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Technological Innovation and Risk Control Strategies in Real Estate Construction Management

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Abstract: Real estate construction management faces technological innovation and risk-control challenges. Digital, intelligent, and green construction technologies are driving management transformation. This paper explores innovation paths like BIM, IoT, AI robots, and eco-friendly materials, analyzes risk characteristics, and proposes strategies such as a full-process risk management framework, technology verification, standardization, and data security systems. It also discusses the supporting role of government regulation, industry standards, corporate governance, and personnel training, aiming to provide theoretical and practical guidance for modernizing real estate construction management.

Keywords: Real estate construction management; Technological innovation; Risk control strategy

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1. Introduction

With the rapid development of the real estate construction industry, technological innovation and risk management have become key issues. This article delves into the application of digital, intelligent, and green construction technologies in engineering management, analyzes the interweaving of traditional and new risks brought about by technological innovation, and proposes a series of collaborative mechanisms and practical strategies such as a full process risk management framework, technical verification and standardization processes, and data security assurance systems. At the same time, it emphasizes the supporting role of government regulation, industry standards, internal control of enterprises, and talent cultivation in technological innovation and risk management, in order to achieve modernization of real estate engineering management.

2. The path of technological innovation in real estate construction project management

2.1. The application of digital and intelligent technologies

2.1.1. Full lifecycle management of BIM technology

BIM technology achieves collaborative management of the entire lifecycle of real estate construction through

3D modeling and data integration [1, 2]. Support multi-disciplinary collaborative optimization solutions during the design phase. Linking the construction phase with the management system to improve efficiency. The operation and maintenance phase is transformed into a digital twin, providing data support [3, 4]. Its core value lies in breaking down information silos and promoting refined and transparent management. Although it has become an industry standard, data standardization and cross platform compatibility issues still need to be addressed [5].

2.1.2. Practice of intelligent construction technology

The integration of the Internet of Things and artificial intelligence is reshaping traditional construction. The Internet of Things collects data for early warning and deployment, and AI robots undertake high-risk operations to improve accuracy and efficiency. For example, intelligent inspection robots reduce safety risks [6]. This type of technology application relies on hardware reliability and promotes the intelligent and unmanned upgrade of engineering management.

2.2. Innovation in green construction technology

2.2.1. Promotion of energy-saving and environmentally friendly materials and processes

Energy-saving and environmentally friendly materials and processes are the key to innovation in green construction. Low-energy concrete reduces resource consumption and carbon footprint, while prefabricated processes reduce construction waste and dust. UHPC enhances strength and reduces volume, photovoltaic exterior wall power generation, and enclosure. Technology promotion faces high costs and incomplete standards, requiring policy incentives and technological iteration to accelerate market penetration.

2.2.2. Renewable energy and resource recycling technologies

Renewable energy and resource recycling technologies reshape the sustainability of construction projects. Solar photovoltaics and ground source heat pumps reduce dependence on fossil fuels. Rainwater collection and reuse of reclaimed water to alleviate water pressure. Resource utilization of construction waste improves utilization efficiency [7]. Zero energy buildings can achieve energy self-sufficiency, but the technical, economic, and integrated aspects need to be improved, and stability needs to be strengthened through intelligent monitoring and regulation.

3. Analysis of risk characteristics under the background of technological innovation

3.1. The continuation of traditional engineering management risks

3.1.1. Quality, schedule, and cost control risks

Under the background of technological innovation, quality, schedule, and cost control risks remain the core traditional risks. The complexity of technology integration leads to poor process connection and quality defects; The introduction of smart devices may disrupt the schedule [8]. Cost risk is reflected in the uncertainty of high investment and return cycles in the early stages of technology application. Traditional risks stem from technological innovation and outdated management system adaptation, and require dynamic monitoring and standardized process optimization to achieve risk mitigation [9].

