Hydraulic and Civil Engineering Technology VIII
M. Yang et al. (Eds.)

doi:10.3233/ATDE230702

Influence of Cutoff Wall on Excavation Deformation of Foundation Pit Under Dewatering Condition

Rui WU [a,b] and Jiajun PENG [a,1]
[a] *The Second Engineering Co., LTD., No.4 Navigation Bureau of China Communications, Guangzhou 510300, China*
[b] *Research Institute Co., Ltd., No.4 Navigation Bureau of China Communications, Guangzhou 510300, China*

Abstract. Based on the first phase foundation pit engineering of a ship lock, the excavation deformation of foundation pit under the condition of precipitation was studied. Taking cutoff wall as the research object, MIDAS numerical simulation is used to study the influence of the cutoff wall on soil deformation around foundation pit at different depths. The results show that: under the condition of precipitation, the soil around the foundation pit is subjected to the upward frictional resistance of the cut-off wall, and the soil settlement decreases with the increase of the depth of the cut-off wall, and decreases with the increase of the distance from the cut-off wall. Small, the mainly affected area of the soil is 1 to 2 times the excavation depth; the soil at the bottom of the foundation pit produces elastic uplift deformation, which is mainly affected by the penetration of water flow and less affected by the depth of the seepage wall.

Keywords. Cut-off wall, precipitation conditions, foundation pit, excavation deformation

1. Introduction

During the excavation of the foundation pit, in order to ensure the dry construction in the pit, it is necessary to lower the groundwater level in the pit to below the excavation surface. According to the code [1], before the construction of earthworks, the groundwater level in the foundation pit should be lowered to not less than 0.5m below the bottom surface of the lower earthwork to be excavated. In order to achieve the dewatering goal, it is necessary to set dewatering wells around or inside the foundation pit, which will inevitably cause seepage inside the soil and deformation of the surrounding environment, which will affect the safety of buildings (structures) near the foundation pit.

Aiming at the law of seepage and deformation of the soil around the foundation pit during the precipitation process, scholars at home and abroad have carried out research through various methods such as indoor model tests and numerical simulation analysis [2-4]. Among them, Ma Changhui et al. [5], Wang Qingyong et al. [6] used Visual

[1] Jiajun PENG, Corresponding author, The Second Engineering Co., LTD., No.4 Navigation Bureau of China Communications, Guangzhou 510300, China; E-mail: 1259743389@qq.com.

MODFLOW seepage software to analyze the seepage field of the foundation pit during the precipitation process, and studied the influence of the depth of the cut-off wall on the precipitation effect; Sun Erxiao et al. [7] borrowed The MIDAS GTS finite element software studies the deformation characteristics of the surrounding environment of the foundation pit during the dewatering and excavation construction process, and analyzes the distribution of the seepage field around the foundation pit.

This paper takes a ship lock foundation pit project as the background, borrows finite element software, establishes a two-dimensional model of foundation pit dewatering excavation, and focuses on analyzing the influence of the depth of the cutoff wall on the seepage field and deformation of the surrounding soil.

2. Project Overview

2.1. Background of Project

A water conservancy project is located at the mouth of Yuxi, the waterway of the Heyu Line. It is a comprehensive hub that controls flood control, drainage and irrigation in the Chaohu Lake Basin, with an important geographical location. In recent years, in order to solve the bottleneck of shipping and adapt to the large-scale development of ships, it is planned to expand the capacity of a certain ship lock. The renovation project of the main body of the ship lock adopts a two-stage and two-stage construction scheme, which is divided into the first-stage foundation pit and the second-stage foundation pit.

The first-stage foundation pit is mainly protected by the temporary flood embankment, the downstream annual cofferdam, the downstream sub-cofferdam and the excavation slope on the right bank. Among them, the excavation slope on the right bank transitions to the bottom of the foundation pit with a slope ratio of 1:3, and the slope surface is protected by turf. At ▽8.0m and ▽1.0m, set up abutment respectively, and the width of the abutment is 10m and 5m respectively. The ground connection wall is set on the 8.0m platform. The top elevation of the ground connection wall is ▽8.0m, and the bottom elevation is ▽-30.0m. Connected to prevent seepage together. A precipitation well is set at the ▽1.0m platform, and the control water level of the precipitation well is -11m. The first-stage foundation pit profile is shown in figure 1.

