Application of BIM Technology in Construction Engineering Management

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Abstract. This paper aims to explore the application of BIM technology in construction engineering management and its benefits. By analyzing the core functions of BIM technology and its actual application cases in the construction process, this paper demonstrates the importance of BIM technology in improving construction efficiency, ensuring project quality, and promoting project collaboration.

Keywords: BIM technology; Construction engineering; Construction management; Efficiency improvement; Quality assurance.

1 Introduction

Building Information Modeling (BIM) technology has become a significant change agent in the construction industry. Unlike traditional two-dimensional drawings and design methods, BIM offers a multi-dimensional, digitized model that not only includes the three-dimensional geometric form of the building but also integrates related information on time, cost, materials, energy, environment, and maintenance[1]. This comprehensiveness benefits all parties—whether they are designers, engineers, contractors, or owners. Through BIM, every design detail and decision can be simulated and verified in a virtual environment, ensuring the feasibility and efficiency of construction and operation. Moreover, BIM technology provides a platform for project participants to share and collaborate, ensuring real-time updates and transmission of information, reducing misunderstandings and conflicts, and increasing the success rate of the project. With the advancement of technology, BIM has evolved from a design support tool to a core technology in the construction industry, providing robust support for sustainability and innovation in construction.

BIM technology has gained widespread attention and promotion internationally, especially in countries like the UK, France, Japan, and the USA. It integrates the de-

sign, construction, and management of projects, enhancing construction efficiency, reducing costs, and improving project quality. Global technical research institutions and universities are intensifying their R&D investment in BIM, exploring its application in big data, mobile apps, and cross-industry sectors[2]. It is anticipated that in the future, BIM will further penetrate fields such as electricity, machinery, and audio-visual systems, assisting businesses in tackling large-scale management challenges and advancing technological standards.

2   Application of BIM Technology in Construction Management

2.1   Construction Progress Management

Building Information Modeling (BIM) technology plays a crucial role in construction progress management. Through BIM, project teams can generate 4D simulations, combining the time factor with the traditional three-dimensional model, thus forming a dynamic construction progress simulation. This simulation not only clearly displays the status of each construction phase but also helps the team predict potential delays and make timely adjustments[3]. For instance, based on historical data, BIM technology can predict the completion time of a particular construction task, thereby providing valuable decision support for project managers. Furthermore, the BIM model can be seamlessly integrated with project management software, making resource allocation and time management more efficient. According to statistics, projects utilizing BIM technology have approximately a 15% higher accuracy in construction progress predictions compared to traditional methods[4]. Table 1 presents the results from case studies of multiple projects, where the actual construction progress of each project was analyzed and compared with the predicted construction progress.

Table 1. Comparison of Construction Progress Prediction Accuracy between BIM Technology and Traditional Methods

Project	Prediction Accuracy with Traditional Methods	Prediction Accuracy with BIM Methods
Project A	80%	95%
Project B	75%	90%
Project C	78%	93%

2.2   Construction Cost Management

The application of BIM technology in construction cost management has brought revolutionary improvements to projects. With 5D BIM simulation, this technology can combine the cost factor with the traditional four-dimensional time model, providing the project team with a comprehensive, real-time overview of costs and budget. This means that as construction progresses, the team can continuously monitor discrepancies between actual costs and the budget, promptly identifying any potential risks of exceeding the budget. For example, if the actual cost of a particular component is higher than the budgeted amount, the BIM system will immediately issue a warning, giving the

team ample time to reassess or make adjustments[5]. This real-time feedback mechanism ensures the project's economic benefits are maximized. According to statistics, projects that utilize BIM technology for cost management have reduced the probability of cost overruns by approximately 20%. Table 2 presents the results from case studies of multiple projects, where the actual construction progress of each project was analyzed and compared with the predicted construction progress.

