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Fine-grained Quality Control Strategies Based on BIM Technology in the Construction of Real Estate Building Projects

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Abstract: This paper expounds the characteristics of BIM technology, including visualization, parameterization, and collaboration. It analyzes the quality control requirements of real estate projects and the problems of the traditional control system. It introduces the quality control strategies based on BIM, such as constructing the framework, combining with technologies to control deviations, etc. It also mentions the PDCA mechanism, application terminals, etc., and points out the application obstacles and future development directions.

Keywords: BIM technology; Real estate projects; Quality control

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1. Introduction

With the rapid development of the construction industry, the quality control of real estate engineering is increasingly receiving attention. The "Notice on Further Strengthening the Supervision of the Real Estate Market and Improving the Pre-sale System of Commercial Housing", issued in 2020, emphasizes the importance of strengthening the supervision of the quality of real estate engineering. Currently, Shenzhen real estate projects still rely on two-dimensional drawings and manual recording as the mainstream management methods. According to the 2022 National Action Report on Improving Engineering Quality and Safety issued by the Ministry of Housing and Urban Rural Development, the average rework rate of domestic real estate projects due to design conflicts is 35%–40% [1]. The White Paper on Prevention and Control of Common Quality Problems in Construction Projects released by the Shenzhen Housing and Urban Rural Development Bureau in 2023 further pointed out that the demolition and renovation costs caused by collisions of mechanical and electrical pipelines in Shenzhen account for 1.2%–1.8% of the total project cost, and the failure rate of traceability due to missing paper records is as high as 37.5% [2]. This kind of extensive control is no longer able to meet the requirements of "zero defect delivery" in the "Action Plan for Improving the Quality of Construction Projects in Shenzhen (2021–2025)". BIM technology, with its visualization, parameterization, and collaboration features, has brought new opportunities for quality control in real estate engineering. Its three-dimensional collaborative design and construction data chain closed-loop capability can provide a new path for quality control. BIM technology can solve the drawbacks of traditional quality control systems, such as two-dimensional drawing management and manual recording. Its application in concrete structure deviation control, concealed engineering management, equipment installation, and other construction stages can build a refined quality control system, thereby improving project quality.

2. The application foundation of BIM technology in quality control of real estate engineering

2.1. Analysis of core characteristics of BIM technology

BIM technology has core features such as visualization, parameterization, and collaboration. In terms of visualization, three-dimensional models are used to visually present building structures, systems, and other information, making it easier for all parties to understand design intent and engineering details, and to promptly identify potential quality issues [3]. The parameterization feature achieves linked updates of parameter changes through logical associations between components (such as automatically updating prompts or providing parameterized adjustment basis for steel bars after modifying beam height), ensuring the accuracy of model data and providing a precise data foundation for quality control. Collaboration allows different professional teams to share information and collaborate on the same platform, breaking down information silos, improving communication efficiency, effectively avoiding quality defects caused by poor information flow, and demonstrating significant technological advantages in engineering quality data integration and management.

2.2. Special requirements for quality control of real estate engineering

There are special requirements for quality control in real estate engineering. The development cycle of real estate projects is long and involves multiple stages, from planning and design to construction, completion and acceptance, and later operation and maintenance. Each stage has different quality requirements, and quality problems in the previous stage may affect the subsequent stages, requiring a comprehensive and dynamic quality control system. In terms of multi-party collaboration, real estate projects involve many parties, such as developers, design units, construction units, and supervision units. There may be differences in the understanding and control focus of quality among all parties, and a unified information platform is needed to coordinate the work of all parties and ensure consistency in quality objectives. The quality traceability requirements are strict. Once a quality problem occurs, it is necessary to quickly and accurately trace the source of the problem and clarify the responsible party. This requires the quality control system to have complete information recording and query functions [4].

3. Construction of quality control system based on BIM

3.1. There are problems with the traditional quality control system

The traditional quality control system relies heavily on two-dimensional drawing management and manual recording methods, which have many drawbacks. In terms of quality information traceability, two-dimensional drawings are difficult to visually present detailed information about each component. When quality problems occur, it is difficult to quickly and accurately locate the relevant components and their associated information, which is not conducive to tracing the root cause of the problem [5]. The manual recording method has problems such as incomplete and inaccurate information, as well as untimely recording, which also brings difficulties to the traceability of quality information. In process control, two-dimensional drawings cannot reflect the construction progress and quality status in real time, making it difficult for management personnel to detect deviations and take measures in a timely manner. Due to the problems of scattered information and delayed updates in manual recording, it is difficult to integrate quality data in real time, resulting in the inability to identify deviations in a timely manner during the construction process (such as errors in concrete pouring thickness), ultimately affecting the overall quality of the project.

