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Research on Fine Management of Construction Engineering Based on BIM Technology

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Abstract: The construction phase is a critical stage in the entire lifecycle of a construction project. However, traditional construction modes often face issues such as high costs, safety risks, and inefficiencies, which compromise construction quality and overall project effectiveness. This paper systematically investigates the application of Building Information Modeling in fine management during the construction phase, focusing on its roles in schedule, cost, quality, and safety management. The study demonstrates that BIM technology significantly optimizes resource allocation, reduces costs, enhances collaborative efficiency, and mitigates construction risks. The findings highlight that integrating BIM with fine management effectively improves construction quality and promotes sustainable development in the construction industry.

Keywords: BIM technology; fine management; construction engineering; construction.

1. Introduction

The construction phase is pivotal in the lifecycle of a building project. Traditional construction management often suffers from high costs, safety hazards, and low efficiency. Fine management, which emphasizes responsibility assignment, procedural clarity, and proactive problem-solving, can address these challenges. BIM technology, characterized by visualization, simulation, and data integration, provides a digital platform for dynamic and collaborative project execution. Combining BIM with fine management enables efficient, coordinated, and continuous operations throughout the construction process. This integration is crucial for advancing construction management practices and fostering sustainable development in the industry[1].

2. Overview of BIM Technology

Building Information Modeling is a digital technology widely applied in the construction industry. It integrates building data and information into a shared model, facilitating collaboration across the project lifecycle. Key features of BIM include visualization, coordination, imulation and optimization, which collectively contribute to cost reduction, schedule compression, and quality enhancement.

3. Overview of Fine Management

Fine management is a systematic and data-driven approach aimed at minimizing resource consumption and management costs. By applying standardized procedures and data analysis to all project phases, it achieves goals such as cost reduction, risk mitigation, and environmental sustainability. For the construction industry, adopting fine management is essential for achieving high-quality development.

4. Application of BIM Technology in Fine Management of Construction

4.1. Schedule Fine Management

By creating a BIM model and integrating it with a construction schedule, 4D software can simulate the construction process to enable real-time progress monitoring. If deviations such as schedule acceleration or delays are detected, the system allows for prompt adjustments to the schedule, thereby improving project control capabilities and expediting construction timelines. Technical issues identified during simulations can also be resolved by modifying construction plans, ensuring feasibility and enhancing operational efficiency. Furthermore, the BIM model precisely calculates the quantities of materials, equipment, and labor required for each construction phase. By aligning resource planning and allocation with the construction schedule[2], this approach effectively reduces costs and optimizes project timelines.

4.2. Cost Fine Management

Utilizing BIM technology for construction cost control is a critical component of achieving fine construction management and a key factor in enhancing the economic efficiency of engineering projects. Firstly, BIM technology offers robust parametric capabilities. Through measurement and valuation software, it automatically extracts comprehensive project information and calculates quantities, which not only improves the efficiency of quantity calculations but also reduces human errors, thereby enhancing data reliability. Secondly, BIM technology enables the aggregation of all cost-related data during the construction phase. By leveraging time-dimension tools within BIM, stakeholders can simulate the construction process and analyze cost dynamics at different stages. This allows managers to monitor real-time cost fluctuations, adjust construction plans promptly, and ensure adherence to budgetary constraints. Thirdly, design changes frequently occur during construction. BIM technology facilitates the immediate synchronization of such changes into the model, automatically recalculating quantities and costs. This capability streamlines cost management and ensures financial control remains responsive and precise[3].

4.3. Quality Fine Management

Quality management during construction is pivotal to the economic viability and sustainability of completed projects, underscoring the critical importance of quality control at the construction stage. Implementing refined quality management involves utilizing BIM models to inspect critical process quality control points during construction. When deviations from quality standards or acceptance criteria are identified, it is imperative to promptly communicate with design personnel to address discrepancies. Furthermore, the integration of IoT technology enables real-time monitoring of construction quality through sensors. These sensors can detect anomalies in specific processes, flagging defective operations and triggering alerts, thereby facilitating immediate corrective actions by management teams. This combined approach ensures adherence to quality benchmarks and enhances overall project outcomes.

