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 an important premise of the construction quality and safety level in building construction, which is a prerequisite for success. Support construction for deep foundation pit can avoid soil lateral pressure produced to the building and wooden ear leaking, which makes a safe and reliable environment for excavation. But the geological conditions of deep foundation pit support construction are complex and dispersed and need high-tech construction. However, any (link/step) neglect will lead to serious safety accidents. It must be fully carried out in-depth the study of deep foundation pit support construction technology management strategies, to carry on quality protection for construction works.

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

2.1 High Risk

This is because the geological conditions of deep foundation pit support construction in building engineering have a lot going on that can be uncertain. Physical and mechanical properties have significant variations of different soil layers, and adverse conditions such as faults, karst caves exist. Together with limits in the position and size of specify points, it becomes harder for CM to get full knowledge of what lies underground, leading to troubles like extreme stress on support mechanics [1]. In addition, many deep foundation pits are surrounded by complex underground pipelines and urban roads. Such facilities are at risk of damage from vibrations and deformations released during support construction. There are many different forms of support for deep foundation pits, and any errors in one phase of construction can affect the bearing capacity and stability of the support structure directly, posing considerable safety risks in later stages.

2.2 Environmental Sensitivity

In building engineering, the stress equilibrium state of soil environment around construction site is affected by excavation phase of deep foundation pit and it leads to soil deformation problems.

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When deformation is beyond certain limits, buildings around may get settle unevenly, walls crack and result to structural safety problems further affecting the intended activity of buildings. Groundwater level change is a particular embodiment of the environmental sensitivity in the construction of deep foundation pits. Various dewatering and water-sealing methods during construction within the support will change not only the inflow direction but also the height of groundwater. A depleting water table may also influence structural support of buildings, and changes to this water level can result in soil silting and piping which cause detrimental geological effects to the environment around it. The dust, noise and vibration from construction of deep foundation pit support also interfere with the normal life of residents nearby.

3. Deep Foundation Pit Support Construction Techniques in Building Engineering

3.1 Soil Anchor Construction Technology

Soil anchor construction technology is one of the main technologies for stabilizing foundation pits during deep excavation support. It consists of drilling holes into undisturbed soil, inserting high-strength strands or rebar in the holes and injecting cement or chemical grout to make a composite tensile structure with the soil and the anchor. Thus, the lateral ground pressure on the supporting structure is transmitted deeper into the soil layer. Prior to the formal implementation, accurate positioning of the anchor holes are prepared according to project drawings and record basis on geotechnical investigative reports. Based on stratum characteristics, appropriate drilling rigs are selected for the hole formation stage. Anchors are treated with anti-corrosive material and centralizers are located in the area of anchor bonding zone to maintain centrality. Under this technology, strong frictional bearing capacity is generated between the anchor and the soil, which limits pit deformation and ensures that the deep foundation pit construction cannot only be safe.

3.2 Cast-in-Place Concrete Pile Construction Technology

Deep foundation pit support is largely dominated by the technical level of construction for cast-in-place concrete piles. Firstly, the locations of piles are chosen based on design drawings, then holes will be made by slurry walled formation. The drilling speed is calibrated before the actual drilling according to geological conditions. Because its main rebars cannot be simply tied with wires, reinforcement design must be highly precise; In the case of field weldings, upper and lower sections must go through coaxial alignment. Concrete is poured through a tremie and the pipe must be deep enough so it does not break the pile. The entire process must monitor hole wall stability and the potential for the reinforcing cage to float, resolving any abnormalities in a timely manner. Immediately after pouring, laitance at the pile top shall be scraped away and over-pour height not less than 0.8m to ensure sufficient stability/integity of pile [2].

3.3 Soil Nailing Support Construction Technology

Soil nailing support technology is generally adopted in weak rock layer for deep foundation pit support. The excavation limit is carefully measured and all obstacles are removed prior to construction. Construction unit also specially tests quality of soil nails. The excavation is carried out in layers and trenches. Soil nails holes are drilled right after excavation, with standard hole depth and inclination control. During installation, nails are gradually placed in holes at controlled grouting pressure and volume to ensure that the soil is filled completely, thus improving the cementation of soil with the nail.

