Construction Technology Management of Deep Foundation Pit Support in Building Engineering Construction

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Abstract: Against the backdrop of deepening urbanization, the number and scale of building engineering projects continue to increase. The construction environment for deep foundation pits in building engineering is complex, often surrounded by numerous structures and underground pipelines, leading to high construction risks. Strengthening construction technology management is crucial for ensuring project quality and schedule. This paper analyzes the characteristics and common techniques of deep foundation pit support construction in building engineering. It proposes management strategies for deep foundation pit support construction technology, such as scientific selection and dynamic design optimization, refined control of materials and equipment, intelligent risk monitoring, whole-process construction collaborative management, and establishing a standardized emergency management mechanism. The aim is to reduce safety risks in deep foundation pit construction through enhanced technology management, providing a valuable reference for the sustainable development of the construction industry.

1. Introduction

Deep foundation pit engineering is a critical foundational aspect of the building construction field, whose construction quality and safety level directly impact the project's outcomes. Deep foundation pit support construction helps buildings resist soil lateral pressure and prevent groundwater seepage, providing a reliable and safe environment for excavation work. However, the geological conditions for deep foundation pit support construction are complex and variable, requiring high construction techniques. Negligence in any (link/step) can lead to serious safety accidents. Therefore, building construction should deeply explore construction technology management strategies for deep foundation pit support to provide safety guarantees for high-quality construction.

2. Characteristics of Deep Foundation Pit Support Construction in Building Engineering

2.1 High Risk

The geological conditions for deep foundation pit support construction in building engineering involve many uncertain factors. Different soil layers exhibit significant differences in physical and mechanical properties, and adverse conditions such as faults and karst caves may exist. Coupled with limitations in the number and depth of survey points, it is difficult for construction managers to fully understand the underground situation, leading to issues like excessive stress on the support structure [1]. Furthermore, complex underground pipelines and urban roads often surround deep foundation pits. Vibrations and deformations generated during support construction can damage these facilities. The forms of deep foundation pit support are also diverse; errors in any construction phase can directly affect the bearing capacity and stability of the support structure, posing serious potential safety hazards in later stages of the excavation.

2.2 Environmental Sensitivity

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The excavation phase of deep foundation pit construction in building engineering affects the stress equilibrium state of the soil environment around the site, leading to soil deformation problems. When deformation exceeds certain limits, surrounding buildings may experience uneven settlement and wall cracking, affecting their overall structural safety and functionality. Simultaneously, changes in groundwater level are a specific manifestation of the environmental sensitivity in deep foundation pit construction. Dewatering and water-sealing methods used during support construction alter the flow direction and height of groundwater. A dropping water table can affect the bearing capacity of building foundations, and fluctuations can induce soil silting and piping, negatively impacting the surrounding geological environment. Dust, noise, and vibrations generated during deep foundation pit support construction also affect the normal lives of nearby residents.

3. Deep Foundation Pit Support Construction Techniques in Building Engineering

3.1 Soil Anchor Construction Technology

Soil anchor construction technology is a primary method for ensuring the stability of foundation pits in deep excavation support. This technology involves drilling holes into undisturbed soil, inserting high-strength strands or rebar into the holes, and injecting cement or chemical grout to form a composite tensile structure combining the soil and the anchor. The lateral earth pressure borne by the support structure is thus transferred deeper into the soil layer. Before formal implementation, precise anchor hole positioning is conducted based on construction drawings and geotechnical investigation reports. Suitable drilling rigs are selected for the hole formation stage based on stratum characteristics. Anti-corrosion treatment is applied to anchors before installation, and centralizers are set in the anchor bond zone to ensure centrality. Supported by this technology, powerful frictional bearing capacity is formed between the anchor and the soil, restricting pit deformation and ensuring the safety of deep foundation pit construction.

3.2 Cast-in-Place Concrete Pile Construction Technology

The technical level of cast-in-place concrete pile construction is key to determining the quality of deep foundation pit support. Initially, pile locations are determined according to design drawings, followed by hole formation using slurry walls. The drilling speed is adjusted based on geological conditions before drilling. Reinforcing cage fabrication requires precise reinforcement design; main rebars are connected mechanically or by welding, ensuring coaxial alignment of upper and lower sections during field welding. The tremie method is used for concrete pouring, maintaining sufficient embedment depth of the pipe to avoid pile breakage. The entire process must constantly monitor hole wall stability and the potential floating of the reinforcing cage, addressing any abnormalities promptly. After pouring, laitance at the pile top must be removed immediately, ensuring the over-pour height is not less than 0.8m to maintain pile stability and integrity [2].

