

# Research on Green Construction Technology and Management Systems in Engineering Projects

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**Abstract.** In the context of increasingly strained global environmental resources, green building construction can achieve a win-win scenario by reducing resource consumption and environmental pollution during the construction process while simultaneously realizing economic and ecological benefits. This study primarily explores the current research on green construction technologies and management systems and their similarities and differences compared to traditional construction practices. It reflects the issues present during the construction process and assesses the current level of green construction in China, highlighting future development trends and objectives for green construction. By validating the effectiveness and significance of Building Information Modeling (BIM) technology and organizational management structures, this research provides relevant insights for the green transformation of the construction industry. It offers valuable references for the continuous improvement and promotion of green construction concepts in China.

## 1 Introduction

With the continuous development of China's construction industry, the environmental pollution caused by carbon emissions has become increasingly severe. In the context of a global trend toward low-carbon energy and industrial development, China has set strategic goals to achieve "peak carbon emissions" by 2030 and to strive for "carbon neutrality" by 2060. The "Green Building Evaluation Standards" introduced by China emphasize that green buildings are essential for promoting a new green development concept, aiming to achieve high-quality green development in construction. Among these, green construction is a critical component of green building development, widely promoted and applied due to its advantages in pursuing high efficiency, low energy consumption, and environmental protection.

In the current state of research on green construction, China is still in its early stages. Scholars such as Wang Zhen-Shuang, Tong Lin, and Tang Li-li argue that traditional construction methods can no longer meet the development demands of the modern construction industry [1-3]. Introducing scientifically sound and reasonable green construction practices can effectively address the conflicts between construction projects and

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the ecological environment. Construction enterprises should eliminate outdated construction models and integrate information technology, green energy-saving construction techniques, and management innovations as future research themes in green construction. However, there needs to be more comprehensive regulatory frameworks and practical standards within the industry. The utilization of construction waste and the construction and innovation of enterprise management also require greater attention. International scholars Suman Paneru and Bahaa Chammout contend that green construction is a critical driver in addressing environmental degradation, resource depletion, and climate change issues caused by the construction industry [4-5]. Among the various factors, decarbonization is essential in determining.

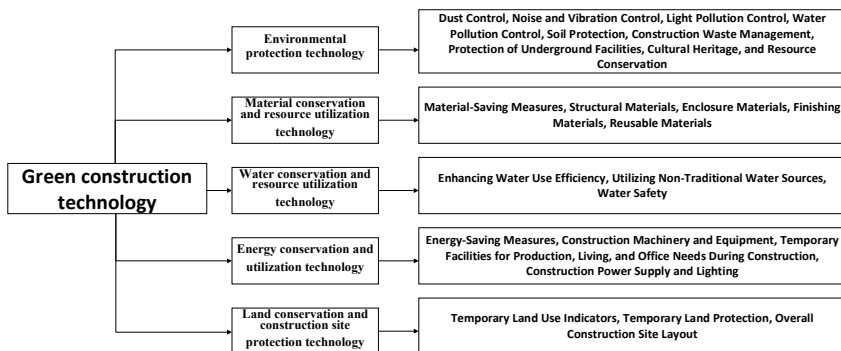
whether green construction standards are met. This necessitates the establishment of labor-management models during the construction process and reforms in carbon emission technologies to address challenges in green construction. Therefore, further in-depth research is needed to promote the establishment of comprehensive green construction technologies and management systems to achieve green construction.

This paper comprehensively analyzes recent research on green construction technologies and management systems. By integrating various green construction measures, such as environmental protection, water and energy conservation, and the preservation of construction sites, the study examines the advanced application of Building Information Modeling (BIM) technology in green construction. Additionally, it reviews organizational management, planning management, and material management initiatives within the green construction management system, using the organizational structure of the Volcano Hospital as a case study. The analysis concludes that it is essential to implement the principles of green, low-carbon, energy-efficient, and environmentally friendly practices throughout the construction and management processes, advocating for a green and low-carbon transformation in the construction industry. This is of significant importance for reducing resource and energy consumption in construction, enhancing the quality of green building development, and achieving sustainable development within the construction sector in China.

