Environmental Impact Assessment of Deep Pit Project in floodplain near Yangtze

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Abstract. The construction of deep pit has a great impact on the surrounding environment, which is mainly reflected in the subsidence of surrounding soil. Because of the particularity in geological and hydrogeological conditions of riverside floodplain area, environmental impact assessment is needed. According to the monitoring data of practical engineering, the deep pit in the floodplain area near Yangtze River may cause a large subsidence of the surrounding soil with a rapid subsidence rate and a wide range of subsidence effects. The subsidence of the surrounding soil increases with the depth and time of excavation, and the post-construction subsidence effect is not obvious. The environmental effects of the deep foundation pit project in this project have provided valuable experience for guiding the implementation of the deep foundation pit near the floodplain in the future.

1 Introduction

During the implementation of the foundation pit engineering, due to the construction of the retaining structure and piles of pit, the dewatering and the excavation of earthwork, the stress field around the foundation pit changes, which has a significant impact on the surrounding environment. The environmental effects of the pit engineering include deformation of the retaining structure caused by excavation and dewatering, horizontal and vertical displacement of the soil around the foundation pit. These deformations and subsidence may affect the normal use and even damage adjacent buildings and underground pipelines.

The environmental effects of the deep foundation pit engineering are mainly affected by the geological conditions of the foundation pit and the characters of the foundation pit. The geological conditions of the foundation pit include the soil within the excavation of the foundation pit, the soil under the foundation pit, and the groundwater. The characters of the foundation pit include excavation depth, dewatering methods, supporting methods, construction techniques, etc. Under different geological conditions, the environmental effects of deep foundation pits are quite different. It is necessary to carry out targeted assessment to determine the impact of foundation pit engineering on the environment, and to select appropriate construction method.

At present, due to the economic prosperity near Yangtze River, a large number of deep foundation pit projects are being built in the floodplain area near Yangtze River. Due to the large thickness of the sand layer and the high permeability, the floodplain has a wide range of influences on the aquifer. Most of the water curtains in the floodplain can not separate the hydraulic connection inside and outside the pit, and the subsidence effect is very obvious. Therefore, it is necessary to evaluate the environmental impacts of the deep foundation pit project in floodplain near Yangtze. This paper takes the deep pit of the open excavation section of the Nanjing Heyan-Road-Crossing-River-Tunnel Project (South Part) as an example to discuss the impact of the foundation pit on the surrounding environment during the excavation process with the suspended water curtain.

2 Project Overview

Nanjing Heyan-Road-Crossing-River-Tunnel Project is located between the Yangtze Bridge and the Second Yangtze Bridge. Shield tunnelling machine is used to bore across the Yangtze River. The shield work shaft size is 27m*47m, with a depth of 25.7m. The supporting system is consisted of a 1000mm thick diaphragm wall of 48m depth, 4 reinforced concrete support and 1 Φ800 steel support.

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Figure.1 shield work shaft profile

The shallow aquifer in the shallow part of the project is mainly composed of cohesive soil and silty soil with a thickness of 7 m. Its permeability and water-richness are poor, and the water volume is poor. The confined aquifers are mainly sandy soils. It appears a distinct binary structure. The upper section are silt and fine sand, while the lower section are medium coarse sand, gravel sand and round gravel. The depth of the groundwater level is generally 1-3m.

3 Environmental effects

The amount of land subsidence has a certain relationship with the excavation depth and excavation time. Generally speaking, the deeper the excavation is, the larger the subsidence is. During the excavation, the surrounding soil is disturbed. Even the excavation is finished, there still exists a considerable long period of consolidation subsidence. Affected by the barrier structure of the retaining wall and other supporting structures, the maximum point of the surrounding ground subsidence is not near the pit wall, but a certain distance from the foundation pit.

Due to the heavy vehicles driving around the foundation pit and the occupation of the site, subsidence monitoring is carried out on the ground 20~50m away from the edge of the foundation pit (0.8~2 times of excavation depth). The relationship between subsidence of monitoring points and its distance to the edge of pit is shown in Figure 2.

At the first week, an excavation of 2m is carried and then after the first concrete support is poured. The point 20m away from the pit (Named **Point A**) has a subsidence of 3.1mm, while the point 50m away from the pit (Named **Point B**) has a subsidence of 1.7mm. The foundation pit is dewatered and the soil around the foundation pit is slightly

consolidation. At this time, the water level in the pit decreased by 9.1m, and the water level outside the pit decreased by 1.6m. It can be seen that the water curtain can not cut off hydraulic connection between the inside and outside of the pit, but the influence of the dewatering in the pit on the ground subsidence outside the pit is small. Then, as the strength of the concrete supporting structure increases, the soil around the foundation pit rebounds slightly.

