process was carried out in accordance with the actual construction, namely established the model of cantilever retaining wall on the weight self-balancing foundation, prestress was inflicted to each anchor cable and subgrade filling construction should be completed in one time, then the numerical calculation of retaining wall during operation periods can be conducted.

Influence factors of the durability of retaining wall analyzed in this paper included three factors, namely attenuation of soil strength, loose of anchor stress and influence of water.

3.1. The attenuation of soil strength

During the operating process of the retaining wall with anchor, as time goes on, the strength of soil would attenuated inordinately, the attenuation of soil strength would be a big threat to the safety of the retaining wall under unchanged vertical load. To analyze the influence of the attenuation of soil strength on the mechanical

characteristic of the retaining wall with anchor, different conditions such as without attenuation of soil strength, attenuate to 90%, 80% and 70% were chosen to conduct the numerical simulation; the results were shown in figure 5 and 6.



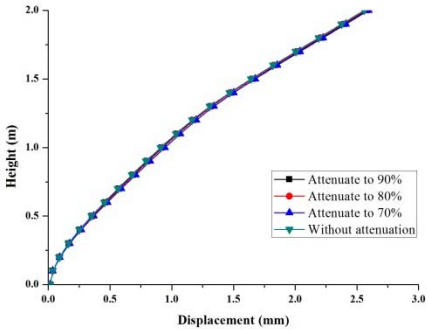


Fig.5 Change law of earth pressure **Fig.6 Change law of displacement**

The figure 5 and 6 showed that when the soil strength attenuation occurs, the lateral earth pressure and displacement of retaining wall with anchor increased somewhat while the variation is relatively small, so the influence of the soil strength attenuation on the stability of retaining wall was tiny and the retaining wall with anchor had a high adaptability to the change of soil strength.

3.2. The loose of anchor stress

Relaxation of prestress is one of the common diseases of anchor and one of its important performance was the loss of prestress, so it's significant to study whether the retaining wall with anchor had a high stability under the loose of anchor stress. The change law of earth pressure was shown in figure 7 when the prestress unload from 80 KN to 65 KN, 55 KN, 32.8 KN and completely uninstalled.

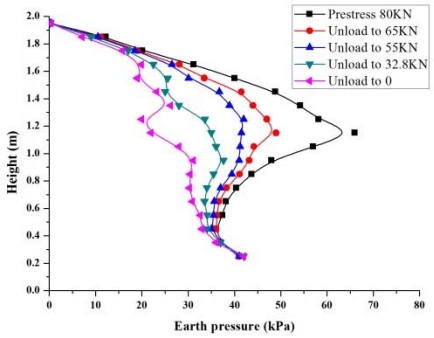


Fig.7 change law of earth pressure

As shown in figure 7, under the influence of anchor prestress, the lateral earth pressure around anchor was the largest and the upper and bottom is relatively small. When the loose of anchor stress occurred, as the recess of the restraint function of anchor and outward bulge of the retaining wall, the earth pressure change value around the anchor was bigger and the upper and bottom was relatively small. It explained that the impact of the loose of anchor on the lateral earth pressure of retaining wall was tremendous, so it's necessary to supervise the loose of the anchor stress and tension in time after the loss to ensure the stability of the retaining wall with anchor.

3.3. The influence of water

During the operating process, the retaining wall with anchor would inevitably be influenced by water surrounding such as rainfall and the rise of groundwater and the retaining wall was widely applied in the river embankment protection, so the durability of retaining wall with anchor under different water level was one of the most important aspect that should be studied in detail. The results were shown in figure 8 and 9.

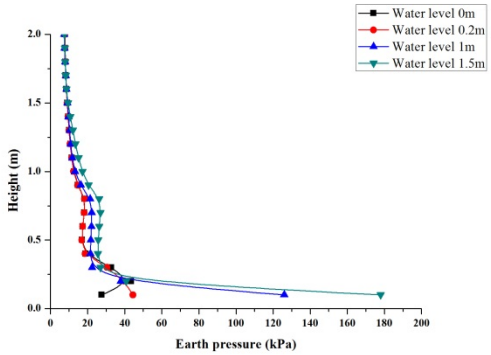


Fig.8 Change law of earth pressure

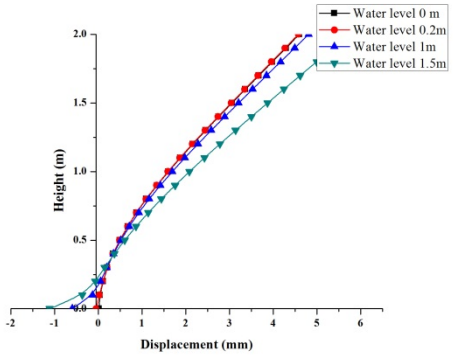


Fig.9 Change law of displacement

As seen in figure 8 and 9, the earth pressure and displacement of retaining wall with anchor under different water level both increased with the increase of water level. In the middle and upper parts of the retaining wall, the change values were relatively small while the bottom was bigger. This indicated that the groundwater effect would reduce the stability of the retaining wall with anchor, to the extent of value, its displacement was little and the earth pressure would increase sharply with the increase of water level at the bottom of the retaining wall. So, the retaining wall had certain resistance to the erosion of water, but necessary waterproof and drainage measures and reasonable reinforcement on the bottom of the retaining wall should be taken to reduce the impact of water erosion effect to the retaining wall.

4. Conclusions

(1)When the soil strength attenuation occurred on the retaining wall, the lateral earth pressure and displacement of retaining wall with anchor increased somewhat while the variation is relatively small.

(2) When the loose of anchor stress occurred on the retaining wall, the earth pressure change value around the anchor was bigger and the upper and bottom was relatively small.

(3) When the retaining wall was influenced by the water, the earth pressure and displacement of retaining wall with anchor under different water level both increased with the increase of water level. In the middle and upper parts of the retaining wall, the change values were relatively small while the bottom was bigger.

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