

Numerical experimental study on the effect of excavation on the stability of loess slope

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Abstract. In order to obtain more land for construction of large excavation slope, steep slope leading to soil, surface increases, serious damage to the original balance of geological environment. It will create the conditions for the occurrence of landslides. It is found through research that there are three types of landslides caused by artificial excavation, including new landslide after chopping slope, old slope reactivation caused by chopping slope, and landslides caused by abandoned earthwork after excavation. Through numerical tests on the stability of the new slope, it is found that with the increase amount of excavation, the stability coefficient decreases, until destruction. The test reflects the change process of the stress state on the sliding surface of the slope. With the shear stress below the shear strength, the anti slide force decreases, the front of the landslide is first revived, the upper part loses support and the whole slide is a traction failure.

1. Introduction

With the rapid development of economy, urban construction scale, the construction quantity and quality are put forward higher requirements, in order to get more land for the construction of large slope excavation, serious damage to the original balance of geological environment, geological disasters caused by landslides, landslides and debris flows[1].

There are a large number of old landslides and ancient landslides in the loess region. After these landslides took place, they underwent a long-term transformation. The shape and internal stress state of the slider both reached a new equilibrium and were in a relatively stable state. For many reasons, most of these historical landslides have not been treated in time, leaving a large hidden danger. The soil after sliding is disturbed soil, which has loose soil, weak structure, cracks and cracks, high porosity and easy deformation. It may revive under the influence of human engineering activities and other factors. Landslide slope excavation, the formation of a high slope, reduce the sliding resistance of old landslide slope excavation, at the same time provide enough space for the old landslide deformation, which is composed of a front part for backward traction sliding form. The resurrection of the old landslides caused by excavation can be divided into two types, the whole slide of the old landslide and the local new landslides, which are determined by the size of the excavation impact. The resurrection of the old landslides caused by the excavation is generally dominated by creep, and the deformation is slow[2].

A great deal of research has been carried out on the effect of excavation on the stability of the slope[3,4]. In the research methods of slope stability, there are usually theoretical calculation, numerical simulation and field test[5-7]. In this paper, the effects of phased excavation on the stability of loess slope are simulated by numerical method.



2. Calculation model and calculation parameter

2.1 calculation model

For the landslide body, 5 finite element models are established along the main sliding direction. The distribution of stress and intensity on the sliding surface at each stage of excavation is calculated by GEO-SLOPE software. The model is shown in Figure 1 (a) ~ 5(a).