Five weeks after, a large-scale excavation begins and surrounding soil descends at a fast rate. The maximum daily subsidence can reach 0.91mm. Six weeks after, excavation depth comes to 6.1m. At this time, the **Point A** settles to 19.8 mm, and the **Point B** settles to 11.6mm. The subsidence of **Point B** is 58.6% compared to that of **Point A**. At this time, the groundwater level in the pit decreased by 14.3m, and that outside the pit decreased by 2.9m. 18 meters away from the foundation pit, the recharge wells begin to operate in order to maintain the groundwater level at the initial water level, and the impact of the groundwater drawdown on the surrounding soil subsidence can be neglected. Nine weeks after, the bottom of pit is excavated. The **Point A** settles to 36.4 mm, and the **Point B** settles to 18.2mm. The subsidence of **Point B** is 50% compared to that of **Point A**. At this time, the groundwater level in the pit decreased by 22.3m, while the groundwater level outside the pit decreased by 4.4m. The recharge wells continue to operate, maintaining the groundwater level at the original initial water level.

After casting the pit floor, surrounding soil subsidence still continues with maximum daily subsidence of 0.77mm. Until fourteen weeks, the subsidence of surrounding soil substantially stopped. The **Point A** settles to 57.3mm, and the **Point B** settles to 31.5 mm. The subsidence of **Point B** is 55% compared to that of **Point A**. As the structural strength of the floor increases, the soil around the foundation pit rebounds slightly by 1~2 mm.

Figure.2 The relationship between the subsidence and the distance to the pit edge

It can be seen from Fig. 2 that with the increase of the excavation depth and the excavation time, the subsidence of the soil outside the foundation pit gradually increases. In the range of 0.8~2 times of excavation depth from the edge of the foundation pit, the subsidence decreases approximately linearly with the increase of the distance from the edge of the foundation pit.

Surrounding soil subsidence caused by excavation effects is mainly due to the foundation heave and retaining wall displacement. Vertical unloading changes the original stress state of the soil at the bottom of the pit, resulting in the uplift of the soil at the bottom of the pit. The difference between the soil pressure inside and outside the pit leads to the displacement deformation of the retaining wall. With the increase of the depth of the excavation, the height difference between the inner and the outer surface of the pit increases. As the pressure difference between the inside and outside of the pit gradually increases, and the soil uplift at the bottom of the pit and the displacement deformation of the retaining wall increase, resulting in a gradual increase in the soil subsidence. After the foundation pit excavation is completed, the soil stress continues to release due to the unfinished support structure. Soil deformation have a certain hysteresis, so the soil around the foundation pit continues to settle and deform. As the foundation pit support and the bottom plate are completed and its strength increases, and the soil around the foundation pit rebounds slightly.

4 Conclusions and prospects

The sandstone layer of the floodplain near Yangtze River is thick, and the groundwater is closely connected with the Yangtze River. It is difficult to cut off the water connection between the inside and outside of the pit, so it

is necessary to evaluate the environmental impact of the foundation pit project. According to the practice of Nanjing Heyan-Road-Crossing-River-Tunnels, it can be seen that the subsidence of the surrounding soil caused by the excavation of the foundation pit is large, and the maximum subsidence is close to 60mm. When the foundation pit in the pit is dewatered, the water level outside the pit changes greatly, and the hydraulic connection between the pit and the outside is relatively tight. Therefore, it is necessary to arrange recharge wells around the protected buildings to maintain the groundwater level outside the pit. The subsidence of soil outside the foundation pit is obviously affected by the excavation depth and excavation time. Within the range of 0.8~2 times of excavation depth from the edge of the foundation pit, the subsidence decreases linearly with the increase of the distance to the edge of the foundation pit. At the range farther to 2 times of the excavation depth, soil subsidence is still significantly affected up to half of the maximum subsidence. The excavation of the foundation pit in the floodplain causes a large subsidence and fast subsidence speed. It has significant difference of the environmental effects with the foundation pit engineering in the soft soil area of Shanghai. Therefore, it is necessary to pay attention to the pit in floodplain and make environmental monitoring assessment and prevention to ensure the normal use of surrounding structures.

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