

The Application of Foundation Pit Monitoring Technology to the Excavation

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ABSTRACT: The foundation pit monitoring plays an important role in the foundation pit supporting projects especially in those deep foundation pit projects. Through the whole monitoring of the foundation pit construction from the excavation to the backfill, we can learn about the forcing and deforming process of the foundation pit supporting system, and grasp the impact of external condition changes on the foundation pit. This paper takes a project in Jinan as an example to establish a specific monitoring program, and then conducts the analysis and evaluation of the monitoring data; the real-time grasp of the foundation pit deformation and internal force changes can help to further ensure the security status of the foundation pit, thus better guiding the construction.

Keywords: foundation pit monitoring; data analysis; foundation pit excavation; construction

1 INTRODUCTION

Foundation pit monitoring refers to the safety inspection and monitoring of the building foundation pit and the surrounding environment within the construction and the use period. Due to the uncertainty of the underground soil nature, load conditions and other factors, the systematic and accurate monitoring must be conducted before the construction. And the feedback guidance will be given for the project according to the dynamic information monitored on site, and the construction intensity will be real-time reflected via the monitoring data to provide a reliable basis for the control of construction costs^[1]. Meanwhile, the foundation pit monitoring can help constructors to learn about extent of the impact on the underground pipeline, underground soil, underground facilities and surface buildings to timely grasp the possible dangers and take emergency measures.

2 PROJECT INTRODUCTION

The project is located in the courtyard area of the city government on Weier Road, and the proposed building is bordered by Zhanqian Street to the east, Jinger Road to the south, and Shengping Street to the north. The foundation pit is about 85m long and 57m wide, and adopts piles for the supporting with the depth of 16.0-17.50m, which is a first class foundation pit. And its building nature is shown in Table 1.

The quaternary geomorphic unit of the field zone is the lower part of a piedmont inclined plain with a flat terrain, and original buildings in the zone have been demolished, covered with a small amount of construction waste, and most of the surrounding buildings are high-rise; the quaternary stratum of the field zone is mainly piedmont alluvial cohesive soil and gravelly soil as well as underlying Mesozoic Yanshanian gabbro, with the natural ground elevation of 33.87 ~ 34.45m; the groundwater is the quaternary porosity phreatic water, and the static level depth measured during exploration is 7.05 ~ 8.00 m.

3 SUPPORTING PROGRAM OF THE FOUNDATION PIT

The row-pile supporting is adopted by this foundation pit project. And the underground water is controlled through the water interception achieved by high pressure jet grouting curtain and water falling achieved by large-diameter tubes. The monitoring of the slop-top horizontal and deep horizontal displacement, surrounding environment deformation and underground water level provide a basis for the information construction and optimization design, thus ensuring the safety of the supporting structure and the protection of the surrounding environment^[2]. The project is divided into six profiles: 1, 2, 3, 4, 5 and 6. And the profiles of the supporting structure are shown in Figures 1-6.

Table 1. Basic Information of the Project

Name	Structure Type	Base Type	Safety Level	Floors/ Height	Column Space/ Span	Length/ Width	Under-ground Floors	Base Depth
Main Building	Frame shear	Pile	2	24 floors /99.15m eters	7.8*8.4m	43.8m/2 4.8m	3 Floors	12.5m
Podiums	Frame	Pile or Raft	2	6 floors /28.35m eters	7.8*8.0m	69.7m/2 8.6m	Floor	12.5m