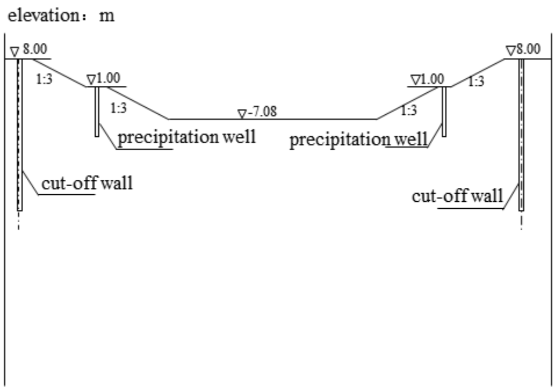

Figure 1. Sectional view of the foundation pit of the first phase.

2.2. Engineering Hydrogeological Conditions

The ship lock site is located at the confluence of the Yuxi River and the Yangtze River. It belongs to the alluvial plain area and the terrain is flat and open. The soil layers within the site range from top to bottom are plain fill, silty clay, silt interbedded silty clay, silty fine sand and gravel. The geological parameters of each soil layer are shown in table 1. The groundwater in the ship lock site is mainly divided into pore phreatic water and pore confined water. The pore phreatic water mainly exists in the silt and silt interlayer of shallow silty clay, and the confined water mainly exists in the silt and fine sand in the lower part of the relative water-resisting layer in sandy soil.

Table 1. Geological parameters of each soil layer.

soil layer	Compression modulus (MPa)	Cohesion (kPa)	Angle of internal friction (°)	Permeability coefficient (cm/s)	Elevation (m)
plain fill	4.45	8.0	17.5	1×10^{-5}	7
Silty Clay	4.10	26.0	13.8	2×10^{-6}	6
muddy silty clay	3.49	12.5	10.1	Level 5×10^{-5} Vertical 1×10^{-5}	-1.5
Silty sand with silty clay	9.92	20	26.6	1×10^{-4}	-5.5
fine sand	10.82	20	26.7	5.0×10^{-4}~2.8×10^{-3}	-38
gravel	200	8.0	28	2×10^{-2}~5×10^{-3}	

3. Computational Model Building

In this study, MIDAS GTS finite element software was used to simulate the whole process of foundation pit excavation and dewatering, and a two-dimensional model was established to analyze the influence of changing the depth of the cut-off wall on the deformation of the surrounding environment of the foundation pit under the condition of precipitation. In order to avoid boundary effects [8], the plane size of the soil is 3 times the excavation depth from the edge of the foundation pit, and the vertical size is 2 times the excavation depth. The size of the model is 226×60m, and it is excavated twice. The depths of each excavation are 7m and 8.08m respectively. The well points are dewatered before each excavation, and the precipitation depths are 5.44m and 11.5m respectively. The grid division of the foundation pit model is shown in figure 2. The linear elastic constitutive model is used for the cutoff wall, and the depths are respectively selected as 20m, 30m, 35m, 40m and 45m, and the modified Mohr-Coulomb constitutive model is used for the soil.

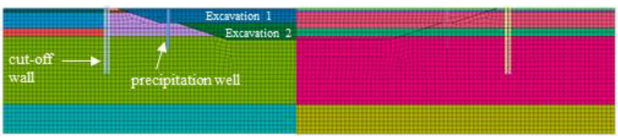

Figure 2. Grid division model of foundation pit.

According to the geological survey report, the initial groundwater level of the model is set at 5.84m, the boundary water head is set at 12.19m based on the 20-year upstream flood level, and the bottom of the foundation pit is set as the drainage boundary.

4. Foundation Pit Excavation Dewatering Simulation

Under the condition of precipitation, the deformation caused by the excavation of the foundation pit is mainly the settlement of the soil around the foundation pit, the uplift of the soil at the bottom of the pit.

