Research on the restrictive factors of the development of Chinese prefabricated buildings

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Abstract. Prefabricated construction is one of the development directions of green construction in China. Its characteristics of fast construction speed and low energy consumption can promote the rapid development of prefabricated buildings. This paper compares the development of prefabricated components at home and abroad. Through literature review and questionnaire survey, five main factors restricting the development of prefabricated buildings are determined. After that, with the government and the market as the main body, the paper puts forward countermeasures to promote the development of prefabricated buildings from demand, technology, cost and other aspects.

1. Introduction
Prefabricated construction is a new type of construction method which is prefabricated in the factory and then transported to the construction site for assembly. Compared with the traditional construction method, prefabricated construction has the advantages of fast construction speed, labor saving, energy saving and emission reduction[1]. According to statistics, at least 80% of water, 70% of energy, 20% of materials and 20% of land are saved in prefabricated construction[2]. At present, the population dividend of our country is disappearing year by year, and the labor cost of the construction industry is increasing year by year, so the prefabricated building is the new direction of the future development of the construction industry, and it is also the essential way for the transformation of the construction industry to green, industrialization and informatization.

Because of the late start of the prefabricated buildings in China, and the increasingly high requirements of the society, prefabricated buildings are facing more and more threats and challenges. Firstly, this paper analyzes and compares the development process of prefabricated buildings at home and abroad. Then through literature review and questionnaire survey, determines the main factors restricting the development of prefabricated buildings in China. Finally, from the market, technology, cost and other aspects, some countermeasures to promote the development of prefabricated buildings are put forward. The goal of this paper is to better promote the sustainable development of prefabricated buildings in China, enhance its important role in social development, and provide new ideas for the future reform of the construction industry.

2. Development status of prefabricated buildings

2.1 Research situation of foreign prefabricated buildings
Prefabricated buildings appeared in the 1940s. After the Second World War, the western countries suffered from housing shortage and labor shortage[3]. Therefore, European countries began to use...
prefabricated buildings to build houses. After that, the United States, Japan, Singapore and other countries also introduced Prefabrication Technology to develop a variety of prefabricated building systems for large-scale residential construction. The construction industrialization of these countries has entered a stage of rapid development. Now, that has reached a very high level. According to statistics, as shown in Figure 1, in 2018, the penetration rate of prefabricated buildings in Sweden, the United States, the United Kingdom, Japan and Singapore reached or exceeded 70%.

Figure 1. Comparison of assembled penetration rates in major countries in 2018.

2.2 Research situation of domestic prefabricated buildings
China's construction industrialization appeared in the 1950s. In the 1980s, the development of prefabricated buildings entered a rapid period. However, in the 1990s, the development of prefabricated buildings stagnated. Its problems such as earthquake resistance, water leakage and poor thermal insulation have not been solved, so it has been replaced by cast-in-place concrete structure. After the 21st century, with the deepening of the concept of sustainable development, prefabricated building has become the development trend of the construction industry. At present, the market of prefabricated building in China has a certain scale. According to the statistical data, the market output value of prefabricated buildings in recent years in China is shown in Figure 2, and its construction area is shown in Figure 3. It can be seen from the development trend of area and output value that China's prefabricated buildings are developing towards scale. It has become a general trend to promote the development of prefabricated buildings. However, the penetration rate of prefabricated buildings in China is only 9% in 2018. Compared with developed countries, the gap is huge.

Figure 2. Output value scale of China's prefabricated buildings in 2012-2018.
Figure 3. 2012-2018 new prefabricated building area in China.

3. Problems in the development of prefabricated buildings
Through literature review, 218 Chinese and English literatures related to prefabricated buildings were found. By collecting and arranging them, the influencing factors restricting the development of prefabricated buildings in China are analyzed. After statistical analysis, 11 main factors were extracted.
Then, this paper conducts a questionnaire survey with construction enterprises and consumers as the survey objects. The results are shown in Figure 4. After deleting the weak constraints on the development of prefabricated buildings in China, the final five main constraints are determined.

![Survey results of restrictive factors of prefabricated buildings.](image)

### 3.1. Backward technology
Although prefabricated construction has a certain development, it still belongs to the new construction method for the Chinese construction industry. Compared with the traditional building construction method, prefabricated construction has higher requirements for construction technology, such as the connection of building component nodes, the accuracy of installation location, seismic performance. There are no mature research results for these key technologies in China. Influenced by the traditional construction method, as a new method, prefabricated construction has many problems such as insufficient technology and equipment quality. Although, Building Information Modeling (BIM) is one of the common technologies used in architecture and civil engineering. It is lack of application in prefabricated buildings\(^4\). The lack of technology in many aspects hinders the development of prefabricated buildings.

### 3.2. High construction cost
There are three reasons: firstly, as prefabricated buildings are in the initial stage, the prefabricated component factories are all newly built, so the component manufacturers hope to recover the factory investment as soon as possible. Secondly, in the case of prefabricated buildings without scale effect, the amortization cost of components is higher, so the price of prefabricated components rises\(^5\). In addition, although prefabricated buildings save labor and formwork cost in the measure project, they also increase the cost of transportation and installation of components. Therefore, the cost of prefabricated buildings is still high, even more than traditional buildings.

