Research on the Implementation Path of Foundation Pit Support Technology in Building Civil Engineering Construction

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Abstract: This study addresses the issues of safety risks and quality hazards in the implementation of foundation pit support technology in building civil engineering due to non-standard processes. Based on the implementation principles of foundation pit support technology, it systematically analyzes four implementation paths: preliminary geological survey and analysis, customized support scheme design, strict construction in accordance with regulations, and full-process monitoring with dynamic adjustment. By sorting out the operational logic and key points of each path, a complete implementation system of "data support - scheme adaptation - process control - dynamic optimization" is summarized. The synergistic effects of each path in ensuring the safety of foundation pit support, improving construction efficiency, and enhancing economic viability are elaborated, providing a reference operational framework for standardizing the implementation of foundation pit support technology in engineering practice.

1. Introduction

Foundation pit support technology is a crucial technique in the foundation pit construction of building civil engineering. It refers to a comprehensive technical system that ensures the safety of foundation pit excavation and underground structure construction, as well as the stability of surrounding buildings (structures) and pipelines. This is achieved by conducting geological surveys, adopting structures such as soldier piles, soil nailing walls, and diaphragm walls, and combining monitoring and protective measures to control foundation pit deformation and resist soil and water pressures. Currently, foundation pit engineering in building civil engineering faces challenges such as complex geological conditions and sensitive surrounding environments. If the implementation of support technology lacks a scientific path, problems such as unreasonable schemes, substandard construction quality, and delayed risk prevention and control are likely to occur, affecting engineering safety and progress. To address these pain points, it is necessary to clarify the operational specifications and core requirements of each link from the perspective of the entire technical implementation process. The following text will focus on the implementation paths of foundation pit support technology, deeply analyzing the implementation points of each path to provide ideas for optimizing the application of foundation pit support technology.

2. Implementation Principles of Foundation Pit Support Technology in Building Civil Engineering Construction

2.1 Prioritizing Safety and Controlling Risks

From the perspective of technical implementation, it is first necessary to consolidate the foundation for risk identification through multi-dimensional geological surveys. In addition to conventional surveys of soil layer thickness, bearing capacity, and groundwater level, it is also essential to focus on detecting the permeability of soil layers, the variation patterns of pore water pressure, and complex surrounding environmental factors. These include the foundation types and settlement sensitivity thresholds of adjacent buildings, as well as the material and pressure-bearing capacity of underground pipelines. These data can provide accurate bases for risk prediction. During

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the risk prediction phase, it is necessary to combine survey data and use professional calculation models such as slope stability analysis models based on soil pressure theory and numerical simulation models for foundation pit deformation to quantitatively assess the probability of occurrence and the scope of impact of risks such as collapse, settlement, and piping that may occur at different construction stages. For foundation pits in soft soil areas, it is crucial to focus on predicting the risk of displacement of support structures due to soil creep during excavation. In terms of active prevention and control, in addition to formulating conventional emergency response plans, it is also necessary to design graded prevention and control measures. For example, reserve safety margins in the design of support structures and adjust the stiffness and strength parameters of support structures according to risk levels. During construction, set multi-level monitoring early warning thresholds. When monitoring data approach the warning values, initiate pre-control measures in advance, such as increasing the prestress of anchor rods and adjusting the excavation pace, rather than responding passively only after the data exceed the standards. Establish a risk responsibility tracing mechanism to clarify the risk management and control responsibilities of each link, ensuring that every step from survey, design to construction and monitoring is controlled by a dedicated person, truly achieving a construction process free of safety hazards.

