Application of Prefabricated Building Technology in Green Building

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Abstract. Under the background of tight environment and shortage of resources, the construction industry, as an important force of China's economic growth, faces great challenges. It consumes a lot of resources and has a huge impact on the environment. The transformation and upgrading of the construction industry concerns the long-term interests of the people. This paper discusses the advantages and development of prefabricated building and green building. Firstly, the prefabrication technology based on green building is studied. Secondly, it is analyzed that the prefabricated housing can be used as the technical guarantee for the popularization of green building. Finally, the advantages and prospects of building information modeling (BIM) in the development of green building are summarized, including a reasonable analysis of data sharing in field gas production, transportation, installation and other aspects. This paper expounds the significance and importance of BIM in the development of green building, and discusses the new ways and trends of BIM technology in the future development of green building industry in China.

Keywords: Green building; prefabricated building; waterproof and thermal insulation; BIM technology.

1. Introduction

In 2020, General Secretary Xi Jinping said during a general discussion at the United Nations General Assembly: "We will increase our contribution to national ownership of policy-making and adopt stronger strategies and initiatives to reach peak CO2 emissions by 2030 and complete carbon neutrality by 2060." The 20th National Congress of the Communist Party of China mentioned that China needs to transform and upgrade its industries and enter a stage of high-quality development. However, as far as the construction industry is concerned, the traditional construction industry is extensive and labor-intensive, which will consume a lot of resources in the construction process, resulting in low construction standards, serious environmental pollution, and difficult to ensure safety and quality in the construction process [1]. From national policies to the shortcomings of the construction industry, there is an urgent need to upgrade to green economy, standardization and information technology. The essence of green building is to save natural resources (soil, energy, water and building materials), to protect the environment, to reduce environmental pollution, to create a safe, suitable and effective living space for human beings, and to build a high quality building in which people and nature live in harmony during the whole life cycle [2]. Prefabricated buildings refer to the mode in which the main structure of a building is poured on site in advance and then transported to the site for assembly [3]. The combination of prefabricated building and green building is conducive to bringing the inherent potential of prefabricated buildings into play and expanding the application of green buildings. The application of prefabricated buildings in green buildings has far-reaching implications for the construction industry. In this paper, the development of prefabricated buildings and green buildings is summarized, and the application of prefabricated buildings in green

buildings is discussed. Finally, the current challenges and future directions for development are put forward.

2. The Advantages and Development Status of Assembled and Green Buildings

2.1. Assembled Buildings

According to statistics, the construction industry consumes more than 35% of the total primary energy consumed worldwide, including fossil fuels [4]. China is currently undergoing rapid urbanization and there is still a huge demand for new buildings, a situation that will create enormous pressure on resources and the environment. At the same time, as the construction industry needs to adapt to the rapid pace of economic and social development, both owners and builders are preferring to build projects with short construction periods and high environmental performance. Therefore, the challenge facing our construction industry in the process of moving towards more sustainable development is arduous and urgent [5]. Against this backdrop, the Chinese government has given strong support to the use of assembled construction, which has certain advantages over traditional construction.

2.1.1 Advantages

(1) It can effectively save resources. The assembled building is designed and constructed in an integrated way, and does not require scaffolding and external frames to be erected at the construction site, saving manpower and material resources.

(2) The construction period is shortened. The assembled building does not require live plastering, masonry and other work tasks on site, effectively shortening the construction period. Traditional buildings are also susceptible to the effects of sun and rain during construction, and bad weather can affect the construction schedule, whereas this is not a concern with assembled buildings.

(3) Reduces construction waste and pollution emissions: traditional buildings emit large amounts of gas and dust, as well as noise pollution, which can be effectively mitigated by assembled buildings.

(4) In terms of safety, a high degree of standardization of prefabricated components and the introduction of national and local standards have improved the high quality of prefabricated components. while in the assembly process, the precision of installation of component parts can be accurate to the millimeter, and the high quality of prefabricated components and the high precision of installation ensure the quality of the housing [6].

(5) In terms of intelligence, the introduction of BIM information management models ensures consistency of engineering data throughout the life cycle [6].