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

4.1 Scientific Selection and Dynamic Design Optimization

It highlights the application of science and technology in ensuring deep foundation pit support technology selection dynamic optimization design management to enhance overall construction effectiveness. Scientific selection should be based on geological conditions and surrounding environment, establishing a multi-dimensional decision-making model that is integrated with theoretical calculations and engineering experience. In some jurisdictions, such as those where the soil is soft or has high groundwater levels, internal bracing systems and diaphragm walls should be selected for their high stiffness and good deformation control properties to reduce disturbance to nearby facilities. Real-time monitoring data and numerical simulation feedback serve as real-time closed-loop management from dynamic design optimization. In Excavation, BIM technology can be used to construct 3D geological models, and the support structure response under different working conditions should be simulated to find some sensitive points of risk. If analysis results from monitoring data reveal over-destination of deformation rate in certain area, analyzes have to be done immediately to identify the reasons, such as enhancing temporary supports, analyzing and simulating better excavation sequence, even strengthening dewatering measures. In addition, a joint monitoring mechanism among multiple departments is also required to coordinate the scheduling of monitoring data with design, construction and supervision units. Replacement Dynamic Revision of design parameters occurs through expert discussions to align the support system based on prevailing conditions. In complex geology, phased design change proposals may be acceptable by implementing trial sections to test feasibility prior to full implementation of the optimized design. At the heart of dynamic design is a feedback loop that begins from establishing the monitoring, analysis and feedback. This requires a detailed monitoring network to be established before construction starts, and continual monitoring during work of critical parameters such as displacement of the support structures, horizontal and vertical displacement deep down in the soil, strut axial force and groundwater level. Enterprises are supposed to do back-analysis of soil parameters with real-time data, actively adjusting and optimizing the following supporting schemes and construction sequences. For instance, if some rapid growing of displacement on one side is observed as a result of monitoring, pre-stressed anchors can timely placed or the axial force in struts may be increased. In this way, the deep foundation pit construction process can be completed efficiently and economically to adapt to complex site environment.

4.2 Refined Control of Materials and Equipment

Refined control of materials and equipment is an important part of construction technology management for deep foundation pit support, which can ensure the quality of the project and better control the risk in construction process. According to the design requirements of support, create a technical parameter list for materials and equipment used in enterprises, including major indicators such as steel strength, concrete mix ratio (particle size distribution), anchor cable tensile strength, etc. There are strict quality inspection protocols in which you need to check for the quality of material like steel structures, anchors, and cement coming into the site especially coordinating with third-party testing agencies performing the mechanical property tests ensuring their quality. This also means making more detailed material and equipment demand plans. On the basis of selecting good suppliers with stable quality and reputation, procurement should do centralization and strategic rupture. One technical parameter and quality certification documentation is strictly reviewed, which must comply with design requirements and national standards. Deep foundation pit construction should pay attention to the characteristics of space, complex environments, rational planning of material storage and equipment parking. Using information platforms that make it possible to track in real time the stock of components and status of equipment, sends resources based on progress in the construction of a project thus limiting idle times or waste [3]. In addition, material and equipment management of resources shall also be supported with performance evaluation mechanisms by data-driven analysis to review the planned vs actual consumption of resources leading to an assessment of usage efficiency and economy. Constantly summarizing experience improves the control process, realizes efficient utilization of resources and controllable costs, and lays a solid foundation for ensuring that building engineering projects can smoothly promote.