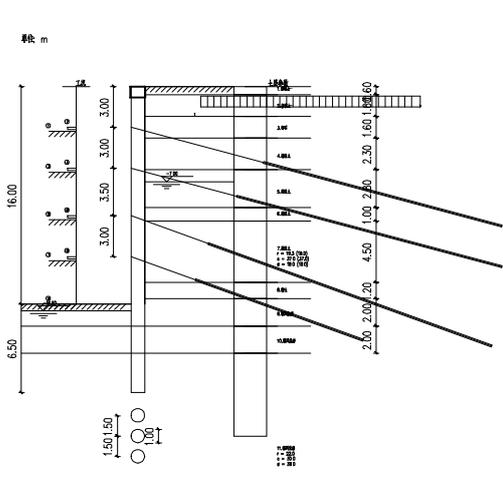


Figure 1. The profile of the supporting structure picture 1-1

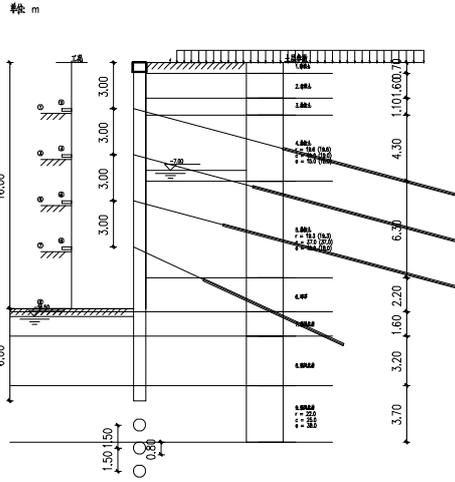


Figure 2. The profile of the supporting structure picture 2-2

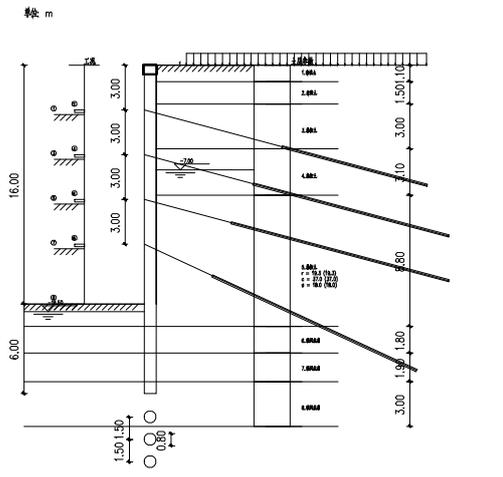


Figure 3. The profile of the supporting structure picture 3-3

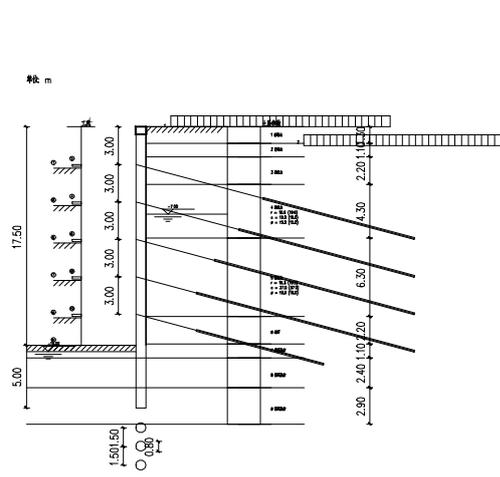


Figure 4. The profile of the supporting structure picture 4-4

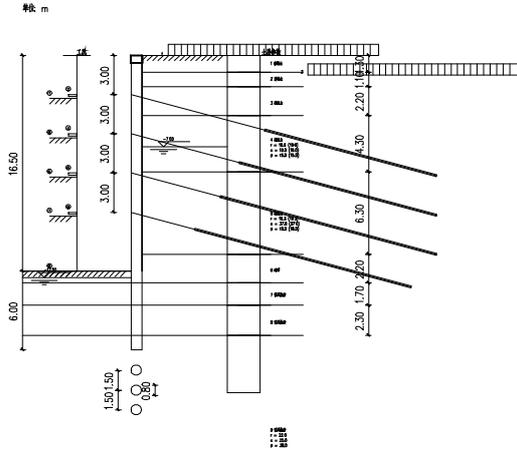


Figure 5. The profile of the supporting structure picture 5-5

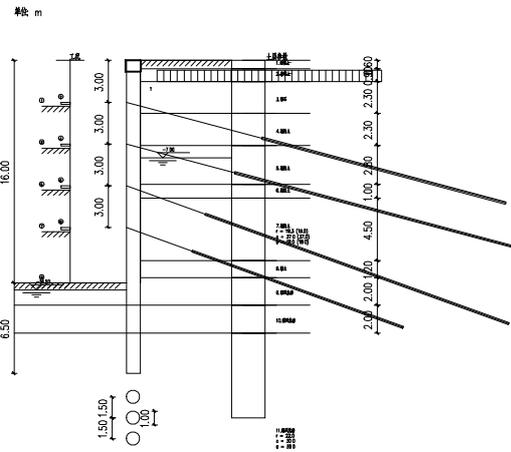


Figure 6. The profile of the supporting structure picture 6-6

Table 2. Alarm Values of the Foundation Pit and Supporting Structure Monitoring

Deformation Feature	Accumulative Value		Change Rate
	Absolute Value(mm)	Control Value of the Relative Foundation Pit Depth (h)	
Pile-top Horizontal Displacement	30	0.2%	3
Pile-top Vertical Displacement	10	0.06%	2
Deep-layer Horizontal Displacement	45	0.28%	2
Ground Surface Vertical Displacement	25	—	2
Internal Force of the Anchor Cable	(60%-70%)f2		—
Ground Water Level	Perennial Chang Amplitude:1m		500

Note: 1. h is the designed excavation depth of the foundation; f1 is the designed load value; f2 is the designed carrying capacity of components. 2. The cumulative value is the minimum value of the absolute value and the control value of the relative foundation pit depth (h). 3. There should be a warning when the change rate of the monitoring project reaches a predetermined value presented in the form or continuously exceeds 70% for three days.

Table 3. Alarm Values of Environment Monitoring Surrounding the Foundation Pit

Deformation Feature		Accumulative Value (mm)	Change Rate(mm/d)	Remarks
Displacement		20	2	-
Crack Width	Adjacent Building Displacement	1.5	Continuously Change	-
	Ground Surface	10	Continuously Changes	-
Pipeline Displacement	Rigid Pipeline	Pressure	10	Data from the Direct Observing Points
		Non-pressure	15	
	Flexible Pipeline	15	4	-

Note: There should be a warning if the overall cumulative gradient value of the building reaches 2/1000 or the gradient rate tilt is continuously greater than 0.001H/d (H is the height of the building bearing structure).

