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Design and Deformation Monitoring of Complex Support in Deep Foundation Pit

Changyi Yu^{1 2 3 4*}

¹ CCCC-Tianjin Port Engineering Institute, Ltd., Tianjin 300222, China

² CCCC First Harbor Engineering Company, Ltd., Tianjin 300461, China

³ Key Laboratory of Geotechnical Engineering, Ministry of Communications, Tianjin 300222, China

⁴ Key Laboratory of Geotechnical Engineering of Tianjin, Tianjin 300222, China;

* Corresponding author's e-mail: yu_longone@163.com

Abstract. In this paper, the supporting scheme of a deep foundation pit project is designed, and the supporting structure system of complex horizontal support form and the ground wall are put forward. On this basis, the necessity of foundation pit construction monitoring is put forward, the contents, principles and basis of foundation pit monitoring are summarized, the purpose and function of foundation pit monitoring, the principles of designing monitoring system and the basic requirements of monitoring are clearly defined, the arrangement of displacement measuring points and data processing methods are emphatically studied, and the methods and methods of measuring point arrangement are given. The monitoring results of soil settlement around foundation pit, horizontal displacement of supporting structure and pit bottom uplift are analyzed and evaluated. It provides a reference for monitoring complex supporting forms of deep foundation pit.

1. Introduction

The traditional foundation pit monitoring focuses on safety prediction, such as monitoring the supporting structure and surrounding environment. The monitoring content and monitoring scheme are mainly determined according to the safety level of the foundation pit and the monitoring capacity of the monitoring unit. The so-called "information construction" only deals with the monitoring data and then estimates the possible characteristics of the foundation pit in the subsequent construction based on the construction experience[1], so as to adjust the construction scheme accordingly. Monitoring of foundation pit construction aiming at safety forecast is very important for safe construction[2].

In the deep foundation pit project, the content of construction monitoring is extensive[3]. Monitoring with safety forecast as the main goal plays an important role in safety construction and information construction, and has gained many successful experiences[4].

The construction monitoring of deep foundation pit is a complicated systematic project, in which the selection of monitoring methods and the arrangement of measuring points are very important[5]. Based on the spatial nonlinear interaction between soil and structure, the monitoring of foundation pit construction for the purpose of displacement back analysis and safety prediction has the following two main functions and purposes[6-7]:



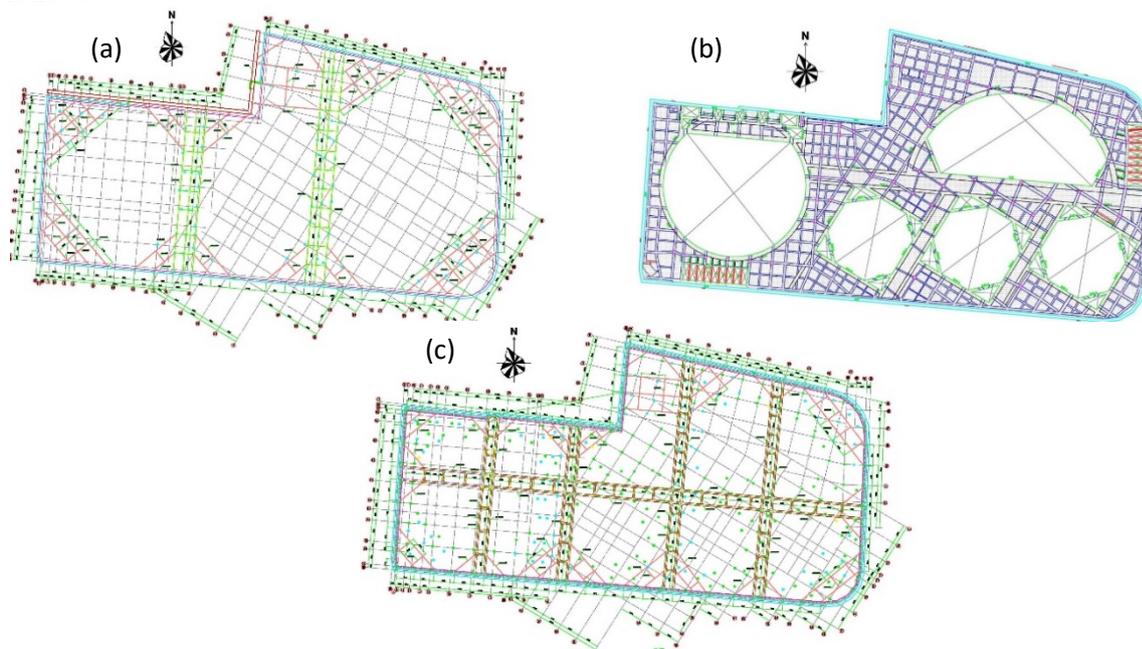
(1) Provide the measured displacement values at different depths on the section of the foundation pit supporting structure to reflect the overall characteristics of the foundation pit, and use these measured values to carry out inversion of soil parameters so as to correct the construction parameters, improve the supporting design, and have a certain understanding of the mechanical state of the foundation pit at each construction stage.

