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Construction Technology and Safety Risk Control Measures of Deep Foundation Pit Excavation

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Abstract: Deep foundation pit excavation is a basic and key step involved in modern building construction. In order to ensure the construction quality and safety of deep foundation pits, this paper takes a project as an example to analyze deep foundation pit excavation technology, including the nature of this construction project, the main technical measures in the construction of deep foundation pit, and the analysis of the safety risk prevention and control measures. The purpose of this analysis is to provide scientific reference for the construction quality and safety of deep foundation pits.

Keywords: Construction engineering; Deep foundation pit excavation; Construction technology; Risk prevention and control measures

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1. Introduction

When excavating deep foundation pits in modern construction projects, the nature of the project and the condition of the construction site should be considered, and reasonable measures should be taken to carry out the excavation. At the same time, appropriate safety risk prevention and control measures should be taken. In this way, the effect of the deep foundation pit can be ensured excavation, and a solid foundation can be laid for the quality and safety of the overall construction project.

2. Project overview

In this paper, a residential construction project is taken as an example to study deep foundation pit excavation. The project consisted of 14 buildings, of which Buildings 1–3 have 17 floors, Buildings 4–10 have 15 floors, and Buildings 11–14 have 21 floors. The overall construction area of the project was 107745.86 m^2, the total area of the above-ground buildings was 83150.45 m^2, and the total area of underground buildings is 24599.41 m^2. The overall foundation is a prestressed pile foundation, and the excavation depth of the foundation pit was designed to be 2.35–8.55 m. According to the on-site investigation, the soil condition of the construction site of the project was relatively poor, and there was groundwater, faults, and silt in the soil layer, which made the excavation of deep foundation pits relatively difficult. This article presents an analysis of deep foundation pit excavation technology and safety risk control measures of the construction project.

3. Analysis of the main technical measures in deep foundation pit excavation

3.1. Enclosure construction of deep foundation pit

For the enclosure of the deep foundation pit, the main excavation method used in this project was the

layered method and sectional method. The excavation depth and layered length were controlled according to the design requirements, and the close combination of excavation and support construction is ensured by means of excavation and support at the same time. For the anchor bolts in the enclosure, in the construction, the grout bag grouting method is mainly used. Before the grouting of the pretensioned anchor bolt pockets, each anchor bolt pocket should be inspected carefully, any damage found should be repaired or replaced in time. Afterwards, the anchor bolt can be installed. If the borehole shrinks or collapses during construction, hole cleaning should be carried out immediately. Hole cleaning should be carried out with the drill bit, and the slag is removed by cleaning the drill pipe several times, so that the borehole diameter and depth met the design requirements and to prevent borehole clogging [1]. In the process of pre-tensioning and anchoring, the tensile strength of the anchoring end should be controlled, and the waist slab should be strengthened. Sand grout can be used to seal gaps between waist slabs and guard piles, and construction can only be carried out when the strength of the concrete is sufficient. The prestressed tension can be divided into three stages of loading, and the design value of the prestressed tension should be reasonably controlled according to the actual situation and construction requirements. **Table 1** shows the required range of values of main technical parameters in the excavation of the deep foundation pit enclosure.

Table 1. Control of main technical parameters in the construction of deep foundation pit enclosure

Serial number	Parameter	
1	Layered excavation depth	≤ 500 mm
2	Layered excavation length	≤ 25 m
3	Tensile strength of anchorage section	>15 MPa
4	Primary tensile strength	14 kN
5	Secondary tensile strength	28 kN
6	Tertiary tensile strength	70 kN
7	Prestress tension design value	70 kN

After the construction of the enclosure was completed, construction quality control should be performed in strict accordance with the requirements, and subsequent procedures can be carried out after the requirements for this part are met, so as to ensure the overall construction quality.

