Deep foundation pit monitoring technology and safety protection for a three-dimensional kitchen waste treatment plant

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Abstract. The three-dimensional kitchen waste treatment plant has the characteristics of intensive use of land resources, and has been applied in the new kitchen waste treatment plant in mega cities. But the super large scale of the foundation pit brings challenges to the safe construction of the foundation pit. Due to the large excavation area and depth, it is easy to affect the surrounding buildings and surrounding environment. Therefore, taking the construction project of food waste treatment plant in Guangming environment Park as an example, three safety protection methods are adopted for the foundation pit, including three internal supports, two internal supports combined with two anchor cables and two supports, and the displacement changes of relevant parts during the construction of the foundation pit are monitored in real time. The monitoring results show that: the monitoring indicators of the foundation pit do not exceed the control value, the protection mode has a certain degree of safety redundancy, and the monitoring technology has high reliability.

Keywords: Deep foundation pit; monitoring technology; kitchen waste treatment plant

1 Introduction

China has a large population and great differences in eating habits. Food waste has the characteristics of huge production, high moisture content and organic matter content, which creates favorable conditions for the resource utilization of food waste[1-3]. Over the years, various places have started the planning and facility construction of food waste treatment projects, and are also constantly exploring the food waste treatment methods suitable for China's national conditions. At present, domestic food waste treatment plants generally adopt planar layout, which covers a large area and is located in a remote location, making it difficult to transport food waste.

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Semi underground food waste treatment plant is a kind of food waste treatment plant with sewage treatment system laid underground and other equipment and facilities laid on the ground in a three-dimensional manner. Its unique three-dimensional building form not only solves the problem of scarcity of land resources, but also effectively solves the problems of remote location, high operation cost and environmental protection difficulty of the traditional food waste treatment plant[4]. But this highly intensive three-dimensional building mode brings new challenges to the safety of foundation pit construction.

Therefore, on the basis of setting up safety protection measures, this paper uses Internet of things and other technologies to carry out safety monitoring of foundation pit construction, puts forward targeted monitoring technology points and feedback opinions, verifies the redundancy of safety protection measures and the reliability of detection methods, and provides reference for similar three-dimensional engineering construction in the future.

2 Materials and Methods

2.1 Project overview

Guangming environment Park project is located in Guangming District, Shenzhen. The main buildings and structures newly built in the project include main workshop, management building, gutter oil workshop, large garden pretreatment workshop, anaerobic tank farm, etc., involving main structure engineering, equipment foundation engineering, foundation pit engineering, pile foundation engineering, slope retaining wall engineering, etc. The proposed building has 1-4 floors above ground and 1-2 floors of local basements. The design elevation ± 0.00 is 50.0m and 57.0m, and the site leveling elevation is about 50.0-57.0m. The excavation depth of the main foundation pit of the project is about 19.30 meters, and the depth of the east area is about 14.30 meters. Within the excavation depth of the foundation pit, the soil layer of the side wall is miscellaneous fill, muddy soil, etc., and the bottom of the foundation pit is located in the sandy cohesive soil layer. The effect picture of the project is shown in Figure 1.

Fig. 1. Project rendering.

2.2 Characteristics of foundation pit construction environment

During the excavation and construction of the foundation pit of the project, combined with the surrounding environment, it is proposed to adopt the form of pile anchor pile support for support. According to the excavation depth, the foundation pit shall be supported by two or three layers of concrete, and the anchor cable shall be added at the necessary position. The impact degree of buildings and structures around the project is shown in Table 1.

Table 1. Impact degree of buildings and structures around the project.

