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Technical Management and Risk Management Practices for a High-Rise Public Building Project in Guangzhou Nansha Free Trade Zone

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Abstract: The construction project of a non-super high-rise public building in Guangzhou's Nansha Free Trade Zone faces unique challenges. The project established a full-cycle technical management system, encompassing technical management across various sectors and BIM collaboration. Simultaneously, it introduced advanced technical management such as deep foundation pits and core tube construction, along with a risk management system and special weather response strategies. Through these measures, the project achieved numerous significant results, forming a unique management paradigm that offers valuable insights for similar engineering projects.

Keywords: Nansha Free Trade Zone; Non-super high-rise public building; Engineering management

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1. Introduction

With the development of the construction industry, non-super high-rise public building projects face numerous challenges and opportunities. The *China (Guangdong) Pilot Free Trade Zone Overall Plan*, issued in 2015, provided policy support for the construction of the Nansha Free Trade Zone in Guangzhou, reflecting the strategic deepening of China's free trade pilot zone policy over the past decade [1]. Against this backdrop, a non-super high-rise public building project in the Nansha Free Trade Zone, due to its unique geographical location and project characteristics, holds significant research value in engineering technology management, risk management, and other areas. This project involves complex structural design, integration of mechanical and electrical systems, and responses to special weather conditions. The adoption of a full-lifecycle management system for materials and equipment has effectively enhanced management efficiency and engineering quality [2], while also achieving remarkable results in cost control and social benefits. Its management model and experiences have certain reference value for non-super high-rise public building projects and provide guidance for improving engineering management under the policy environment of the free trade zone.

2. Project overview and technical management framework

2.1. Overview of Nansha Free Trade Zone engineering projects

The public building project in Guangzhou Nansha Free Trade Zone boasts a unique profile. Located within the Free Trade Zone and facing coastal geological conditions, this project poses special requirements for engineering construction. The building comprises multiple clusters and adheres to specific technical parameters. Notably, the structural characteristics of the public building are prominent, and the design and construction of its structural system are challenging, requiring consideration of various factors such as wind loads and seismic effects. Additionally, the electromechanical system is extremely complex, encompassing multiple subsystems such as water supply and drainage, electrical, and heating and ventilation, which necessitate high coordination and integration to ensure the normal operation of the building. To effectively navigate these complexities and achieve the dual objectives of cost excellence and quality, the project management draws upon and implements advanced high-quality management processes [3].

2.2. Construction of a full-cycle technology management system

A non-super high-rise public building in the Nansha Free Trade Zone of Guangzhou City boasts a unique engineering profile. Located within the free trade zone and facing coastal geological conditions, it imposes special requirements on engineering construction. The building comprises multiple clusters, possesses specific technical parameters, and exhibits notable structural characteristics, necessitating consideration of various factors such as wind load and seismic effects [4,5]. The structural system design and construction of this project are challenging. Additionally, the electromechanical system is extremely complex, encompassing numerous subsystems such as water supply and drainage, electrical, heating and ventilation, etc. High coordination and integration among these subsystems are required to ensure the normal operation of the building. These characteristics pose numerous challenges to the engineering technology management of this project.

3. Key construction technology management practices

3.1. Technical management of deep foundation pit and pile foundation engineering

In non-super high-rise public building projects in the Nansha Free Trade Zone of Guangzhou, technical management of deep foundation pits and pile foundation engineering is crucial. For the construction of waterproof curtain using triaxial mixing piles, precise control of construction parameters is required to ensure uniform mixing, continuous pile body, and achieve good waterproofing effect. For the control of the verticality of prestressed pipe piles, strict control is needed from multiple aspects such as the installation and commissioning of pile drivers, lifting and positioning of pile bodies, and real-time monitoring during the construction process to ensure that the pipe piles are driven vertically into the ground and meet design requirements. In addition, a linkage mechanism for foundation pit monitoring data is established, integrating various monitoring data such as displacement, settlement, and water level, to analyze data trends in a timely manner, respond quickly when abnormalities occur, and ensure the safety and stability of deep foundation pit and pile foundation engineering construction.

3.2. Structural construction quality control

In non-super high-rise public building projects in the Nansha Free Trade Zone of Guangzhou, the application of the core tube construction system ensures construction safety and efficiency. This system features high automation and rapid construction progress, effectively shortening the construction period and improving construction quality. The high-strength concrete pumping process is a key link in structural construction. By reasonably selecting pumping equipment and optimizing concrete mix proportions, it ensures that high-strength concrete can be smoothly transported to the designated location, meeting structural strength requirements. The integrated management of the structural health monitoring system is crucial for construction quality control. This system can monitor structural deformation, stress, and other parameters in real time, promptly identify potential problems, and take corresponding measures to ensure the safety and stability of the structure during construction.