3.1.2. Contract and supply chain management risks

Under the drive of technology, contract and supply chain management risks present new characteristics. Vague technical terms in contracts can easily lead to disputes and increase performance risks. The dependence on building materials and equipment technology in the supply chain is increasing, and the global supply chain is affected by various factors. Traditional management lacks evaluation and flexibility mechanisms [10]. Resolve the need to restructure contract technology adaptability and establish a supply chain resilience assessment system.

3.2. New risks brought by the application of new technologies

3.2.1. Technical compatibility and system security risks

Under technological innovation, compatibility and security vulnerabilities of heterogeneous systems have become new sources of risk. Due to differences in interface protocols, there are data exchange barriers in multi-technology integration, increased system openness increases the external attack surface, and the contradiction between technological iteration and outdated facility updates exacerbates the risk of system collapse. At present, technical compatibility relies on vendor proprietary protocols, and security protection is mostly a single-point defense, lacking full chain resilience design. It is necessary to reduce systemic risks through cross-platform standardization and active defense systems.

3.2.2. Data privacy and network security risks

In the digitization of construction engineering, there are risks of privacy breaches and network attacks in the data collection, transmission, and storage processes. The theft of construction site data can lead to the leakage of commercial secrets and infringement of workers' privacy. The cloud-based engineering management platform is vulnerable to hacker attacks, such as data tampering, device hijacking, etc., which can disrupt engineering decisions. Cross-border data flow increases legal risks due to judicial differences. Traditional protection is difficult to prevent AI-driven attacks, and the boundaries of data ownership and sharing are unclear. To solve the problem, it is necessary to integrate technologies such as blockchain and zero trust architecture, and improve data governance regulations.

4. The collaborative mechanism between technological innovation and risk management

4.1. Risk identification and assessment driven by technology

4.1.1. Risk prediction model based on big data and AI

Integrating big data and artificial intelligence technology with engineering historical data to construct risk prediction models. Machine learning algorithms can identify potential patterns, such as quality defects, such as natural language processing can analyze implicit risks in contracts. The model is dynamically trained to optimize accuracy and supports active warning. However, applications face challenges such as data silos and insufficient interpretability of algorithms, requiring breakthroughs in technical bottlenecks.

4.1.2. Construction of dynamic risk monitoring system

The dynamic risk monitoring system is based on the Internet of Things, BIM, and cloud computing technology, which can perceive and close-loop control engineering risks in real time. Sensor networks collect data on construction environment, equipment, and personnel behavior, and edge cloud collaborative analysis triggers threshold warnings; BIM integrates monitoring data to generate dynamic heat maps for locating high-risk areas, such as intelligent helmets tracking workers' movements to avoid collisions. The system breaks through the bottleneck of information lag, but the real-time processing capability of multi-source heterogeneous data is insufficient. It needs to integrate edge computing and digital twin technology to improve the response speed and decision-making reliability.

4.2. Adaptive optimization of management processes

4.2.1. Restructuring of organizational structure and decision-making mechanism

Technological innovation drives the transformation of traditional pyramid organizations towards flatness and agility, and cross-functional project management promotes the integration of technology and business, such as the integration of technology application and risk control in digital offices. Data-driven intelligent decision-making tools shorten the response chain and dynamically monitor risks through a visualization platform. In the face of organizational inertia and cultural conflicts, it is necessary to optimize the dynamic allocation of rights and responsibilities and assessment system to resolve resistance to change and strengthen the management resilience empowered by technology.

4.2.2. Building a cross-departmental collaboration and information sharing platform

The cross-departmental collaboration and information sharing platform builds a risk control linkage system by breaking down data barriers in design, construction, operation, and maintenance processes. A cloud native collaborative platform integrates BIM models, IoT data, and contract documents to achieve real-time interaction and version control among multiple parties. Blockchain technology ensures data traceability and audit transparency, reducing disputes caused by information asymmetry. In practice, platform efficiency is limited by departmental interest games and differences in technical literacy. It is necessary to promote the upgrade from “data sharing” to “value co-creation” through standardized interface protocols and training mechanisms for all staff.

