Numerical Simulation Analysis and Research of Large Scale Garden Construction Waste Mounding Hill Landscaping

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Abstract. Along with the rapid development of international metropolis, China's urbanization is developing faster and faster. In the process of China's urbanization development, mountain mounding with construction waste is one of the most direct, effective and economical means to deal with construction waste, not only that, but also, one of the important methods for ecological restoration project of landscape gardening, this method has several advantages such as green construction, green low carbon, energy saving and carbon reduction, etc. It also improves the utilization rate of resources, has high economic and environmental benefits, and also has high High research value and social significance.Since there are differences in the mechanical properties of the original soil and the mounded hill materials in the process of construction waste mounding, as well as, differences in the soil quality in different regions, it is necessary to study the stability of the hill. In this paper, the following research results are obtained through actual case studies of typical landscape projects: first, geomechanical tests are conducted on the raw soil and construction waste mound hill materials to obtain the particle size ratios, maximum dry density and optimum moisture content, and compression modulus of specific mixes, and the triaxial shear test proves that each stress-strain curve basically conforms to the Duncan-Zhang hyperbolic relationship assumption before the peak occurs.Finally, numerical simulations were carried out for different working conditions in combination with the three-dimensional calculation model, and the calculation and analysis of the Bishop consolidation theory were used to obtain the settlement displacement, horizontal displacement development and pore pressure dissipation process of the calculation model. The landslide stability of the slope is calculated and the minimum safety coefficient under normal conditions and the minimum safety coefficient under seismic conditions are both calculated by Swedish method and Bishop method respectively, both of which meet the requirements and determine the technical feasibility and reasonableness of the scheme. In the conclusion part of this paper, the problems and handling measures in the construction process are summarized to provide valuable experience for similar projects.

Keywords: garbage mountain building, construction waste, Beal consolidation, stability.

1. Introduction

With the continuous development of urbanization, a large amount of construction waste is generated, and conventional construction waste cannot be directly reused, people usually use the landfill method to deal with it [1]. It was found that people can be used in parks by treating construction waste [2]. In China, some scholars have conducted a statistical analysis on the reuse of construction waste and obtained that it has about 20% utilization space, and the reuse of construction waste is also growing year by year under the promotion of Chinese national regulations and related policies [3].

In the study of Tianjin, China, the construction waste landfill landscape project, the stability of the foundation was evaluated [4], and the stability monitoring and control of the foundation at the construction site of the Tianjin waste disposal site was summarized and analyzed, and the construction waste on the mountain landscape and its environmental benefits were studied [5, 6].

Through the landfill of construction waste, due to the different soil quality in different areas, there are studies in soft soil areas to evaluate the stability of soft ground under the mountain [7], summarize the design and construction of municipal construction waste pile mountain for engineering on soft soil

[8], and mathematical analysis of foundation treatment and stability of silty soil during artificial pile mountain in soft soil areas [9]. The stability analysis of construction waste landfill can be applied in non-soft soil areas by applying the triaxial numerical test model based on PFC3D [10], applying the numerical simulation analysis by applying the software ANSYS in the piled hill project [11], and applying the displacement inverse analysis method in the stability analysis of construction waste landfill [12].

In Xi'an, although there are scholars who analyze the major initiative of reusing construction waste, there is a lack of research examples related to stability analysis of local waste mountain building in Xi'an. Therefore, it is of great research significance to carry out consolidation settlement and stability analysis from physical and mechanical property tests to three-dimensional calculation models from the example of the construction site of Ripple Lake in Xi'an, combined with on-site geomechanical research, to provide construction experience and data accumulation for similar construction waste hill-making projects.

2. Project Overview

Meibe Lake water system ecological zone infrastructure project is a topographic transformation in landscape engineering. The main structures on the mountain of Meibe Lake are corridors, underpasses, bridges and other architectural structures sensitive to deformation, which are large earth hill mounding projects.

The stratum of the proposed site mainly consists of fill ①-1 layer of miscellaneous fill (Q4ml), ①-2 layer of plain fill (Q4ml), Quaternary Holocene alluvium, ②-1 layer of loess-like soil (Q4al+pl), ②-2 layer of loess-like soil (Q4al+pl), Quaternary Upper Pleistocene residual paleosol, ③-layer of paleosol (Q3el), alluvial chalky clay, ④-layer of chalky clay (Q3al+pl), ⑤-layer of chalky clay (Q3al+pl), etc.