Name of buildings in the plant	Name of adjacent buildings	Safety distance (m)	
		Standard value	Design value of protection scheme
Large and green waste treatment workshop	220kV high voltage line	≥40	44.5
	Great outer ring expressway	≥30	38
	West east gas pipeline 2	≥50	156
Office building	220kV high voltage line	≥40	45.5
Tank in anaerobic reaction area	220kV high voltage line	≥40	46.5
Complex building	Great outer ring expressway	≥30	47
	West east gas pipeline 2	≥50	165
	Planning Kefa Road	≥15	90.2
Main power house	Planning Kefa Road	≥15	68.5
Double film gas holder	Planning Kefa Road	≥15	67
torch	Planning Kefa Road	≥15	50

2.3 Monitoring scheme

The monitoring points are uniformly arranged at the positions of the inner support structure and the surrounding buildings (structures) to form a three-dimensional monitoring system, so as to systematically understand the displacement, deformation, stress and other conditions of all monitoring objects during the whole construction process.

The monitoring objects of the project are mainly divided into foundation pit support and structure monitoring, surrounding environment monitoring and slope monitoring.

The main monitoring contents of the foundation pit support and structure monitoring are the horizontal displacement monitoring of the top of the support pile, the vertical displacement monitoring of the top of the support pile, the deep horizontal displacement (inclinometer) monitoring, the support axial force monitoring, the support column settlement monitoring, and the anchor cable stress monitoring. The main contents of the surrounding environment monitoring are the underground water level monitoring, the surface settlement monitoring, and the building (structure) settlement monitoring, The main contents of slope monitoring are slope top settlement monitoring, slope top horizontal displacement monitoring and anchor rod tension monitoring [5-8]. The control and early warning values of various monitoring indicators are shown in Table 2.

Table 2. Control and early warning values of monitoring indicators.

Serial number	Monitoring items	Rate of change	Cumulative control value	Early warning value
1	Groundwater level	/	5m	4m
2	Surface subsidence	3mm/d	30mm	16mm
3	Settlement of surrounding buildings	2mm/d	20mm	16mm
4	Supporting axial force	/	5000kN 13000kn 14000kn	4000kn 10600kn 11200kn
5	Deep horizontal displacement	3mm/d	50mm	40mm
6	Horizontal displacement of retaining pile top	3mm/d	30mm	24mm
7	Settlement of retaining pile top	2mm/d	20mm	16mm
8	Support column settlement	2mm/d	20mm	16mm
9	Anchor cable stress	/	600kN 500kN	480kn 400kN

2.4 Monitoring instruments and related equipment and facilities

In this monitoring project, the monitoring instruments and related equipment and facilities are shown in Table 3.

Table 3. Monitoring instruments and related equipment and facilities.

Name	Model and specification	Quantity	accuracy

Level gauge	Sdl1x	1	± 0.3mm/km
Total station	Try S5	1	1+1.5ppm
Intelligent wireless acquisition terminal	Lrk-dz622a	20	0.1Hz
Inclinometer	Cx-3e	1	0.01mm/0.5m
Automatic water level gauge	Ryy-sw02	14	1mm
Computer, printer		1	/

2.5 Monitoring information data processing

The informatization of real-time monitoring process, the establishment of smooth and efficient information transmission channels, and the timely and accurate feedback of monitoring information are very important for the safe construction of foundation pit. In this monitoring project, the monitoring information transmission process is shown in Figure 2.