5. Practical strategies for risk control in real estate engineering

5.1. Technical risk response strategies

5.1.1. Strengthen technical validation and standardization processes

The process of technology validation and standardization is the key path to reducing the uncertainty of technology application. New technologies need to be validated for reliability through laboratory simulations and small-scale on-site testing, such as using virtual simulations to evaluate the stability of construction robots. The standardized process covers all aspects of technology selection, deployment, and maintenance, clarifying operational guidelines and acceptance criteria to reduce human operational deviations. The internationally recognized ISO 19650 standard provides a framework for BIM technology collaboration, and companies need to develop localization guidelines based on project characteristics. Standardization enhances technical compatibility, facilitates risk tracing and responsibility definition, and requires promoting cross-enterprise collaboration through industry alliances and policy guidance.

5.1.2. Technical pilot and iterative optimization mechanism

The technology pilot and iterative optimization mechanism balance innovation and risk through gradual promotion. The pilot project focuses on typical scenarios, such as the local application of AI inspection systems in smart construction sites, identifying algorithm blind spots and hardware defects through data feedback. Based on the agile development concept, establish a “test, improve, expand” cycle to shorten the technology maturity cycle. For example, the prefabricated construction process accumulates error control experience through multiple pilot projects and optimizes the design of component connection nodes. This mechanism needs to be accompanied by a dynamic risk assessment tool to monitor the effectiveness of the pilot program in real time and adjust the technical route to avoid systemic risks caused by iterative lag.

5.1.3. Development of technical standards and operating procedures

The formulation of technical standards and operating procedures is a prerequisite for the large-scale application of technology. At the industry level, it is necessary to unify technical interface protocols and data formats, such as IFC standards. At the enterprise level, it is necessary to refine operating procedures, such as maintenance cycles for smart devices and emergency response processes for faults. The formulation of standards needs to balance cutting-edge and practical aspects, such as incorporating blockchain certification requirements into electronic contract specifications or setting airspace compliance clauses for drone inspections. The dynamic update mechanism of the standard system needs to be embedded in technological evolution trends and continuously improved through expert committees and empirical research.

5.1.4. Improvement of data security guarantee system

The data security protection system resists privacy breaches and network attacks through both technical and management dimensions. At the technical level, end-to-end encryption, data anonymization, and zero trust architecture are adopted to restrict access to sensitive data. Establish a data classification and grading system at the management level, clarify the storage boundaries and sharing rules of core data. For example, facial recognition data from construction sites needs to be stored locally and regularly destroyed, while cloud-based engineering documents use multiple identity authentication. The effectiveness of the system relies on continuous threat monitoring and emergency drills, and third-party security audits need to be introduced to ensure that protection strategies are in line with actual threat evolution.

5.1.5. Multi-level network protection strategy

The multi-level network protection strategy reduces systemic security risks through layered defense. Physical layer isolation industrial control network. Use firewalls and IDS to filter traffic at the network layer; Implement vulnerability scanning and patch management at the application layer. Edge computing nodes in intelligent construction sites reduce cloud exposure. Regular drills are conducted to verify the effectiveness of protective measures. The strategy needs to integrate adaptive security architecture and utilize AI to dynamically adjust defense rules.

5.2. Strategic optimization at the management level

5.2.1. Construction of the whole process risk management framework

The whole process risk management framework covers the entire cycle from project initiation, design, construction to operation and maintenance, based on the PDCA cycle, embedded with risk databases and intelligent analysis tools, such as real-time collection of quality deviation data during construction and linkage with design optimization and supply chain adjustment. It emphasizes moving the risk threshold forward, predicting potential conflicts through early warning models, and iteratively improving through feedback mechanisms from stakeholders. Practice should follow international standards such as ISO 31000 to establish risk management guidelines that are suitable for the characteristics of real estate engineering, ensuring their implementation and operability.

5.2.2. Risk classification and responsibility allocation mechanism

The risk grading and responsibility allocation mechanism achieves precise prevention and control by quantitatively evaluating the impact and losses of risks. Based on the risk matrix, classify levels and clarify response strategies; The responsibility allocation adopts the RACI model to ensure that risks are assigned to each position and person. For example, technical compatibility risks are led by the technical department, while supply chain risks are followed up by the procurement department in collaboration with the legal team. The operation of the mechanism needs to be accompanied by dynamic assessment indicators, and responsibilities should be implemented through performance linkage.

