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Research on Technology and Risk Control Strategy in Real Estate Construction Engineering Management

Senlin Ma*

Shenzhen Merchants Real Estate Co., Ltd., Guangzhou 518100, Guangdong, China

**Author to whom correspondence should be addressed.*

Abstract: The complexity of real estate construction project management is highlighted, and this paper deeply discusses its technology and risk control strategy. Analyze the application field of technology and the construction of risk management system, and verify the effectiveness of the strategy through cases. The is concluded that the integration of technology management and risk control is the core path to improve the efficiency of the project, and it points out that the application of intelligent tools should be strengthened and explore the new management mode under the dual-carbon goal.

Keywords: Real estate construction engineering management; Technology application; Risk control

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1. Introduction

Real estate construction project management, as the key to project success, is facing increasingly complex challenges. Against the backdrop of the current transformation and upgrading of the construction industry, traditional management models are no longer able to meet the demands of high-quality development. In October 2021, China issued the "Action Plan for Peaking Carbon Emissions Before 2030", which clearly requires the construction industry to promote green transformation, which puts higher demands on the technical application and risk control in real estate construction project management. Construction project management not only involves complex coordination in multiple stages, but is also influenced by various external factors such as market fluctuations and policy adjustments. On the technical level, the widespread application of emerging technologies such as prefabricated buildings and intelligent construction has improved construction efficiency and quality, but it has also put forward higher requirements for construction accuracy, process connection, and cross disciplinary collaboration. At the same time, the infiltration of green construction concepts requires the management process to take into account environmental benefits and form a multidimensional collaborative framework of "technology economy society". In this situation, in-depth research on the technology and risk control strategies in real estate construction project management, exploring their deep integration paths, is of great significance for improving project efficiency and achieving sustainable development of the industry.

1.1. Overview of real estate construction project management

1.1.1. Definition and core content of real estate construction project management

Real estate construction project management is the process of planning, organizing, coordinating, and controlling the entire life cycle of real estate projects using a systematic approach, covering stages such as project planning, design, construction, delivery, and operation and maintenance, with the aim of achieving a balance between quality, cost, schedule, and safety goals. Its core content includes resource integration and configuration optimization, scientific decision-making of technical solutions, risk identification and dynamic control, as well as the construction of a multi-party collaboration mechanism. Modern engineering management emphasizes the full process digital empowerment, such as the application of BIM technology to achieve integrated design and construction, and the integration of prefabricated building technology to promote standardization and industrialization. At the same time, the infiltration of green construction concepts requires consideration of environmental benefits in the management process, forming a multidimensional collaborative framework of “technology economy society”. On the theoretical level, it relies on systems engineering theory, project management methodology, and lean construction thinking, while on the practical level, it needs to combine policy norms, market dynamics, and technological innovation to form a dynamic adaptive management system.

1.2. The main challenges of current real estate engineering management

Real estate engineering management faces multiple complex challenges. The problems of project schedule pressure and cost overruns are prominent, influenced by market fluctuations, policy regulation, and unstable supply chain factors. The phenomenon of project cycle compression and budget loss control is frequent, and material price fluctuations, frequent design changes, and labor shortages further exacerbate cost risks. The technological complexity has significantly increased, and the application of emerging technologies such as prefabricated buildings and intelligent construction has put forward higher requirements for construction accuracy, process connection, and cross disciplinary collaboration. Traditional management models are difficult to adapt to modular construction and digital driven technological iteration. The difficulty in resource coordination manifests as conflicting goals among multiple stakeholders, such as unclear division of responsibilities between developers, contractors, design units, and government departments, and information gaps across stages leading to decision-making delays [1]. In addition, the tightening of environmental regulations and the requirements for energy conservation and emission reduction under the “dual carbon” target have forced engineering management to incorporate sustainability considerations in the selection of technical paths and resource allocation, further increasing management complexity. It is urgent to build a resilient management system through technological innovation and institutional optimization to cope with uncertainty in dynamic environments [2].

