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Study on Deformation Evolution of Loess Cutting Slope in Expressway

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Abstract. To reveal the long-term evolution law of the Loess Cutting Slope in the process of construction and operation, A typical loess cutting slope in is selected as the research object, and the numerical analysis and field monitoring is adopted. Layout of monitoring sections, the subgrade settlement and lateral displacement of the slope as the main monitoring parameters, which the deformation rule of slope for long-term is monitored. The stability of the slope before and after the excavation is compared and analyzed. The monitoring data and analysis results guide the construction of loess slope well, and reveal the deformation and evolution law of the loess slope.

1. Introduction

The stability of the cutting slope is the basic guarantee for the safe construction and operation of the slope. The rational analysis of the stability of the slope provides an important theoretical basis for the design and construction of the slope, and the long-term monitoring of the deformation can be used to feedback and evaluate the effect of the slope design.

The study of slope stability analysis is divided into deterministic analysis and uncertainty analysis. Deterministic analysis is divided into quantitative analysis and qualitative analysis. The methods of quantitative analysis include limit equilibrium method and numerical analysis method. Qualitative analysis includes engineering analogy method and graphic method. Uncertainty analysis includes reliability analysis, grey system analysis, catastrophe theory and so on.

In the engineering practice, the deformation monitoring information of slope soil can directly reflect the dynamic stability of the slope. Therefore, the stability analysis and research of the slope, and the on-site monitoring of the solid engineering of the slope, have the important theoretical and practical significance to the design, construction and operation and maintenance of the highway slope.

Based on a typical loess cutting slope, the finite element analysis software is used to carry out nonlinear numerical analysis on the slope section, and the long-term monitoring of the construction and operation process of the slope is carried out to reveal the long-term evolution law of the loess cutting slope.

2. Engineering background

The strata of the slope engineering are composed of the Quaternary Middle Pleistocene alluvial flood loess and the Quaternary upper Pleistocene aeolian collapsible loess. The alluvial flood loess is relatively homogeneous, with a small amount of calcareous nodules and gravel, small pores and vertical joints developed, showing a hard plastic state and no collapsibility. The collapsible loess is light yellow, with homogeneous soil texture, loose structure, large pores and insect holes, with vertical joints and a hard state. The excavated slope is shown in Figure 1.

Figure 1. The excavated slope

3. Numerical analysis of slope stability

3.1. Numerical model establishment

The slope calculation model is shown in Figure 2. The model is 75m high and 200m wide, and the right side of the excavation slope is 25m and 5 platforms. Figure 2 is a two-dimensional finite element model of the slope.

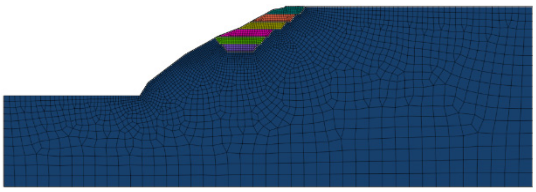

Figure 2. Two-dimensional finite element model of the slope

The parameters of the model material are shown in Table 1.

Table 1 Material parameter table

	Elastic modulus (MPa)	Poisson's ratio	Cohesive force (kPa)	Cohesive force (°)
Soil	150	0.3	91.81	35.24

The left and right sides of the model are horizontal displacement constraints, the bottom is a fixed boundary condition, and the surface is a free boundary.

3.2. Comparison and analysis of slope stability before and after excavation

The equivalent plastic strain contrast maps before and after excavation are shown in Figure 3.

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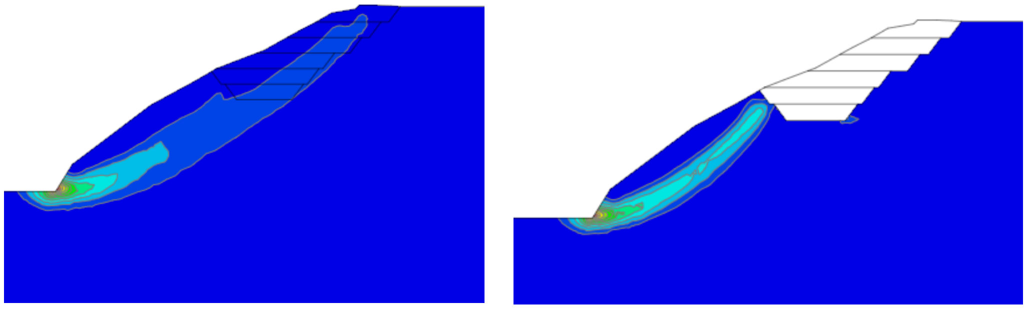

(a)Before excavation (b)After excavation

Figure 3. The equivalent plastic strain contrast map

From the plastic area distribution, it can be seen that the plastic zone of the slope before the excavation is concentrated on the foot of the lower slope and develops upward. After the excavation, the plastic area of the lower slope is basically through, the lower slope is less stable and the upper slope is basically non plastic zone distribution.

