Research on Information-Driven Innovation in Green Building Design

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Abstract. In the context of mounting global demands for sustainable development, the construction industry finds itself confronted with dual challenges: environmental protection and sustainable development. Green building, a novel paradigm in construction development, has emerged as a pivotal trend within the global construction sector.The advent of information technology has precipitated a transformation in the construction industry's management paradigm, propelling it towards a data-driven and collaborative approach that encompasses the entire lifecycle. Notably, Building Information Modelling (BIM) technology has emerged as a pivotal catalyst for innovation in green building design and management models. This study explores the application of BIM technology in green building design and analyses how it can improve the energy efficiency, resource utilisation and environmental performance of building design through information technology.Using a hospital project in Yunnan as a case study, the research demonstrates how BIM technology can be used to optimise building energy simulation, environmental impact assessment, energy-saving measures and intelligent management. The findings of the case study demonstrate that BIM technology has the capacity to optimise the design decision-making process, to achieve refined control during the construction and operation and maintenance stages. The research results provide both theoretical and practical support for the transformation of the construction industry's information technology and innovation of management models, and help to achieve the goal of sustainable development in the construction industry.

Keywords: BIM technology, green building, innovative management models, informatisation, energy-saving optimisation

1   Introduction

In the context of accelerating urbanisation and mounting environmental and resource pressures, the construction industry, as a major consumer of energy and emitter of carbon, is under significant pressure to achieve sustainable development goals through technological innovation and management model transformation. Green buildings are regarded as a pivotal catalyst for industry transformation due to their whole-life cycle resource optimisation and environmentally friendly characteristics. However,

traditional management models rely on fragmented design and empirical decision-making, which are difficult to meet the needs of complex environmental impact assessments. The in-depth integration of information technology has become the key to breaking the deadlock.

Building Information Modeling (BIM) technology provides a new paradigm for design optimisation and management innovation in green buildings, with its 3D modelling, data collaboration and dynamic simulation capabilities. Domestic research demonstrates that BIM technology can enhance the design efficiency and energy performance of green public buildings (Liu, 2021) [1], for instance, by optimising the thermal performance of the envelope to reduce energy consumption by 15%-20% (Wang et al., 2022) [2]. International research further validates the potential of BIM technology for cross-disciplinary collaboration. Wong and Zhou (2021) propose a BIM-based digital twin framework to support data management throughout the life cycle of green buildings[3]; Lee et al. (2022) verify the optimisation of BIM in building energy consumption analysis through case studies[4]; and Tanaka and Suzuki (2022) combine BIM with the Internet of Things (IoT) technology to achieve dynamic monitoring and energy efficiency improvement during the operation and maintenance stage of green buildings[5]. In addition, research shows that BIM technology can reduce the rate of design changes by 30% through standardised processes and improve resource utilisation efficiency (Smith & Hosseini, 2023) [6].

The present study adopts an 'informatisation and management model innovation' research orientation, employing a hospital construction project in Yunnan as a case study to systematically analyse how BIM technology can empower the design optimisation of green buildings and explore how BIM technology can restructure the management process of green buildings.

2 Green Building Design Innovation Driven by Informatisation

2.1 Data Support of BIM Technology for Green Building Design

BIM technology has been identified as a key driver of innovation in the field of green building design, through the integration of lifecycle data to systematically optimise energy efficiency and environmental performance. The implementation of BIM encompasses three primary phases. In the initial planning phase, BIM facilitates multi-criteria site analysis through the utilisation of 3D environmental modelling, synthesising ecological parameters (wind patterns, solar radiation, and thermal dynamics) with geographic data. In the Yunnan hospital project, comprehensive data parameters were utilised to generate a 3D representation of the external environment, thereby providing relevant data support for the quantitative assessment of the building's site selection, layout, orientation and passive energy-saving optimisation strategies. In the context of design optimisation, the utilisation of parametric BIM models has been shown to facilitate climate-adaptive energy consumption forecasting through the integration of local meteorological data (e.g., Kunming's annual temperature fluctuations). Furthermore, the project team has employed a comparative carbon emission analysis of design alternatives to quantify trade-offs between economic costs and environmental benefits.