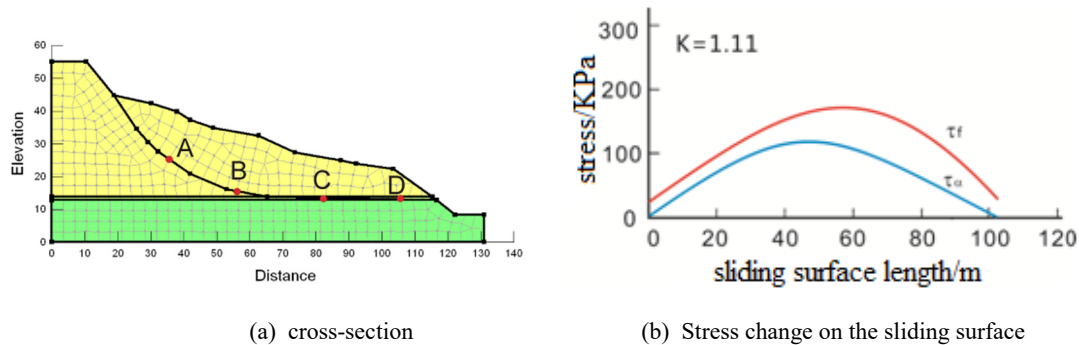


Fig.1 Before excavation

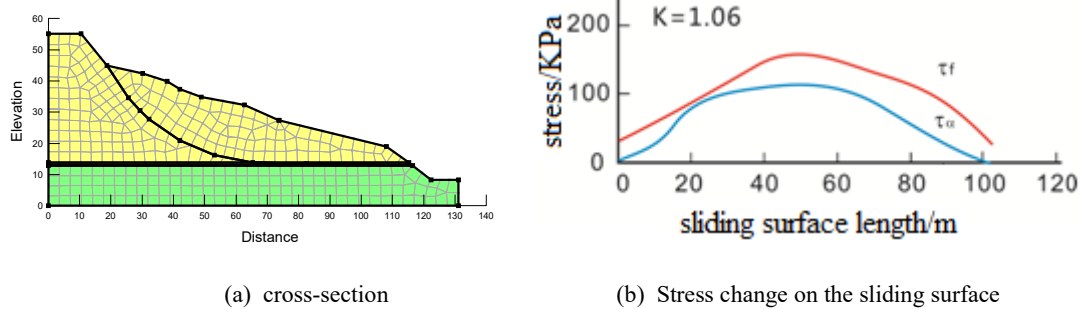


Fig.2 Excavation process I

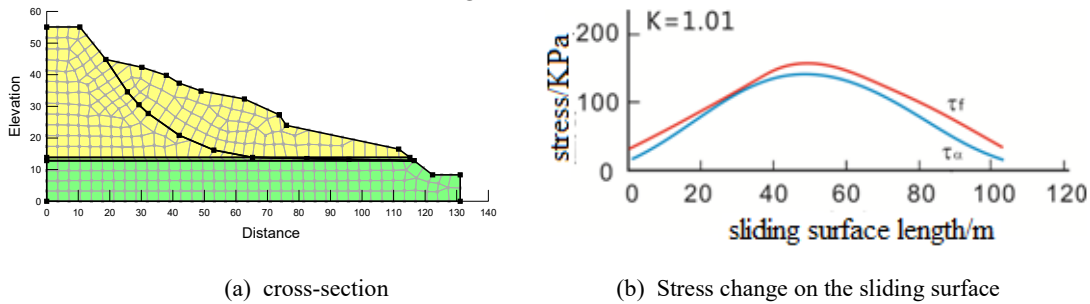


Fig.3 Excavation process II

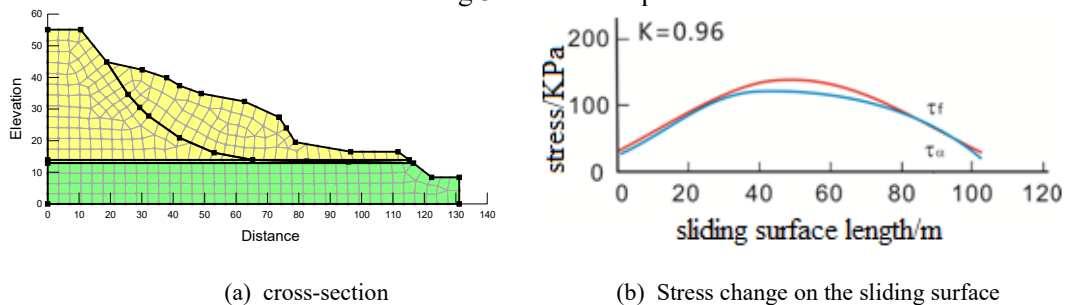


Fig.4 Excavation process III

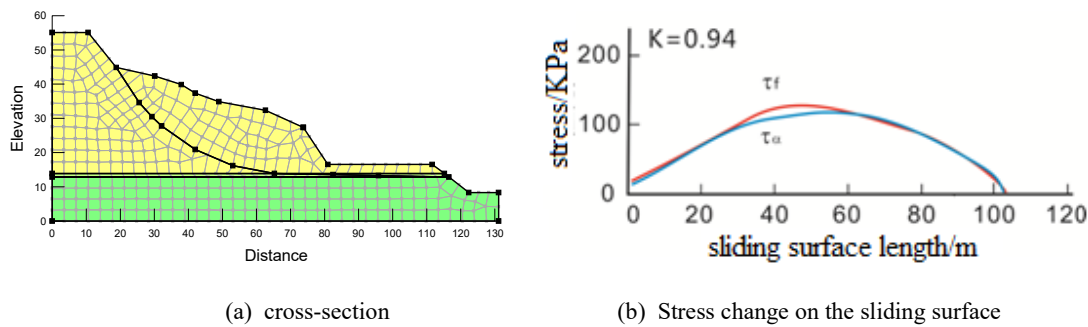


Fig.5 After excavation

2.2 calculation parameter

The parameters of the slope body are shown in Table 1.