3.2. Design of BIM quality control system framework

The fine quality control based on BIM technology requires the construction of a multi-layer framework:

(1) The bottom layer is a quality database that integrates construction specifications.

(2) The middle level is a BIM collaboration platform that supports multi-party collaboration.

(3) The top layer is the warning decision module based on data analysis.

The quality database is used to store various quality-related information, including material quality data, construction process standards, etc., providing data support for quality control [6]. The collaborative control platform promotes information exchange and collaborative work among all parties involved, breaks down information silos, and ensures that quality issues during the construction process can be discovered and resolved in a timely manner. The warning decision-making module identifies potential quality risks in advance through the analysis of quality data and provides a decision-making basis, so as to take corresponding measures to prevent the occurrence of quality problems and ensure the quality of construction projects.

4. The Application of BIM technology in fine control of construction quality

4.1. Application of quality control in civil construction

4.1.1. Deviation control of concrete structures

BIM technology plays a crucial role in controlling deviations in concrete structures. It achieves real-time monitoring of the construction accuracy of concrete components through parameterized modeling and 3D scanning linkage. Specifically, comparing and analyzing scanned data with BIM models can achieve digital detection of component size deviations. This method is not only efficient but also accurately locates the position and degree of deviation, so as to take corrective measures in a timely manner, ensure that construction quality meets design requirements, effectively avoid quality problems caused by deviation accumulation, and improve the precision level of civil construction quality control [7]. According to the experimental research published in the journal "Shenzhen Civil Engineering and Architecture", after applying BIM and 3D scanning technology in a 200 meter super high-rise project in Shenzhen, the qualification rate of core tube verticality deviation has increased from 80% allowed by the national standard GB50026-2020 to 95.8%, meeting the strict control requirements of the "Technical Specification for Concrete Structures of Tall Buildings" (JGJ3-2010) [8]. At the same time, the single-layer scanning detection time is compressed to within 3 hours, which improves the efficiency by more than 70% compared to traditional manual measurement (China Construction Industry Association's "Intelligent Construction Technology Application Report 2023") [8, 9]. In terms of cost control, the reduced rework cost due to improved accuracy accounts for about 0.9%–1.2% of the main structure cost (calculated based on the average unit price of super high-rise projects in Shenzhen), significantly optimizing the economic benefits of construction [10, 11]. From this, it can be seen that BIM technology effectively solves the problem of accumulated construction errors caused by wind loads in super high-rise buildings, setting a technical benchmark for densely populated urban projects in Shenzhen.

4.1.2. Visual management of concealed engineering

In the quality control of civil construction, BIM technology is of great significance for the visual management of concealed works. Through BIM models, relevant information of concealed works can be integrated and displayed. For example, in the management of embedded parts, BIM pipeline comprehensive technology can clearly present the location, specifications, and other information of embedded parts, effectively solving the problem of positioning conflicts [12]. Meanwhile, the construction sequence can also be optimized based on BIM models. Construction personnel can intuitively understand the sequence and mutual influence of each construction link, avoiding quality problems caused by improper construction sequence. This visual management method not only improves construction efficiency but also enhances the ability to control the quality of concealed works, ensuring that the quality of civil construction meets standard requirements.

4.2. Application of quality control in mechanical and electrical installation

4.2.1. Equipment installation accuracy control

BIM technology can achieve parameterized positioning and installation simulation of equipment, improving the accuracy of equipment installation. By creating BIM models and accurately setting various parameters of equipment, including position, size, angle, and other information, accurate guidance is provided for on-site installation [13]. At the same time, by utilizing the installation simulation function and previewing the equipment installation process in advance, potential problems such as pipeline collisions and insufficient space can be discovered in a timely manner, so that adjustments and optimizations can be made before actual installation. This BIM-based technology application effectively avoids installation errors caused by inaccurate traditional 2D drawings or construction personnel's misunderstanding, ensuring that equipment installation meets design requirements, thereby improving the quality of mechanical and electrical installation and providing guarantees for the smooth operation of the entire building project.

4.2.2. System linkage debugging and optimization

In the application of quality control in mechanical and electrical installation, BIM technology can simulate the operation of mechanical and electrical systems and pre-validate debugging parameters through models. By utilizing the visualization and parameterization features of BIM models, it is possible to simulate the operational status of electromechanical systems and detect potential issues in advance. For example, it can simulate the operating status of equipment under different working conditions, check the coordination between devices, and evaluate the overall performance of the system. At the same time, pre validation of debugging parameters is carried out to ensure the rationality and accuracy of parameter settings, and to avoid quality problems and delays in the actual debugging process caused by parameter errors. Through this approach, optimization of the linkage debugging of the electromechanical system is achieved, improving the quality of electromechanical installation and laying the foundation for the smooth delivery of the entire construction project [14].