BIM's integration extends to construction and operations. Virtual construction simulations enabled 4D clash detection, cutting rework costs. Post-commissioning, IoT-enhanced BIM platforms achieved smart operations management. Predictive maintenance algorithms further ensured equipment reliability by correlating energy consumption patterns with operational anomalies. This closed-loop data framework validates environmental performance continuity from design to occupancy phases, exemplifying BIM's transformative role in green building value chains.

2.2   Standardised Path for Information-based Design

To facilitate efficient collaboration in green building design, it is imperative to establish a standardized BIM application process, as illustrated in Table 1.

Table 1. Table captions should be placed above the tables.

Stage	Core task	Output
Concept design	Climate analysis and functional differentiation	Preliminary energy model, daylight simulation report
Schematic design	Multi-scenario comparison and parameter optimisation	Optimised BIM model, carbon emission comparison table
Design development	Professional collaboration and conflict detection	Collision-free model, construction atlas
Operation and maintenance	Data handover and O&M rule formulation	BIM O&M manual, IoT interface protocol

3   Integration of Innovative Management Models and BIM

The conventional construction management models are unable to address the issues of fragmented workflows, delayed information exchange, and inefficient resource allocation, which often result in cost overruns and quality deviations. Building Information Modelling (BIM) technology has been developed to address these limitations by establishing a unified data platform that integrates design, construction, and operational data. This enables process reengineering and data-driven decision-making, thus improving the efficiency and accuracy of construction projects.

3.1   BIM Technology Reconstructs the Project Management Process

The integration of BIM into linear project management has been shown to facilitate lifecycle integration and interdisciplinary collaboration. In the context of the Yunnan hospital project, three innovations were implemented. Cross-phase collaboration, the implementation of a BIM-based platform resulted in the unification of architectural, structural, and MEP models, thereby resolving design conflicts during virtual

coordination, thus minimising the necessity for on-site rework. 4D/5D dynamic management, the integration of 4D simulations with BIM models, in conjunction with construction schedules, has enabled the visualisation of resource allocation for the outpatient building. 5D cost management automated material quantification and budget updates, maintaining cost deviations below 3% through real-time market price integration. Furthermore, the utilisation of BIM models fosters proactive risk management through the dynamic integration of environmental and construction data. Carbon emission hotspots and predicted safety risks were identified, enabling material substitutions and prompting preemptive installation of protective measures.

3.2   Data-Driven Decision Support System

BIM technology integrates environmental data, construction data and operation and maintenance data to construct a multi-dimensional decision support system, thereby promoting a shift from experience-driven to data-driven management. The hospital project in Yunnan has developed an operation and maintenance management platform based on BIM that integrates intelligent subsystems to achieve functions such as asset management, property management, safety monitoring and low-carbon intelligent energy consumption management. The function of intelligent low-carbon energy consumption management has been shown to enhance the sustainability, comfort and green energy efficiency of the building. This function can be subdivided into two stages: energy consumption monitoring and analysis. In the energy consumption monitoring stage, the project integrates intelligent ventilation, intelligent lighting, and intelligent energy control systems with BIM, combining various types of information, including daily operational management models, external weather and environmental factors, and the operating conditions of facilities and equipment. It establishes an accurate analysis model for the integration of water and electricity equipment to display the system energy consumption data and trends of each building in real time, conveniently and efficiently completing the collection of energy consumption data for each building. During the energy consumption analysis stage, the combination of the collected energy consumption data allows the automatic extraction of the energy consumption trend, which is convenient for the identification of effective energy-saving methods through the management of key circuits during the operation of the hospital.