4. Implementation of engineering risk management system

4.1. Risk identification and assessment mechanism

4.1.1. Construction of a comprehensive process risk checklist

The implementation of an engineering risk management system requires the construction of a comprehensive risk checklist. Firstly, it is necessary to conduct a comprehensive identification of potential risks, taking into account various stages of the project and various influencing factors. For example, a non-super high-rise public building project in Nansha Free Trade Zone, Guangzhou, established a 12-category risk matrix including geological risks, high-altitude operation risks, cross-construction risks, etc., covering up to 62 risks. Through the analysis of similar projects and the summary of past experience, the possible links and manifestations of various risks were sorted out. After identifying risks, they need to be evaluated to determine the level of risk, so as to take targeted management measures subsequently. This process requires a combination of qualitative and quantitative methods, such as the Analytic Hierarchy Process (AHP), considering the likelihood of risk occurrence and the severity of consequences, providing accurate and effective basis for engineering risk management [6].

4.1.2. BIM risk simulation and prediction

In the implementation of the engineering risk management system, BIM risk simulation and prediction are crucial components. Tools such as Revit and Dynamo are utilized for digital rehearsals, including curtain wall installation collision simulation and electromechanical integrated pipeline conflict detection. By accurately modeling and simulating the curtain wall installation process, potential collision risk points, such as spatial conflicts between different components, can be identified in advance. Similarly, for electromechanical integrated pipelines, conflicts such as intersections and overlaps that may arise during actual installation can also be detected. This BIM-based risk simulation and prediction enables the discovery of potential risks before project implementation, provides accurate data support for risk assessment, and aids in the formulation of effective risk response measures [7]. Consequently, it helps reduce risk losses during project implementation and enhance project quality and efficiency.

4.2. Risk response measure system

4.2.1. Strategies for dealing with special weather conditions

In a non-super high-rise public building project located in the Nansha Free Trade Zone of Guangzhou, effective response strategies have been formulated for special weather conditions, especially during the typhoon season, through a systematic decision-making process. For the curtain wall unit panels, a temporary fixing scheme has been devised to ensure the stability of the panels during typhoon weather, preventing displacement or even detachment caused by strong winds, thereby safeguarding the building’s appearance and the safety of surrounding personnel. Additionally, a wind prevention plan has been established for tower cranes, which operate at heights and are significantly affected by wind forces. The plan specifies detailed operational guidelines for tower cranes under different wind levels, such as reinforcement measures before a typhoon arrives and the parking position of the lifting arm, to prevent serious accidents such as collapse caused by strong winds [8]. This ensures that construction safety and progress are not unduly affected by special weather conditions..

4.2.2. Cross-construction coordination mechanism

In terms of the coordination mechanism for cross-construction, it is crucial to establish standards for the handover of various professional procedures. Clarifying the handover requirements and quality standards for each discipline at different construction stages ensures the continuity and accuracy of construction, avoiding risks caused by improper procedure connections. Meanwhile, the development of a mobile collaborative management system provides strong support for construction interface management. Through this system, construction teams can share information such as construction progress, problems, and solutions in real time, strengthening communication and collaboration. Management personnel can grasp the on-site situation in a timely manner, effectively coordinate and schedule cross-construction, promptly resolve potential conflicts and contradictions, improve construction efficiency, and reduce risks caused by poor information flow or ineffective coordination.

5. Analysis of the effectiveness of management practices

5.1. Verification of technical management achievements

5.1.1. Analysis of quality acceptance pass rate

The project has achieved remarkable results in terms of the quality acceptance pass rate. The detection rate of Class I piles in the pile foundation testing reached 96%, indicating that the quality of the pile foundation works is high and meets the relevant standard requirements. The verticality deviation of the main structure is $\leq H/2000$, reflecting the precision and high quality of the main structure construction. These measured data verify the quality level of the project under technical management from different aspects. The high quality of the pile foundation and the precise construction of the main structure have laid a solid foundation for the overall project quality, reflecting that strict control over each key link in the practice of technical management has achieved good results and effectively ensured the pass rate of the project quality acceptance.

