Research and Prospect on the present situation of assembled buildings in China

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Abstract: This paper summarizes the understanding and theoretical basis of different scholars on the idea of assembly architecture, mainly introduces the development history, development status, problems faced in the development of China's assembled buildings and suggestions for solving the corresponding problems. Assembling building is a new type of architectural model building in our country in recent decades, which is prefabricated by PC component factory to spare parts and structural components, and then transported to the construction site, using machinery for assembly completion in the construction site. However, due to the backwardness of technology, the shortage of professional talents, the narrow market, the high cost and other problems block the development of assembly-type buildings in China. In order to develop the rapid development of assembled buildings in China, we need to solve the problem fundamentally, vigorously train professional and technical personnel, standardize the standardization of structural components and support the national policy, and so on.

1. INTRODUCTION

1.1 The development of prefabricated buildings
The wooden frame-assembled houses that emerged in the 17th century American New Immigrant era are considered to be the prototype of the early assembly buildings. The "Crystal Palace" built in London in 1851 is the world's first large-scale assembly building [2]. Due to the Second World War, the housing construction in Western Europe and Japan was extensively damaged. In order to solve the housing problem quickly, the prefabricated buildings were vigorously developed, which led to the boom of residential industrialization. At the PCI annual meeting in 1991, the United States proposed to regard the development of prefabricated buildings as an opportunity for the development of the US construction industry, which brought long-term development of prefabricated buildings in the United States for more than 20 years. At present, it is estimated that the proportion of prefabricated buildings in concrete structures in the United States is about 35%. In Asia, Japan's fabricated building technology is already mature, and it is also the level of world-class building industrialization. In the 1960s, Japan proposed the “10-year plan for residential construction” and revised it regularly. Today the construction of Japanese assembly buildings has surpassed that of traditional buildings.

The start-up time of China's prefabricated buildings is not very different from that of Western European countries. China's prefabricated buildings were enlightened in the 1950s, but the development of fabricated buildings was blocked until the late 1980s. During this period, China's prefabricated
buildings were built. Various structural members such as prefabricated roof beams, crane beams, prefabricated roof panels, prefabricated hollow slabs and large-scale buildings have emerged, but these components have problems such as small span, low carrying capacity, poor integrity, and poor ductility. After entering the 1990s, due to the design level of the prefabricated building itself, the components are out of fineness and other reasons and assembly techniques and rapid development of technology, the application of moulded concrete prefabricated buildings, especially in civil buildings, is at a low tide [5]. Since the beginning of the 21st century, with the rapid development of China's economy and science and technology, the processing, structural technology and management level of structural components on the prefabricated buildings have been relatively improved. In addition, in response to the national “improvement of construction level, environmental protection, and resource conservation”, the architectural model of prefabricated buildings has gradually attracted various construction enterprises and construction investors, thus promoting the development of prefabricated buildings in China [7]. At present, some well-known construction companies in China have gradually developed prefabricated buildings, such as Yuhui Group, Zhongmin Zhuyou, Zhongnan Group, etc., especially the Zhongmin Zhuyou Group, which specializes in the research and development of fabricated buildings. And achieved good results and it also applied for a number of patented technologies. Despite the current low profitability of prefabricated buildings, prefabricated buildings can more effectively improve the construction efficiency, protect the environment, and facilitate the safety and quality inspection, which will bring long-term benefits.

2. MATERIAL AND METHODS

2.1 Analysis of the status quo of fabricated buildings

2.1.1 Analysis of foreign status
At present, foreign prefabricated building technology is relatively mature. Xia Lin once mentioned in the "Overview of the development of fabricated buildings at home and abroad" that the assembled components in the United States are now marketized. And the National Industrialized Housing Construction and Safety Act mentioned by Gu Taichang was approved by the US government in the 1976, and the internationally influential PCI Design Handbook was made by the Prefabricated and Prestressed Concrete Association. Developed by PCI, German fabricated building technology is at a mature stage. Japan is the first country in Asia for assembling architecture. It has successfully learned from the advantages of European and American assembling architecture. It combines local characteristics with foreign ones. As an island country with multiple earthquakes, Japan has made breakthroughs in the integral aseismic and isolation design of prefabricated structure system [6].

2.1.2 Domestic status analysis
In recent decades, the development speed of prefabricated buildings in China has been increasing year by year, successfully solving the problems of low on-site construction efficiency, high labor cost, poor air quality, serious environmental pollution, etc., and has low construction cost, high construction efficiency, and construction, igh safety and low pollution in the construction environment. The application of prefabricated buildings in Hong Kong and Taiwan in China is very common, and it has a relatively complete system of prefabricated architectural design and construction specifications. However, there is still a gap between the fabricated building technology in mainland China and Hong Kong and Taiwan in China. In 2014, Gu Taichang, deputy chief engineer of the China Building Standard Design and Research Institute, mentioned that the capital Beijing, Shenyang, Shanghai, Hefei and other cities are prefabricated at home and abroad. But there are also some problems. For example, the domestic building development system is imperfect, and the basic research on assembly buildings is insufficient, etc [7]. There are still many problems to be solved in the development of China's construction industry. For example, the prefabricated components of PC component factories lack standardization and standardization, the assembly component technology is not mature, the assembly construction industry
does not have relatively perfect industry norms, and sound management modes. These are all problems that need to be solved urgently.