Tab.1 Rock and soil parameters of slope

Soil property	Severe $\gamma(\text{kN}\cdot\text{m}^{-3})$	cohesive strength $c(\text{kPa})$	internal friction angle $\varphi(^{\circ})$	modulus of elasticity (kPa)	poisson ratio
Sliding zone (natural loess)		18.7	26.2		
Sliding zone (saturated loess)		9.8	10.2		
Slippery loess	16.5			50000	0.35
Pebble	20.0			80000	0.30
Sandstone	28.0			140000	0.28

3. Result analysis

Table2 shows the variation caused by the landslide stability coefficient of slope toe excavation. We can see that with the increase of the amount of excavation, the stability coefficient decreases, until the destruction. From figure 1, figure 5 (b) ~ (b) visible along the sliding surface on the normal stress σ , shear stress showed increases at first and then decreases. Comparing the figure shows, with the lower part of the slope excavation, it should continue to reduce the force competed at the lower part of the sliding surface, the shear strength decreased, while the relative shear stress shear strength increased when shear stress exceeds the shear strength, the overall instability and resurrection.

Tab.2 Changes in the stability of slope toe excavation

working condition	Before excavation	Excavation process I	Excavation process II	Excavation process III	After excavation
Stability coefficient	1.11	1.06	1.01	0.96	0.94

A, B, C and D, as shown in Figure 1 (a), are the positions of 25.9m, 48.9m, 75.5m and 99.2m on the sliding surface respectively, and the stress changes are analyzed in the figure 6. The abscissa is the working condition of excavation, and the 0 corresponds to the stress state before excavation. 1, 2 and 3 correspond to the stress state of the excavation stage I, II and III respectively, and 4 corresponds to the stress state after excavation. Figure6 (a) shows that in the excavation process of the landslide stress, shear stress, σ force remained unchanged is the lower part of the excavation, did not affect the stress distribution of the upper part of the landslide. Figure 6 (b) for the stress distribution of 48.9m on the surface, in the early stage of excavation (see section I before the excavation to the excavation process curve), shear stress maintained the normal stress σ , and decreased slightly after the excavation process II, surface normal stress, shear stress σ remain unchanged. Figure 6 (c) 75.5m on the sliding surface stress changes at the middle and lower parts of the ancient landslide, with the excavation position of normal stress σ decreased gradually, the shear strength decreased, slope unloading, shear stress

increases slowly, exceed the shear strength in the excavation process of post. Figure 6 (d) for the stress distribution of 99.2m on the surface, showing in the excavation process of cutting slope stress changes, the position is visible with the excavation stress σ rapidly decreased, the shear strength decreases rapidly, shear stress increases slowly, exceed the shear strength in the excavation process after IV. According to figure1 (b) ~ figure5(b), foot excavation section of anti slide, anti slide force decreases, and the upper part of the landslide sliding force constant, with the continuous excavation, when less than the sliding force of anti slide force when the slide happened.

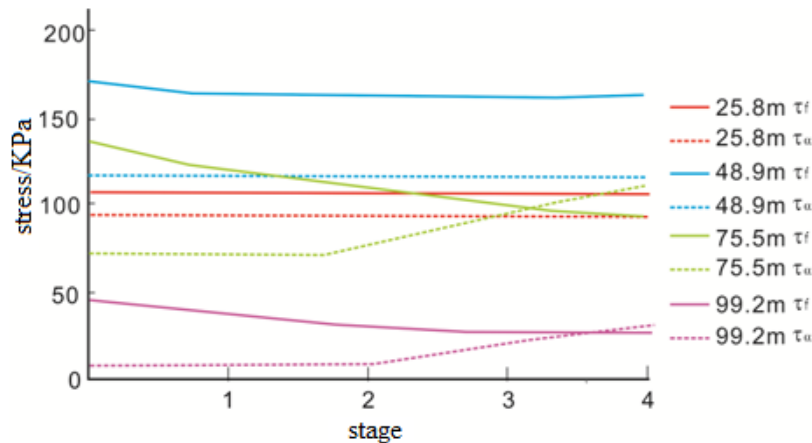


Fig.6 Stress change during excavation in typical position of slide surface

4. Conclusion

This paper simulates the change process of the slope stability of the Loess Slope during the stage of excavation by the numerical test method. Finite element simulation results reflect the changing process of stress of the slope sliding surface, the excavation part in the anti sliding section, with the lower part of the slope shear stress exceeds the shear strength, anti slide force of landslide is reduced, the dead, the upper losing support, the overall sliding traction, belonging to the type of failure. The slope increases with the amount of excavation, the stability coefficient decreases, until the destruction.

Acknowledgement

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