Research on the Optimization of Whole-Process Management of Construction Engineering Projects Based on BIM Technology

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Abstract: Construction engineering projects are characterized by long construction periods and large capital investments. Effective cost control at each stage is essential to significantly enhance the value of engineering projects. With its unique advantages, BIM technology has gradually become a core tool for optimizing the whole-process management of construction engineering projects. It not only helps construction enterprises save substantial costs but also promotes the transformation of the construction industry towards informatization and intelligence. Starting from the characteristics of BIM technology, this paper analyzes the problems existing in its application in the whole-process management of construction engineering projects and proposes targeted optimization strategies, including improving the technology application system, establishing a collaborative management mechanism, and strengthening the training of BIM professionals. The aim is to provide references for enhancing the efficiency of whole-process management of construction engineering projects and to promote the in-depth application and development of BIM technology in the construction engineering field.

1. Introduction

In recent years, the scale of China's construction industry has continued to expand, and the complexity of engineering projects has been constantly increasing. Traditional project management models have faced numerous challenges and can no longer meet the demands for high-quality and efficient management in modern construction engineering. Against this backdrop, BIM technology, as a digital technology integrating data collection, modeling analysis, and collaborative management, offers a new solution for optimizing the whole-process management of construction engineering projects. Currently, the application of BIM technology in the construction engineering field has gradually shifted from the initial exploration stage to a large-scale and in-depth development stage. However, its full management value is restricted by various factors in practical applications, necessitating that construction enterprises actively explore scientific and feasible optimization strategies to enhance the management level of individual construction engineering projects.

2. Characteristics of BIM Technology

BIM technology has become an important innovative tool for construction project management due to its three core characteristics that distinguish it from traditional technologies. These characteristics provide key technical support for optimizing whole-process management.

Firstly, information integration. BIM technology can break through the limitations of fragmented information in traditional project management and achieve centralized integration and dynamic management of various types of information throughout the entire life cycle of a construction engineering project. From geological survey data and design parameters in the early stages of the project to schedule plans, material information, and cost data during the construction phase, and then to equipment parameters, energy consumption data, and maintenance records during the operation and maintenance phase, all can be incorporated into a unified BIM model. Its integrated nature not only enables one-time input and multiple reuse of information, avoiding errors caused by

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repeated data entry but also provides complete and accurate information support for all project participants, ensuring the scientific nature of management decisions [1].

Secondly, 3D visualization. Compared with traditional 2D drawings, BIM technology can construct 3D visual models, presenting the design schemes, construction processes, and component details of construction engineering projects in an intuitive manner. This facilitates designers in identifying design flaws and optimizing schemes in advance. It also enables construction personnel, construction units, supervision units, and other parties to have a clearer understanding of project requirements, reducing communication discrepancies.

Thirdly, collaboration. The whole-process management of construction engineering projects involves multiple participants, including design units, construction units, supervision units, construction units, and operation and maintenance units. In traditional management models, information transfer among various parties often relies on paper documents or single software, which is prone to issues such as information delays and poor communication. BIM technology achieves real-time data sharing and collaborative work among all participants in the same model environment through the establishment of a collaborative management platform. Design units can update optimized design schemes to the BIM model in real time, construction units can adjust construction plans based on the updated model, supervision units can monitor construction quality through the model in real time, and operation and maintenance units can obtain project design and construction information in advance to prepare for later operation and maintenance [2].

3. Problems with BIM Technology in the Whole-Process Management of Construction Engineering Projects

3.1 Incomplete Technology Application System and Insufficient Adaptability to Actual Project Requirements

Currently, the application of BIM technology is mostly concentrated on modeling and clash detection in the design stage, with insufficient coverage in in-depth application scenarios such as dynamic schedule control, real-time cost accounting during the construction stage, and intelligent equipment management during the operation and maintenance stage. As a result, the management value of BIM technology has not been fully realized. For example, although some projects have built BIM models in the design stage, they still rely on traditional schedule management software during the construction stage and do not deeply integrate the BIM model with the schedule plan, making it impossible to achieve real-time tracking and deviation warnings of construction schedules. There are currently many types of BIM software on the market, and the data format compatibility among different software is poor, which easily leads to the formation of "data islands," hindering information transfer among different stages and participants of the project. Moreover, some BIM technology solutions focus too much on technological advancement and tend to overlook the actual scale, type, and management requirements of the project, resulting in a disconnect between technology application and actual projects and significantly increasing project management costs.

