Research on the Digital Construction System of Prefabricated Buildings

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Abstract: This paper explores the prefabricated digital construction system in depth, explains its core connotations and specific components, analyzes the problems that exist in practical applications, and proposes comprehensive response strategies in a targeted manner. Firstly, the article introduces the current status of prefabricated buildings and the development of digital technology, highlighting the necessity of researching the digital construction system of prefabricated buildings. Then, the article introduces the connotation of the digital construction system for prefabricated buildings. Then, the article delved into the composition of the digital construction system for prefabricated buildings. Subsequently, a thorough analysis will be conducted on the series of challenges that the current digital construction system for prefabricated buildings is facing in its development process. On this basis, the article elaborates on measures and strategies to address these challenges in order to provide theoretical support for the digitalization process of the prefabricated construction industry, help improve construction efficiency, ensure project quality, and promote sustainable development of the industry. Finally, Finally, the main content of this article was summarized.

Keywords: Prefabricated Building; Digital Technology; Construction Management; System Integration; Countermeasures

1. Introduction

With the acceleration of global urbanization, the construction industry, as an important pillar industry of the national economy, is facing many challenges such as resource scarcity, environmental pressure, and labor shortage. Prefabricated construction, as a new type of construction method, involves prefabricating building components in factories and transporting them to construction sites for assembly [1,2]. It has significant advantages such as fast construction speed, controllable quality, energy conservation and environmental protection, and labor savings, and has gradually become an important direction for the transformation and upgrading of the construction industry.

In recent years, the Chinese government has vigorously promoted the development of prefabricated buildings and introduced a series of related policies. For example, the "Thirteenth Five Year Plan for Prefabricated Buildings Action Plan" proposes that by 2020, the proportion of prefabricated buildings in new construction in China will reach over 15%, with key promotion areas reaching over 20% [3,4]. The Guiding Opinions on Promoting the Coordinated Development of Intelligent Construction and Building Industrialization clearly state the need to vigorously develop prefabricated buildings and promote the establishment of a specialized, large-scale, and information-based production system based on standard components. Under the guidance of policies, prefabricated buildings have experienced rapid development in China, with their application scope continuously expanding to cover multiple fields such as residential, commercial, and public buildings.

At the same time, with the continuous development of the global economy and the rapid advancement of technology, digital transformation has become a necessary path for various industries to enhance competitiveness and achieve sustainable development. The rapid development of digital technology has also provided new opportunities for the development of prefabricated buildings. Introducing digital

technology into the construction process of prefabricated buildings can achieve integrated management of building information, visual simulation of construction processes, precise control of component production, and intelligent monitoring of construction sites, thereby effectively improving construction efficiency, reducing costs, enhancing quality, and ensuring safety. For example [5-7], Building Information Modeling (BIM) technology can simulate and analyze the entire lifecycle of a building project in a virtual environment, helping designers optimize their design plans and allowing construction workers to detect and solve potential problems in advance; IoT technology can achieve real-time monitoring and management of construction site equipment and components, improving resource utilization efficiency; Big data and artificial intelligence technology can analyze and mine the massive data generated during the construction process, providing scientific basis for project decision-making [8-10].

In short, the introduction of digital construction systems can meet various engineering management needs such as engineering design, procurement, construction, and commissioning, improve the level of information management in construction process management, and achieve integrated requirements for comprehensive control of engineering progress, investment, quality, safety, technology, and environment [10-11]. By utilizing advanced digital design and management software, we aim to improve efficiency, standardize management, and provide effective information and data support for the later operation and maintenance of buildings.

Although prefabricated buildings have achieved certain development results in China, they still face many challenges in the process of digital transformation, especially the slow progress of digital construction systems for prefabricated buildings. Based on this, this article studies the digital construction system of prefabricated buildings, hoping to improve construction efficiency and quality, promote the digitalization process of prefabricated buildings, and further promote the transformation and upgrading of the construction industry.

2. The Connotation of Prefabricated Digital Construction System

The prefabricated digital construction system relies on digital technology and is a highly integrated system that comprehensively manages and precisely controls the entire life cycle of prefabricated buildings from design concept, production and manufacturing, transportation and distribution to on-site construction.

3. Composition of Digital Construction System for Prefabricated Buildings

The prefabricated building digital construction system is a complex and comprehensive system, which integrates hardware, software, and network elements in its architecture.