4.4. Safety Fine Management

Safety management is a crucial component of fine management in construction engineering, and BIM technology plays a pivotal role in enhancing construction safety.BIM technology enables safety simulations and risk predictions during construction processes. Prior to construction, the development of a three-dimensional BIM model, integrated with schedule simulations, allows for the identification of potential safety hazards. This facilitates the formulation of targeted safety measures to mitigate risks at the source, thereby reducing accident rates[4]. Besides, BIM technology supports real-time monitoring and safety management. By integrating BIM with IoT technology, on-site personnel and equipment can be continuously tracked, enabling the timely detection of safety risks and proactive risk avoidance. This combined approach ensures a safer construction environment and strengthens compliance with safety protocols.

5. Case Study: Yongjing Shanghewan Phase I Project

Building on the aforementioned applications of BIM technology in the fine management of construction engineering, the following section conducts an in-depth analysis through a specific project case.

5.1. Project Overview

The project is named Yongjing Shanghewan Phase I, with a total construction area of 18,928.56 square meters. The building comprises 26 stories and reaches a height of 78.55 meters. It features a cast-in-place reinforced concrete shear wall structure, while the upper multi-story structures and the single-story basement adopt cast-in-place reinforced concrete frame systems. All individual buildings are interconnected as a unified whole through the basement. The design working life of the project is 50 years, with a seismic fortification intensity of 7 degrees. The fire resistance rating meets Grade II for above-ground sections and Grade I for underground components[5].

5.2. Pre-Construction Preparation

During the preliminary construction preparation phase, Revit software is employed to develop a 3D BIM architectural model based on drawing information. Subsequently, Pinming BIM-5D software is utilized to create a BIM-5D model by integrating the 3D BIM model and associated data with critical construction process parameters, including cost, schedule, quality, and safety. This integration enables comprehensive data linkage and dynamic management across all project dimensions.

Figure 1. BIM 3D Model

Figure 2. BIM 5D Model

5.3. Schedule Management

Based on the construction duration and work segment division, develop a construction schedule using Microsoft Project software and create a project schedule Gantt chart. Subsequently, import the schedule plan from Project software into Pinming 5D software, link the schedule with the BIM model to establish a 4D construction simulation model.

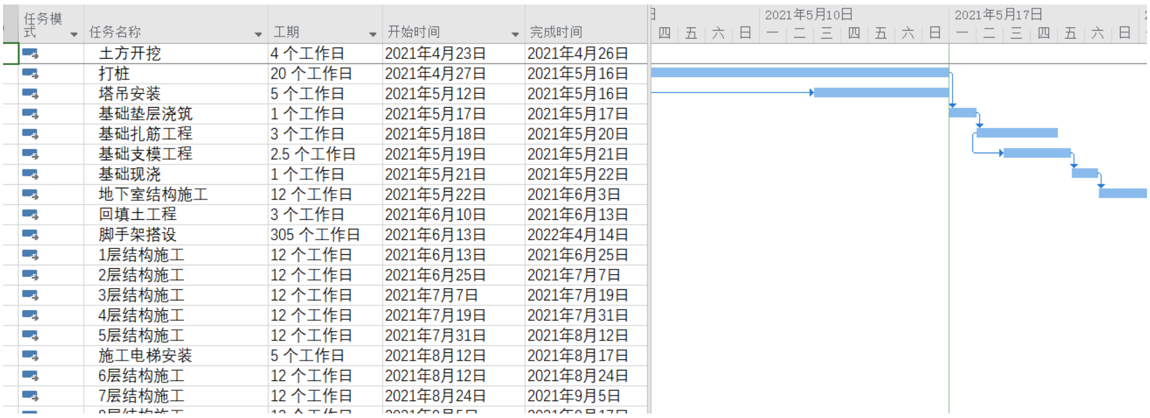

Figure 3. Construction Schedule

Figure 4. Construction Simulation

Conduct construction simulation for the building project by integrating surrounding structures, roads, and site conditions to prevent worker idling and work stoppages caused by spatial or workspace conflicts. Through preliminary calculations, site layout optimization is projected to reduce the construction duration by 10 days, while the planned compliance rate for reinforcement materials delivery scheduling exceeds 98%, thereby ensuring adherence to the project timeline.

5.4. Cost Management

Among the cost elements in construction projects, material expenses represent a critical focus for cost control. Consequently, managing material costs and improving material utilization rates are central to effective cost management during construction.

By leveraging BIM 3D models, budgeted quantities for specific components can be calculated, followed by an analysis of discrepancies between model-derived quantities and actual usage. This process identifies controllable material loss ranges, enabling project managers to regulate material consumption by construction teams through data-driven oversight. The integration of this data into management systems facilitates precise cost control. For example, analyses of concrete and steel reinforcement usage are presented in Table 1 and Table 2.