2.1.3 Classification of fabricated building structures
Ma Junqing once explained in the "Assembled Building Review" that the so-called prefabricated building is a building assembled with prefabricated components on the construction site. According to the difference between the structural form and the construction process, it can be roughly divided into the following five types. Firstly, block building, the building wall is made of prefabricated block material [8], the prefabricated building of this type of building has simple production process, low cost and strong applicability, generally suitable for construction of 3-5 layers. Building. Secondly, panel building, composed of large prefabricated panels such as interior and exterior walls, floors and roofs. This type of building has the advantages of reducing structural weight, high labor productivity and guiding ability, but the lack of flexibility in the internal separation of the building. Thirdly, Box building, which is based on the panel building, has the characteristics of high degree of industrialization and convenient installation. The assembly forms of box-type buildings are mainly divided into four categories: full-box, plate-box, core-box and skeleton-box. However, the development of box-type buildings is limited due to the shortcomings of large investment and inconvenient transportation. Fourthly, skeleton sheet construction, composed of prefabricated skeleton box plates, due to the rationality of the construction of the building, this type of building has the advantages of reduced weight and internal arrangement flexibility, usually suitable for multi-storey and high-rise buildings. Fifthly, liter plate and riser building, this building is to cast the slab and roof slab back and forth on the bottom concrete slab. Firstly, the prefabricated reinforced concrete column is set up reasonably, the column is used as a guide rod, and the hydraulic jack raises the slab and the roof slab by means of the column. Go to the design height and fix it. The slabs of the slab building are also relatively strong, and are generally used in shopping malls, warehouses, construction sites and multi-storey garages [8].

3. RESULTS

3.1 Promoting factors for the development of fabricated buildings in China
Since the beginning of the 21st century, China’s economy, science and technology, and architecture have developed rapidly. The national government has also paid more attention to the ecological environment. General Secretary Xi Jinping mentioned that Jinshan Yinshan is not as green as green mountains, and should pay attention to ecological civilization and increase the intensity of environmental governance. The development of this type of prefabricated building in China is a contemporary inevitability.

Firstly, From the national conditions of China, the construction of China's construction is still based on traditional construction methods, such as on-site masonry, on-site pouring, etc. However, this construction method has a long construction period, low construction efficiency, and poor quality of construction environment. However, prefabricated buildings can well overcome these problems, and this can also be a good way to successfully transform the traditional architecture of our country.

Secondly, From the national policy, the development of prefabricated buildings is a transformational path for the construction industry. As a new type of construction mode in the new era, it not only promotes the reform of the production end, but also promotes the development of new urbanization.

Thirdly, From the performance of the building, the prefabricated structural members can improve the accuracy of the structural dimensions and reduce the error, thereby ensuring the structural stability and integrity of the building, and effectively improving the structural shock resistance and service life.

Fourthly, From the construction site, the prefabricated building construction process can effectively reduce on-site wet work and scaffolding operations, and can also effectively reduce construction noise, reduce air pollution, and reduce construction waste.

Fifthly, From the environmental resources, compared with the traditional construction technology, prefabricated buildings not only have higher resource utilization rate, but also have the advantages of...
energy conservation, environmental protection and emission reduction, which is in line with China's policy of adhering to green development. Zhang Xin once compared the amount of cast-in-situ structure with the amount of construction materials used in the construction of the prefabricated building bottleneck and countermeasures, and found that the fabricated building can reduce the loss to about 30% compared with the cast-in-place structure.

Sixthly, Compared with foreign fabricated building technology, China's fabricated building technology is not mature enough. The standardization level of prefabricated structural members is low, the standardization of prefabricated structural components is not perfect, the seismic technology of prefabricated structural components is not mature enough, and the production cost is relatively high compared with traditional buildings. In order to cope with the transformation of new construction mode in the new era, China's prefabricated building technology People also need constant efforts and learning.

4. DISCUSSION

4.1 Problems in the development of fabricated buildings in China

4.1.1 National conditions
There are many earthquake zones in China, and different requirements are applied to different earthquakes in different regions. For this reason, the seismic requirements for buildings are also different. At present, China's research on the seismic and seismic field of fabricated buildings is still not deep enough, especially for material properties, thermal insulation structural joints, waterproof structural joints, etc., which still lacks long-term practice and inspection [10]. China's fabricated building technology Compared with foreign assembled buildings, the gap is still relatively large, and more researchers are needed to participate in this business.