3. Research on the physical and mechanical properties of soil–slag mixes

3.1. Particle gradation test and analysis

Particle gradation test and analysis: the test slag mix with particle gradation <5mm is more than 73%, and the test slag mix with <10mm is more than 88%.

3.2. Relative density experiment and compaction test analysis

Relative density experiment and compaction test analysis: the test dry density of the mixture was obtained as 1.59g/cm3, and the optimum moisture content was 12.4%.

3.3. Solidification fast shear test and compression test

The compression modulus data of the soil-slag mixes were obtained by the consolidation fast shear test and compression test, which were in the order of 103~104kPa and were medium compressible materials.

3.4. Static triaxial test

The test results show that each stress-strain curve basically conforms to the Duncan-Tension hyperbolic relationship assumption before the peak value appears.

4. Jingshan model construction

4.1. Computational model

A three-dimensional computational model is created as follows.

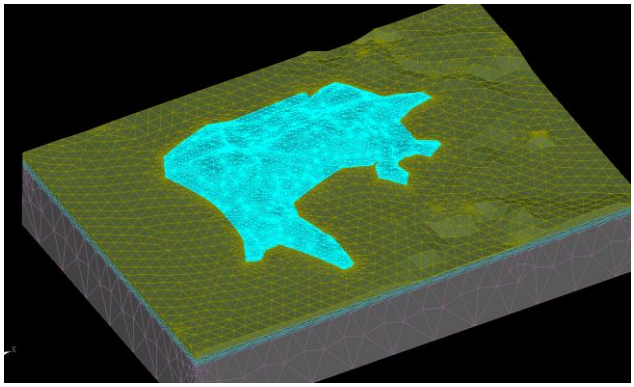


Figure 1. Finite element mesh

4.2. Calculation of working conditions and parameters

The consolidation and settlement processes of the foundation were calculated for three loading rates assuming one year (12 months), one and a half years (18 months) and two years (24 months), espectively. The mountain part was simulated by layer loading, divided into twelve layers of mounding with a layer height of 2.5m, and the elevation of the foundation base was taken as 313.0m, i.e., the thickness of the foundation was about 100m, and the consolidation calculation hole pressure observation points and displacement observation points were set.

5. Kingston consolidation settlement analysis

5.1. Calculation results

Six slices were studied for this model, and vertical and horizontal slices of the completion period were performed for each slice location, and settlement clouds for some of the slices are listed.

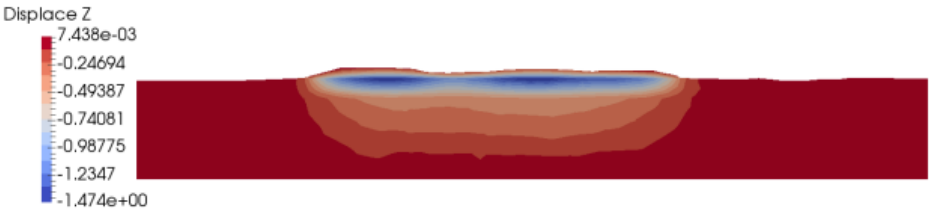


Figure 2. Settlement slice during the completion period 4 (unit: m)



Figure 3. Completion period horizontal displacement slice 4 (unit: m)

According to different working conditions: the construction period is 12 months, 18 months, 24 months for example, respectively, the end of construction, the end of 24 months after the settlement calculation analysis, simulation of different working conditions of settlement, horizontal displacement

and super hole pressure and other results, the process of some of the working conditions of the analysis and calculation is shown in the following figure, And analysis and data statistics were conducted.

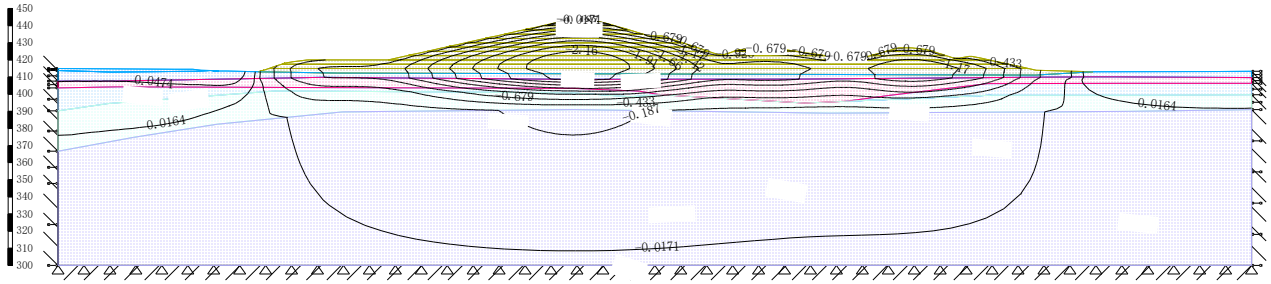


Figure 4. Settlement contour map at the end of construction (unit: m)