3.2 Inadequate Collaborative Management Mechanism and Low Collaborative Efficiency among Multiple Participants

Although BIM technology has the characteristic of collaboration, most construction engineering projects have not yet established a comprehensive collaborative management mechanism based on BIM technology, leading to low collaborative efficiency among multiple participants. Firstly, there is a lack of unified collaborative management standards. All participants have not clearly agreed on information entry specifications, update frequencies, and permission divisions for the BIM model, which easily leads to problems such as non-standard information entry, untimely updates, and confused permissions, affecting the orderly conduct of collaborative work. Secondly, the functions of the collaborative management platform are incomplete. Some platforms only have simple information-sharing functions and lack core collaborative functions such as real-time communication, task assignment, schedule tracking, and problem feedback, failing to meet the

actual needs of collaborative work among multiple participants [3]. Thirdly, the collaborative awareness of all participants is insufficient. Some units are still accustomed to the traditional "independent operation" management model and do not attach enough importance to BIM collaborative management. They show resistance in terms of information sharing and work cooperation, further reducing collaborative efficiency.

3.3 Insufficient Reserve of Professional Talents and Weak BIM Technology Application Ability

The effective application of BIM technology requires composite professionals who not only have knowledge of construction engineering project management but are also familiar with BIM technology operation and application. However, the current reserve of such talents in the construction industry is severely insufficient, becoming an important bottleneck restricting the in-depth application of BIM technology in whole-process management. On the one hand, the knowledge structure of traditional construction industry practitioners is relatively single. Most personnel only have traditional project management experience and lack systematic learning in BIM technology principles, software operation, and data analysis, making them unable to skillfully use BIM technology to carry out management work. On the other hand, the construction of BIM-related majors in universities and vocational colleges lags behind, and the curriculum settings are out of touch with actual industry needs. Graduates often lack practical project experience and find it difficult to quickly adapt to job requirements. In addition, enterprises do not provide sufficient training on BIM technology for existing employees, and the training content mostly focuses on basic software operations, lacking in-depth training on application scenarios in whole-process management, resulting in employees' BIM technology application abilities being unable to meet project management needs [4].

4. Optimization Strategies for Whole-Process Management of Construction Engineering Projects Based on BIM Technology

4.1 Improve the BIM Technology Application System and Enhance the Adaptability of Technology to Project Requirements

The application of BIM technology in whole-process project management can make up for the deficiencies in traditional management. To fully realize its application value, construction enterprises need to build a complete BIM technology application system and enhance its adaptability to project requirements. Specifically, construction enterprises should promote the in-depth application of BIM technology throughout the entire life cycle of the project and break the application pattern of emphasizing design while neglecting construction and operation and maintenance. In addition to conventional modeling and clash detection in the design stage, construction enterprises should also use BIM technology for performance analysis and scheme comparison to improve the scientificity and rationality of design schemes. During the construction stage, they should deeply integrate the BIM model with schedule plans, cost data, and quality standards, and build an integrated platform of "BIM + schedule management," "BIM + cost management," and "BIM + quality management" to achieve real-time tracking of construction schedules, dynamic cost accounting, and precise quality control. During the operation and maintenance stage, they should build a smart operation and maintenance platform based on the BIM model, integrating information such as equipment operation data, energy consumption data, and maintenance records to achieve equipment fault warnings, energy consumption optimization, and intelligent formulation of maintenance plans, improving operation and maintenance management efficiency [5].

On the basis of the above work, construction enterprises should also continuously strengthen the compatibility construction of BIM software and promote the unification of data standards. On the one hand, industry associations should take the lead in formulating unified BIM data exchange standards, clarifying data formats and information coding rules among different software to reduce "data islands." On the other hand, software enterprises should be encouraged to develop BIM

software with cross-platform data compatibility functions or develop third-party data conversion tools to achieve seamless data connection among different software. At the same time, at the project initiation stage, appropriate BIM software and technology solutions should be selected according to the project scale, type, and management requirements to avoid blindly pursuing technological advancement and ensure that technology application matches actual project needs.