## **2 Green construction technology**

### **2.1 Summary of green construction technology**

Green construction technology operates to ensure project quality and safety while adhering to a people-centered and context-specific approach. It aims to maximize environmental, economic, and social benefits, balancing and coordinating these three aspects. At its core, it emphasizes technological innovation and progress, which can reduce resource waste and minimize the negative impacts on the environment during the construction process. Green construction technology is not merely a reformative innovation; it is not entirely separate from traditional construction techniques but rather represents the practical application of sustainable development principles in the construction process. To meet the technical innovation evaluation criteria outlined in the "Green Construction Evaluation Standards for Building and Municipal Engineering" and to achieve the goals of resource conservation and environmental protection, recent research on green construction technologies can be categorized into several specific types based on their functions, as illustrated in Figure 1.



**Fig. 1.** Green construction technology classification chart [6]

Environmental protection technology refers to a series of measures to reduce or eliminate negative impacts on the natural environment, ensuring a harmonious coexistence between humans and nature. By controlling factors such as dust, noise, water resource pollution, and construction waste, CO<sub>2</sub> emissions can be reduced, air quality improved, and the living conditions of both construction workers and residents enhanced [7]. This approach promotes harmonious relationships between construction enterprises and society while maintaining ecological stability in the natural environment.

Material conservation and resource utilization technology involves optimized design, efficient use, and recycling to reduce material consumption and maximize utilization efficiency [8]. This technology encompasses two main aspects: control of material usage and the application of environmentally friendly materials. During construction, dynamic management of material resources is conducted based on construction schedules, material inventories, and spatial layouts. Using insulation, waterproofing, and high-performance building materials, such as high-strength steel and concrete, aims to minimize resource consumption and improve construction methodologies.

Water conservation and resource utilization technology are vital to addressing global water scarcity. Advanced water-saving techniques enhance water resource utilization efficiency during construction by minimizing losses during water delivery and reducing waste [9]. Additionally, utilizing unconventional water resources, such as rainwater, reclaimed water, and desalinated seawater, alleviates the pressure on traditional water resources. The government, enterprises and the public must collaborate, employing various water-saving technologies and management practices to ensure the safety of construction water use and promote the sustainable utilization of water resources.

Energy conservation and utilization technology refers to measures taken during construction to achieve energy savings, environmental protection, and sustainable development by enhancing energy efficiency, reducing energy losses, and improving energy structure [10]. In architectural design and construction, adopting energy-efficient materials, green roofs, natural lighting, and high-efficiency air conditioning systems reduces energy consumption and environmental pressure. It promotes the upgrading and improvement of industrial economic structures. This approach is a significant pathway for advancing sustainability in the building industry.

Land conservation and construction site protection technology involves adopting scientific management and technical measures during the construction phase to minimize land occupation and degradation, enhance land utilization efficiency, and protect and improve the ecological environment. This technology achieves a harmonious integration of construction land and ecological space through optimized planning and construction, standardization of construction site layouts, and promotion of vegetation restoration on construction sites [11]. Promoting this technology and related policies to revitalize abandoned land contributes to the

harmonious advancement of engineering construction and environmental protection, thereby facilitating the sustainable utilization of land resources.

## **2.2 Comparative similarities and differences between traditional construction technology and green construction technology**

Traditional and green construction technology involves costs related to materials, labor, equipment, and management, with effective cost control crucial for project profitability and corporate competitiveness. Although green construction typically incurs higher initial investments due to the use of advanced equipment and materials, it can significantly reduce resource waste and operating costs over the long term through measures aimed at water conservation, energy savings, and material efficiency [12]. Additionally, green construction considers the impact of environmental pollution on surrounding communities, safeguarding residents' quality of life and enhancing social benefits. Using strategies such as green supply chains and prefabricated components, green construction technology optimizes building materials and energy use while effectively managing construction waste. The construction phase must adhere to green principles, encompassing raw materials production, transportation, and storage, to minimize the environmental costs associated with transportation and production activities.