5.2. Displacement calculation results analysis

The displacement development and pore pressure dissipation processes of the computational model were obtained by using the Brio consolidation calculation analysis, and the following conclusions were obtained:

Construction generates superporous water pressure in the foundation, and this pore water pressure dissipates continuously over time.

Calculations show that the construction-induced superporous pressure is affected by the upper pile load and the physical properties of the foundation, and the larger the upper pile load and the poorer the permeability of the foundation are, the larger the superporous pressure is and the slower it dissipates. Twenty-four months after the end of the construction period, the superporous pressure caused by mounding basically dissipated.

Horizontal displacement results show that a certain amount of horizontal displacement occurs in the foundation, its maximum value occurs in the section between the edge of the rockery and the highest part of the mound, near the elevation 417~420m, the direction is away from the rockery, its maximum value occurs at the end of construction, the horizontal displacement caused by consolidation after construction is small and negligible

5.3. Kingston slip resistance stability analysis

1) Calculation analysis considering super-hole pressure

Due to the complexity of the calculation process, this section does not list them all, taking the construction period of 24 months, the end of construction, 24 months after the end of construction as an example, the results of the calculation of slip resistance stability are See the figure below.

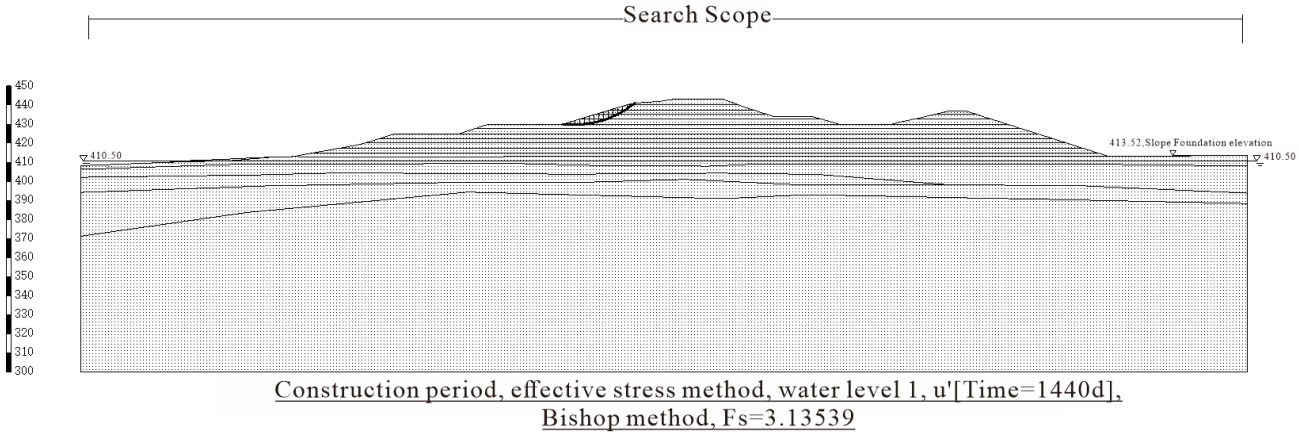


Figure 5. 24 months after the end of construction (sliding to the left)