### 3.3. Imperfect standards and specifications
If prefabricated buildings want long-term development, they must have a sound standard system. At present, many cities are vigorously constructing the demonstration area of fabricated building industry, and promoting the prefabricated construction industry. Therefore, a set of standard system is necessary to guide the construction. The existing national and local standards for prefabricated buildings include evaluation standards, Atlas, design regulations, etc, but there are still large gaps. In addition, due to the lack of a unified national framework, the requirements for the production and transportation of components in the provincial codes and standards are inconsistent, which further affects the promotion of prefabricated buildings in China.
3.4. Low market recognition
Foreign prefabricated construction industry has developed for many years, with high recognition of society, market and industry, and perfect industrial chain construction. But in China, prefabricated buildings are still in infancy. Many prefab factories need to be rebuilt, which increases the one-time input cost of enterprises and greatly reduces the enthusiasm of construction enterprises. At the same time, the developers are not willing to develop prefabricated houses because of their low recognition of prefabricated buildings. In addition, even if individual developers are willing to develop prefabricated buildings, consumers will take a conservative attitude towards prefabricated buildings because of the low penetration rate. They are reluctant to buy them.

3.5. Lack of professionals
Because prefabricated construction is a comprehensive production activity involving design, production, assembly and other links, the requirements for the comprehensive quality of employees are very high. But at present, most of the construction management and production personnel of prefabricated buildings are transformed from the traditional construction related technical personnel. Their application level and specialization level of building informatization are not high enough, and the assembly construction team with corresponding qualification is also lacking. These conditions are not conducive to the sustainable development of prefabricated construction industry.

4. Development proposals
According to the analysis results of constraints of prefabricated buildings, based on the government and market, the paper puts forward countermeasures to promote the development of prefabricated buildings, aiming at policies, demands, technologies, costs and other aspects, as shown in Figure 5.

4.1 Improve technical level
Technological innovation is particularly important for the development of modern industry, as well as the support of technological innovation for prefabricated buildings. For the key technologies of prefabricated construction, the relevant departments of the state need to actively study, and provide the most fundamental technical support for the development of prefabricated construction method. Secondly, prefabricated buildings need to be integrated with information technology, so that BIM can be used not only in the early design, but also in all stages of a construction project, to establish an information integration system of the whole industrial chain, and give full play to the industrialization advantages of prefabricated buildings. Thirdly, in combination with the needs of the development of prefabricated construction method, a large number of new building talents need to be trained. More efforts should be made to popularize the use of professional production equipment[6]. On the basis of
ensuring the support of corresponding technical talents, combined with the needs of market development, more BIM technical talents and practical talents should be trained to promote the transformation and development of construction enterprises.

4.2. Enterprises strengthen cost control
At present, the high cost of prefabricated buildings is mainly due to the cost of prefabricated components and installation costs. In order to control the cost of prefabricated components, the designer should pay attention to the standardization of components and reduce the model cost of prefabricated components from the design stage. In the aspect of controlling the installation cost, the construction unit needs to reasonably divide the flow section and improve the installation speed to reduce the mechanical cost and reinforcement cost.[7]

4.3. Strengthen government support
National support is one of the important factors to promote the development of prefabricated construction industry. First of all, the government needs to formulate more perfect policies. Through the legal constraints to promote the development of prefabricated buildings [8]. Secondly, in order to support the relevant enterprises and encourage the implementation of prefabricated buildings, the state needs to introduce relevant support and incentive policies to solve the worries for the relevant enterprises. Finally, the government must increase investment in financial subsidies and policy guarantees to provide more support for the development of prefabricated buildings.

4.4. Improve the technical standard system
First of all, the mainstream prefabricated buildings should continue to study its mature technical system, and form a standard system that can adapt to different regions and different climatic conditions. Secondly, according to the needs of social development, the standard of each big prefabricated building structure system is improved, especially the research of super high-rise steel structure system[9]. At present, its application is relatively less, but the demand is gradually increasing. Finally, prefabricated buildings should adhere to the integrated design and collaborative construction of all disciplines, and improve the standard documents and evaluation standards of each stage.

4.5. Strengthen promotion and publicity
The first problem to solve the market demand of prefabricated buildings is to improve the public's cognition level of prefabricated buildings. Therefore, it is necessary for the government and enterprises to strengthen the publicity of prefabricated buildings, and popularize the knowledge of prefabricated buildings through TV, Internet and other media, especially focusing on the architectural performance and environmental benefits of prefabricated buildings. Finally, the public has a correct understanding of prefabricated buildings, so as to support the development of prefabricated construction industry.

5. Conclusion
Prefabricated construction is a kind of environmental protection, energy-saving and efficient production mode. It is a new structural form of construction industry. However, there are also a series of development bottlenecks such as high production cost and low technology level, which limit its application in China. The systematic research and analysis of the prefabricated building can not only find out its constraints, but also help its stable development. Through the efforts of all parties, prefabricated buildings will surely develop rapidly in the Chinese construction market in the future.

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