Research On Analyzing Of Deep Excavation Under Seepage Condition

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Abstract. The round excavation with high groundwater level is near to a building. The safety of excavation needs to take into account the geological conditions, the influence of groundwater level and the surrounding environment; combined with the excavation monitoring example, the finite element software is used to simulate the influence of seepage and the stability of the adjacent building, and the simulation results are used to guide the layout of the monitoring points and the optimization of the monitoring scheme; the simulation results show that the effective stress value increases when considering the seepage effect. A 19mm lateral displacement will occur at the top of the underground diaphragm wall adjacent to the building, and a 59mm settlement will occur at a distance of 10m from the top of an underground diaphragm wall. The pore water pressure of the soil will gradually dissipate as the construction progresses; the difference between monitoring results and calculation results is small. The finite element simulation considering the seepage effect can well simulate the excavation with high groundwater leve. It is suggested that the effective stress caused by the seepage flow should be consider when the excavation with high groundwater level.

1.introduction

In recent years, with the continuous development of infrastructure construction, the construction conditions for foundation excavation have become more and more complicated [1-3], and the safety of foundation excavation has also been increasingly emphasized [4-6]. The groundwater level in the coastal and river (river) cities in China is generally high, and the impact of seepage on the stability of the foundation excavation must be accurately and reasonably considered in order to reasonably carry out the design of the excavation support structure, the arrangement of construction procedures, and the safety monitoring points Arrangements [7-8]. Finite element simulation is one of the simplest and most convenient methods for safety assessment of excavation. In recent years, it has been increasingly used in the safety design of foundation excavation. However, how to select more reasonable and more practical calculation parameters, and the simulation results how to guide engineering design, construction and safety monitoring need further research and exploration. This article takes advantage of the excavation project under high water level and adjacent buildings, and the PLAXIS finite element software is used to simulate the whole construction process.

2.Finite Element Simulations

2.1. Parameter selection

This calculation and analysis uses the Moore Coulomb model to simulate the soil, Characterization of soil properties using parameters such as Young's modulus, Poisson's ratio, cohesion, internal friction angle, and expansion angle to express. The connecting wall of the retaining structure is simulated by plate units, and the steel supports are simulated by bolt units.

According to the actual situation of the project, it is assumed that the seepage of water in the soil conforms to Darcy's law and the soil is isotropic. The influence scope of the seepage is characterized by the radius of influence R .considering the influence of precipitation on the foundation pit and its surrounding buildings, taking the 100m of the submerged line as the influence radius. The basic depth of the model is taken as 60m, and the deformation of the soil skeleton and the pore pressure dissipation are taken into consideration simultaneously in the calculation. The physical parameters of the finite element calculation are shown in Table 1.

Table 1 Physical Parameter Table of Finite Element

Soil layer	Severe γ/(kN/m^3)	Young's modulus E /(MPa)	Poisson's ratio v	cohesion c(kPa)	internal friction angle /φ(°)	expansion angle /ψ(°)	Permeability coefficient /K(m/day)	surface reduction factor /R_{inter}
Miscellaneous filling	16.5	9	0.32	20	15	0	0.1	0.6
Silt	16.5	9	0.33	26	19	0	0.11	0.6
Silty clay	17	10	0.32	25	19	0	0.12	0.63
Silt	17.2	20	0.31	24	17	0	0.14	0.65
Silty clay	18	30	0.3	28	15	0	0.1	0.7
Fine sand	18.5	80	0.3	4.5	28	0	0.13	0.7

As there are two office buildings in the southern part of the foundation pit, according to the design data of the building, the building has a strip foundation, the foundation width is 2.5m, and the load does not exceed 180kN/m. The excavation section in the direction of the office building is selected for calculation. A uniform load was applied at the 15m edge of the pit to simulate the presence of the office building.

A finite element model was established. This calculation was divided into 896 units and 6,457 nodes. Set the bottom surface of the model as a hydraulic boundary datum and impervious to water. The head of water and pore water pressure is calculated according to the height of the water line, and the water pressure at the water level line is 0. The pore water pressure distribution before and after the excavation is calculated. . The simulation was carried out strictly in accordance with the design and construction schedule. The first step of the simulation analysis was the balance of the ground stress, and the simulation steps were followed in accordance with the construction schedule, and the water level change caused by each precipitation was considered.
During the calculation, the groundwater level of the ground soil is input into the program. The program will generate external underwater pressure according to the external boundary conditions. When the deformation is calculated, the program will automatically treat the external water pressure as the load, the calculation results will be closer to the actual project at this time.