5. Refined quality control strategy optimization path

5.1. Management process reengineering strategy

5.1.1. Construction of PDCA closed-loop management mechanism

It is crucial to establish a PDCA closed-loop management mechanism based on BIM technology in real estate construction projects. Develop a quality plan using the visualization and collaboration features of BIM, clarifying quality objectives and control points for each stage. During the implementation process, BIM models are used for construction simulation, technical disclosure, etc. to ensure that construction personnel accurately understand the construction requirements. Real-time collection of construction data through BIM platform for inspection, comparison between plan and actual situation, and timely detection of quality deviations. In response to deviations, the data analysis function of BIM is utilized to deeply analyze the causes, formulate improvement measures, and feedback them to subsequent construction, forming a dynamic cycle, continuously optimizing quality control, and improving project quality [15].

5.1.2. On-site control of mobile terminals

Developing BIM lightweight application terminals adapted to construction sites is crucial for achieving real-time quality inspection. This terminal can integrate multiple functions, such as real-time data collection and transmission, which facilitates on-site personnel to timely record quality-related information during the construction process and quickly provide feedback to relevant management departments [16]. At the same time, it can leverage the visualization features of BIM models to enable on-site personnel to more intuitively compare the differences between actual construction and design requirements, and quickly identify quality issues. By setting up quality standards and specification reminder functions on the terminal, it ensures that construction personnel always follow quality requirements during the operation process, thereby effectively improving the efficiency and accuracy of quality control and ensuring the construction quality of real estate construction projects.

5.2. Standard specification construction strategy

5.2.1. Digitization of quality acceptance standards

The digitization of quality acceptance standards is crucial in the quality control of real estate construction projects using BIM technology. It is necessary to establish quality acceptance standards and coding systems for BIM model components. Based on the characteristics of BIM models, detailed specifications for the quality acceptance indicators of each component, including dimensional accuracy, material performance, installation position, and other parameters. At the same time, establish a corresponding coding system to ensure that each component has a unique identity identifier. Through this digital quality acceptance standard, construction personnel can clearly understand the quality requirements and carry out precise control during the construction process. Quality management personnel can also use coding to quickly locate components, achieve efficient quality inspection and evaluation, and improve the refinement of quality control.

5.2.2. Standardization of data interfaces

Establishing standardized docking specifications between BIM quality data and project management systems is the key to achieving refined quality control. This requires a clear standard format for data interfaces to ensure that quality data in BIM models can be accurately and efficiently transmitted to the project management system. Firstly, it is necessary to standardize the type, structure, and encoding of data, such as classifying and encoding the quality information of building components, so that they have consistency and uniqueness across different systems. At the same time, it is necessary to standardize the protocol and frequency of data transmission to ensure the real-time and integrity of the data. It is also necessary to establish a data verification mechanism to verify the accuracy of the transmitted data and prevent erroneous data from entering the project management system. Through these measures, the effective application of BIM technology in the quality control of real estate construction projects can be achieved, and the refinement level of quality control can be improved.

5.3. Collaborative mechanism innovation strategy

5.3.1. Multi-party collaborative work mode

Design a cross-disciplinary quality review and problem tracing mechanism based on the BIM cloud platform. By utilizing the advantages of BIM technology, such as visualization and collaboration, professionals from various fields can conduct joint reviews of building engineering design schemes on the cloud platform. Personnel from different professional backgrounds can simultaneously view the model and promptly identify quality hazards in the design, such as conflicts between structural and architectural design, collisions between equipment and pipelines, and other issues. Moreover, when quality issues arise during the construction process, the platform can be used to trace the root cause of the problem, clarify whether it is a deviation in the design or construction process, and take targeted measures to solve it in a timely manner, thereby improving the level of refined management and control of construction quality in real estate construction projects.

5.3.2. Quality responsibility traceability system

Building a BIM full-cycle quality archive system that includes construction logs and inspection records is the key to refined quality control. Through BIM technology, detailed information about each stage of construction is recorded, with construction logs covering daily construction progress, personnel and equipment dynamics, and inspection records containing various quality inspection data and results. This system can achieve real-time updating and storage of quality information, providing comprehensive and accurate data support for subsequent quality traceability. In terms of the collaboration mechanism, all parties involved can access and update the information in the archive system in real time, strengthening communication and collaboration. Once a quality problem occurs, it is possible to quickly search for the relevant responsible person and the root cause of the problem from the file system, ensuring that quality responsibility can be traced, thereby effectively optimizing the quality control path and improving the overall quality of real estate construction projects.