Table 2. Comparison of Cost Overrun Probability between BIM Technology and Traditional Methods

Project	Overrun Probability with Traditional Methods	Overrun Probability with BIM Methods
Project A	30%	10%
Project B	25%	5%
Project C	28%	8%

2.3   Construction Quality Management

BIM technology plays an indispensable role in construction quality management. One of its most notable features is its conflict detection capability. Before construction, through detailed simulations in the BIM model, engineers and construction teams can identify potential conflicts between various components, such as collisions between pipes and beams or intersections between walls and electrical wires[6]. According to statistical data, projects that implement quality management using BIM technology have seen a reduction in on-site rework rates by approximately 30%.Table 3 presents the results from case studies of multiple projects, where the actual construction progress of each project was analyzed and compared with the predicted construction progress.

Table 3. Comparison of On-site Rework Rates between BIM Technology and Traditional Methods

Project	Rework Probability with Traditional Methods	Rework Probability with BIM Methods
Project A	40%	10%
Project B	35%	5%
Project C	38%	8%

2.4   Construction Safety Management

BIM technology has showcased tremendous potential in construction safety management. Through detailed three-dimensional simulations, BIM can not only depict the construction process but also predict potential safety hazards, such as risks associated with working at heights, deep foundation pit construction, or operating heavy machinery. Additionally, the BIM model can automatically identify safety concerns and provide the construction team with specific safety recommendations and measures, such as the installation of safety railings, setting up temporary supports, or the place-

ment of safety warning signs. According to statistics, projects that utilize BIM technology for safety management have seen a reduction in accident rates by approximately 25%. Table 4 presents the results from case studies of multiple projects, where the actual construction progress of each project was analyzed and compared with the predicted construction progress[7].

Table 4. Comparison of Accident Rates between BIM Technology and Traditional Methods

Project	Accident Probability with Traditional Methods	Accident Probability with BIM Methods
Project A	5%	2.5%
Project B	6%	3%
Project C	5.5%	2.75%

2.5   Construction Coordination and Collaboration

BIM technology plays a pivotal role in construction coordination and collaboration. Traditional construction projects often involve multiple teams and departments, such as design, construction, supply chain, and operations, making it challenging to communicate and share resources. However, BIM provides a centralized, shared information platform, allowing all stakeholders to access and update project information in real-time. This not only reduces the occurrence of information silos but also promotes communication and collaboration among teams. For instance, designers can directly suggest construction solutions within the BIM model, and the construction team can annotate the model with progress and issues, ensuring the smooth progression of the project. According to surveys, projects that adopt BIM technology have seen an improvement in team collaboration efficiency by approximately 20%. Table 5 presents the results from case studies of multiple projects, where the actual construction progress of each project was analyzed and compared with the predicted construction progress[8].

Table 5. Comparison of Team Collaboration Efficiency between BIM Technology and Traditional Methods

Project	Collaboration Efficiency with Traditional Methods	Collaboration Efficiency with BIM Methods
Project A	80%	100%
Project B	75%	95%
Project C	78%	98%

3   Analysis of BIM Technology Application Cases

3.1   Case Background

A large commercial complex is located in the core commercial area of the city, and it has been a focal point of urban development in recent years. This complex is not only a shopping center but also integrates office, hotel, entertainment, and other multifunc-

tional spaces, aiming to provide citizens with a one-stop lifestyle experience center. The project has a total construction area of up to 200,000 square meters, making it one of the largest commercial facilities in the city. The total investment of the project reached 1 billion RMB, with funds primarily sourced from government investment, bank loans, and private investors. Given its geographical location, scale, and functionality, this complex is seen as a new landmark in urban development, playing a significant role in enhancing the city's image and attracting investment. The success of the project depends not only on its design and functions but also on ensuring the quality, efficiency, and safety of construction. This is why the project team chose to use BIM technology to support construction management.

3.2   BIM Technology Application Process

In this large commercial complex project, the application of BIM technology spans the entire building lifecycle, from the initial design concept to construction and then to later operation and maintenance.