2.2 Simulation Results

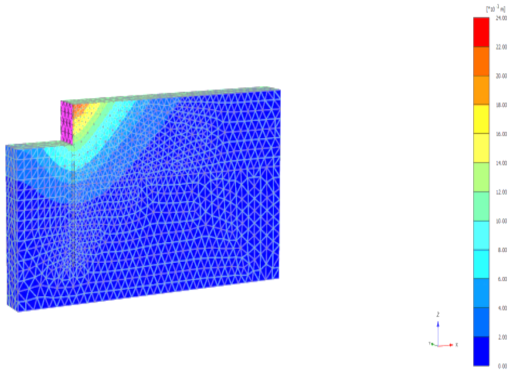

Fig. 1 Schematic diagram of excavation

According to Figure 1, the deformation of the foundation pit is mainly caused by the lateral displacement of the diaphragm Wall, and there is a settlement behind the wall. According to the simulation results, the main displacement during the excavation of the foundation pit occurred in the ground part of the diaphragm wall and the middle of the excavation depth. The maximum displacement of the wall of the diaphragm wall was 22mm, and the deep horizontal displacement of the diaphragm wall was 19mm. The maximum bending moment of the wall is 940kNm/m.

The calculation result of the soil settlement behind the wall shows that as the foundation pit excavation progresses, the surface settlement continues to increase. The maximum point is located 10m at the edge of the foundation pit, reaching 59mm. The surface settlement increases first and then decreases with increasing distance from the earth wall. Meet the general rule that the settlement of the foundation pit becomes smaller. The reason for the large settlement caused by the 10m edge of the foundation pit was analyzed. On the one hand, the uniform distribution of the office building was imposed on the edge of the foundation pit at 15m. On the other hand, the diaphragm wall produced a lateral displacement at the depth of the foundation pit of 9-13m. It will also lead to increased ground subsidence.

During the excavation and dewatering of foundation pit, the hydraulic conditions in the soil are changed, the original hydraulic equilibrium state is broken, the seepage field is generated, and the seepage force is converted into effective stress, which has an impact on the deformation of the soil and the stability of the slope.

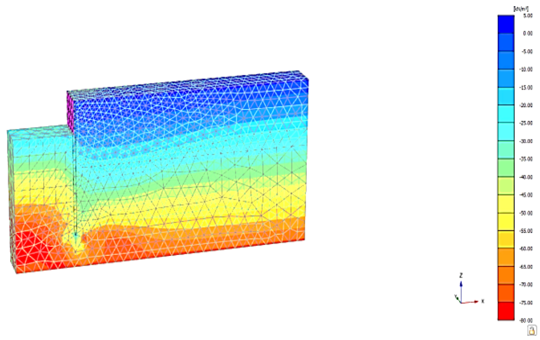

Fig. 2 Schematic diagram of Effective stress

Figure 2 shows the effective stress cloud map. Based on the calculation results, the total head energy in the foundation pit during excavation is smaller than that outside the pit, and the minimum point is located at the center point of the excavation surface of the foundation pit. Water flows from the out into the pit, possibly causing piping surges in the pit. The wall of the pit is unstable; precipitation will inevitably cause the pore pressure of the soil in the pit to dissipate, which will cause subsidence in the area near the pit. It is recommended that the well be kept away from the support structure to avoid potential safety hazards. Considering the effect of seepage on the effective stress, the pit will be affected. Settlement calculations increase during excavation.

In some practical engineering deformation calculations, the influence of the infiltration force (especially caused by the water level drop) on the effective stress is rarely considered. Since the increase of effective stress in geotechnical engineering is the main factor for the deformation and settlement of soil, it is necessary to pay attention to the change of effective stress in the calculation of deformation.

3.monitoring data analysis

According to the actual engineering needs and the calculation results of the stress and displacement of the finite element method, the data of the foundation pit section near the office building are selected for analysis.

3.1 monitoring results of horizontal displacement of ground wall

It can be seen from the monitoring results that the deep horizontal displacement of the ground wall in the adjacent office building changes most, the horizontal displacement of the diaphragm wall is on the inner side of the foundation pit, the maximum value is 20mm, and the maximum change rate in the early stage of excavation reaches 2.45mm/d.