2.2 Adapting to Actual Engineering Conditions

During the preliminary on-site investigation phase, it is necessary to go beyond basic information collection and conduct detailed investigations. In addition to the depth of the foundation pit, the distribution of surrounding buildings, and the direction of underground pipelines, it is also essential to focus on understanding the distribution of obstacles within the excavation range of the foundation pit, the limitations of the site's topography and geomorphology on the operation of construction machinery, and the impact of local climatic conditions on construction. These details directly determine the feasibility of the support scheme. When selecting the type of support, it is necessary to conduct multi-dimensional comparative analysis based on on-site conditions. When there are dense old buildings around the foundation pit, the use of soil nailing wall support may affect the safety of surrounding buildings due to construction vibrations. In this case, it is necessary to prioritize support types with low vibrations and high stiffness, such as soldier piles or diaphragm walls. If the foundation pit is deep and the groundwater level is high, it is necessary to combine dewatering technology with the design of support structures to avoid anti-seepage failure caused by relying solely on support structures. Scheme adaptation also needs to consider construction convenience and later-stage integration The construction process of the support structure should match the site space, and whether the support structure can be integrated with the later-stage main structure should be considered to reduce resource waste and construction conflicts. Through this all-round adaptation design, it can be ensured that the support scheme not only meets technical requirements but also fits the actual operational needs of the engineering site, ensuring stable and reliable support effects.

2.3 Balancing Economy and Efficiency

From the perspective of cost control, it is necessary to establish a refined cost accounting model, breaking down the cost of the support scheme into sub-items such as material costs, equipment costs, labor costs, and management costs, rather than just calculating the total cost. In material cost accounting, it is necessary to compare the cost-effectiveness of different specifications of steel and concrete and select the optimal materials based on the design parameters of the support structure. In equipment cost accounting, it is necessary to choose the optimal scheme for renting or purchasing equipment based on the construction period and equipment utilization rate. In terms of efficiency improvement, it is necessary to reduce redundant time in construction links through scheme optimization. In the design of the support scheme, coordinate the sequence of support structure construction and foundation pit excavation to avoid sequence waiting or cross-interference. Choose construction processes with short cycles and mature technologies, and consider the collaborative operation efficiency of construction equipment. Adopt integrated support construction equipment to reduce equipment conversion time [1]. When balancing cost and efficiency, it is necessary to establish a dynamic evaluation mechanism. When one scheme has a slightly higher cost but can significantly shorten the construction period, it is necessary to calculate the subsequent engineering benefits brought by the shortened period and comprehensively evaluate the overall benefits of the scheme. If multiple schemes have similar costs and efficiencies, priority should be given to schemes with low later-stage maintenance costs and minimal impact on the surrounding environment to achieve a balance between short-term costs and long-term benefits, truly reducing resource waste and improving the overall economic viability and implementation efficiency of the project under the premise of ensuring safety and quality.

3. Implementation Paths of Foundation Pit Support Technology in Building Civil Engineering Construction

3.1 Preliminary Geological Survey and Analysis

Clarify the boundaries of the survey area. Based on the excavation boundary of the foundation pit, the horizontal extension distance should meet the following requirements: for foundation pits with a depth of less than 5 m, extend to a range of 2 times the depth; for foundation pits with a depth of 5–10 m, extend to a range of 2.5 times the depth; for foundation pits with a depth of more than 10 m, extend to a range of 3 times the depth. At the same time, include the area within 30 m around the foundation pit, including buildings (structures) and underground pipelines [2]. During the detection phase, adopt a combination of "drilling + geophysical exploration" methods. Arrange drilling holes in a quincunx pattern, and adjust the hole spacing according to the complexity of the soil layers. For homogeneous soil layers, control the spacing at 20–25 m; for complex soil layers, reduce it to 15–18 m. Collect soil layer samples at different depths from each hole, with a minimum of 8 groups of samples per layer. Focus on measuring mechanical indicators such as the compression modulus, cohesion, and internal friction angle of the soil layers, and record the seasonal variation range of the groundwater level. Increase the monitoring frequency to twice a week in summer and once a week in winter. Clarify the corrosion grade (divided into strong, medium, and weak) of groundwater on steel and concrete [3]. During the data verification phase, compare the survey data with historical survey data in the same area. If the deviation of mechanical parameters exceeds 10%, supplement drilling holes for verification. Finally, form a survey report that includes a three-dimensional distribution model of soil layers and groundwater movement patterns to provide accurate data support for the design of the support scheme and avoid insufficient safety factors of support structures due to data errors.