(2) According to the requirements of foundation pit safety forecast, provide timely and accurate physical and mechanical observation values, and judge the status and possible development trend of foundation pit by analysing these observation values. Once the observation values are close to the early warning values, measures can be taken in time to prevent engineering accidents.

2. Foundation pit supporting design

The proposed foundation plane area of the foundation pit project is about 13000~14,000m², and the entire foundation pit depth is 19.40 m. There are both subway stations and urban main roads around the foundation pit, with dense pipelines and very high requirements for deformation of the foundation pit. In addition, due to the existence of the confined water layer at the bottom of the pit, the anti-surge capacity at the bottom of the pit is insufficient, which may lead to surge damage. Special attention should be paid to taking effective measures to avoid the surge damage of the pit. The type of surface groundwater in the site is quaternary pore phreatic water. The main soil is silty sand and silt. The underground water level is about 1.3m below the surface of the earth. It belongs to the diving type and is mainly replenished by atmospheric precipitation and discharged by evaporation.

According to the underground soil quality of the project, the surrounding site conditions and the depth of foundation pit, as well as the height requirements of each basement floor, it is reasonable to choose a two-wall integration scheme with a 1000 mm thick underground continuous wall as the structural wall. In order to reduce the supporting cost, control the deformation around the foundation pit, save the construction period, reduce the construction difficulty and facilitate the mechanized construction of earthwork excavation of the foundation pit, five horizontal supports are set up in the foundation pit. It is convenient for the construction of the main building and foundation of the building, and the horizontal support is set as a large-diameter circular hole. The working condition diagram is as follows:



(a) First support. (b) Second to fourth support. (c) Fifth support.

Figure 1. Schematic diagram of horizontal support.

3. Arrangement of monitoring points

In order to accurately measure the horizontal displacement of the supporting structure in the process of foundation pit construction and provide accurate and reliable measurement data for displacement back analysis, a careful and effective displacement measurement system is needed, which is the key to inversion of soil parameters. However, the previous layout of measuring points did not fit well with the supporting design. The number of survey points is limited, so the differences of geological conditions and supporting structures in various regions cannot be considered, and the overall information of foundation pit status reflected is not comprehensive enough. In addition to considering the requirements of the traditional safety forecast monitoring on the arrangement of measuring points, it is necessary to meet the dual requirements of displacement back analysis and safety forecast.

This project focuses on monitoring the lateral displacement of the underground continuous wall, the layered settlement of the soil layer outside the pit, and the water level outside the pit.. The layout of each monitoring point is shown in figure 2.

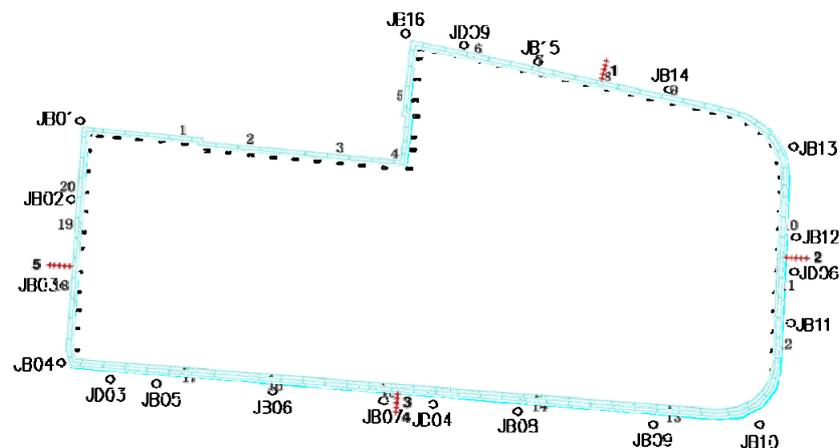


Figure 2. Measuring point layout. (△) Lateral displacement of diaphragm wall. (JB) Ground settlement monitoring points outside the pit. (++++) Water level monitoring points outside the pit.