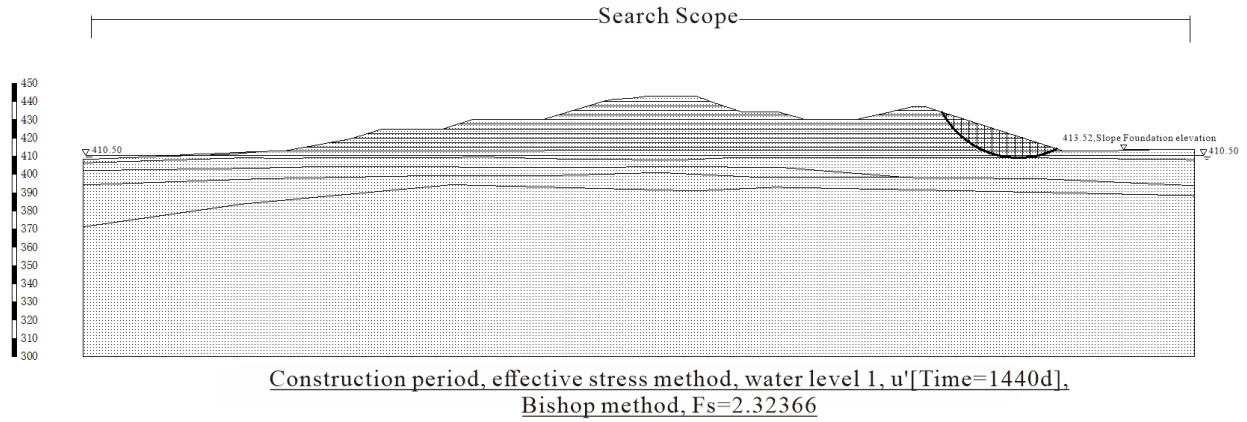


Figure 6. 24 months after the end of construction (sliding to the right)

This section presents the calculation results for profile 3-3 with a small slip resistance stability coefficient. The results show that the selected profile has a slip stability coefficient minimum value of 2.24 during the construction period and the subsequent consolidation process (24 months) and of 1.72 considering the seismic effect (seismic acceleration 0.2 g), which satisfies the slip stability requirement.

2) Calculation analysis without considering super-hole pressure

Calculation of a typical profile selected, due to the complexity of the process, this section does not list, to 2-2 profile as an example, anti-slip stability calculation results are shown in the following figure:

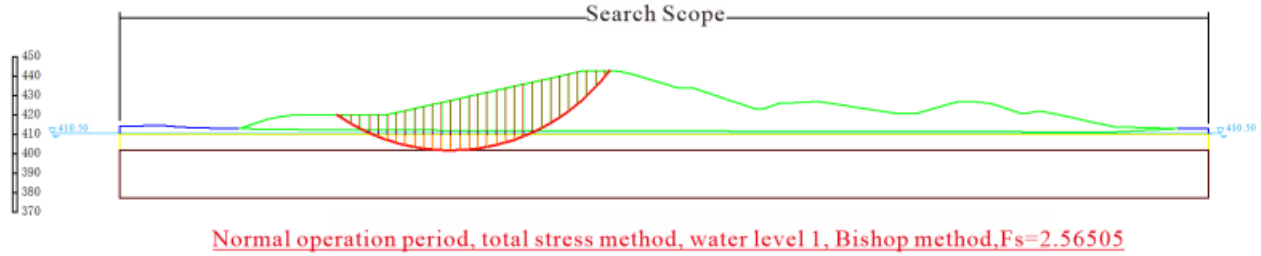


Figure 7. Normal working condition of profile 2-2: Bishop method of antislip stability calculation slip arc position (normal sliding to the left)

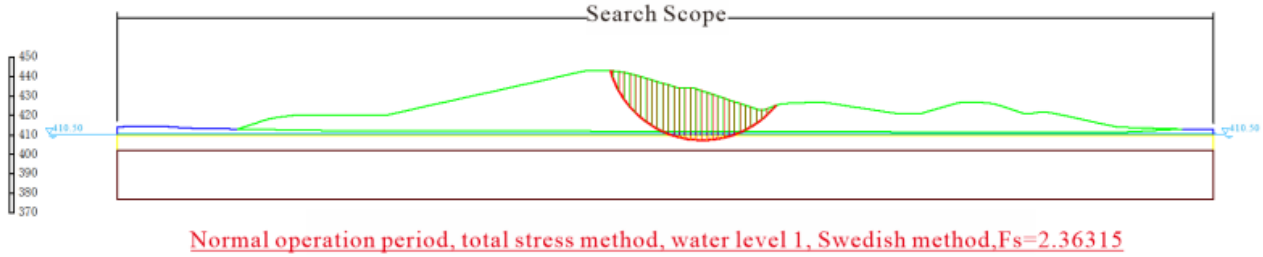


Figure 8. Normal working condition of profile 2-2: Bishop method slip stability calculation slip arc position (normal sliding to the right)

The minimum safety factor of the Swedish method is 1.463 for normal conditions and 1.167 for earthquake conditions, and the minimum safety factor of the Bishop method is 1.598 for normal conditions and 1.268 for earthquake conditions, meeting the requirements of the relevant codes.