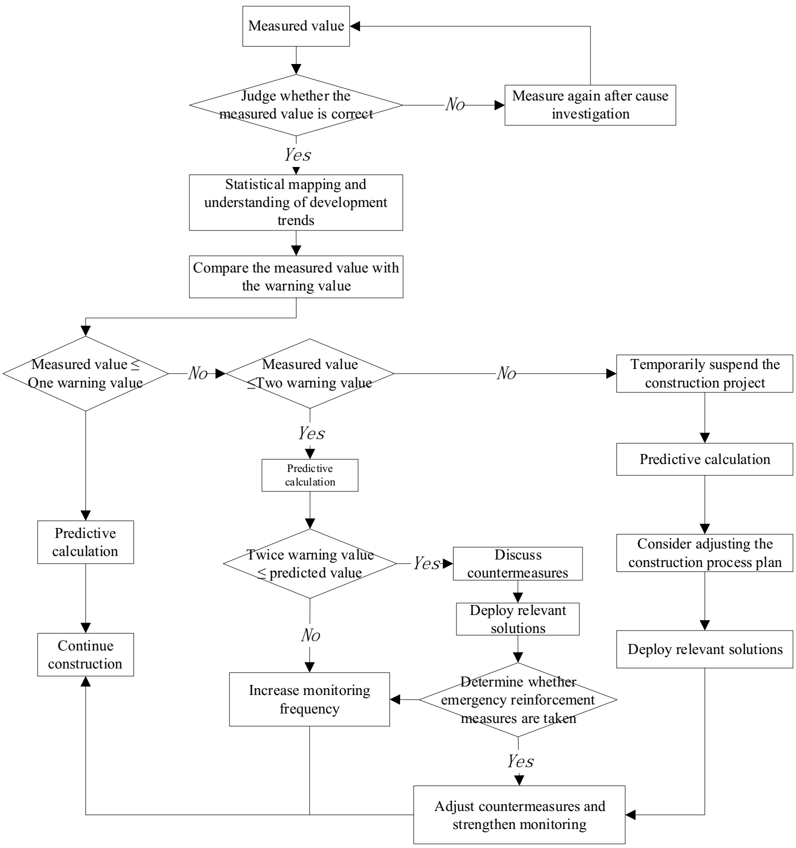

Fig. 2. Monitoring information transmission process.

3 Results & Discussion

The monitoring period of this monitoring project is 12 months. The following is a representative analysis of the monitoring contents of groundwater level, support axial force, horizontal displacement of retaining pile top and horizontal displacement of slope top in combination with the summary data.

3.1 Groundwater level

As shown in Figure 3, the monitoring data of groundwater level is basically stable, and the maximum accumulated settlement point is SW5, which is located in the east of the foundation pit. The accumulated change is -2516.00mm, and the change is within ± 5000mm of the control value. At the later stage of monitoring, it tends to converge and the change rate tends to moderate.

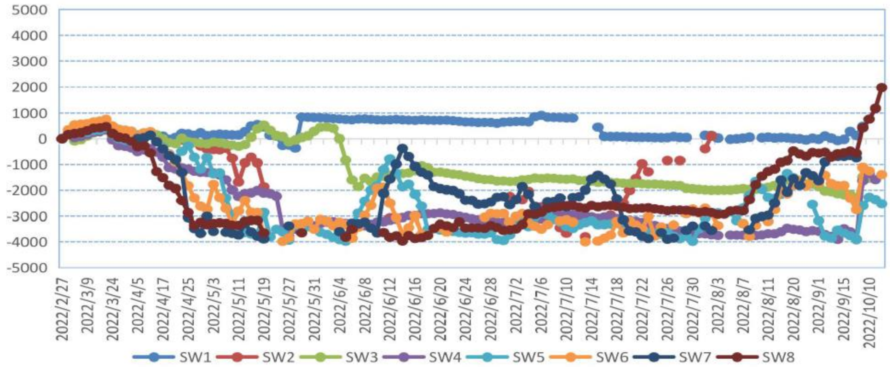

Fig. 3. Groundwater level.

3.2 Supporting axial force

As shown in Figure 4, the monitoring data of the horizontal displacement at the top of the retaining pile is basically stable, and the maximum accumulated settlement point is w9, which is located at the north side of the foundation pit. The accumulated displacement is -20.30mm, and the variation is within the control value. The change rate during observation is also lower than the control requirement of ± 3mm/d. Other monitoring points basically tended to converge and the change rate tended to moderate in the later period.

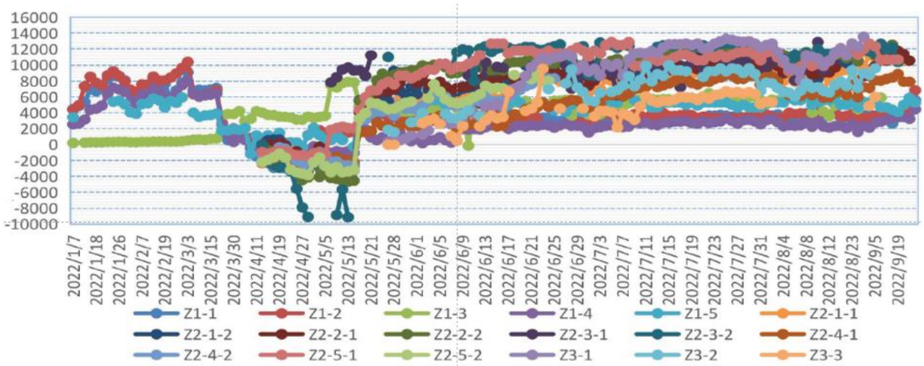

Fig. 4 supporting axial force.