4.1. Analysis of Soil Settlement around Foundation Pit

Figure 3 and figure 4 show the cloud diagram of the vertical displacement of the surrounding soil and the settlement curves of the soil around the foundation pit under different working conditions after two dewatering excavations of the foundation pit.

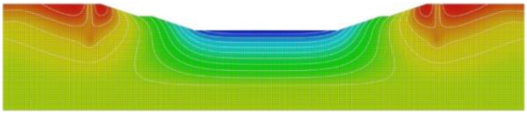

Figure 3. Cloud diagram of vertical displacement of soil around foundation pit.

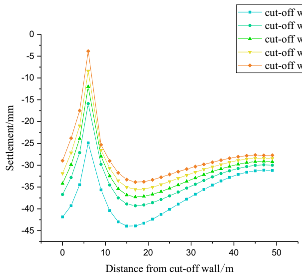

Figure 4. The settlement curve of the soil around the foundation pit.

It can be seen from figure 3 and figure 4 that the closer to the anti-seepage wall, the smaller the surrounding soil settlement, mainly due to the relative displacement between the soil settlement and the anti-seepage wall, and the anti-seepage wall body provides the upward friction of the soil. The downward movement of the soil is hindered, resulting in a smaller subsidence of the soil around the cutoff wall than in other areas; as the depth of the cutoff wall increases, the upward frictional resistance provided by the wall continues to increase, and the settlement of the soil Then it decreases, and as the distance from the cut-off wall increases, the settlement of the far soil also decreases with the increase of the depth of the cut-off wall. It can be seen from figure 4 that when the depth of the cutoff wall reaches 45m, the soil settlement is not much different from that when the cutoff wall is 40m, indicating that the depth of the cutoff wall has little effect on the soil settlement at this time, and the wall has no effect on the soil. It can be seen from figure 4 that the maximum settlement occurs at a distance of 10m from the cut-off wall, indicating that the main impact area of foundation pit precipitation is 10-15m from the wall, that is, 1 times the excavation depth, and from 40m to the outside The soil around the foundation pit is basically not affected, and the monitoring range of the foundation pit precipitation excavation in the future can be controlled to 1 to 2 times the excavation depth.

4.2. Analysis of Uplift of Foundation Pit Bottom

Since foundation pit excavation is a process of unloading, the soil at the bottom of the foundation pit rebounds, and at the same time, it is affected by the seepage force, and the bottom of the pit is uplifted and deformed [9]. Figure 5 is the cloud image of the uplift of the soil at the bottom of the foundation pit, in which the black line is the undeformed position of the foundation pit. In order to show the effect of the uplift of the bottom of the pit, the deformation of the cloud image has been enlarged by 100 times. Figure 6 is a diagram of the internal flow path of the foundation pit when the 20m cutoff wall acts as a water barrier, and figure 7 is a curve diagram of soil uplift within the bottom range of the foundation pit under the condition of cutoff walls of different depths.

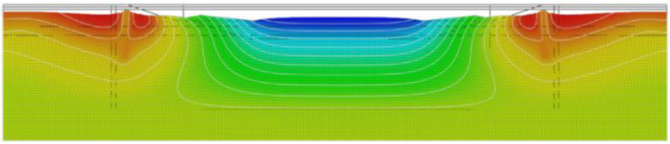

Figure 5. Cloud map of soil uplift at the bottom of the foundation pit.

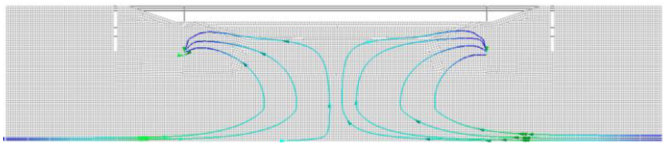

Figure 6. Diagram of the internal flow path of the foundation pit.