2.1.2 Development status

Prefabricated construction is widely used in the short construction period of the project, and the assembled construction technology is also one of the more common construction methods in the field of modern architecture. In the current context, it has become a consensus to develop assembled buildings, innovate construction methods and help transform and upgrade the construction industry. In September 2016, the State Council issued the Guidance Opinions on Vigorously Developing Assembled Buildings, and the promulgation of this document has given a strong impetus to the development of the assembled building industry, with several enterprises engaged in assembled building design, production and construction growing rapidly after 2016, injecting new vitality into the assembled building industry [7]. At the local level, assembled buildings have received special funding, and policy incentives such as fiscal tax breaks have further promoted the development of assembled buildings. By the end of 2020, more than 2,000 component manufacturers were counted nationwide, and a record 630 million square meters of assembled buildings were constructed and started in 2020 [8]. Despite the optimistic development, assembled buildings also face problems such as the lack of industry codes or standards to support them.

2.2. Green Building

With the change of urban planning pattern around Beijing and the continuous improvement of urban functions, some new buildings in urban planning have added the design concept of urban greening. The greening construction has also aroused great attention from government departments at all levels and citizens, because they love the green plants, green shade and lake water near the houses. The good natural environment not only greatly improves the empty space of urban residents It also creates a better place for them to rest and travel in the city. It also gives them a more pleasant sense of security and a healthier life.

2.2.1 Advantages

(1) Energy saving environment protection

the construction of building greening engineering follows the design concept of saving and environmental protection, and usually adopts environmentally friendly building materials and technical equipment for construction, so as to reduce the interference and damage of building materials to the surrounding environment.

(2) Promoting the comprehensive utilization of natural resources

In environmental construction, people are increasingly using low consumption of resources, such as the use of natural resources, solar energy recovery system, etc.

(3) Providing comfortable living environment

Green buildings mostly use environmentally friendly building materials, and maximize the use of natural ventilation in the design and construction process, effectively reduce the concentration of harmful substances in the building materials or inside the building, and reduce later operating costs through energy saving technology.

2.2.2 Development status

In 2017, the Ministry of Housing and Urban-Rural Development issued the 13th Five-Year Plan for Conservation in Construction and Green Building Development, which makes overall arrangements for conservation in construction and healthy development of green buildings during the 13th Five-Year Plan period. The article also believes that the infrastructure and energy system of low carbon, saving, high efficiency, intensive, afforestation, ecology will be formed step by step to provide a new way for our sustainable economic development. From the 1980s to now, Chinese green building work has been in full swing and has gradually shifted to the stage of high-quality development, and the concept of green building has been gradually refined [9]. The Chinese government has introduced a series of policies to encourage the development of green buildings. At present, the main bodies of green building investment and construction in China are governments at all levels and real estate enterprises, and various green building design and construction technologies have been widely applied and promoted. However, in the process of development, there are still problems such as unbalanced regional development and incomplete laws and regulations to guarantee the development of green buildings. Therefore, the government must take corresponding measures to promote the development of green buildings to the direction of low cost, low energy consumption and high quality.

3. Practical Application of Fabricated Building Technology in Green Building

3.1. Door and Window Prefabrication Technology

In the traditional construction mode, the position of doors and windows is usually reserved through building blocks, while in the assembly building mode, it can be done by means of prefabricated doors and windows. Fig. 1 shows an example of this kind of building. In the prefabrication of wall panels, the positions of door frames and window frames should be reserved according to the relevant requirements of the assembly drawing. And the formwork is used to cast the opening of the door,

window and masonry and the drip irrigation line at one time to ensure the accuracy of the size and reduce the consumption of human resources [10].



Fig. 1 PC Components of Reserved Doors and Windows [11]

3.2. Sleeve Grouting Technology

Grouted sleeve connection technology is a new type of steel connection that has arisen as a result of the needs of engineering practice and technological development and has been rapidly developed and applied. Traditional welding methods are prone to poor welding and rusting of welded joints when connecting reinforcement elements, and the quality of nodal connections is related to the overall quality of assembled buildings. The use of sleeve grouting technology, where a pre-prepared slurry is filled into a concave and convex circular sleeve, allows reinforcement to be tightly connected. This technique is highly resistant to tensile and compressive forces, and the use of the sleeve to make a tighter connection between the reinforcement bars is highly effective in improving the quality of assembled buildings [12]. However, the construction process is relatively complex and costly at present, and the grouting must be full during construction. It is also worth noting that after the grouting of the sleeve is completed, the quality of the entire sleeve should be checked to prevent any problems with the quality of the sleeve, which could pose a safety hazard to the assembly building due to the substandard quality of the sleeve [13]. Fig. 2 is a schematic diagram of this technology.