The adoption of BIM Internet+ technology further enhances cost management by monitoring materials from their source and comparing these data with on-site measurements. Through systematic material tracking and analytical optimization, approximately ¥500,000 in cost savings has been achieved.

Table 1. Standard Floor Concrete Analysis

Concrete volume of the 1st standard floor				
Construction area	Revit model quantities (m^3)	Budget Model Quantities (m^3)	Loss value (m^3)	Loss rate (%)
7F	171.38	172.65	1.27	0.74

Table 2. Standard Floor Steel Reinforcement Analysis

Reinforcement Quantity of the 1st Standard Floor				
Construction area	Revit model quantities (t)	Budget Model Quantities (t)	Loss value (t)	Loss rate (%)
7F	18.4	18.7	0.3	1.6

5.5. Quality Management

During the construction process, strict control is implemented over the model's position, material, and dimensions, with verification and inspection carried out by designated responsible personnel. For any quality issues that arise, they are marked in the model, analyzed for root causes, and addressed with remedial measures. Taking pile foundation quality control as an example: First, the pile foundations are tagged in the BIM5D software, enabling precise identification of any component or construction process. Based on feedback from the construction site, it was discovered that the pile driving depth was insufficient, failing to penetrate the bedrock. The proposed solution involves lengthening the pile foundations to ensure they reach the required bedrock depth.

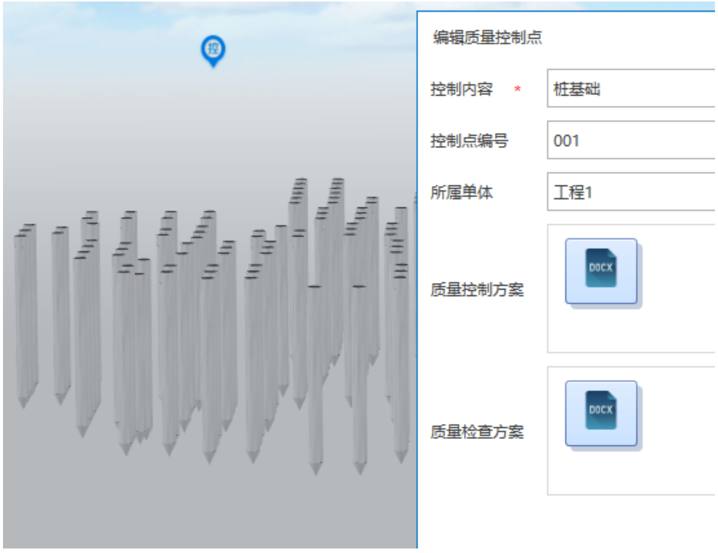

Figure 5. Pile Foundation Quality Feedback

Figure 6. Pile Foundation Quality Control

5.6. Safety Management

Technical personnel utilize BIM technology to develop integrated site layout plans, optimizing the allocation of construction roads, temporary structures, electrical/water supply systems, tower crane locations, material storage areas, and vehicle parking zones to ensure orderly site operations. Through the application of BIM models visualizing actual construction conditions, this approach enables rational configuration of site layout and construction traffic organization while providing safety-critical operational data for tower crane lifting operations, as illustrated in Figure 7.

Figure 7. Safety Layout Diagram

5.7. Summary

In this engineering case, by integrating BIM technology with refined management practices—such as establishing 3D models, calculating material quantities, developing construction schedules, and simulating construction processes—the project achieved meticulous construction management. This approach enabled timely resolution of on-site issues, mitigation of safety risks, and optimization of construction plans. As a result, the project successfully shortened the construction period by 30 days, saved 560,000 yuan in costs, and significantly enhanced the overall project quality.

6. Conclusion

The integration of BIM technology with refined management practices represents an innovative approach to enhance construction quality. Through BIM-enabled data processing, simulation analysis, and real-time construction management, this methodology optimizes workflow sequencing, strengthens risk mitigation, improves project quality, and facilitates a paradigm shift from experience-based to data-driven decision-making. Although BIM adoption continues to expand, persistent challenges in BIM implementation and latent deficiencies in precision management frameworks remain. Future advancements require intensified talent development, technological innovation, and continuous refinement of BIM-management integration methodologies, ultimately driving the construction industry toward greater efficiency, cost-effectiveness, safety, and sustainability.

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