5.1.2. Benefits of new technology application

Prefabricated construction technology has demonstrated significant advantages in a non-super high-rise public building project in Nansha Free Trade Zone, Guangzhou. Through efficient assembly of prefabricated components, the construction period has been greatly shortened, saving 47 days. This not only accelerates the project progress but also potentially brings a series of chain benefits, such as economic benefits generated by early commissioning. At the same time, the application of the smart construction site system has also achieved good results. This system optimizes management processes through information technology, achieves real-time monitoring and precise management of the construction site, and effectively reduces management costs by 18%. This cost reduction enhances the economic benefits of the project and provides strong support for quality and safety management, ensuring the smooth progress of the project.

5.2. Risk management performance evaluation

5.2.1. Risk accident statistics

The project's risk management system demonstrated considerable effectiveness, as evidenced by accident statistics throughout the construction phase. Records indicate zero major safety incidents and a notable reduction in minor accidents, with the total accident frequency rate 22% lower than the industry average for comparable projects. This outcome is largely attributed to the predictive capabilities of the BIM-based risk simulation platform, which enabled proactive identification and resolution of over 85% of potential spatial and procedural conflicts prior to on-site execution [9]. Furthermore, the systematic application of a social sustainability assessment framework throughout the project lifecycle facilitated enhanced stakeholder coordination and oversight of subcontractors, effectively mitigating risks associated with workforce management and operational interfaces [10]. The integration of these structured preemptive measures substantiates the robustness of the implemented risk management protocols.

5.2.2. Insurance cost control

In a non-super high-rise public building project located in the Nansha Free Trade Zone of Guangzhou, significant achievements have been made in risk management and control measures, particularly in terms of insurance cost control. Through effective risk management, the engineering all-risk premium rate has been reduced by 0.15 percentage points. This is primarily attributed to the precise identification and assessment of risks in various aspects of the project, as well as the formulation and implementation of targeted risk response strategies. For instance, comprehensive monitoring and timely handling of potential safety risks, quality risks, and schedule risks during the construction process have reduced the probability of risk events. Simultaneously, close communication with insurance companies has been maintained, and more favorable insurance premium rates have been negotiated based on the results of risk management and control. This reduction in insurance costs not only directly reduces the financial expenditure of the project but also indirectly reflects the effectiveness of risk management practices, providing strong guarantees for the smooth progress of the project and the enhancement of economic benefits.

5.3. Comprehensive benefit output of the project

5.3.1. Social benefit analysis

As one of the first non-supertall demonstration projects in the Free Trade Zone, this project has achieved remarkable social benefits. In terms of industry influence, it has set a benchmark for technology and risk management in non-supertall public building projects. Its advanced technology management model and risk management strategies can be used as references by the industry, promoting the improvement of technology and management levels in the construction industry. The successful implementation of the project has enhanced society's confidence in the safety and reliability of non-supertall public buildings, promoting the sustainable development of urban construction. At the same time, the construction of this project has attracted the attention of many related enterprises and talents, driving the development of upstream and downstream industries. It has played a positive role in regional economic restructuring and employment growth, enhancing the comprehensive competitiveness and social influence of the region.

5.3.2. Benefit analysis of management optimization

Through technical optimization and risk management measures, the project has achieved remarkable results in construction efficiency and cost control. In terms of construction technology, advanced construction techniques and materials have been adopted to optimize the construction process and reduce waste of labor and materials. For example, the new concrete pouring technology has improved construction accuracy and effectively reduced unnecessary consumption of materials. In terms of engineering design, non-essential structural and decorative elements have been reduced through streamlining the design scheme, further optimizing resource utilization. Risk management measures have successfully avoided construction delays and rework risks caused by geological issues by comprehensively identifying and assessing potential risks and implementing targeted prevention and control strategies, such as conducting geological condition analysis and response in advance. These measures ensure the efficient progress of the project and the rational utilization of resources, providing strong guarantees for the smooth implementation of the project.

6. Conclusion

This project has formed a unique "dual-driven" management paradigm in a non-super high-rise public building project located in the Nansha Free Trade Zone of Guangzhou. On the one hand, a digital twin management system has been established with the help of BIM + IoT technology, enabling efficient and precise management of the project. On the other hand, a risk prevention and control system has been constructed, which includes a risk warning index model and a multi-party collaborative decision-making mechanism, effectively reducing engineering risks. These two systems complement and coordinate with each other, providing a useful reference for the management of non-super high-rise building projects. At the same time, considering the special policy environment of the free trade zone, suggestions for improvement in engineering management have been proposed. For example, in terms of cross-border engineering standard alignment, further exploration is needed to integrate different standard systems; in terms of green construction certification, relevant research should be deepened to meet the requirements of sustainable development, providing more targeted and operable experience for the management of similar projects in special environments.

Disclosure statement

The author declares no conflict of interest.

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