4.3 Implementing Whole-Process Construction Collaborative Management

Deep foundation pit support construction technique management should actively implement whole-process collaborative management. During the early stage of a project you set up technical briefings to involve geological survey teams, third party examining specialists and construction units. Leverage BIM technology to generate 3D geological models and backing structure models for parametric generation concept design and construction feasibility analysis. Implement dynamic collaborative control with a daily construction coordination meeting system of which the project manager is a lead, with participation by technical leads and safety officers, monitoring team leaders, and subcontractor representatives. Based on daily monitoring data, the construction parameters are dynamically adjusted. As an enterprise needs to build a special construction scheme approval system for deep foundation pit support at the technical collaboration level, clarifying the handover acceptance criteria of key processes such as earth excavation, support structure and dewatering operations and some requirements not do that once when delaying a lot of losses which is usually inexcusable for enterprises. Use of IoT sensors to collect stress and strain on the support structure in real-time, which are directly interfaced with the project management platform so that the design units can check if the system is within stress limits. In addition, during collaborative management, construction teams can develop detailed construction plans organically by integrating the excavation depth where support will be installed and the design strength development time associated with the installation. Real-time observation and prevention: Use daily meetings and on-site joint dispatching, loosen the coordination between branches of the project team to avoid global risks or work delays caused by lagging in any link, in order to achieve good construction efficiency. In addition, all parties involved in the project should collectively identify and analyze risks at all stages, define specific responsibilities, procedures and channels of communication during emergencies. This allows for immediate commencement of emergency management as soon as an incident occurs and provision of adequate resources, possible at a centralized level to ensure prompt and effective response to minimize the extent of losses.

4.4 Implementing Intelligent Risk Monitoring

Intelligent risk monitoring for deep foundation pit support technology (DFPST) management should closely integrates IoT, big data, and AI into a systemic risk prevention-control system. Deploy intelligent sensors in the support structure and nearby environment, forming a 3D monitoring matrix by integrating monitoring parameters of displacement, stress, strain, pore water pressure and groundwater level. By training machine learning algorithms on historical monitoring data, quantitative relationship models of deformation and risk levels can be established in support structures, thereby dynamically predicting the probability of risk occurrence. The system should push the early warning information to project managers by APP, SMS and other means when monitoring parameters exceed thresholds. At the same time, enterprises can also use IoT technology to upload sensor data to the cloud platform in real-time, carry out cleaning, fusion and standardization of multi-source heterogeneous data to form a unified risk database as much as possible for further 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

Deep foundation pit support construction technology management should establish a multi-level standardization of emergency response mechanism to minimize the risk of accidents. Enterprises can also sort special emergency plans, clarify standard response procedures from the detection of danger to on-site locking, personnel evacuation, expert consultation. Conduct quarterly emergency drills, create an expert database on emergencies that incorporates geotechnical engineering, structural safety, etc. [4]. Undergo a root-cause analysis within 72 hours after an emergency response, yielding optimization strategies along dimensions of design rationality, construction standardization, and monitoring accuracy. Use the PDCA cycle (Plan-Do-Check-Act) to iteratively improve emergency plan and construct a dynamic closed-loop management system to fundamentally improve the emergency management level of deep foundation pit engineering. Organization and resources are essential to effective emergency response. As required by the plan, enterprises must prepare enough materials, tools and vehicles for emergency rescue and regularly check, maintain and update them so as to always be ready for an emergency. Emergency response must adhere to the standard operating procedures set out by your plan after an incident happens. Quickly, the technical support group assumes a specific and targeted technical measurement analysis task, while the rescue operation group ensures their own safety and complete they tasks to establish an internal cooperative and external link multi-dimensional disaster structure network. Post-evaluation procedure should be initiated upon the lifting of emergency state. Continuously optimize and improve the emergency plan, resource allocation, warning indicators and other aspects based on evaluation results, keep the high adaptability based on evaluation results by means of regularly updating and improving disaster risk management mechanism.

5. Conclusion

So far, the paragraph summarizes that deep foundation pit support construction accounts for a very important part of the building construction field and affects the safety and stability of engineering projects as a whole. In-depth foundation pit support construction of civil engineering, so it is necessary to strengthen the construction of selection and design, pay attention to refined control in materials and equipment in kind, implement construction whole-process collaborative management, carry out smart monitoring carried by potential risk points and standardize emergency management mechanism. It will help achieve high-quality development of the entire construction industry.

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