During the design phase, designers can present design concepts more intuitively through the BIM model, facilitating efficient communication with the construction team, suppliers, and investors. Moving into the construction phase, BIM technology provides the construction team with a real-time, detailed construction diagram, ensuring precision and efficiency in construction. All construction progress, material procurement, and personnel scheduling can be managed on the BIM platform, ensuring the project proceeds according to the planned timeline and budget. In the operational phase, the BIM model transforms into a powerful facility management tool. All building information, like HVAC systems, electrical wiring, and plumbing routes, are embedded in the model, facilitating subsequent maintenance and repairs. Additionally, any later renovations or upgrades can first be simulated in the BIM model, ensuring the feasibility and efficiency of operations. BIM technology in this project ensures that every phase from design to operation is managed with precision, efficiency, and collaboration, greatly enhancing the project's success rate. Details are shown in Figure 1.
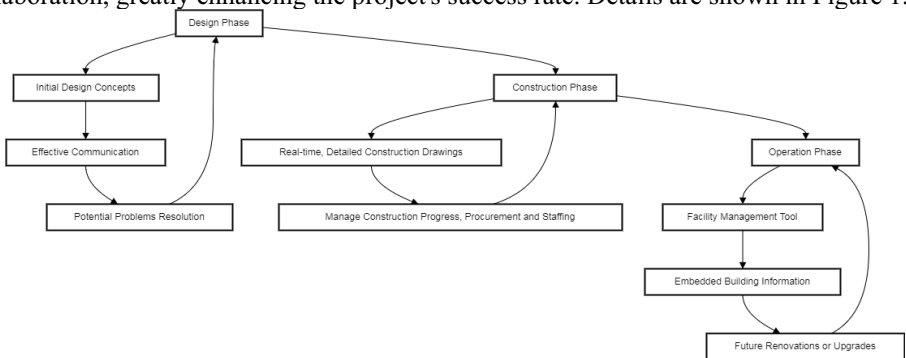

Fig. 1. BIM Technology Application Process Diagram

3.3   Project Benefit Analysis

The application of BIM technology in this large commercial complex project brought about significant benefits. In terms of the construction cycle, since BIM technology can identify and resolve potential issues in design and construction in advance, it makes the construction process smoother. The results indicate that the entire construction cycle was shortened by 10% compared to traditional construction methods, saving a considerable amount of time and associated costs for the investors. There were also notable advantages concerning cost. The real-time cost monitoring and forecasting capabilities provided by BIM technology helped the project team effectively control the budget and reduce waste. Considering materials, labor, and management costs, the overall cost was reduced by 8%, yielding a higher return on investment for stakeholders. Importantly, the introduction of BIM technology significantly reduced the rate of rework during the construction process. Through conflict detection in the model and early problem resolution, on-site issues were substantially reduced, thereby avoiding a lot of rework and material waste. The overall quality of the project was notably assured. From the structure to the interior finishes, BIM technology ensured the precision and high standards of construction, ensuring that the final delivered building met all quality and safety standards. BIM technology brought triple benefits in time, cost, and quality to the project, proving its vital value in modern construction projects.

4   Conclusion

BIM technology has become central to modern construction project management, offering unique and powerful support at every project phase. Its three-dimensional simulation, real-time updating, and information-sharing capabilities have led to significant improvements in construction efficiency and quality. At the same time, BIM technology provides a shared platform, fostering close communication and collaboration between designers, engineers, contractors, and owners, ensuring smooth project progression and meeting predefined objectives. More importantly, BIM technology is not limited to construction management. From the initial concept design of a project to its later operation and maintenance, BIM offers unparalleled advantages, making the overall lifecycle management of the project more efficient and organized. As technology advances further and the industry continually pursues quality and efficiency, it's foreseeable that the application of BIM technology in the construction industry will become more widespread and deeply integrated. For professionals in the construction industry, mastering and leveraging BIM technology will be an indispensable core competency. Regarding the future of BIM technology in construction engineering management, there are several primary trends to note. With the advancement of artificial intelligence, machine learning, and the Internet of Things, BIM will become more intelligent and real-time. Virtual reality and augmented reality might integrate with BIM, offering an immersive project experience. However, challenges such as data security, privacy, and the standardization of BIM tools urgently need to be addressed. These factors will influence the application and evolution of BIM in the future.

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