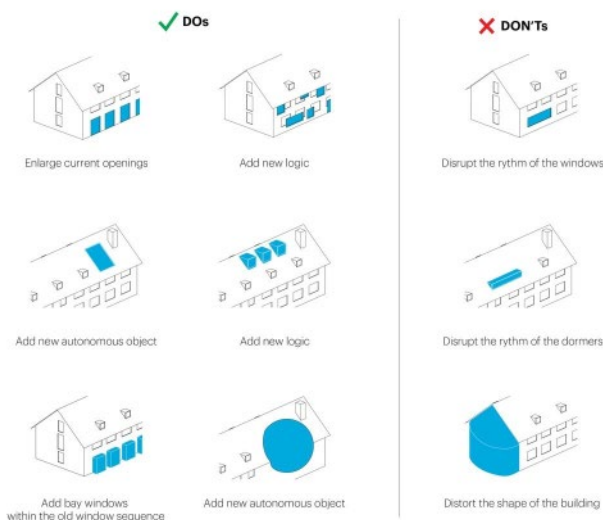
In construction, cost reduction and environmental impact considerations must be balanced to enhance efficiency. Green construction technology represents an innovation over traditional methods, which rely heavily on manual operations and often lack efficiency and precision, as well as a strong awareness of resource conservation. In contrast, green construction technology employs advanced techniques to address challenges associated with delays and quality defects typical of traditional construction while simultaneously reducing environmental impacts. This technology enhances resource utilization efficiency through local materials, optimized material selection, and advanced water-saving technologies. By integrating intelligent construction technologies, real-time monitoring and analysis of the construction site can be achieved, effectively resolving construction issues and improving overall work efficiency [13].

Green construction technology has been widely adopted globally, demonstrating superior structural, aesthetic, and innovative characteristics compared to traditional construction methods. Amid rapid economic growth, conventional techniques have led to a homogenization of architectural styles. The focus in the construction industry has shifted towards standardization and financial efficiency, while green construction emphasizes environmentally friendly design. This includes using natural lighting, ventilation, modular structures, rainwater harvesting, and green roofs to reduce environmental impact. In terms of material innovation, the incorporation of prefabricated components effectively reduces construction waste. Low-carbon and renewable materials such as bamboo, wood, and stone are increasingly utilized. Additionally, using low volatile organic compound (VOC) paints and sealants minimizes air pollution and improves the quality of the construction environment.

Traditional and green construction technology fulfill engineering construction tasks, aiming to meet contractual requirements for quality, safety, schedule, and cost. However, their focal points differ. Traditional construction technology emphasizes cost reduction while ensuring compliance with quality, schedule, and safety standards, often neglecting considerations for energy conservation, emissions reduction, and environmental friendliness. In contrast, green construction technology prioritizes resource conservation and environmental protection during the construction process, striving for the sustainable development of project construction.

### 2.3 BIM technology analysis and case application

Building Information Modeling (BIM) technology represents a transformative advancement in the construction industry. As shown in Figure 2. It provides visual support for project planning, design, construction, and operation by integrating three-dimensional model information with shared data. This integration fosters team collaboration and significantly improves design efficiency, operational effectiveness, and cost control [14]. For instance, in the Arnhem region of the Netherlands, BIM technology enabled designers to revitalize a World War I German military base by incorporating natural elements and preserving historical features, thereby enhancing the architectural cultural expressiveness. Furthermore, BIM technology can assess the potential for material recycling, optimize material selection, reduce dependence on traditional building resources, improve energy systems, and encourage using renewable energy sources. During the construction design phase, it simulates interactions between buildings and their environments, including lighting, air quality, and microclimates. This project utilized local materials, recycled plastics, and solar panels to achieve resource circularity, showcasing an innovative application of green construction technology.



**Fig. 2.** Kamp Koning Noord building adjustment analysis diagram [15]

In the practical application of cross-sea bridges, objective factors such as extreme weather conditions, including typhoons, uncertainties in the hydrogeological environment surrounding the bridge, and the instability of imposed loads must be addressed. To effectively manage these challenges, cross-sea bridges must employ Building Information Modeling (BIM) technology, which differs from conventional construction methods. This approach should be progressive and integrated with other advanced technologies to achieve a more efficient, safer, and cost-effective construction process [16].

