Research on key technologies for construction of super-deep railways stations near existing lines in the flood land area of the Yangtze River

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Abstract. In this paper, taking Nanjing Mochou Lake Metro Station as an example, the key technologies for the construction of super-deep stations near existing lines in the flood land area of the Yangtze River are studied. Mochou Lake Station is located in Mochou Lake Park on the Qinhuai River. It is a four-level underground island-type platform station, which is interchanged with the existing Line 2 Mochou Lake Station. The station used the "two-light and two-dark" construction method. The first and the second underground floor of the station used an open excavation order method, and the third and the fourth underground floor used to cover and cut-bottom up method. According to the monitoring results and settlement analysis results of the main structure, the construction method of "two-light and two-dark " can help control the deformation of the construction area and ensure the safety of the surrounding structures and existing stations.

1. Introduction

Mochou Lake Station is located in Mochou Lake Park, Jianye District, Nanjing. The excavation depth of the foundation pit is 35.26m. This station is a four-level underground island-type platform station, which is interchanged with the existing Line 2 Mochou Lake Station. The site liquefaction index is 0.45 to 1.12, which is a slightly liquefied site. The buried depth of the soft cohesive soil layer is shallower than that of the base of the main structure of the station. During the construction, the soil stress will be unbalanced, which will adversely affect the construction of the project. The trough wall of the station envelope is reinforced by TRD (trench cutting re-mixing deep wall) construction method of cement-soil mixing wall, 45m deep and 600mm wide [1]. In the range of 3m below the second floor of the underground floor and 5m below the foundation pit bottom, the RJP (rodin jet pile) construction method is used to spin the pile skirt drawbar reinforcement [2]. The ground connection wall has a depth of 64m (3-6m into the weathered rock) and the width of the wall is 1.2m, with a milling joint used. A blocking wall is set in the middle of the pit to divide the foundation pit into two small foundation pits with a length of 100m and 60m respectively [3]; the standard section support form is the first, fifth, and sixth concrete supports and the second, third, and fourth steel supports[4].
Wells precipitation pipe is used in the foundation pit, and observation wells are located outside the foundation pit.

2. **Construction of the main structure of the station "two-bright and two-dark" [5]**

- Excavate the soil to the first supporting bottom, and pour the first concrete support.
  - Excavate to 0.5m below the steel support, install the steel enclosing purlin and set up the steel support.
  - Open 0.5m below the 4th support, install steel enclosing purlin and set up the 4th steel support.
- Excavate the soil to 1.8m below the negative second-floor slab, construct the negative second-floor cushion, erection of short scaffolding, pouring the floor and 1.8m side wall under the pouring floor.
  - After the bottom plate of the negative second floor reaches the design strength, remove the 4th steel support, and make the lower half of the negative second floor sidewall in the open excavation.
  - After the lower sidewall of the negative second layer reaches the design strength, remove the third steel support and steel enclosing purlin, and make the upper part of the negative second layer sidewall, column, and plate in clear cut.
- After the superstructure of the negative second layer reaches the design strength, remove the 2nd steel support, enclosing purlin, and construct the side wall and column of the negative first layer. Set up the scaffold system, tie up the roof reinforcement, set up the formwork, pouring concrete.
  - After the roof reaches the designed strength, cut the first concrete support, construct the excavated retaining wall, and partially backfill the roof.
  - After the roof is backfilled, continue to lower the excavator from the bottom plate of the negative second floor to excavate the soil of the sixth floor and construct the fifth concrete support.
  - After the 5th concrete support reaches the designed strength, the 7th layer of soil shall be excavated to 1.8m below the negative three-layer bottom plate, and the construction cushion shall be constructed, and the plate-hook scaffold shall be constructed, and the negative three-layer bottom plate and 1.8m side wall shall be constructed.
  - After the bottom plate of the negative three layers reaches the designed strength, the eighth layer of soil is excavated and the sixth concrete support is constructed.
  - After the 6th concrete support reaches the designed strength, continue to dig the 9th-floor earthwork, and construct the grounding net, plain concrete cushion, waterproof layer, and negative four-layer bottom plate.
  - After the negative fourth-floor reaches the designed strength, remove the sixth concrete support and construct the negative fourth floor sidewall.
  - After the fifth support is removed, the negative three-storey and the lower half of the side wall shall be constructed.

3. **Monitor measurement analysis**

3.1 **monitoring scope and level**

In view of the geological conditions of the newly built Mochou Lake Station and the surrounding complicated structures, the excavation depth of 3 times the foundation pit is taken as the scope of influence of this station. According to the relevant specifications, the risk level of the foundation pit project itself is level one, the surrounding environment risk level is level two, and the project monitoring level is comprehensively determined as level one.
3.2 Analysis of settlement data during construction

(1) Analysis of vertical settlement and horizontal displacement of the pile top of the retaining structure

A total of 20 settlement points and 20 horizontal displacement points were arranged for the top of the wall. During the whole construction period, the settlement change, horizontal displacement and changing trend of the wall roof are relatively small.

![Figure 1. Wall top settlement curve](image1)

![Figure 2. Curve of horizontal displacement of wall top](image2)

(2) Analysis of vertical displacement of column pile

A total of 8 column settlement points were established. During the entire construction period, the uplift of the column is relatively small and does not exceed 14mm.

![Figure 3. Change curve of column settlement](image3)

(3) Analysis of ground settlement around foundation pit

The soil at Mochou Lake Station is relatively loose. Affected by construction during the construction process, especially the construction of heavy-duty machinery and equipment, the surface settlement of the site originally belonged to the bush greening area was relatively large, and the surface settlement of the existing Line 2 farther away was relatively small. (from August 9 to December 4)
(4) Settlement analysis of surrounding buildings (structures)

The existing buildings (structures) within 3 times the excavation depth of the foundation pit are monitored, and the settlement speed rate of surrounding buildings are small. (from July 7 to December 4)

3.3 Settlement analysis of existing stations

The affected area (length 370m) was protected and monitored. The monitoring data show that the tunnel settlement is -14.2mm. The maximum monthly change rate of the tunnel settlement is Y27: -0.119mm. After on-site inspections, no new cracking or collapse has been found. The existing structure of Line 2 has a small impact.

4. Conclusions

The research work presented in this paper analysed the interaction between soil and the new composite retaining structure and recommendations are obtained.

- Abundant groundwater, weak strata and prone to subsidence in the flood land areas. The "two-bright and two-dark" construction method helps control the deformation of the foundation pit, effectively controls the settlement of surrounding structures and ensures the safety of the foundation pit.
- The application of the "two-bright and two-dark" construction method saves materials and construction time, reduces construction safety risks, and has achieved good technical results and economic benefits.
- During the construction of the envelope structure, the construction quality of the diaphragm wall is strictly controlled to ensure the construction quality of the envelope structure. The continuity and uniformity of the TRD cement-soil mixing wall reduce the risk of water leakage from the wall joints.
The underground continuous wall into the rock effectively cuts off the connection between the inside and outside of the foundation pit. The foundation pit uses well pipe precipitation to carry out precipitation according to construction requirements, and each time the water level is lowered to 1-1.5 meters below the excavation surface. During the excavation of the foundation pit, the erection of the support in time, and the tunnelling will follow the erection. If the erection of the support is not timely or over-excavation, it may easily cause the foundation pit to deform and settle, and cause leakage in the wall joints.

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