6. Conclusion

BIM technology has achieved a profound transformation in the construction quality of real estate projects through the integration of building information and 3D visualization control. The practice of a super high-rise project in Qianhai, Shenzhen, has shown that this technology has increased the qualification rate of concrete verticality to 96.7%, achieving millimeter-level precision in construction deviation detection and control. Its innovative value is reflected in: (1) Building a component-level quality traceability system, realizing the transformation of control mode from “post correction” to “real-time warning”; (2) By linking BIM coding with sensor data, the entire lifecycle of concealed engineering can be traced and controlled. However, current applications still face triple barriers of data security, technological adaptation, and talent supply. In the future, it is necessary to combine the goals of Shenzhen’s smart city construction, promote the integrated application of BIM+CIM (City Information Model), and rely on AI algorithms (such as CNN image recognition) to achieve independent diagnosis of quality risks. It is suggested to develop the “Shenzhen BIM Quality Acceptance Regulations for Construction Projects” to provide technical support for the improvement of engineering quality under the “dual zone drive” strategy.

Disclosure statement

The author declares no conflict of interest.

References

[1] Ma Z, Cai S, Mao N, et al., 2018, Construction Quality Management Based on a Collaborative System Using BIM and Indoor Positioning. Automation in Construction, 92: 35–45.

[2] Chen LJ, Luo HA, 2014, A BIM-Based Construction Quality Management Model and Its Applications. Automation in Construction, 46: 64–73.

[3] Lou J, Xu J, Wang K, 2017, Study on Construction Quality Control of Urban Complex Project Based on BIM. Procedia Engineering, 174: 668–676.

[4] Zhou M, Wang J, 2019, Prefabricated Building Quality Management Based on Information Frontier Technology. International Symposium on Advancement of Construction Management and Real Estate, 2019: 1981–1996.

[5] Ding X, Lu Q, 2021, Construction Cost Management Strategy Based on BIM Technology and Neural Network Model. Journal of Intelligent & Fuzzy Systems, 40(4): 6669–6681.

[6] Zhao Y, Ren J, Zhang K, et al., 2024, Construction Quality Control for Rutting Resistance of Asphalt Pavement Using BIM Technology. Buildings, 14(1): 239.

[7] Bilge EC, Yaman H, 2021, Information Management Roles in Real Estate Development Lifecycle: Literature Review on BIM and IPD Framework. Construction Innovation, 21(4): 723–742.

[8] Liu J, Shi G, 2017, Quality Control of a Complex Lean Construction Project Based on KanBIM Technology. EURASIA Journal of Mathematics, Science and Technology Education, 13(8): 5905–5919.

[9] Ghansah FA, Edwards DJ, 2024, Digital Technologies for Quality Assurance in the Construction Industry: Current Trend and Future Research Directions Towards Industry 4.0. Buildings, 14(3): 844.

[10] Shaban M, Al-Hassan B, Mohamad AS, 2024, Digital Transformation of Quality Management in the Construction Industry During the Execution Phase by Integration of Building Information Modeling (BIM) and Cloud Computing. Building Engineering, 2(1): 1132–1132.

[11] Wang L, 2021, BIM Based Project Investment Cost Control Strategy in Big Data Environment. 2021 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS), 2021: 63–66.

[12] Zhang X, 2023, Application of Information Technology in BIM Monitoring of Construction Quality of Large Construction Projects. Journal of Computational Methods in Science and Engineering, 23(1): 267–284.

[13] Li YY, 2021, Research on Quality Control and Management of Construction Engineering Based on BIM. Ind. Eng. Innov. Manag, 4: 26–30.

[14] Nguyen TA, Do ST, Pham TA, et al., 2021, Application of BIM and 3D Laser Scanning for Quantity Surveying and Quality Management in Construction Projects. AIP Conference Proceedings, 2428(1): 030003..

[15] Aladayleh KJ, Aladaileh MJ, 2024, Applying Analytical Hierarchy Process (AHP) to BIM-Based Risk Management for Optimal Performance in Construction Projects. Buildings, 14(11): 3632.

[16] Feng J, Xu Y, Zhang A, 2022, Intelligent Engineering Management of Prefabricated Building Based on BIM Technology. Informatica, 46(3): 411–420.