4 MONITORING ITEMS AND METHODS OF THE FOUNDATION PIT

The on-site monitoring of the foundation pit is conducted with a combined method of instrumental monitoring and inspection. Those key parts of the monitoring object are the focus of observation, and there is a supporting system for the project, thus forming an effective and complete monitoring system. Based on specifications and requirements, the monitoring of the pile-top horizontal and vertical displacement, settlement of the surrounding buildings and pipelines, deep horizontal displacement of piles, internal force of the anchor cable, ground water level outside the foundation pit, ground surface settlement and surrounding road settlement^[3] is conducted.

5 MONITORING ALERT VALUE AND RESULT ANALYSIS

The alarm value of the foundation pit and supporting structure monitoring is shown in Table 2; and the alarm value of environment monitoring surrounding the foundation pit^[4] is shown in Table 3:

Analysis of monitoring results:

(1) Pile-top vertical displacement

The pile-top vertical displacement presents an overall descending trend, indicating that there is a slight settlement deformation, with a small amount of change and basically stable data. Comparatively, the site of ZD5 (eastern part in the north area) shows a relatively big change, and by March 14th, 2014, the maximum change value was -8.30mm. The cumulative value of all observation points was less than the warning value and within the control range, and there was no big pile-top vertical displacement in the construction process. From the starting of the excavation to the completion of the backfill, the cumulative vertical displacement value of the slop-top was stable.

(2) Pile-top horizontal displacement

The Pile-top horizontal displacement shows a descending trend, indicating that there is a slightly pit-inward displacement with a small overall amount of change and basically stable data. By March 14th, 2014, the maximum change value was 26.28mm (ZD18, the southern part in the west area). The cumulative value of all observation points was less than the warning value and within the control range, and there was no big slop-top horizontal displacement in the construction process.