3.3 Soil Nailing Support Construction Technology

Soil nailing support technology is typically used in weak rock layers for deep foundation pit support. Before construction, the excavation boundary is precisely measured, and obstacles are thoroughly removed. Construction units also strictly inspect the quality of soil nails. Excavation is conducted in layers and sections. Immediately after excavation, holes for soil nails are drilled, controlling standard hole depth and inclination. Nails are slowly inserted into the holes during installation, strictly controlling grouting pressure and volume to ensure grout fills all voids, enhancing the bond between the nail and the soil.

4. Construction Technology Management Strategies for Deep Foundation Pit Support in Building Engineering

4.1 Scientific Selection and Dynamic Design Optimization

Management of deep foundation pit support technology must emphasize scientific selection and dynamic design optimization to improve overall construction efficiency. Scientific selection should consider factors like geological conditions and surrounding environment, establishing a multi-dimensional decision-making model combining theoretical calculations and engineering experience. For instance, in areas with soft soil or high groundwater levels, internal bracing systems or diaphragm walls should be prioritized for their high stiffness and strong deformation control capabilities, reducing the impact on existing facilities. Dynamic design optimization relies on real-time monitoring data and numerical simulation feedback for closed-loop management. Excavation should utilize BIM technology to build 3D geological models, simulating support structure responses under different working conditions to identify potential risk points. For example, if monitoring data shows excessive deformation rates in a specific area, causes must be immediately analyzed, and construction parameters adjusted, such as adding temporary supports, optimizing excavation sequence, or enhancing dewatering measures. Furthermore, a multi-department collaboration mechanism is needed, synchronizing monitoring data with design, construction, and supervision units. Design parameters are dynamically revised through expert discussions to ensure the support system matches actual conditions. Under complex geology, phased design change proposals can be submitted, implementing trial sections to verify feasibility before rolling out the optimized design comprehensively. The core of dynamic design is establishing a closed-loop control mechanism encompassing monitoring, analysis, and feedback optimization. This involves setting up a comprehensive monitoring network before construction begins, overseeing key indicators like support structure displacement, deep soil horizontal and vertical displacement, strut axial force, and groundwater level throughout the process. Based on real-time data, enterprises should perform back-analysis of soil parameters, promptly adjusting and optimizing subsequent support schemes and construction sequences. For example, if rapid displacement growth is detected on one side during monitoring, pre-stressed anchors can be added promptly, or strut axial force increased. This ensures efficient and economical completion of deep foundation pit construction in complex environments.

4.2 Refined Control of Materials and Equipment

Implementing refined control of materials and equipment is a core aspect of construction technology management for deep foundation pit support, ensuring project quality and controlling construction risks. Enterprises should develop technical parameter lists for materials and equipment based on support design requirements, specifying key indicators such as steel strength, concrete mix ratio, and anchor cable tensile strength. Strict quality inspections must be conducted on materials like steel structures, anchors, and cement entering the site, coordinating with third-party testing agencies for mechanical property tests to guarantee quality. Refined control also involves developing precise material and equipment demand plans. Procurement should prioritize suppliers with stable quality and good reputation, implementing centralized purchasing and strategic cooperation. Technical parameters and quality certification documents must be strictly reviewed to ensure compliance with design requirements and national standards. Deep foundation pit construction must fully consider the characteristics of limited space and complex environments, rationally planning material storage and equipment parking areas. Utilizing information platforms enables real-time monitoring of inventory levels and equipment status, dynamically dispatching resources based on construction progress to reduce idleness and waste [3]. Additionally, material and equipment management requires a performance evaluation mechanism, comparing planned vs. actual consumption through data analysis to assess usage efficiency and economy. Continuously summarizing experience optimizes control processes, achieving efficient resource utilization and controllable costs, laying a solid foundation for the smooth progress of building engineering projects.