4. Monitoring of deformation evolution law of slope

In order to clarify the deformation law of the whole life cycle of the Loess Slope in the construction - post construction settlement - operation, the loess slope is monitored, and the subgrade settlement and side deformation of the slope are selected as the main monitoring parameters. The roadbed settlement is monitored by single point displacement meter. The range is 40cm and the accuracy is 0.1mm. Side slope deformation is measured by inclinometer tube inclinometer, with a range of + 30 degrees and a precision of 0.1%.

4.1. Subgrade settlement

The subgrade settlement time history curve of monitoring section is shown in Figure 4.

From the overall trend, the subgrade settlement law in different positions is the same, that is, the settlement of subgrade is increased significantly in the initial 16 days of the sensor burial (first 16 days), the settlement of subgrade increases significantly, and the settlement has increased in sixteenth days to thirty-second days, and the settlement has a small decrease in thirty-second days to fifty-fifth days; after fifty-fifth days, the subgrade is consolidated due to consolidation of soil. Other factors slowly increase and then tend to be stable.

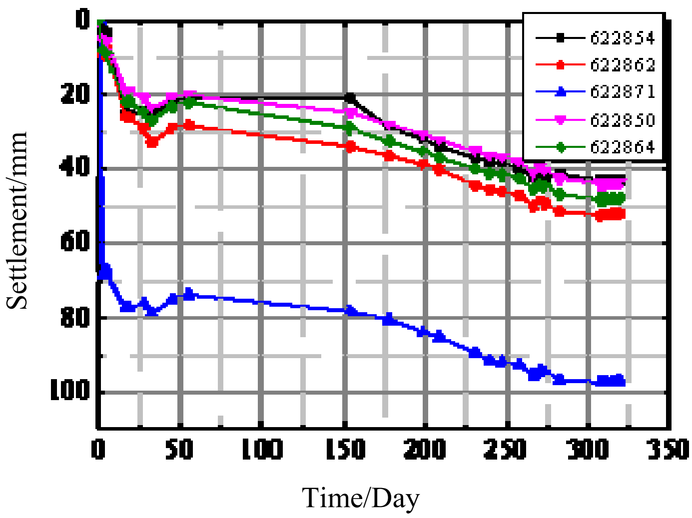

Figure 4. Subgrade settlement curve

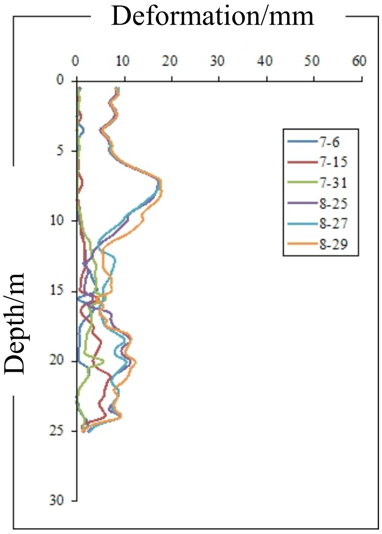

Figure 5. Horizontal deformation curve

4.2. Horizontal deformation of slope

The horizontal deformation curve of the slope of the monitoring section is shown in Figure 5.

As can be seen from Figure 5, the overall trend of lateral deformation is from the slope surface to the deep, and the lateral deformation gradually decreases, and the partial lateral deformation curve in the range of 5-10m and 15-25m ranges from a large decrease. The analysis is due to the inability of the erect of the loess to lead to the insufficient contact between the inclinometer tube and the hole wall.

The study of slope stability analysis is divided into deterministic analysis and uncertainty analysis. Deterministic analysis is divided into quantitative analysis and qualitative analysis. The methods of quantitative analysis include limit equilibrium method and numerical analysis method. Qualitative analysis includes engineering analogy method and graphic method. Uncertainty analysis includes reliability analysis, grey system analysis, catastrophe theory and so on.

Based on a typical loess cutting slope, the finite element analysis software is used to carry out nonlinear numerical analysis on the slope section, and the long-term monitoring of the construction and operation process of the slope is carried out to reveal the long-term evolution law of the loess cutting slope.

5. Conclusion

Through the numerical analysis of the stability before and after the excavation of the cutting slope and the long-term monitoring of the deformation of the subgrade slope, the long-term evolution law of the slope deformation is obtained.

First, the combination of numerical analysis and field monitoring can well guide the construction, optimize the design parameters, and ensure the safety of slope construction.

Second, when the slope is excavated in the middle part of the slope, the stability of the slope is decided by the stability of the lower slope, and the upper slope tends to be stable.

Acknowledgments

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