The displacement of the horizontal displacement of the wall is shifted to the inside of the foundation pit, the maximum displacement occurs at the depth of the 10-11m foundation pit, the maximum value is up to 23.2mm, and the maximum daily change rate of its history is 2.28mm/d. The horizontal displacement curve of the wall top is analysed. It is known that in the early stage of the foundation pit excavation, the soil pressure in the inner and outer sides of the wall is unevenly changed. The soil inside the foundation pit is excavated and the wall is affected by the lateral soil of the foundation pit, and the top is moved to the inner part of the foundation pit. The earth pressure is gradually balanced, and the change rate of horizontal displacement at the top of the wall gradually decreases. The maximum daily variation rate has decreased to 0.03mm/d at the later stage, and it has been in a stable state.

According to the monitoring points of the foundation pit section in the direction of the office building, the lateral displacement and deep horizontal displacement of the top wall are 23.2mm and 20mm respectively. Compared with the finite element simulation results, the result of finite element simulation is about 5% smaller.

3.2 soil pressure and pore water pressure monitoring results

In the process of foundation pit excavation, the soil pressure in the inner excavation surface is reduced to 0 because of the excavation in the foundation pit, and the wall is shifted to the inside of the foundation pit under the active earth pressure. With the increase of the excavation depth, the joint effect of the beam and the vertical rib is affected,

The lateral displacement of the wall near the office building gradually becomes smaller. During the excavation of the foundation pit, the change trend of the earth pressure corresponds is similar to the displacement of the ground wall; in the later period of the monitoring, the soil pressure on the outside of the foundation pit has little change, and presents the basic stable state.

In the whole foundation pit, the change of pore water pressure on the outside of the ground wall has little change, and the maximum pore water pressure change is about 60kPa. With the excavation of the foundation pit, a certain horizontal migration of the ground wall to the inner side of the foundation pit is produced, and the pore water pressure of the soil outside the wall is gradually reduced and the effect of the water level and the pore water dissipating is the same. In the later stage of monitoring, the pore water pressure of the soil outside the foundation pit changes little, which showing a basically stable state.

3.3 surface subsidence monitoring results

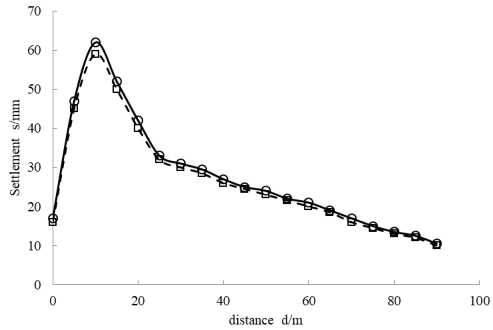

Fig. 3 Comparative chart of settlement and distance

The monitoring data of the settlement point near the office building is extracted and compared with the finite element simulation results. The results of the analysis are shown in Figure 4. The results show that the monitoring data are in good agreement with the finite element analysis results. This also reflects the accuracy of the finite element method for excavation considering the influence of seepage. According to the monitoring results, the maximum point of ground settlement is located at the edge of the foundation pit 10 m, the maximum value is about 62mm.

Compared with the finite element simulation results, the maximum surface settlement at 10m from the edge of the foundation pit is about 62mm, and the finite element simulation results are about 3% smaller.

4.Conclusions

1) The simulation analysis shows that the top of the wall will appear 19mm lateral displacement, the deep horizontal displacement of the diaphragm wall at the depth of the foundation pit is 22mm, and the maximum settlement of the ground surface is about 59mm from the 10m of the foundation pit at the edge of the foundation pit, compared with the actual engineering monitoring data, results show that the difference between the lateral displacement of diaphragm wall and the ground settlement is 5% and 3% respectively.

2) Considering the effect of seepage on the effective stress of soil, the increase of effective stress will lead to increasing of soil pressure and the change of the retaining structure of the foundation pit; when the water level is high, the dissipation of pore water pressure may lead to the occurrence of piping in the inner soil of the foundation pit or the instability of the foundation pit.

3) According to the comparison and analysis of the results of the engineering monitoring and the simulation analysis, the simulation analysis results is closer to the monitoring results when the deep foundation pit excavation in the area with high groundwater level. Considering the effect of the seepage to the stability is closer to the actual situation of the project.

It is suggested that the seepage to soil should be considered in the analysis of the stability of the foundation pit under the similar working conditions.

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