4.3 Implementing Whole-Process Construction Collaborative Management

Construction technology management for deep foundation pit support should actively implement whole-process collaborative management. During the initial project stage, organize technical briefings involving geological survey teams, third-party monitoring agencies, and construction units. Use BIM technology to create 3D geological models and support structure models for parametric design briefing and construction feasibility simulation. During construction, implement dynamic collaborative control, establishing a daily construction coordination meeting system led by the project manager with participation from technical leads, safety officers, monitoring team leaders, and subcontractor representatives. Dynamically adjust construction parameters based on daily monitoring data. At the technical collaboration level, enterprises need to establish a approval system for special construction schemes for deep foundation pit support, defining handover acceptance criteria for key processes like earth excavation, support structure construction, and dewatering operations. Integrate IoT sensors to real-time collect stress and strain data from the support structure, feeding it into the project management platform to allow remote verification of the support system's stress state by design units. Construction teams can also develop detailed construction plans during collaborative management, organically combining excavation depth, support installation timing, and design strength development time. Use daily meetings and on-site joint dispatching to keep all teams aligned, avoiding global risks or work delays due to lagging in any link, thus maximizing construction efficiency. Furthermore, all project participants should jointly identify and assess risks at various stages, clarifying responsibilities, procedures, and communication channels under emergency conditions. This ensures rapid initiation of emergency response when incidents occur, mobilizing all necessary resources for efficient and coordinated handling to minimize potential losses.

4.4 Implementing Intelligent Risk Monitoring

Implementing intelligent risk monitoring for deep foundation pit support technology management should deeply integrate technologies like the Internet of Things (IoT), big data, and artificial intelligence (AI) to build a comprehensive risk prevention and control system. Deploy intelligent sensors on the support structure and in the surrounding environment, integrating monitoring parameters such as displacement, stress, strain, pore water pressure, and groundwater level to form a three-dimensional monitoring matrix. Machine learning algorithms can be used to train on historical monitoring data, establishing quantitative relationship models between support structure deformation and risk levels, dynamically predicting the probability of risk occurrence. When monitoring parameters exceed thresholds, the system should push early warning information to project managers via APP, SMS, etc. Simultaneously, enterprises can use IoT technology to upload sensor data to the cloud platform in real-time, performing cleaning, fusion, and standardization of multi-source heterogeneous data to form a unified risk database, providing a foundation for in-depth analysis.

Additionally, enterprises should build risk prediction models based on machine learning algorithms, analyzing monitoring data in real-time to identify abnormal patterns and predict trends.

Establish linkage between mobile terminals and the command center to ensure timely information transmission and accurate implementation of measures.

4.5 Establishing a Standardized Emergency Management Mechanism

Construction technology management for deep foundation pit support should establish a standardized emergency management mechanism to reduce accident risks. Enterprises should compile special emergency plans, clarifying standardized response steps from danger detection, site locking down, personnel evacuation, to expert consultation. Organize quarterly emergency drills, establish an emergency expert database incorporating geotechnical engineering, structural safety, etc. [4]. Within 72 hours after each emergency response, conduct a root cause analysis, developing optimization strategies from perspectives like design rationality, construction standardization, and monitoring accuracy. Utilize the PDCA cycle (Plan-Do-Check-Act) to continuously optimize emergency plans, forming a dynamic management closed-loop to fundamentally enhance the emergency management level of deep foundation pit engineering. The key to efficient emergency response lies in organization and resources. Enterprises should equip adequate emergency rescue materials, equipment, and vehicles according to plan requirements, conducting regular inspections, maintenance, and updates to ensure constant readiness. Emergency response must strictly follow the plan's standard procedures post-incident. The technical support group must quickly analyze targeted technical measures, and the rescue operation group must ensure their own safety while performing tasks, forming an internal collaborative and external linked multi-dimensional rescue network. After the emergency state is lifted, a post-assessment procedure must be initiated. Based on evaluation results, optimize and revise aspects like the emergency plan, resource allocation, and warning indicators, maintaining the emergency management mechanism's high adaptability and effectiveness.

5. Conclusion

In summary, deep foundation pit support construction is an indispensable and critical component of the building construction field, significantly impacting the overall safety and stability of engineering projects. Therefore, construction enterprises should prioritize selection and design in deep foundation pit support construction, strengthen refined control of materials and equipment, implement whole-process construction collaborative management, conduct intelligent monitoring of potential risks, and establish standard emergency management mechanisms. This will enable the entire construction industry to achieve high-quality development.

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