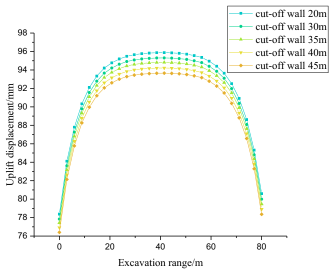

Figure 7. Uplift curve of pit bottom soil.

It can be seen from figure 6 that the soil mass at the bottom of the foundation pit is affected by the seepage force, and under the action of the pressure head, the soil mass at the bottom produces an uplift effect. It can be seen from figure 7 that the uplift deformation of the soil at the bottom of the pit is elastic uplift, which is characterized by "large in the middle and small on both sides", and the uplift displacement decreases with the increase of the depth of the cut-off wall. Increase, the flow path of free water inside the soil increases, the effect on the soil decreases, and the maximum uplift decreases from 95.8mm to 93.6mm. However, the amount of uplift of the soil at the bottom of the foundation pit decreased slightly, indicating that the amount of uplift at the bottom of the pit was under the condition of precipitation, and at the same time, it was squeezed by the horizontal displacement of the cutoff wall on the soil of the foundation pit and the upward seepage force [10]. And it is more affected by the penetration of water flow.

5. Conclusion

In this paper, the finite element numerical method is used to calculate and analyze the deformation of the surrounding soil during the excavation of the first-stage foundation pit of a certain ship lock under the condition of precipitation. Based on different depths of cut-off walls, the following conclusions are mainly drawn:

(1) Under each working condition, the soil around the foundation pit is affected by the upward frictional resistance of the cut-off wall during the subsidence process, and the settlement decreases with the increase of the depth of the cut-off wall, and decreases with the increase of the distance from the cut-off wall.

(2) Under the condition of precipitation, the soil around the foundation pit will be most affected at 15m from the side wall of the foundation pit, which is 1 times the excavation depth of the foundation pit. In actual construction projects, the monitoring range can be controlled to 1 to 2 times the excavation depth, and the monitoring of the vertical displacement of the cut-off wall should be strengthened.

(3) Under the condition of precipitation, the soil at the bottom of the pit shows "elastic uplift", which is mainly affected by the seepage force of upward water flow, and less affected by the depth of the seepage wall. Drainage measures should be taken in the project.

References

[1] Construction Code for Building Foundation Engineering: GB51004-2015, Beijing: China Planning Press, 2015

[2] Xiong ZB. Building Foundation Pit Support. Beijing: China Architecture and Building Press, 2013

[3] Ding CL, Zhou SH, Zhang SD. Factors influencing stability of confined water foundation pit deformation based on centrifugal test. Journal of Tongji University. 2005; 33(12): 1586–1591

[4] Huang LH, Wang GF. Study on environmental impact assessment of precipitation in a foundation pit in Shanghai. Construction Supervision and Cost. 2010; 3(5):5-8

[5] Ma CH, Mao Y, Huang W, et al. Research on the effect of curtain on seepage and deformation around foundation pit under precipitation conditions. Journal of Geotechnical Engineering. 2014; 36(Supplement 2): 294-298

[6] Wang QY, Jia ZH, Liu XF, et al. Visual MODFLOW and its application in groundwater simulation. Journal of Water Resources and Water Engineering. 2007; 18(5): 90-92.

[7] Sun EX, Zhao YC. Analysis of deformation behavior of foundation pit excavation under seepage-stress coupling. Journal of Shijiazhuang Railway University (Natural Science Edition). 2015; 28(4):48-52

[8] Yu HL, Lu JF, Li SD. Analysis of seepage characteristics of deep foundation pit engineering. Journal of Zhejiang University (Natural Science Edition). 2002;29(5): 595-600

[9] Cao LQ, Zheng G. Finite element analysis of the influence of precipitation in the pit on the uplift of deep foundation pit bottom in soft soil area. Journal of Geotechnical Engineering. 2008; 30 (Supplement): 332-337

[10] Ping Y, Bai SW, Xu YP. Numerical simulation research on seepage-stress coupling analysis of deep foundation pit engineering. Journal of Geotechnical Engineering. 2001; 22(1):37-41