2. Key areas of real estate construction engineering technology management

2.1. Application and management of prefabricated building technology

Prefabricated building technology focuses on standardized design, factory production, and modular construction, and achieves innovation in engineering construction mode through efficient integration of prefabricated components. Its core advantage lies in standardized production, which reduces the amount of on-site work, shortens the construction period, and reduces manual dependence. At the same time, its green features are significant, responding to the demand for sustainable development by reducing construction waste and energy consumption. However, prefabricated construction faces technical difficulties, and the reliability of node connections and overall structural stability rely on refined processes. For example, the precision control of grouting sleeve connections and bolt anchoring directly affects building safety; The coordination requirements between component production and on-site installation are strict, and dimensional deviations can easily lead to assembly failures. Therefore, 3D scanning and BIM technology are needed to assist in error correction [3]. In addition, insufficient supply chain management and cross stage collaboration may exacerbate technical risks, and a full chain quality control system needs to be established to ensure the implementation of technology.

2.2. Engineering management driven by digital technology

Digital technology has reconstructed the traditional engineering management model, and BIM technology integrates design, construction, and operation data through 3D models to achieve cross disciplinary collaborative design and conflict detection, optimize construction plans, and reduce rework [4]. BIM based 4D/5D simulation during the construction phase can accurately predict progress and costs, improving resource scheduling efficiency. The Internet of Things and intelligent monitoring system collect real-time data on the construction site environment, equipment status, and personnel behavior through sensors, and combine AI algorithms to analyze safety hazards and quality defects, dynamically adjusting management strategies. For example, the tower crane operation monitoring and deep foundation pit deformation warning system can reduce the risk of accidents, and RFID technology can achieve accurate management of building materials traceability and inventory. The deep application of digital technology relies on data standardization and system compatibility, requiring the construction of a unified platform to break information silos and promote the transformation of engineering management towards intelligence and transparency.

3. Construction of risk management system for real estate engineering

3.1. Identification and assessment of engineering risks

3.1.1. Classification of main risk factors

Real estate engineering risks can be divided into two categories: technical risks and non-technical risks. Technical risks arise from technical defects in the design and construction process, such as building functional conflicts caused by lagging design specifications, structural safety hazards caused by immature connection processes of prefabricated component nodes, or quality deviations caused by insufficient adaptability of construction technology. Non-technical risks involve uncertainty in the external environment, including the impact of policy adjustments on project compliance (such as changes in land transfer rules, upgrades to environmental standards), delays in building material supply or cost surges caused by supply chain disruptions, and the risk of funding chain disruptions caused by market fluctuations. Two types of risks interact with each other, for example, policy tightening may force technological path adjustments, while insufficient technological iteration may amplify policy compliance risks [5]. It is necessary to construct a multidimensional risk list through a systematic identification framework, combined with the characteristics of the entire project cycle, to provide a basis for subsequent evaluation and control.

3.1.2. Risk assessment methods

The Analytic Hierarchy Process (AHP) quantifies the weight and priority of risk factors by constructing a hierarchical structure model of “objectives criteria indicators”, which is suitable for complex risk assessment scenarios with multiple objectives and multiple subjects. For example, breaking down technical risks into sub items such as design, construction, and materials, and combining expert scoring to determine the relative importance of each level. The risk matrix rule divides risk events into “high medium low” levels through probability impact two-dimensional analysis, achieving the transformation from qualitative to quantitative. The combination of the two can improve evaluation accuracy: AHP solves the problem of indicator weight allocation, and the risk matrix clarifies the ranking of risk levels [6]. In practice, it is necessary to dynamically update evaluation parameters, such as policy change frequency and supply chain stability data, and use Monte Carlo simulation to predict risk superposition effects, in order to enhance the timeliness and reliability of evaluation results.