(3) Road settlement

The road settlement shows a descending trend, indicating that the road slightly descends with a small overall amount of change and basically stable data. By March 14th, 2014, the maximum change value was 8.15mm (DL4). The cumulative value of all observation points was less than the warning value and within the control range, and there was no big road settlement in the construction process. From the starting of the excavation to the completion of the backfill, the cu-

mulative horizontal displacement value of the slop-top was relatively stable.

(4) Pipeline settlement

The pipeline settlement shows a descending trend with a small overall amount of change and basically stable data. By March 14th, 2014, the maximum value was 12.70mm (GX5). The cumulative value of all observation points was less than the warning value and within the control range, and there was no big abrupt settlement change of the pipeline in the construction process.

(5) Settlement of the surrounding ground surface

The settlement of the surrounding ground surface shows a descending trend with a small overall amount of change and basically stable data. By March 14th, 2014, the cumulative value change of a group of ground surface settlement points were maximum; and the value of DB1, DB2, DB3 and DB4 were respectively 6.74mm, 9.20mm, 6.86mm and 8.43mm. The cumulative value of all observation points was less than the warning value and within the control range.

(6) Settlement of the surrounding buildings

The settlement of the surrounding buildings shows a descending trend with a small overall amount of change and basically stable data. By March 14th, 2014, the maximum value occurred at J16, which was 9027. From the starting of the excavation to the completion of the backfill, the cumulative value of all observation points was less than the warning value and within the control range; and the change of the cumulative settlement value of the neighboring buildings was relatively stable.

(7) Ground water level

The ground water level shows a descending trend with a small overall amount of change and basically stable data. By March 14th, 2014, the maximum cumulative change amount occurs at the northwestern SW1, which was 2.49m. From the starting of the excavation to the completion of the backfill, the cumulative value of all observation points was less than the warning value and within the control range; and there was no abrupt change of the ground water level in the construction process with relatively stable data change.

(8) The internal force of row-pile

The internal force of row-pile is in a strengthening trend, and by April 18th, 2014, the southern maximum cumulative change amount was 36.686KN. The cumulative value of all observation points was less than the warning value and within the control range. The analysis result based on the force data of row-pile, which were 16m away at the south, was shown in the following table, and it was apparent that the internal force of row-pile gradually increased and then tended to be stable from the starting of the excavation to the completion of the backfill.

9) The internal force of the anchor cable

The internal force of the anchor cable will intensify first and then weaken and finally keep at a stable value, because a part of prestress will be lost in the initial period when the anchor forces the prestress; the inter-

nal force will strengthen and finally keep at a stable value in the later period in order to control the deformation of the foundation pit. By April 18th, 2014, the maximum cumulative change amount appeared at the MS8-3 with 72.042KN. From the starting of the excavation to the completion of the backfill, the cumulative value of all observation points were less than the warning value and within the control range.

6 CONCLUSIONS

According to the monitoring results, currently overall foundation pit deformation is well controlled, and the monitoring design and implementation of the foundation pit is rational with obvious deformation characteristics and laws; and the following conclusions can be arrived based on the monitoring of the force changes in the whole excavation process, combined with the actual situation:

(1) Timely master the change of the soil and the supporting structure as well as the deformation of structures through monitoring.

(2) Compare the monitoring data with the estimated value to provide timely and effective measures aimed at the environment safety around the foundation pit.

(3) Verify the correctness of foundation pit excavation program and the environmental protection program through the monitoring of the surrounding buildings and structures, and timely to analyze emerging issues to provide basis for the development of timely and effective measures aimed at the environment safety around the foundation pit.

(4) Due to the different geological conditions at various sites, different construction techniques and surrounding environments, a variety of complex factors are not included in the calculation of the foundation pit design; the analysis and study of on-site monitoring result as well as the application of the monitoring result to the feedback optimization design will provide the basis for improving the design.

(5) Make analysis and judgment of the foundation pit working state based on the on-site inspection and instrument observation, and give an immediate alert when there are abnormal situations or dangerous state to avoid the deformation damage of the foundation pit and nearby buildings^[5].

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