4. Monitoring results

The maximum horizontal displacement of the east underground continuous wall into the pit is 20.9 mm, which occurs at about 16.0 m below the ground, the maximum horizontal displacement of the south underground continuous wall into the pit is 44.5 mm, which occurs at about 16.5 m, the maximum horizontal displacement of the west underground continuous wall into the pit is 39.7 mm, which occurs at about 15.0 m, and the maximum horizontal displacement of the north underground continuous wall into the pit is 13.1 mm, which occurs at about 14.0 m .. The monitoring data curve of representative monitoring points is shown in figure 3.

According to the monitoring data of ground settlement outside the pit, the accumulated value of ground settlement outside the pit is generally between 20.0 mm and 22.0 mm. The ground settlement curve of monitoring points is shown in figure 4.

According to the analysis of monitoring data of underground water level outside the pit, the underground water level outside the pit is relatively stable, the fluctuation amplitude of water level is small, and the fluctuation is less than 2.0m. The monitoring curve of groundwater level outside the pit at representative monitoring points is shown in figure 5.

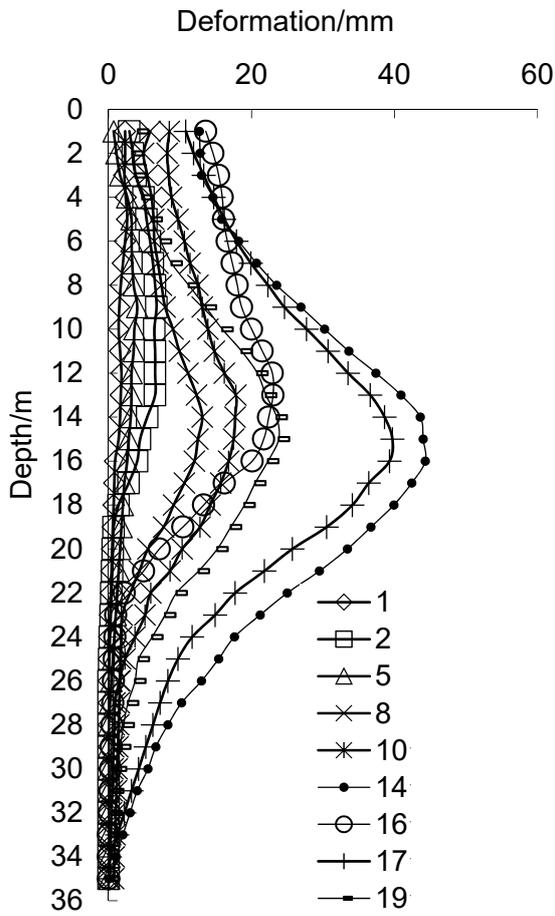


Figure 3. Horizontal displacement curve of underground continuous wall.