5.2.3. Emergency plan and rapid response mechanism

The emergency plan and rapid response mechanism focus on pre-preparation and handling during the event. The contingency plan library covers typical scenarios, clarifies processes, resource allocation, and decision-making chains. Rapid response relies on intelligent monitoring, automatic warning, and team activation. The effectiveness of the mechanism depends on regular drills and reviews, and third-party resources need to be reserved to enhance fault tolerance.

5.2.4. Cultivation of composite technical management talents

Composite technical management talents need to possess knowledge of engineering technology, information technology, and risk management to cope with cross-disciplinary challenges under technological innovation. The cultivation path includes interdisciplinary course design (such as BIM+project management), job rotation practice, and cross-border project participation, such as dispatching technical personnel to participate in smart construction sites and synchronously mastering IoT deployment and risk management skills. Enterprises need to collaborate with universities and industry associations to develop a talent capability map, and accelerate experience transfer and shorten the talent growth cycle through the "mentorship system" and "innovation laboratory".

5.2.5. Normalized risk awareness training

Normalized risk awareness training shapes a culture of prevention and control for all employees through institutionalized learning and assessment. The training covers technical risk cases, regulatory updates, and practical tools, using a hybrid online and offline model. Assessment will incorporate risk knowledge into job evaluation, such as simulating exams to test familiarity with contingency plans. In practice, the focus is dynamically adjusted according to the engineering stage, and safety operation training is strengthened during the construction peak period, with emphasis on data privacy protection education during the operation and maintenance period.

5.3. Policy and institutional support

5.3.1. The guiding role of government regulation and industry standards

The government should strengthen supervision in the field of real estate construction engineering, promote the formulation and implementation of industry standards, and provide clear guidance for technological innovation and risk management. Through standard guidance, promote the standardized development of the industry, and enhance the quality and safety level of engineering.

5.3.2. Policy incentives for technology application

Introduce a series of policy incentives to encourage enterprises to adopt new technologies and processes, such as tax reductions and funding subsidies, to reduce the cost of technological innovation and accelerate the transformation and application of technological achievements.

5.3.3. Improvement of risk management regulations

Improve relevant laws and regulations on risk control, clarify the responsibilities and obligations of all parties, and provide legal protection for risk identification, assessment, monitoring, and response. Through regulatory constraints, reduce the occurrence of risk events and ensure the smooth progress of the project.

5.3.4. Strengthening the internal control system of enterprises

Enterprises should establish a sound internal control system, integrate risk control into daily management, and enhance risk control capabilities through institutionalized and procedural means. Strengthen internal supervision and auditing to ensure effective implementation of risk control measures.

5.3.5. Risk control performance evaluation mechanism

Establish a risk control performance evaluation mechanism, incorporate the effectiveness of risk control into the enterprise performance evaluation system, and motivate employees to actively participate in risk control work. Through performance evaluation, promote the implementation of risk control responsibilities and enhance the overall level of risk management.

5.3.6. Third-party evaluation and audit mechanism

Introduce third-party evaluation and auditing mechanisms to objectively and fairly evaluate and supervise real estate construction projects. By utilizing third-party professional expertise, potential risks are identified, improvement suggestions are proposed, and the enterprise is encouraged to continuously improve its risk management work.

6. Conclusion

This article explores the technological innovation and risk management of real estate construction project management. BIM, the Internet of Things, AI robots, and green construction technology are driving management transformation, but they also bring intertwined risks. The article proposes strategies such as building a risk management framework, strengthening technical verification, and improving data security protection, emphasizing the supporting role of government regulation, industry standards, enterprise internal control, and talent cultivation. It looks forward to exploring future technology application scenarios and collaborative control models.

Disclosure statement

The author declares no conflict of interest.

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