4.2 Establish a BIM Collaborative Management Mechanism and Improve the Collaborative Efficiency among Multiple Participants

Since construction engineering projects involve multiple subject entities during implementation, a BIM collaborative management mechanism needs to be established according to specific circumstances to enable all subject entities to reasonably use BIM technology. Firstly, unified BIM collaborative management standards should be formulated to clarify the responsibilities and work processes of all participants. At the project initiation stage, the construction unit should take the lead and jointly formulate the "BIM Collaborative Management Manual" with design, construction, supervision, operation and maintenance, and other parties to clarify information entry specifications, update frequencies, and permission divisions for the BIM model, ensuring that collaborative work has rules to follow. Secondly, the functions of the BIM collaborative management platform should be optimized to meet the collaborative needs of multiple participants. Construction enterprises should add real-time communication modules, task assignment modules, and problem feedback modules to the existing platform to achieve the whole-process collaborative management of "information sharing - task assignment - problem solving - achievement archiving" [6]. At the same time, mobile access should be supported to facilitate on-site management personnel to view models, enter data, and feedback problems in real time, improving the convenience and timeliness of collaborative work. Thirdly, the collaborative awareness of all participants should be strengthened to promote the construction of a collaborative culture. Construction enterprises should use project initiation meetings and special training sessions to publicize the importance and advantages of BIM collaborative management to all participants, transforming the traditional "independent operation" management concept. A collaborative work assessment mechanism should be established, incorporating indicators such as the timeliness of information sharing and the efficiency of problem rectification into the performance assessments of all participants to motivate all parties to actively participate in collaborative work and form a collaborative and win-win management atmosphere [7].

4.3 Strengthen the Training of BIM Professionals and Improve the Technology Application Ability of Practitioners

To enrich the force of composite talents in construction enterprises, it is necessary to strengthen the training intensity of BIM technology for existing employees and improve their technology application abilities. In practice, construction enterprises should formulate tiered and categorized training plans. Specialized training on the integration of "BIM technology and project management" should be carried out for management personnel to improve their ability to make decisions using BIM technology. In-depth training on BIM software operations and whole-process application scenarios should be conducted for technical personnel to improve their technological application levels. Basic training on BIM model viewing and information understanding should be provided for front-line operational personnel to ensure that they can carry out construction operations according to the BIM model. At the same time, employees should be encouraged to participate in BIM-related professional qualification certifications, and the certification results should be linked to title evaluations and salary promotions to stimulate employees' learning enthusiasm [8].

In addition to strengthening personnel training, construction enterprises also need to build an industry BIM talent exchange platform to promote talent growth. Industry associations can regularly hold BIM technology application seminars and skill competitions to provide a platform for practitioners to exchange learning and showcase their skills. A BIM talent pool should be established to integrate excellent talent resources in the industry, providing talent support for projects and offering career development opportunities for practitioners, thereby promoting the overall quality improvement of the industry's BIM talent team. Besides, cooperation with

universities should be strengthened. Universities should add practical courses such as the application of BIM in construction management, BIM and smart operation and maintenance, and BIM data analysis according to the actual needs of whole-process management of construction engineering projects, increase the class hours of project case teaching and software practical training, improve students' practical abilities, and enable students to participate in the BIM application of actual projects to accumulate practical experience, achieving "school-enterprise collaborative education."

5. Conclusion

BIM technology, as a core tool for the digital transformation of the construction industry, provides strong technical support for optimizing the whole-process management of construction engineering projects. More and more construction enterprises are beginning to apply BIM technology to whole-process project management and have achieved certain results. However, they still face problems such as an incomplete technology application system, an inadequate collaborative management mechanism, and insufficient reserve of professional talents. Corresponding measures need to be taken to address these problems in order to fully realize the maximum application value of BIM technology. In the future management of construction engineering projects, with the in-depth integration of BIM technology with emerging technologies such as big data, artificial intelligence, and the Internet of Things, its application in whole-process management will become more intelligent and efficient, providing impetus for promoting the continuous development of China's construction industry towards high quality and intelligence.

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