4.1.2 Policy issues
At present, although the relevant departments of China have issued corresponding encouragement policies, the local governments have not implemented them. The specific implementation is not detailed enough. The organization and training of construction enterprises are lacking, and the transformation of the original enterprises has not been properly guided. The policy system of related prefabricated buildings is not perfect enough, so that the problems of organizational disorder, market chaos, etc. in the process of development of fabricated buildings are difficult, and the support of policies is not enough. It is difficult to mobilize the enthusiasm of builders and investors, and finally lead to the blocked development of prefabricated buildings In addition, having a complete set of standard system for prefabricated building codes is the key to the success of prefabricated building development. Therefore, the primary task of the development of prefabricated buildings in China is to solve the problem of standardization of prefabricated components.

4.1.3Market issues
In recent years, although the development market of prefabricated buildings has slowly eased, as far as the entire construction market is concerned, there are still problems in the industry that are insufficiently recognized, market cultivation and development are slow. For the first-tier cities such as Shanghai and Shenzhen, the public has a relatively deep understanding and understanding of the prefabricated buildings. For the second- and third-tier cities, perhaps some people and some construction companies still know about the prefabricated buildings. However, the development of prefabricated buildings was hindered by this prejudice. In addition, research shows that the construction cost per square meter of prefabricated buildings is slightly more expensive than traditional construction methods of 500-700 yuan [13], and the seismic performance of fabricated buildings has been questioned by social groups, resulting in many construction enterprises on the assembly of buildings. Development lacks confidence or is on the sidelines.
4.1.4 Technical issues
Prefabricated buildings have the advantages of convenient construction and short construction period, but at the same time, the assembled buildings have higher requirements for the process [12]. The level of prefabricated components and assembly technology will determine the construction period, building quality and so on. At present, there are still large technical loopholes in the construction of prefabricated buildings in China. For example, the design of prefabricated structural members is not standardized enough, and the technical system that can be widely implemented has not been formed; the assembly technology level between the components is not high enough, and the positioning of the assembled buildings by engineering and technical personnel is not clear, and the overall professional quality is not high. There are no more mature technologies; production equipment is not advanced enough.

4.1.5 Talent issues
With the rapid development of the construction industry in recent years, related architectural courses are also included in the university curriculum, but the content of these courses is mostly from the perspective of traditional architecture, so that China is now specialized in assembly architecture. There is a shortage of demand for personnel. Firstly, the shortage of professional design talents. Most of the architectural courses offered by many universities in China are related to the traditional architectural model. There are no related courses and contents related to the new architectural model. The relevant materials are difficult to collect, so that those who want to learn the assembled buildings cannot get more systematic learning. Secondly, construction workers have poor professionalism. Although the construction period of the prefabricated building is short and the number of workers required is small, the professionalism of the workers has higher requirements. In general construction projects, although the number of manual construction on the prefabricated building is generally 8-12, the technical requirements for these workers are very strict. Because the training of these talents requires the construction unit to spend time and cost, many construction units are reluctant to carry out the construction of the assembly building [14]. Thirdly, the shortage of professional managers. Prefabricated buildings are in the early stages of development. During the production of prefabricated components and assembly processes, many problems will be encountered and corresponding problems will be solved to form new construction methods. However, management will also be improved and management models will be continuously updated. As well as the need for regular maintenance and improvement by professionals after completion, the talent needs in this area are also a serious problem.

4.1.6 Cost problem
The cost of traditional buildings is mainly composed of raw material costs and labor costs, while the cost of fabricated buildings mainly includes raw materials, manufacturing, transportation and assembly costs. Manufacturing and transportation costs are the main factors driving the overall construction cost of the building. The design of prefabricated structural members in China is not standardized enough, the component template system is not perfect, so that the reuse rate of component templates is low, and the materials are unqualified, resulting in serious material waste, which are the main reasons for the high manufacturing cost. In addition, transportation costs are closely related to the location of the prefabricated component factory. Xia Lin once summed up the mature PC building factory in China, which has about 9 PC sites in its prefabricated concrete component production base, mainly Suzhou, Wuhan, Chengdu, Tianjin, Henan, Fujian, Shanghai, Weibei Industrial Park, Anhui Feidong, however, the transportation of prefabricated components to the construction site will be very inconvenient, which will lead to a high transportation cost. In some projects, assembly-type construction projects suffered losses due to the factory address being too far from the construction site and inconvenient transportation.