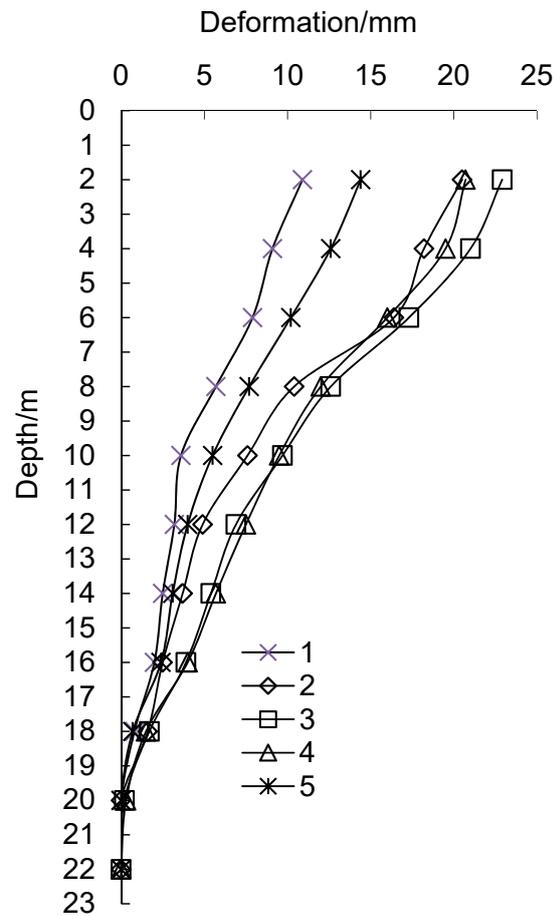


Figure 4. Ground settlement curve outside the pit.

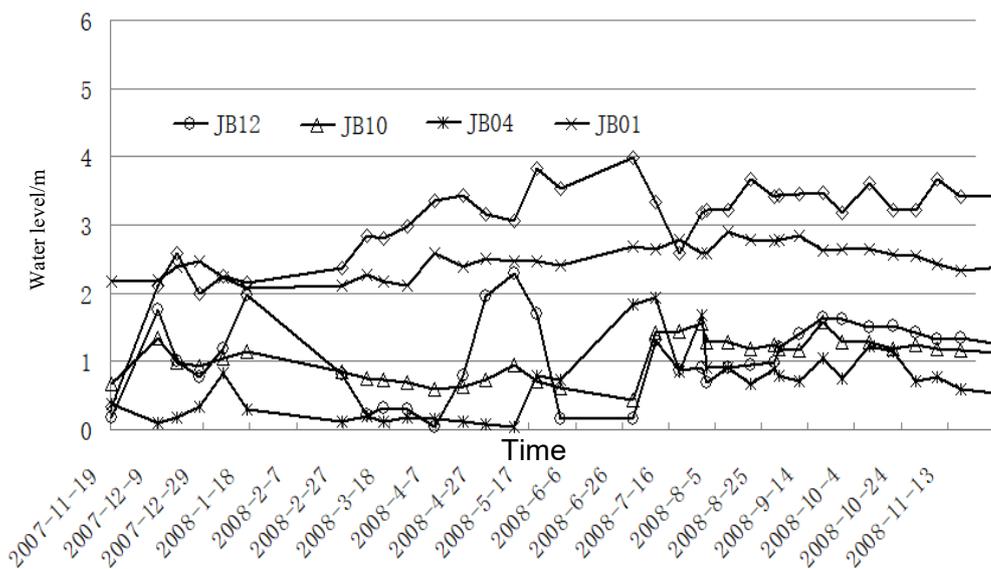


Figure 5. Water level change curve outside the pit.

5. Conclusion

During the excavation of foundation pit, the excavation of earthwork will result in the temporary empty surface, which will lead to large settlement of soil around the foundation pit. If not properly controlled, it will easily cause damage to surrounding buildings and underground pipelines. The displacement of soil decreases with the increase of distance from foundation pit. The farther away from foundation pit, the smaller the displacement would be, and the displacement of soil increases with the increase of excavation depth. For coastal soft soil areas, the rheological effect of soil is obvious, and the soil displacement caused by rheology is the main part of the total displacement of soil. Therefore, in the process of foundation pit excavation, the exposure time of unsupported structures should be reduced as much as possible, the progress of bottom slab casting should be accelerated, and excessive horizontal and vertical displacement due to soil rheology should be prevented. With the excavation of the foundation pit, the horizontal displacement of the supporting structure of the foundation pit gradually increases, the horizontal displacement of the top of the supporting structure is the largest in the center of the pit wall, and the displacement of the end part is relatively small. The deeper the pit wall is, the greater the horizontal displacement would be. According to the monitoring data, the underground continuous wall of the foundation pit supporting structure has different degrees of lateral horizontal displacement at different depths, and the maximum lateral deformation of the underground continuous wall appears in the middle and lower part of the supporting structure. The monitoring data of the water level outside the foundation pit show that the change range of the groundwater level outside the pit is small and the maximum is only 2.0m. Considering the monitoring period is longer than one year, seasonal water level changes will also affect the groundwater level, indicating that the curtain of the project design is very effective.

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