3.2. Deep foundation pit earthwork excavation

In the earthwork excavation construction of deep foundation pit, the foundation elevation needs to be consistent with the structural drawings. If elevation of the structure of the foundation is different from the drawings, the structural drawings are followed, and the situation should be reported to the construction party in time. Before the excavation of deep foundation pits, it was necessary to do a good job in the transfer of pile positions and take appropriate protective measures. Before excavation, the engineering technical supervisor should determine the specific excavation sequence and method and construction requirements through technical discussions and complete the silicon pad construction in time to avoid unnecessary safety hazards issues during foundation pit excavation [2]. During specific excavation, the construction should be carried out in strict accordance with the principle of layering and section. Lime should be sprinkled on each designed pile position to achieve a reasonable calibration of the construction position. During the excavation process, the excavator must not collide with the piles, so as to avoid unnecessary quality problems caused by the dislocation of the piles. For excavated stripped soil, layering can be done, and the thickness of the stripped soil should be well controlled. For the earthwork, ground beams and caps in the deep foundation pit, in the process of partial deep excavation, the last section of excavation was carried out

by manual excavation, so as to reduce the interference of mechanical excavation to the deep foundation pit and prevent over-excavation. For the position of caps, skip excavation method should be adopted. When the excavation reached the bottom of the foundation pit, excavation was carried out in sections, and the plain concrete pad was laid out within the specified time frame. At the same time, the thickness of each excavation layer should be strictly controlled according to the design, and compaction should be carried out layer by layer with an excavator or a frog rammer to avoid the deviation of the center line of the deep foundation pit. **Table 2** shows the control of the main technical parameters of the deep foundation pit excavation of this project.

Table 2. Control of main technical parameters in this deep foundation pit excavation construction

Serial number	Parameter	
1	Thickness of soil removed in layers	≤ 1.2m
2	Thickness of manual earthwork excavation	300 mm
3	Earthwork excavation thickness of ground beam	300mm
4	Manual excavation thickness of platform cap	300mm
5	Duration from the end of foundation excavation to the laying of concrete cushion	< 72h

3.3. Backfilling of foundation pits

In the process of backfilling the foundation pits, it is necessary to consider the impact of climate change on the backfill body. The backfilling process should be suspended or covered with a waterproof cover if necessary. The quality of the backfill soil must also be strictly controlled during construction, and the soil with water content exceeding the standard, saturated with water, or soaked by rainwater cannot be used asbackfill soil. During construction, if the surface of the backfill area was wet or soaked by rainwater, the wet soil layer on the surface must be removed before backfilling. During the backfilling process, organic impurities should be cleaned up in time, and the deep foundation pit backfilling construction can only be continued after the cleaning is confirmed. After backfilling, rolling is carried out at the construction site. During the rolling process, waterproof protection must be done for the foundation and exterior walls. In this way, the construction quality of backfilling can be ensured, thereby effectively ensuring the subsequent construction quality and safety of the overall project.

3.4. Deep foundation pit dewatering and drainage construction

Because of the relatively unfavorable geological conditions of the project's location, the soil layer within the overall deep foundation pit excavation construction range had low permeability. Based on this, through comprehensive consideration of various factors, a deep foundation pit drainage construction plan was proposed. Firstly, an open channel drainage treatment was carried out inside the pit. The open channels were excavated 1 m away from the slope point, and the depth was controlled within 300–500mm. A water collection well was placed at every 20 m, with a total of 22 water collection wells. During the drainage process, a drainage pump was used for all-weather pumping treatment to ensure the cleanliness of the pit. For the exterior of the pit, the drainage treatment was mainly carried out by means of brick drainage ditch. The width of the drainage ditch was 300 mm and the depth was 500 mm. Cement mortar was applied on the outside of the drainage ditch to prevent surface water from seeping into the drainage ditch [3]. At the same time, water collection wells were arranged around the drainage ditch, and a total of 15 water collection wells were set up to collect construction water and surface rainwater in the construction area. The collected water was discharged into the urban sewage pipe network after being treated in the sedimentation tank.

In order to ensure the quality of the drainage and drainage construction, special personnel should be assigned to monitor the water level changes in the collection wells, so as to avoid the adverse impact of excessive groundwater on the excavation construction of deep foundation pits [4]. During this process, it is also necessary to pay close attention to the specific dynamics of the slope of the pit and make scientific adjustments to its design plan accordingly, so as to ensure the safe and orderly construction of the deep foundation pit. For equipment such as water pumps and generators used in drainage projects, professional maintenance personnel should be employed to conduct regular inspections to ensure their functionality, so that groundwater in the pits can be discharged in time, so as to ensure the safety of deep foundation pits. After the completion of the deep foundation pit drainage construction, the drainage facilities should be sealed properly. Partial sump wells may be plugged until the basement building is maintained. For the remaining water collection wells, proper protection and treatment should be carried out during the construction of the bottom plate. After the overall deep foundation pit construction is completed, the water collection well can be filled with gravel and compacted.