5. CONCLUSIONS

5.1 Measures to promote the development of fabricated buildings
5.1.1 Policy aspects
The support and active guidance of government policies can effectively promote the development of prefabricated buildings. It can be strengthened from the following aspects: firstly, improve the economic incentive mechanism for prefabricated buildings, and support economic development to promote the development of prefabricated buildings. For example, the introduction of relevant preferential policies in project approval, land supply, financial subsidies, research and innovation incentives, credit loans, etc., can effectively encourage construction companies and investors to actively participate in relevant technology research and development, housing construction and other projects to promote assembly building development; secondly, standardization of sound assembly building standards and pricing standardization. Complete technical standards can make assembly buildings more standardized and standardized in the structural design stage, reducing unnecessary waste, and standardization of pricing can make the pricing results more accurate; thirdly, establish a professional assembly-type construction department. Because China’s fabricated building technology is relatively backward. For this reason, the professional work department can effectively solve the problems encountered in the development of the prefabricated building, and can provide technical support for the construction unit in a targeted manner, and can also effectively regulate the construction of the prefabricated building.

5.1.2 Market aspects
For the continuous and stable development of prefabricated buildings, it is necessary to build a positive market atmosphere. It is necessary to use various platforms to promote the propaganda of prefabricated buildings so that the masses can correctly understand the prefabricated buildings. Firstly, First-hand cities promote the assembly of buildings. The economic level of first-tier cities is relatively high, so that it is relatively easy to accept the high housing prices of prefabricated buildings. After the prefabricated buildings have gained public recognition and trust in the first-tier cities, they will be promoted to second- and third-tier cities. Secondly, the platform promotes prefabricated buildings and popularizes the knowledge of prefabricated buildings to the public. It is possible to promote prefabricated buildings through online social media such as WeChat and Weibo, so that the public can correctly understand the prefabricated buildings; interview professionals in the field of prefabricated buildings, explain to the public through them and promote the necessity of the development of fabricated buildings in China. Produce documentaries on the construction and construction of prefabricated buildings.

5.1.3 Technical aspects
Technology is the support of assembly building. In order to further develop assembly building, first of all, we need to improve the technical level. Establishment and improvement of assembly building technology system, a set of perfect building system can not only improve the design speed of designers, but also facilitate the construction unit to understand the design intent and project construction. We will encourage R& D and innovation of assembly building technology, and introduce and learn advanced foreign technologies. For example, the anti-cracking and anti-seepage technology of the joints of the assembled components and the anti-seismic technology of the whole assembled building, etc. Optimize and improve the standardized production process of PC component factory. In recent years, when PC component technology is used to assemble staircases, hollow floor and prefabricated beams, but the level of industrialization construction is low because of the imperfect construction level in the past. Therefore, it accelerates the standardization process of PC components, promotes the development of PC components, and reaches the industrialization level of residential buildings in China. [15].

5.1.4 Talent aspects
In order to promote the development of China's prefabricated buildings, the cultivation of professional and technical personnel is also an important aspect. Firstly, increase the intensity of personnel training. Courses related to prefabricated buildings are opened in colleges and universities in China, and the theoretical knowledge of related assembly buildings can be correctly understood and learned during the schooling period. At the same time, the innovative ability of the students can be promoted, and the
theory can be reasonably applied to practice. It is also a professional and technical talent in society. Secondly, conduct relevant technical training. All departments of the construction unit should regularly carry out training on new technologies, and designers, construction workers and management executives should actively participate in it. Regularly promote the latest developments and latest technologies of prefabricated buildings to the public. Thirdly, introduce professional talents. In the case of employee recruitment, the prefabricated building units need to broaden their horizons and recruit professional talents.

5.1.5 cost aspects
The investment in construction cost is one of the important reasons for blocking the development of China's prefabricated buildings. To solve this problem, we must first control the cost input. Firstly, control the cost by the construction of affordable housing. The structural design of affordable housing is simple and large. In addition, the government has introduced relevant incentive policies in the construction of relevant affordable housing. To this end, the use of affordable housing as a breakthrough in the development of prefabricated buildings, to a certain extent, can reduce costs. Secondly, reasonably set up the prefabricated component factory. Since the transportation cost occupies a large part of the total construction cost, for this reason, in the early planning of the project, it is necessary to analyze the problem of the component processing factory address of the fabricated building, and finally determine the optimal site selection plan. Thirdly, improve the construction process and reduce the cost of prefabricated components. Standardize component design and standardize the modulus to increase the number of times the prefabricated mold is used.

5.1.6 summarize
In summary, compared with traditional buildings, fabricated buildings have obvious advantages in terms of resource consumption, environmental pollution, construction period and so on. In addition, the prefabricated building is also responding to the call for green sustainable development, which is also the development of China's prefabricated buildings. However, China is in a preliminary stage of development in the prefabricated construction industry, and it has also been hindered by many factors, hindering the development of fabricated buildings. In the face of problems in the development of fabricated buildings, we must fundamentally solve them. We must not rely solely on government support, but also on the cultivation of professional talents and technological innovation and standardization. Only in this way can we better promote the development of architecture prefabrication.

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