4   Case Analysis – Green Building Project of a Hospital in Yunnan

4.1   BIM Technology Application Practice

4.1.1 Energy Consumption Simulation and Envelope Optimisation. Utilising a BIM model in conjunction with climate data specific to Kunming and the standard, the project team simulated the energy consumption of the outpatient medical technology building and inpatient building. This analysis revealed that the thermal performance of the external windows did not meet the aforementioned standards. The team then proceeded

to optimise the design through several modifications, including the upgrading of the materials used, the incorporation of Low-E insulating glass in place of standard glass, and the strategic realignment of the window-to-wall ratio. Specifically, the window-to-wall ratio of the inpatient building facing south was optimised from 0.53 to 0.42, a strategy employed to achieve a balance between daylighting and heat loss. A comparative analysis of the thermal performance optimisation is presented in Table 2.

Table 2. Comparison of thermal performance optimisation of the envelope.

Building area	Heat transfer coefficient before optimization [W /(m^2 • K)]	Heat transfer coefficient after optimization [W /(m^2 • K)]	Energy saving rate increase
Outpatient medical building	2.70	2.20	18%
Inpatient building	2.70	1.95	28%

4.1.2 Lighting Design and Enhancement of the Natural Light Environment. In order to address the issue of inadequate lighting within the rooms, the project team utilised the DALI software to perform parametric optimisation. The installation of light pipes and reflectors was undertaken to enhance the depth of natural light incidence. Furthermore, a dynamic lighting simulation was conducted, the results of which indicated an increase in the lighting compliance rate from 70% to 93%. Concurrently, there was a reduction in artificial lighting energy consumption of 28%.

4.1.3 Wind Environment Simulation and Ventilation Strategy Optimisation. CFD (Computational Fluid Dynamics) simulations utilising the green building software VENT have revealed that the wind pressure differential on the leeward side of the inpatient building is 11.67 Pa, which exceeds the standard wind pressure differential. Optimisation measures have been identified which include adjusting the building form, adding wind deflectors to improve air flow, enhancing natural ventilation, and adjusting the opening angle of the windows.

4.2   Innovation Management Results

In this project, BIM technology was employed across all phases of the building lifecycle, encompassing design, construction, and operation and maintenance. The BIM platform facilitated data integration between design, construction, and operation and maintenance, thereby ensuring the seamless execution of green building design. During the design phase, BIM was utilized for energy efficiency simulation, environmental impact assessment, and resource optimisation management. In the construction phase, the platform was instrumental in identifying and resolving conflicts, as well as in the management of progress and the allocation of resources, thereby markedly enhancing construction efficiency and reducing errors and rework. In the operation and maintenance phase, the BIM model is connected to the building's energy management system

(BMS), enabling real-time monitoring of energy usage. The analysis of energy efficiency in the building's air conditioning, lighting and heating systems, facilitated by BIM technology, enables the adjustment of system settings in a timely manner, thereby reducing unnecessary energy expenditure. Furthermore, the viewing of operating data from equipment facilitates the development of maintenance and repair plans, ensuring that the building's systems are maintained in optimal operating condition.

Through the implementation of precise design and intelligent management methodologies, the project has been successful in achieving efficient utilisation of resources and optimal energy allocation, thereby enhancing the overall environmental performance of the building. Moreover, the project team continues to employ BIM technology to meticulously monitor and optimise the building's energy consumption and environmental quality during the construction and operation phases, ensuring that the building can maintain green building standards in the long term..

5   Conclusion

This study explores the application of BIM-based innovations in the design and management of green buildings. Using a hospital project in Yunnan as a case study, it demonstrates the potential for widespread application of BIM technology in the field of green building. BIM technology not only optimises energy efficiency, environmental impact, and resource management in building design, but also promotes innovation in the management model of building projects. The study further posits that, with the advent of sophisticated information technology, BIM will assume an even more pivotal role in the construction industry, particularly in achieving green building objectives, enhancing management efficiency and curbing carbon emissions. It is anticipated that this will engender revolutionary changes in the industry.

Acknowledgement

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