3.2 Customized Support Scheme Design

Set core design parameters based on survey data. Classify the safety level of the foundation pit according to the sensitivity of the surrounding environment. The horizontal displacement limit of the support structure for a first-level safety level is 30 mm, 50 mm for a second-level, and 80 mm for a third-level. At the same time, determine the anti-seepage design standard. When the groundwater level is higher than the excavation surface, the anti-seepage grade of the support structure should reach P6 or above. Based on these parameters, initially design at least three support schemes such as soil nailing wall + waterproof curtain, soldier pile + anchor rod, and diaphragm wall, and calculate the key indicators of each scheme respectively [4]. For the soil nailing wall scheme, the length of the soil nails should be determined according to soil pressure calculations, generally 1.2–1.5 times the excavation depth, with a spacing of 1.5–2.0 m. For the soldier pile scheme, the reinforcement ratio of the pile body should be determined according to the bending moment calculation results, usually not less than 0.8%. For the diaphragm wall scheme, the length of the trench section should be determined according to the construction equipment, generally 6–8 m. During the scheme comparison phase, quantitatively analyze the costs and benefits. Taking the diaphragm wall scheme as an example, its initial cost is about 25% higher than that of the soldier pile scheme, but its later-stage maintenance cost can be reduced by 30%, and its impact on the surrounding environment during construction is smaller [5]. Finally, organize an expert review team of 7 or more people to score the schemes from four dimensions: structural safety, environmental impact, economic cost, and construction difficulty, with weights of 40%, 20%, 25%, and 15% respectively. The scheme with the highest score should be optimized according to the review opinions, such as adjusting the grout mix ratio of anchor rods and increasing the embedded depth of support structures, to ensure that the scheme complies with regulations and is suitable for the actual engineering conditions.

3.3 Strict Construction in Accordance with Regulations

During the pre-construction preparation phase, complete the double verification of equipment and materials. The straightness error of the drill rod of the drilling machinery should be less than 0.3%, and the impact energy of the percussion drill should reach 1.1 times the design requirement. Conduct spot checks on the mechanical properties and chemical composition of steel bars. The ratio of the measured tensile strength to the measured yield strength should not be less than 1.25, and the ratio of the measured yield strength to the standard value should not be greater than 1.3. The concrete mix ratio should be determined through laboratory trials, with a slump error controlled within ±20 mm. Conduct special tests for the anti-seepage grade, with a minimum of 6 test blocks per group [6]. During the construction process, adopt a dual control method of "informatization + manual inspection". When constructing soldier piles, use a laser plumb bob to monitor the verticality of the pile body, with a deviation of less than 0.8% and a pile top elevation error controlled between -50 mm and +100 mm. When constructing anchor rods, record the drilling speed and grouting pressure throughout the process. The grouting pressure should be stable at 0.6–0.8 MPa, and the grouting volume should reach more than 1.2 times the theoretical calculation volume to ensure full grout[7]. Node acceptance should be carried out according to the construction sequence. After the construction of the soil nailing wall is completed, conduct pull-out resistance tests, with a sampling quantity of not less than 1% of the total number and not less than 3 pieces. The average pull-out resistance should be not less than 1.1 times the design value. After the construction of the soldier piles is completed, conduct pile integrity tests, with a sampling quantity of not less than 20% of the total number and at least 1 piece per pile cap. All acceptance results should be documented in written reports. Unqualified items must be rectified until they meet the standards before proceeding to the next process to eliminate quality hazards caused by non-compliant operations.