Fig. 2 Schematic Diagram of Sleeve Grouting Technology [14]

3.3. Waterproof and Thermal Insulation Technology

The waterproofing and insulation performance of a building is an important indicator and a key item in the construction of a house building. Traditional housing construction, the overall waterproofing and insulation of the house, roof waterproofing, etc., are carried out at a later stage. Each part of the waterproofing and insulation needs to be constructed separately, not only time-consuming and labor-intensive. While coupled with the high-rise, super high-rise buildings, the difficulty of transporting building materials increases, and high-altitude work can lead to an increase in the construction risk factor [12]. The use of assembled buildings can improve this situation to a

certain extent. When manufacturing the relevant building components for assembled buildings, standardized waterproof layer and thermal insulation layer can be made at the same time in the factory, and according to the requirements of the relevant standards, the waterproofing and insulation layers will be spliced into the building structure, so that it is integrated with the whole building into a whole. This gives the building a high level of waterproofing and thermal insulation, while the building has obvious advantages in terms of fire protection and sound insulation, laying a good foundation for better use of the building.

3.4. BIM Technology

BIM technology refers to the creation of a three-dimensional model of the building project, using digital technology to obtain many relevant data throughout the life cycle of the building. BIM technology can be used in green buildings to enable data sharing in many aspects of production, transport and installation, which can make the whole building construction process more efficient, facilitate the release of information and decision-making. It can guarantee the safety of construction and construction progress, thus reducing the corresponding cost loss and further enhancing the efficiency of resource use [10]. In addition, in order to make the construction process smoother, BIM technology can also be used to analyze the possible adverse factors in advance. And finally formulate the corresponding disposal scheme, the whole construction quality inspection and control. In this way, the construction company can find problems in time and propose rectification plans, further standardize and regulate the corresponding energy use, and ultimately achieve the goal of energy conservation and environmental protection. Fig. 3 shows how BIM technology is applied.

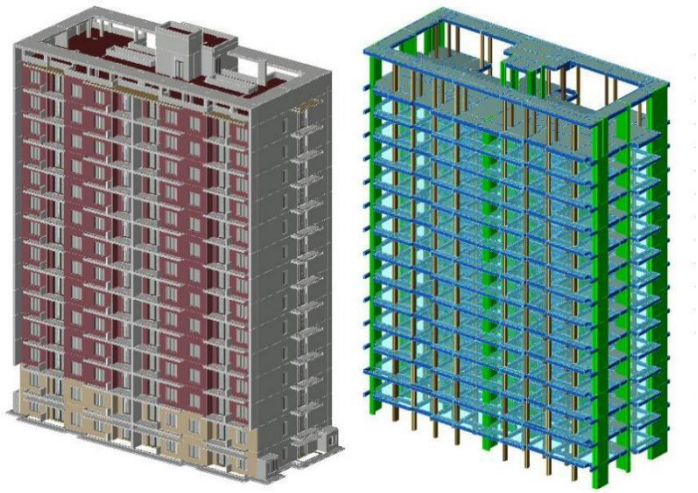


Fig. 3 Schematic Diagram of BIM Modeling [15]

4. Opportunities and Challenges Faced by Prefabricated Building Technology in the Application of Green Buildings

The energy crisis and environmental pollution caused by population growth and urban development have put Chinese traditional construction industry into a dilemma. In the current era, the construction concept and process technology used in Chinese traditional construction industry are no longer applicable. Instead, they are replaced by greener, energy-saving and efficient construction theory and process technology [16]. As a pillar industry of Chinese national economy, the construction industry has a vital impact on Chinese economic development. With the slowdown of Chinese economic growth, the requirement for the construction industry to transform and upgrade has become very urgent in order to achieve sustainable economic growth and the need for the construction of an environmentally friendly construction industry. In such a situation, the application of assembled construction and its related technologies in green building faces many challenges and some opportunities, which will be further discussed here.