3.1 The Hardware Architecture Covers Various Intelligent Devices, Sensors, Data Acquisition Terminals, Servers, and Other Hardware Facilities

By installing intelligent controllers and sensors on various devices, real-time monitoring and remote control of the device's operating status can be achieved. The data collection terminals are distributed at various key locations on the construction site, used to collect environmental parameters, personnel location information, component status, and other data. As the core hardware device of the system, the server is responsible for storing and processing massive construction data, providing powerful computing and storage support for the operation of the system.

3.2 Software Architecture Mainly Includes Operating Systems, Database Management Systems, Application Software, Etc.

The operating system provides the basic operating environment for the entire software system, ensuring that various software can run stably and efficiently. The database management system is responsible for storing, managing, and maintaining various data generated during the construction process, ensuring the integrity, consistency, and security of the data. Application software is the key to implementing various functions of the system, including design management software, production management software, construction management software, quality management software, and other modules. Each module has specific functions and cooperates with each

other to jointly complete the digital management of the entire process of prefabricated building construction.

3.3 Network Architecture is an Important Support for Data Transmission and Information Sharing in Prefabricated Building Digital Construction Systems

It mainly includes the local area network, wide area network, and Internet of Things at the construction site. The local area network at the construction site connects various hardware devices and servers together, achieving data transmission and sharing within the construction site. The wide area network connects the construction site with external stakeholders such as prefabricated component production factories, design units, and construction units, enabling real-time information exchange and collaborative work among all parties. The application of Internet of Things technology further expands the perception range of the system, by connecting the equipment, components, personnel, etc. on the construction site with the network, achieving comprehensive perception and real-time monitoring of the construction process.

4. Challenges Faced by Digital Construction Systems

4.1 Difficulties in System Integration at the Technical Level

In the construction process of prefabricated building digital construction systems, there are many difficult problems in integrating different digital technologies Compatibility comes first and foremost. The digital construction of prefabricated buildings covers various technologies such as BIM, Internet of Things, big data, and cloud computing, which are often provided by different suppliers with different underlying architectures, data formats, and communication protocols, creating compatibility barriers for system integration Data exchange is also a major challenge. The construction data of prefabricated buildings is large and diverse, such as design, production, construction, quality inspection data, etc. These data need to be efficiently exchanged between different platforms and modules to achieve comprehensive monitoring and management. However, due to the lack of unified data standards and interface specifications, data exchange is difficult and prone to issues such as data loss, errors, or delays. In addition, the speed of updates and upgrades for different digital technologies varies, which poses long-term maintenance and upgrade challenges for system integration. If a certain technology upgrade may change the compatibility with other technologies, the entire system needs to be re debugged and optimized.

4.2 Inconsistent Technical Standards

Currently, the problem of inconsistent digital construction technology standards for prefabricated buildings is severe, causing multiple impacts on the development of the industry. For example, during the design phase, different regions and enterprises have varying design standards, resulting in a lack of universality in the dimensions, specifications, and connection methods of prefabricated components. At the same time, the lack of unified design standards makes it difficult to share and collaborate design results, compressing the space for design innovation and optimization. During the construction phase, differences in technical standards result in inconsistent construction techniques and quality acceptance standards. Construction companies rely on their own experience and habits to carry out construction, with different methods and technologies, making it difficult to standardize construction and prone to quality disputes and safety hazards.

4.3 The Transition Process of Management Mode is Slow

For a long time, the management concepts and methods of traditional building management models have been deeply rooted in enterprise operations. This model focuses on experience management as its core, relying on the personal experience and judgment of management personnel for decision-making and coordination, emphasizing post accounting, and lacking full process control. The digital management mode of prefabricated building digital construction system emphasizes real-time information sharing and collaboration, and achieves efficient communication and collaboration through digital platforms, which is significantly different from traditional modes. Information is stored, transmitted, and processed in digital form, which can be

quickly and accurately transmitted, improving decision-making efficiency and accuracy.

However, the transition from traditional to digital management models is not an easy task. The management of the enterprise has insufficient understanding of the new model, lacks enthusiasm for change, and is unwilling to invest resources in transformation. The low digital literacy and skills of enterprise employees make them unable to adapt to new models, resulting in a slow process of management mode transformation.

4.4 Shortage of Professional Talents

In the field of digital construction in prefabricated buildings, there are extremely high requirements for the ability and quality of talents. However, the talent training system in the field of digital construction in prefabricated buildings in China is not yet perfect, resulting in a shortage of professional talents. In terms of higher education, although some universities have already offered related majors or courses, there is a certain disconnect between the curriculum and teaching content and the actual work needs. Some universities still focus on imparting traditional architectural knowledge, with relatively less teaching content on prefabricated buildings and digital technology, and lack practical teaching links. The knowledge and skills learned by students in school are difficult to meet the requirements of practical work. In terms of vocational training, although there are some training courses on prefabricated construction and digital technology in the market, the quality of training varies greatly and there is a lack of unified standards and specifications. Some training institutions, in pursuit of economic benefits, provide simple and crude training content, lacking systematicity and depth, which cannot effectively enhance the professional abilities and qualities of their students.