3.2. Risk management strategy

3.2.1. Organizational measures

The allocation of risk responsibility should be based on contract terms and stakeholder roles, clarifying the risk bearing boundaries of developers, general contractors, design institutes, and supervisors, such as transferring technical risks to contractors through the EPC general contracting model. The emergency plan system should include risk warning thresholds, response processes, and resource reserves, such as setting up emergency special funds to deal with supply chain disruptions, or establishing a policy tracking team to interpret regulatory changes in real time. In terms of organizational collaboration mechanism, regular joint meetings and information sharing platforms should be held to ensure risk linkage response among design, construction, procurement and other departments, and to avoid risk diffusion caused by information silos.

3.2.2. Technical measures

Redundancy design enhances the system's ability to resist risks by increasing structural safety factors or backup supply chain paths, such as reserving adjustment margins for components in prefabricated buildings to cope with installation errors. Dynamic monitoring technology relies on sensors, BIM, and IoT platforms to collect real-time construction data and analyze anomalies, such as warning of prefabricated node deformation through stress monitoring, or simulating design compliance after policy changes using BIM models [7]. Technical measures need to be deeply integrated with digital tools, such as embedding risk matrices into BIM systems to automatically trigger warnings, or using machine learning algorithms to predict the probability of supply chain disruptions, to achieve a transition from passive response to active intervention, forming a closed-loop management chain of "monitoring analysis decision-making feedback".

4. Technology and risk collaborative control strategy

4.1. Collaborative mechanism between technical management and risk control

4.1.1. Integration of technical standards and risk management processes

The synergy between technical standards and risk management processes needs to be embedded in the PDCA (Plan Do Check Act) cycle framework, forming a closed-loop optimization mechanism. During the planning phase, technical standards are used to clarify design specifications and construction processes, and a risk identification checklist is developed simultaneously; Real time monitoring of construction quality and risk trigger points during the execution phase, combined with BIM and IoT technology, such as automatic warning when the installation deviation of prefabricated components exceeds the limit; During the inspection phase, digital tools are used to compare actual data with technical standards, analyze the root causes of deviations, and assess the impact of risks; Dynamically adjust technical solutions and control strategies during the processing phase, such as optimizing node connection processes or updating emergency plans. This model achieves a bidirectional coupling of "technical compliance risk controllability" through rigid constraints of technical standards and flexible adaptation of risk management, reducing secondary risks caused by technical defects [8].

4.1.2. Cross departmental collaboration and information sharing mechanism

Cross departmental collaboration requires building a collaborative network centered around data flow, breaking down information barriers between design, construction, procurement, and operations departments. For example, a collaborative platform based on BIM integrates design drawings, material lists, and construction progress data to ensure real-time transmission of risk information between departments. The information sharing mechanism relies on standardized data interfaces and permission allocation, such as synchronously pushing supply chain interruption risk warning signals to the procurement and project departments to trigger joint decision-making. Through regular risk joint meetings and digital dashboards, clarify the responsibility boundaries and response time of all parties, and avoid risk escalation caused by communication lag. In addition, blockchain technology can enhance data credibility, record the entire process of risk event handling, and provide a basis for responsibility tracing and experience reuse.

4.2. Dynamic control supported by information platform

4.2.1. Construction of BIM + risk warning system

The integration of BIM and risk warning system advances risk control to the design stage, with a risk parameter library embedded in the model (such as policy compliance indicators, structural safety thresholds), automatically detecting design conflicts and construction feasibility risks. During the construction phase, BIM models are linked with sensor data to map real-time on-site progress and quality status, such as monitoring the installation accuracy of prefabricated components, triggering warnings and pushing correction plans when exceeding limits. The system supports risk visualization display, identifying risk levels through red, yellow, and green colors to assist managers in quickly identifying high priority issues. This model breaks through the limitations of traditional static control and forms an intelligent control chain of "model driven data feedback dynamic adjustment".