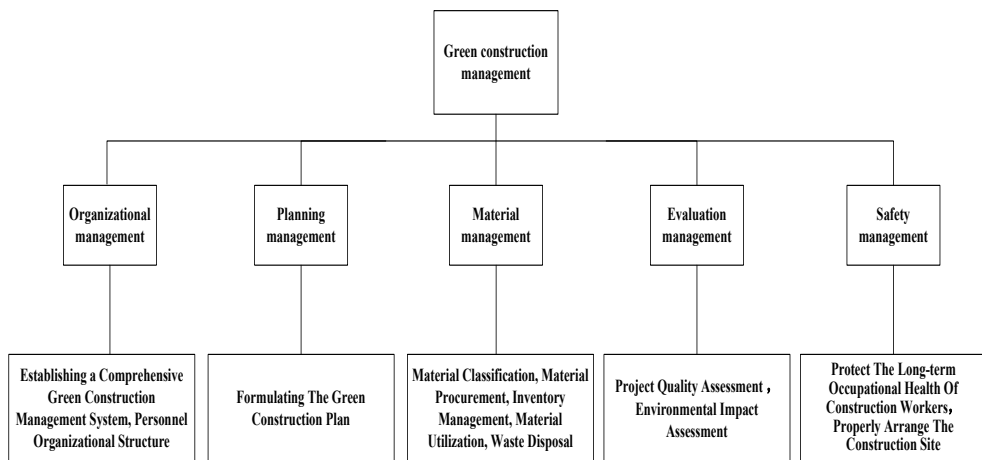
BIM technology in building project management needs to adequately consider the impact of the surrounding geographical environment, limiting its accuracy in spatial information management [17]. The integration of Geographic Information System (GIS) technology addresses this shortcoming by enhancing the efficiency of integrated management between architectural and geographical information, effectively reducing the negative environmental impacts of construction [18]. For instance, using Revit software for BIM modeling with GIS technology in bridge engineering enables refined three-dimensional modeling and visual

management for the entire bridge construction process, optimizing resource allocation, logistics pathways, and cost control [19]. In the case of the Yongzhou Cross-Sea Bridge project, the application of BIM-GIS technology established a construction supervision platform, improving the precision of construction activities, shortening project timelines, addressing the complexities of bridge structures, and promoting the practice of green construction technology [20].

### 3 Green construction management

#### 3.1 Summary of green construction management system

Implementing green construction in any engineering project necessitates establishing a robust green construction management system and regulatory requirements. The green construction management system is crucial for achieving resource conservation, environmental protection, pollution reduction, and ensuring the sustainability of the construction process within building projects. Traditional construction management focuses on achieving fundamental goals such as short construction durations, high quality, low costs, and efficient outcomes. In contrast, green construction management introduces new concepts that augment these original goals with sustainable development, resource conservation, and environmental protection, promoting high integration among social, economic, and ecological benefits [21,22]. As illustrated in Figure 3, the green construction management system primarily encompasses the following five categories.



**Fig. 3.** Green Construction Management System Framework diagram(Picture credit: Original)

Organizational management refers to the systematic planning, organization, guidance, control, and coordination activities undertaken within construction projects to achieve green construction objectives. Its core components include establishing a green construction management system and allocating responsibilities among construction units. A management system founded on ecological friendliness and low-carbon environmental protection should be developed, along with establishing management goals and standards. An appropriate personnel structure aids in clarifying responsibilities, enhancing decision-making efficiency, and promoting communication and team collaboration. The project manager is responsible for allocating construction personnel to ensure the effective implementation of green construction practices [23].

Planning management refers to the detailed design and planning of the entire construction process in the early stages to ensure that construction activities maximize resource conservation, minimize environmental impacts, and promote the greening of the construction process. This requires developing a green construction plan that includes effective measures for environmental protection, energy conservation, and water savings. The plan must be reviewed and approved by relevant regulations and standards, reflecting the green construction objectives established during the design phase.

Material management primarily focuses on environmentally friendly, economical, and efficient use of materials during construction. It prioritizes selecting green building materials that are recyclable, low toxicity, and have low carbon emissions. A well-planned procurement strategy is essential for choosing reliable suppliers to ensure material quality. Appropriate storage methods should be employed to minimize material loss during storage. Information technology can track material usage in real time, enhancing the transparency of material management. Additionally, controlling the generation of construction waste, along with its classification, recycling, and reuse, is vital to prevent environmental pollution and degradation.

Evaluation management refers to the assessment and oversight of whether construction activities meet green construction standards during the project development process. Construction units must establish evaluation criteria within the green construction management system and form an expert evaluation team to conduct thorough assessments at various stages, from initiating the green construction plan to project completion. This includes comprehensive benefit assessment, engineering quality evaluation, and environmental impact assessment, ensuring the construction project complies with green construction requirements.

Safety management refers to a series of management measures and activities implemented during the green construction process to ensure the safety and health of construction personnel, the regular operation of construction equipment, and the protection of the environment and surrounding areas. This typically includes arranging appropriate construction sites, providing necessary medical emergency measures, improving the daily living conditions for construction workers, and safeguarding living and office areas from harmful impacts caused by construction activities.