3.4 Full-Process Monitoring with Dynamic Adjustment

During the monitoring point layout planning phase, scientifically set up monitoring points. Evenly arrange ground settlement monitoring points around the foundation pit with a spacing of 10–15 m and a distance of not less than 2 m from the edge of the foundation pit. Set displacement monitoring points for the support structure at the top and key sections of the piles (walls), with 1 point set every 3–5 piles (walls). Set groundwater level monitoring holes on both the inside and outside of the foundation pit, with the inside hole 1–2 m away from the support structure and the outside hole 5–10 m away from the support structure [8]. Adopt an automated monitoring system for data collection, and adjust the sampling frequency according to the construction stage: once every 3 days before foundation pit excavation, twice a day during excavation, and once every 2 days after excavation. The monitoring accuracy for displacement should reach 0.5 mm, and for groundwater level, it should reach 10 mm. The data should be transmitted to the monitoring platform in real-time to automatically generate change curves. Set up four-level early warning values for graded disposal: the first-level early warning is 60% of the design limit, the second-level is 75%, the third-level is 90%, and the fourth-level is 100% [9]. When the first-level early warning is reached, increase the monitoring frequency to three times a day. When the second-level early warning is reached, organize a technical team to analyze the reasons and adjust construction parameters such as reducing the excavation step distance and applying anchor rod prestress in advance. When the third-level early warning is reached, suspend excavation operations and initiate temporary reinforcement measures such as adding steel supports. When the fourth-level early warning is reached, immediately organize personnel evacuation and implement emergency rescue plans such as backfilling the foundation pit. After the monitoring data return to stability, re-evaluate the safety of the support system and determine the subsequent construction scheme to ensure that the support system remains under control throughout the construction process.

4. Conclusion

The above research shows that the implementation of foundation pit support technology in building civil engineering construction relies on four core paths: preliminary geological survey and analysis provide accurate data support for scheme design to avoid safety hazards caused by data deviations; customized support scheme design combines survey data with actual engineering conditions to ensure adaptability through multi-scheme comparison and expert review; strict construction in accordance with regulations ensures construction quality through equipment and material verification, process control, and node acceptance; full-process monitoring with dynamic adjustment maintains the stability of the support system through scientific monitoring point layout, real-time data collection, and graded disposal. These four paths are progressive and mutually synergistic, effectively reducing the risks of foundation pit support and improving the safety, economic viability, and efficiency of technical implementation.

References

[1] Feng, Y. T., & Hu, W. J. Application of foundation pit support construction technology in civil engineering of residential buildings[J]. Architecture & Decoration, 2025(5):138-140.

[2] Wang, R. Application of foundation pit support technology in civil engineering construction of buildings[J]. Petrochemical Construction, 2025, 47(2): 115-117.

[3] Huang, C. R. Application of foundation pit support technology in civil engineering construction of buildings[J]. Architecture & Decoration, 2024(16):149-151.

[4] Li, Q. Q. Exploration on the application of foundation pit support construction technology in civil engineering construction of buildings[J]. Architecture, Building Materials & Decoration, 2024(21):70-72.

[5] He, R. W. Practical exploration of deep foundation pit support technology in civil engineering construction of buildings[J]. Architecture, Building Materials & Decoration, 2025(13): 169-171.

[6] Chen, H. W. Exploration on the application of deep foundation pit support technology in civil engineering construction of buildings[J]. Brick World, 2025(6):28-30.

[7] Yang, Z. Y. Exploration on the application of foundation pit support construction technology in civil engineering construction of buildings[J]. Development Guide to Building Materials, 2023, 21(23):77-79.

[8] Yao, Z. Y. Analysis on the application of foundation pit support construction technology in civil engineering of residential buildings[J]. Development Guide to Building Materials, 2024, 22(23):75-77.

[9] Li, Z. C., & Guo, J. J. Research and application of deep foundation pit support technology in civil engineering construction[J]. Urban Architecture and Development, 2025, 6(9): 58-60.