4.2.2. Risk prediction and decision-making driven by big data

Big data technology integrates historical project data, market dynamics, and policy texts to construct multidimensional risk prediction models. Machine learning algorithms analyze the correlation patterns of supply chain interruptions, project delays, and other events, quantifying the probability and scope of risk occurrence. For example, predicting cost overruns risk based on time-series data of building material price fluctuations, or using natural language processing technology to capture policy keywords and predict compliance risk trends. The decision support system integrates predicted results with real-time data to generate multi scenario response plans, such as dynamically adjusting procurement plans or optimizing construction processes. The data-driven decision-making model reduces subjective judgment bias, enhances the foresight and accuracy of risk response, and promotes the transformation of engineering management from experience oriented to science oriented.

4.3. Typical case analysis

4.3.1. Technical risk management practice for prefabricated residential projects

Prefabricated residential projects need to focus on the synergy between component production, transportation, and installation in technical risk management. Taking the Gucun Town resettlement housing project in Baoshan District, Shanghai as an example, it adopts a standardized design with a prefabrication rate of 36.1%, using prefabricated exterior wall panels, composite floor slabs and other components, but faces the risks of component size deviation and node connection hazards.

The project uses 3D laser scanning technology to detect the accuracy of prefabricated components, combined with BIM models for error correction to ensure installation compatibility; At the same time, establish a full chain quality control system, implement "one component, one file" traceability management from factory production to on-site lifting, and reduce the rate of component damage. To address the risk of node connection, a composite process of grouting sleeve and bolt anchoring is adopted, and real-time monitoring of node stress changes is carried out through IoT sensors. The data is integrated into the BIM platform to generate risk warning reports and achieve dynamic control [9].

In addition, the project introduces PDCA cycle optimization process standards, such as adjusting the grouting material ratio through post construction evaluation to improve node reliability. This case demonstrates that technology risk management needs to integrate digital tools and lean management, and strengthen full process collaboration.

4.3.2. Full cycle risk management of high-rise building complex projects

High rise building complex projects require the establishment of a risk management system that covers the entire lifecycle due to their complex functions and numerous participants. Taking a commercial complex project in the core area of a certain city as an example, its integrated risk identification, assessment, and response mechanism runs through the design, construction, and operation stages. During the design phase, BIM technology is used to simulate building functional conflicts and structural safety, and identify potential design defects; During the construction phase, the Internet of Things system is used to monitor the deformation of deep foundation pits and the operation status of tower cranes, combined with a risk matrix to quantify safety risk levels and trigger graded response plans.

To address the risk of supply chain disruptions, establish a diversified supplier database and safety stock mechanism, and record contract performance data through blockchain technology to reduce the probability of default. During the operation and maintenance phase, we rely on big data platforms to analyze historical data on energy consumption and equipment failures, and predict maintenance needs. The project also integrates data from the design institute, general contractor, and supervisory party through a cross departmental information sharing platform to achieve risk linkage response, such as quickly adjusting fire compliance design when policies change. The full cycle risk management model deeply integrates technical measures (such as redundant structure design) with organizational measures (such as joint meeting system), effectively enhancing project resilience [10].

5. Summary

In the management of real estate construction projects, the deep integration of technology and risk control is the core path to improve project efficiency. This article systematically expounds the connotation and challenges of real estate construction project management, deeply analyzes the application and management points of key technology fields such as prefabricated building technology and digital technology, and constructs a comprehensive risk management system covering risk identification, evaluation, and control strategies.

At the same time, it explores the dynamic control mode supported by technology and risk collaborative control mechanism and information platform, and verifies the effectiveness of the proposed strategies through typical case analysis. Research has found that the coordinated promotion of technology management and risk control can not only effectively address the complex challenges in current real estate engineering management, but also significantly improve the achievement of project quality, cost, schedule, and safety goals.

However, there are still shortcomings in current research, and the deep application of intelligent tools in risk prediction needs to be strengthened. The new management mode under the dual carbon target needs further exploration. Future research will focus on the integration and innovation of intelligent technology, in order to provide more accurate and efficient risk prediction and control solutions for real estate construction project management, and promote the industry’s development towards green, intelligent, and resilient directions.

Disclosure statement

The author declares no conflict of interest.

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