### **3.2 Similarities and differences between traditional construction management systems and green construction management systems**

Green construction managers advocate for dynamic monitoring of costs to identify and control factors associated with green construction expenses, thereby constraining project expenditures. Through an evaluation mechanism, construction activities are supervised, enabling timely correction of actions that violate green construction regulations, thus reducing resource waste and rework. While controlling costs, ensuring safety, quality, and environmental protection standards is essential. Unlike traditional construction, which primarily pursues profit, green construction emphasizes respect for people and the environment, avoiding disturbances to residents during nighttime work and protecting regional vegetation and wildlife to maintain biodiversity. Although initial costs may increase, this approach enhances corporate image and improves social and environmental benefits [24].

Traditional construction management focuses on reducing costs to maximize profits while ensuring progress, quality, and safety, often overlooking energy efficiency and construction waste management. Addressing these issues requires a shift in management perspectives to enhance environmental awareness and foster a green construction atmosphere through training and education. Project managers should establish green construction objectives, impose limitations on carbon emissions over time and space, and create evaluation and

incentive mechanisms to reward environmentally friendly practices [25]. Collaboration with government, clients, and other stakeholders is essential to promote green construction, integrating these principles into corporate culture and continuously optimizing management processes to facilitate the long-term development of green construction practices.

In summary, both require construction enterprises to possess qualifications following national standards and utilize management methods for resource allocation to achieve the contractual objectives of safety, cost, schedule, and quality while conducting construction at the project site until the building product meets established standards [26]. The green construction management system represents an evolution of traditional management systems, emphasizing environmental protection, resource conservation, and sustainable development. This shift is of significant practical importance in addressing ecological pollution issues within the construction industry.

### **3.3 Organizational structure management analysis and case application**

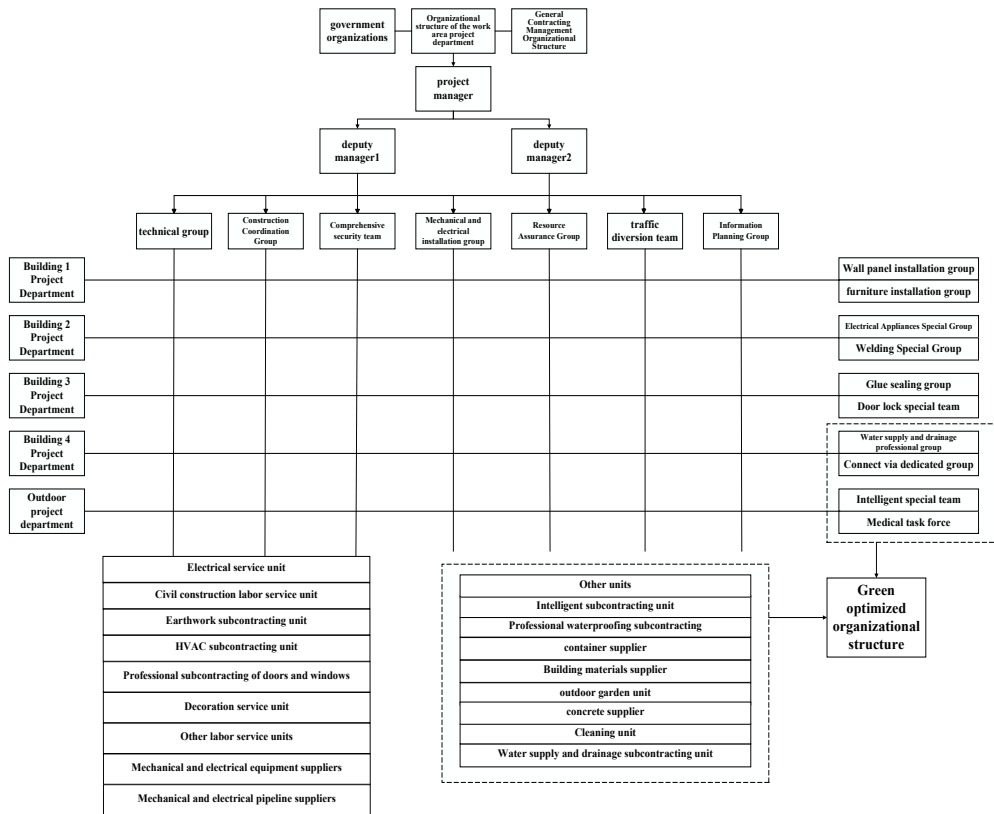
Optimizing the management of organizational structures in green construction is vital for the sustainable development of building projects. Traditional hierarchical management frequently leads to problem-solving and information flow inefficiencies, causing prolonged project timelines and higher labor costs. To tackle this challenge, it is essential to adopt a unified planning approach that involves all project stakeholders. This collaboration will help establish effective decision-making, supervision, and evaluation mechanisms within the construction leadership and operational organization.