5. Response Strategies and Suggestions

5.1 The Government Fully Plays a Leading Role, While Enterprises Exert Their Main Force

The government and industry associations need to take the leading responsibility, fully play their leading role, formulate comprehensive and unified standards and specifications, cover the entire process of design, production, construction, and acceptance, and clarify key content such as data formats and interfaces.

As the main driving force for industry development, enterprises also need to actively take action. Enterprises should vigorously strengthen technical exchanges and cooperation, fully utilize diversified platforms such as industry seminars and technology alliances, and share their technical experience and practical achievements in the field of prefabricated construction. Discuss and improve the formulation of standards, such as establishing a technology alliance to carry out related work. In addition, strengthen the promotion and training of technical standards, enhance the awareness and implementation ability of enterprises and personnel towards standards, and ensure the effective implementation of standards.

5.2 Strengthen Technology Research and Innovation

Strengthening industry university research cooperation is the core path to promote innovation in digital construction technology for prefabricated buildings. Universities, research institutions, and construction enterprises should closely cooperate to jointly tackle key technical bottlenecks in the digital construction system of prefabricated buildings, such as system integration, data security, intelligent construction, and other technologies. As the practice subject of technological innovation, construction enterprises transform scientific research achievements into practical productivity. Enterprises provide practical platforms and project cases for universities and research institutions, making research more targeted and practical. At the same time, we will increase investment in technological innovation, establish research and development teams, strengthen external cooperation and communication, and enhance our own innovation capabilities. In addition, we should actively expand international technological exchanges and cooperation, and introduce advanced foreign technology and experience. Organize industry delegations to participate in international activities, carry out cooperation projects with foreign enterprises and institutions, learn from their advanced experience in digital construction technology,

and promote the innovative development of digital construction technology for prefabricated buildings in China.

5.3 Vigorously Enhance the Abilities of Employees

In the development of digital construction in prefabricated buildings, enterprises need to vigorously enhance the capabilities of their employees. On the one hand, we need to increase training efforts. Adopting various methods such as internal training, external training, and online learning, we invite industry experts and technical backbones to share the latest technology and management experience, organize employees to participate in external courses and seminars, and broaden their horizons.

On the other hand, establishing incentive mechanisms is also crucial. Encourage employees to learn and improve independently, provide rewards and promotion opportunities to employees who have obtained relevant certificates and skills, and stimulate their enthusiasm and initiative for learning. In this way, employees can proactively enhance their professional skills and digital literacy to meet the requirements of digital construction in prefabricated buildings, contribute more to the development of the enterprise, and help the enterprise maintain competitiveness in the industry.

5.4 Building a Talent Cultivation System for the Digital Construction Industry of Prefabricated Buildings

Establishing a multi-level and multi-channel talent training system is the key to meeting the talent needs of the digital construction industry in prefabricated buildings. At the higher education level, universities optimize their major offerings and offer related majors to cultivate versatile talents. The course emphasizes the combination of theory and practice, increases the proportion of digital technology courses, collaborates with enterprises to establish internship bases, and allows students to participate in practical projects.

In vocational education, strengthening cooperation between schools and enterprises to carry out order based training, developing targeted plans, offering professional courses, cultivating practical operational skills and professional qualities, and familiarizing students with the process through practical teaching.

In addition, universities cooperate with enterprises to develop talent training programs, optimize courses and teaching content, and strengthen practice. At the same time, we will strengthen the construction of the teaching staff, introduce and cultivate dual qualified teachers, invite enterprise experts to serve as part-time teachers, improve teaching quality, and cultivate professional talents that meet industry needs.

6. Conclusion and Prospect

This article provides an in-depth analysis of the digital construction system for prefabricated buildings, covering its meaning, current development status, and system composition. It analyzes the challenges faced by the digital construction system for prefabricated buildings and proposes corresponding strategies to address these challenges. It is of great significance to promote the digital transformation of prefabricated buildings and improve the informationization level and management efficiency of the construction industry. Through in-depth research on the digital construction system of prefabricated buildings, new ideas and methods have been provided for the development of the construction industry, which will help achieve the goals of green, industrialized, and intelligent development in the construction industry.

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