4. Analysis of the main safety risk prevention and control measures in the construction of deep foundation pits

4.1. Risk control of deep foundation pit excavation plan

The safety risk control of deep foundation pit excavation should be done during the construction plan. In this process, first of all, it is necessary to fully understand the actual situation of the construction site, the construction requirements of deep foundation pits, and the technicalities of the construction. The construction plan should then be outlined carefully based on the aforementioned requirements and other factors [5]. After the construction plan is established, it should be reviewed by relevant units, so as to discover problems in the construction plan and correct them in time. The construction plan can only be executed after the actual engineering requirements are met, so as to provide scientific guidance for the construction of deep foundation pits. Responsibilities of each personnel should be assigned according to the plan in each construction link, and construction plan should be adjusted according to the changes in the construction site, so that it can be further improved [6]. In this way, the construction risks of deep foundation pits can be reduced, and the safety of deep foundation pits can be ensured to the greatest extent, thus laying a good foundation for the subsequent construction of the overall project [7].

4.2. Risk control in deep foundation pit excavation monitoring

For deep foundation pits in construction projects, data monitoring can directly affect the construction quality and safety. Therefore, in order to effectively control the safety risks, relevant units need to do a good job in the control of deep foundation pit excavation risk monitoring by formulating suitable monitoring schemes and selecting appropriate monitoring methods to obtain scientific, comprehensive and accurate monitoring data that can truly reflect the state of the pits [8]. In this project, , the monitoring points were reasonably arranged in the deep foundation pit according to the engineering standards and monitoring requirements, and the total displacement of each monitoring point within a continuous 3 d period should not exceed 3 mm, and the overall displacement should not exceed 30 mm. If the obtained monitoring data did not meet this requirement, it was reworked in time to ensure the safety of deep foundation pit construction. According to the analysis of the monitoring results, it was found that during the entire monitoring process, the total displacement of any monitoring point within any 3 d time did not exceed 3 mm, and the total displacement of the overall deep foundation pit did not exceed 30 mm. It can be seen that the displacement and settlement of the deep foundation pit in this construction project were acceptable, which means it is safe and stable.

4.3. Risk control of deep foundation pit excavation personnel

For deep foundation pit excavation, the professional qualities of construction personnel is also the key to determining its overall construction safety. Therefore, relevant units must do a good job in risk control of construction personnel to avoid unnecessary safety accidents caused by human factors [9]. In this project, the safety risks of construction personnel were mainly controlled through a few measures. (i) Proper technical briefing was given before construction, so that the staff were clear on the construction technology and safety measures, so as to ensure safe construction [10]. (ii) The responsibilities of each management personnel should be well divided, especially the safety management personnel. Relevant management personnel was held accountable for potential safety hazards or problems detected during construction in strict accordance with the regulations. (iii) During the construction process, safety education and training were conducted regularly for all construction personnel, so that their knowledge and technology in safe construction could be continuously innovated, and their safety awareness could be further improved to avoid safety risks [11]. In this way, the level of risk control of deep foundation pit excavation personnel can be effectively improved, and safety accidents caused by human factors can be prevented.

5. Conclusion

In short, deep foundation pit excavation is a basic step in the construction of modern architecture. Only by ensuring the quality of deep foundation pits can a solid foundation be laid for subsequent construction projects, so that the overall construction quality and safety can be ensured. Therefore, during the process of excavation, the condition of the site and relevant standards should be considered when applying construction technology. At the same time reasonable measures should be taken to control its construction safety. Only in this way can we fully meet the needs of deep foundation pit construction in modern construction projects, improve the construction quality and safety of deep foundation pits, and promote the good construction, application, and development of overall construction projects.

Disclosure statement

The author declares no conflict of interest.

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