In optimizing organizational structure management, enterprises should form a core leadership team comprising representatives from the government, suppliers, and other stakeholders tasked with overseeing project environmental protection. The project manager should be designated as the primary responsible for environmental protection. The core leadership team implements green construction policies and legal regulations, establishes rules and guidelines, and addresses significant ecological protection issues. The project manager's responsibilities include formulating a green construction plan, clearly defining environmental protection tasks, minimizing overlapping responsibilities, supervising and guiding ecological protection efforts in construction, exemplifying the execution of environmental policies, encouraging innovations in environmentally friendly technologies, and ensuring the advancement of green construction practices [27].

In the construction case of Wuhan Huoshenshan Hospital, faced with the dual challenges of the pandemic and the Spring Festival, there was an urgent demand for hospital construction with high-quality standards. An efficient organizational structure was established, comprising a construction command group formed by government agencies, a general contracting management organization led by China State Construction Engineering Corporation, and project subcontracting by various participating units. As illustrated in Figure 4, the project manager was comprehensively responsible for managing designated areas, integrating resources, and collaborating with the team to ensure task completion. In contrast, two deputy managers assisted in resource allocation and personnel coordination.

Through specialized teams and subcontractors, construction wastewater was collected and treated in a fully enclosed system, with disinfection processes implemented before being discharged into the municipal sewage network. The ventilation specialist team established independent fresh air and exhaust systems for the patient wards to ensure fresh air circulation and proper discharge of disinfected air. Suppliers provided HDPE impermeable membranes to protect underground foundations, while waterproof subcontractors prevented contamination. The medical specialist team designated a specific area to dispose of medical waste safely within the hospital. These measures exemplify the advantages of optimizing organizational structure; through collaborative division of labor and effective communication,

management decision-making capabilities and employees' efficiency in environmental protection efforts were significantly enhanced.



**Fig. 4.** Organizational chart of the Huoshenshan Hospital Project Department [28]

## 4 Conclusions

Currently, China has made significant research achievements in promoting realizing its "dual carbon" goals through building energy efficiency and the development of green building planning. This paper explores integrating sustainable building concepts into traditional construction processes from green construction technology and management systems perspectives. It examines the entire lifecycle of engineering projects during the construction phase. The following conclusions have been drawn:

1. This paper compares the similarities and differences between green and traditional construction technology, identifying factors contributing to environmental pollution arising from conventional construction, such as lifecycle operating costs, the lack of environmental protection concepts, and outdated technologies reliant on personnel experience. Solutions are also proposed. Additionally, BIM technology is analyzed as a case study, highlighting its advantages in information processing, construction planning, and problem-solving. This demonstrates that BIM technology better embodies sustainable development principles than traditional construction methods, showcasing the possibility of harmonious coexistence between modern engineering projects and the natural environment, thus representing a more rational and advanced level of construction technology.

2. The research identifies the similarities and differences between traditional and green construction management systems, reflecting the deficiencies in efficacy and concepts within traditional management frameworks. Through an empirical case study of the organizational structure during the construction of Huoshenshan Hospital, the remarkable advantages of the green construction management system are thoroughly demonstrated in optimizing personnel allocation, providing specific measures, and distributing construction tasks. This underscores the profound care that green construction demonstrates for the environment and the efficient use of resources.

This paper acknowledges that specific research achievements have been made in green construction technology and management. However, due to considerations regarding the feasibility of implementation costs and the challenges of market promotion, improvements in the study of green construction technologies for specific scenarios still need to be made. Future research is recommended to explore further integrating BIM technology with the Internet of Things, finite element analysis, artificial intelligence, and other technologies applied to green construction to enhance efficiency and standards. Currently, the green construction management system is discussed solely from an organizational management perspective; it is suggested that future studies incorporate quantitative evaluation mechanisms for a more comprehensive analysis.

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