3.3 Horizontal displacement of retaining pile top

As shown in Figure 5, the monitoring data of the horizontal displacement at the top of the retaining pile is basically stable, and the maximum accumulated settlement point is w9, which is located at the north side of the foundation pit. The accumulated displacement is -20.30mm, and the variation is within the control value. The change rate during observation is also lower than the control requirement of ± 3mm/d. Other monitoring points tend to converge and the change rate tends to moderate in the later period.

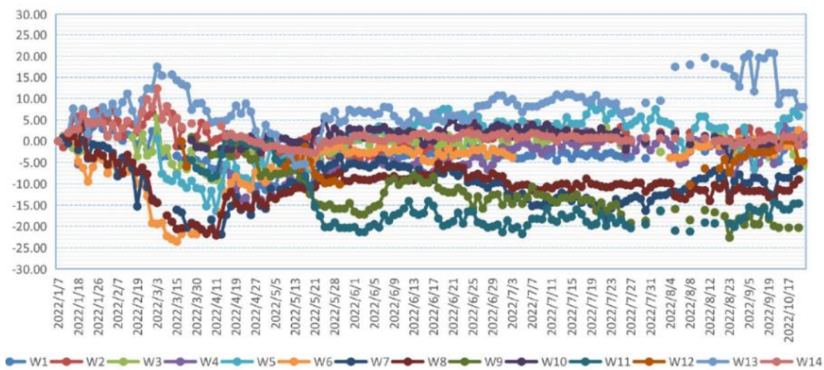

Fig. 5. Horizontal displacement of enclosure pile top

3.4 Horizontal displacement of slope top

As shown in Figure 6, the monitoring data of slope settlement is basically stable. The maximum point of cumulative settlement is BP1, which is located in the north of the foundation pit site. The cumulative change value is -7.93 mm, and the change value is within ± 30mm of the control value. The change rate during the observation period was also lower than ± 3mm/d. Other monitoring points basically tended to converge and the change rate tended to moderate in the later period.

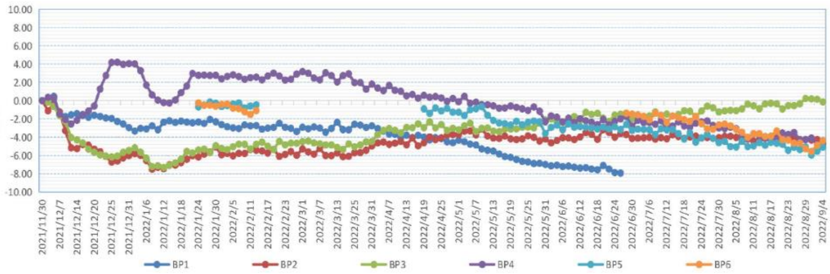

Fig. 6. Horizontal displacement of slope top

4 Conclusions

Taking the construction project of Guangming environmental Park as an example, this project uses information monitoring means to conduct regular statistical analysis on the data of groundwater level, surface settlement, surrounding building settlement, support axial force, deep horizontal displacement and so on. The analysis shows that the deep foundation pit of this project is in a safe state in the early stage of construction monitoring.

In addition, in view of the deformation of the retaining structure of the foundation pit and the surrounding environment during construction, the process arrangement of the foundation pit excavation and the number of on-site mechanical construction were optimized, and the cumulative monitoring value did not exceed the control value, avoiding the occurrence of safety accidents.

To sum up, the safety protection measures of the project have good redundancy, and the detection method has certain reliability, which can provide reference for similar three-dimensional engineering construction in the future.

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