6. Other BIM technology applications in scenic areas

6.1. Numerical simulation mechanical analysis of scenic bridges

During the design deepening process, the bridge structure was analyzed in static, stability and eigenvalue calculation analysis and two-stage and two-level seismic design analysis by using large finite element software to analyze the rationality of the bridge design.

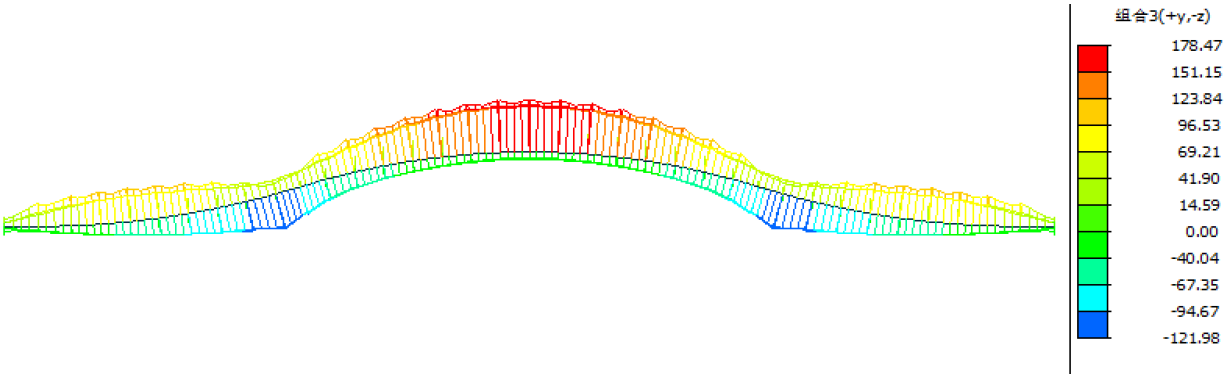


Figure 9. Combined stress envelope at the lower edge of the steel box girder (unit: MPa)

6.2. Scenic tower 3D modeling

Use 3D modeling technology to replicate on-site construction and improve work efficiency. After the finished components are transported to the site, they are installed one by one according to the 3D model number, and attention is paid to the finished product protection of the components during the lifting process to prevent collisions from affecting the appearance quality.

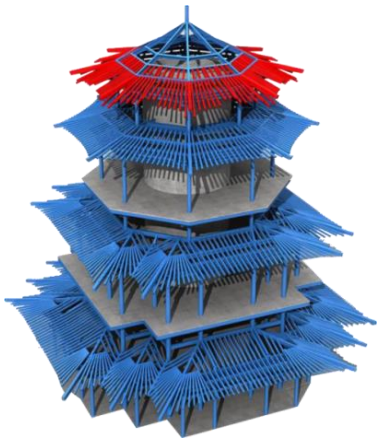


Figure 10. Tower 3D model

7. Conclusion and recommendation

The core problem of construction waste mounding project is how to ensure the stability of the mounding project during construction and use. Too fast loading rate of the pile during construction will lead to settlement deformation in the vertical direction and foundation shear damage due to the pile load exceeding the soil strength, so the construction quality should be controlled during the construction process and the construction should be carried out according to the design requirements.

Monitoring needs to be strengthened during the construction process, which should be done dynamically and adjusted in time. Firstly, because of the large stress difference at the edge of the pile, it will cause sliding instability of the foundation and collapse of the pile carrier in different degrees. Secondly, there will be different loading rates, so that the growth of shear strength in the soil body can not adapt to the growth of shear stress caused by the applied load, then the point of damage in the foundation is increasing, and finally through the formation of damage.

As in the actual construction of the project, it is impossible to take accurate measures to eliminate or attenuate the foundation settlement, ground uplift and the impact caused to the surrounding structures caused by the mounded hill. Therefore, more detailed exploration of the location of underground pipelines on the structures near the site is needed before construction, and the impact of damage to relevant facilities should be strictly monitored during the construction of the project to prevent safety accidents, and the monitoring of settlement displacement and horizontal displacement of landfill should be strengthened.

Acknowledgments

This work has received guidance and financial support from Engineer Li Shoufu. Thank you again.

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