4.1. Opportunity

(1) Huge potential in the market for assembled buildings

According to the Outline for the Development of Modernization of the Construction Industry, it is estimated that by 2025, the market space for assembled buildings is expected to reach 4.7 trillion yuan. And the proportion of assembled buildings to new buildings is over 50%, and the proportion of guaranteed housing projects taking assembled construction reaches over 60%. Meanwhile, according to statistics from the Ministry of Housing and Construction, in 2021, the country's new construction of assembled floor space will reach 740 million square meters, an increase of 18% from 2020, accounting for 24.5% of new construction. All these figures show the huge potential of assembled buildings in the current construction market.

(2) Policy support from the state and competent departments

In 2020, the Ministry of Housing and Urban-Rural Development issued "Several Opinions on Accelerating the Development of New Type of Building Industrialization". In 2021, the State Council issued the "Action Plan for Carbon Reaching the Peak by 2030", requiring vigorous development of assembled buildings and the promotion of steel-frame housing. Because assembled buildings and their related construction technologies respond positively to the national mandate to reduce carbon emissions and implement the concept of sustainable, energy-efficient and environmentally friendly development, they have received strong support from the state and governments at all levels. Compared to the traditional construction industry, assembled buildings can effectively reduce carbon emissions in all aspects of the whole life cycle, including construction, renovation and post-use, which makes it possible to greatly alleviate the problem of high energy consumption in traditional buildings.

(3) Social requirements for transformation and upgrading of construction industry

With the rapid development of Chinese urbanization and urban modernization process, the contradiction between the lack of energy and resources has become more and more prominent. The construction industry, which was originally built based on relatively low labor prices in China, has seen labor costs increase as the demographic dividend disappears. In addition, the traditional construction style has a long construction period and is also susceptible to various weather factors. Therefore, the traditional construction technology of cast-in-place buildings can no longer match the needs of modern society, so this has had a certain impact on Chinese construction industry. The construction industry is therefore required to progress in industrialization and upgrade. The traditional construction will gradually change from the traditional rough building to the intensive and refined industrial production. This can effectively reduce the demand for labor, improve the working environment, and reduce the demand for physical labor [17]. The use of assembled construction can alleviate this phenomenon to a certain extent, and with the application and further development of relevant assembled construction technologies, it is believed that these problems can be further resolved at a later stage.

4.2. Challenge

(1) Lack of industry standards and codes

At this stage, China has not yet introduced a nationally applicable standard specification system for assembled buildings, and the modulization and standardization of architectural design and component production needs to be improved [7].

(2) Lack of design, management and construction talents

Compared to the traditional construction industry, assembled buildings are quite rare in terms of design, management and technical talents, for example, technical talents may need to have a certain mastery of BIM technology, 3D printing and other emerging technologies, which are currently quite scarce in the construction industry.

(3) The level of electronic information technology in the construction process is low.

No matter the traditional building or the new prefabricated building, the information integration and sharing system has not been fully established in the whole life cycle of the building, especially in the construction process.

(4) The cost of prefabricated buildings is high.

The manufacturing of prefabricated parts has led to high costs due to the small variety and number of component products and low standardisation, which has also led to a low degree of product industrialisation. The inability to achieve complete replacement due to the different prefabricated components produced by various manufacturers, further limiting the development of marketisation.

(5) The popularity of building applications is not high.

The industry is not sufficiently aware of the environmental and economic benefits of assembled buildings, and there is also a personalised demand from consumers for building decoration design. Therefore, the consumer market is still keen on products in the form of rough deliveries [18].

5. Conclusion

Adopting prefabricated construction technology for green construction provides a new way of thinking for the low-carbon neutral development of construction industry. While integrating technology, it also aims at efficient, low-carbon and scientific development, providing scientific and technological basis for the efficient development of the construction industry. At present, there are still some problems in the practical application of prefabricated building technology, which can be said to be both opportunities and challenges. It is believed that in the near future, with the emergence of new materials and new technologies, the installation and support of modern building technology will be more perfect, so as to bring more powerful guarantee for green low-carbon life and social sustainable development. In addition, how to gradually reduce the production costs of prefabricated construction and how to use computer technology to enhance the use of prefabricated construction and building technology in green construction still needs to be studied.

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