The Development and Application of Residential System with Fabricated Steel Structure

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Abstract: Industrialization and urbanization are the foundation of modernization. Therefore, the industrialization of high-rise residence with fabricated steel structure is a major strategic demand for developing China's life-long green building, promoting the transformation and upgrading of residential industrialization and resolving the current overcapacity of steel. It is the only way to achieve modernization of China's construction industry. Based on the author's learning and practical experience, this paper first analyzed the domestic and international development of the residential system with fabricated steel structure, then discussed the major opportunities for the development of residence with fabricated steel structure. Finally, this paper proposed key issues in the development of residential system with fabricated steel structure.

1. Introduction

Since the 1990s, steel structures have been gradually used in China's construction projects, such as typical industrial buildings and storage buildings with a portal structure, and various types of buildings and public facilities with a covered structure of grid net shells and beam string structure systems. However, there are still some problems in the practical application of steel structures, which limits the development of steel structures to some extent. This paper will study the status, opportunities and problems of residential system with fabricated steel structure based on the actual situation.

2. Development Status of Domestic and International Residential Systems with Fabricated Steel Structure

The industrialization of steel structure residence abroad mainly focuses on low-rise fabricated steel structures. France was the earliest country in the world to promote the industrialization of buildings. In 1978, they formulated the rules for the coordination of dimensions and proposed an industrialized building system. The main structure was a tool-type large-scale composite framework. The Italian BSAIS industrial building system is suitable for the construction of 1 to 8-store steel houses. It has novel design, reasonable structural force, good seismic performance, fast construction speed and comfortable and convenient office. It is widely used in Europe, Africa, Middle East and other regions and countries. Germany's prefabricated houses mainly adopt laminated structure, concrete, shear wall structure system, shear wall panels, beams, columns, slabs, inner partition panels, external panels, balcony panels and other components. These components use fabricated system and concrete structures. This makes the building durable. Sweden is the most developed country in the world for residential industrialization with 95% of its prefabricated components in light steel structures. In addition, the typical prefabricated residential system includes LSFB light steel frame building system in the United States, and Sekisui and Toyota Homes residential systems of Water Supply Housing Co., Ltd in Japan.

For the residential buildings with fabricated multiple-floor steel structure, a representative structural system abroad is the Conxtech steel frame system recommended by the 2010 edition of the *American Steel Structure Seismic Design Code*, as shown in Figure 1. Since the frame column of the system is integral, its use scope is generally limited to multiple-floor buildings. The other is a high-rise mega-steel residential system proposed by Japan. The residence separates the structural

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members from the building components. The main body of the structure is a steel frame composed of steel columns, steel beams and supports. However, the column connection of the structural system is field welding, and full assembly is not achieved. The industrialization of steel structure residence in China started relatively late. The representative projects for low-rise light steel assembly houses include the Beixin thin steel plate residential system developed by Beixin Group and low-rise layered assembled steel structure industrialized residential system developed by Tongji University United Baoye Group and Japan Yamato Housing Co., Ltd.. Beixin thin steel plate residential system brings together many modern high-tech achievements with less steel consumption, good seismic performance, rich exterior wall decoration, good thermal insulation performance and energy self-sufficiency. Low-rise layered assembly steel structure industrialized residential system features in dense column, beam penetration, column and beam articulation, horizontal force mainly with column support, modular integrated design, standardized production and layered assembly construction .

For the industrialization development of high-rise residence with fabricated steel structure, China is still in its infancy. Hunan's Yuanda Kejian Technology Co., Ltd. has taken the lead in research and development of a diagonally strengthened steel frame system. The diagonally strengthened steel frame system is mainly composed of a main board, steel column and diagonal bracing. The profiled steel plate concrete composite slab, truss girder and column seat are prefabricated as the whole main board in the factory, and the various types of pipes are integrated as the assembly module. The assembly process of the system realizes the full bolt connection, which is easy to install, disassemble and maintain under the premise of ensuring the strength. Beijing University of Technology has carried out a large number of experiments and theoretical studies on the performance of the system, and optimized and improved the system.

3. Major Opportunities for the Development of Residence with Fabricated Steel Structure

3.1 The development background of China's residence with steel structure.

As the world's largest steel producing country with a capacity of 1 billion tons, China has a surplus capacity of 100 million tons. At present, China's residence with steel structure did not really realize industrialization. Its steel construction accounts for only 5%, while that in developed countries accounted for more than 50%. China’s steel residence is less than 1%. China needs 20 billion tons of strategic reserve steel. On September 22, 2013, Xi Jinping made a speech to resolve the overcapacity at the meeting of Central Politburo Standing Committee of CPC. He said to reduce steel output of 80 million tons and address the steel overcapacity. Since then, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Housing, Urban-Rural Development, the Steel Structure Association and large steel structure enterprises have taken action to discuss the application of steel structures in construction houses. We must implement the spirit of the Central City Work Conference and the spirit of the National Conference on Housing and Urban-Rural Construction. We must seize the rare opportunity of low steel prices and excess production, and actively promote the industrialization of residence with fabricated steel structure in China. This is an effective way to improve quality and seismic performance and reduce the loss caused by earthquake disasters. It is also the best way to modernize the steel structure residence industry in China.

3.2 National steel structure development plan from 2015 to 2020.

The National 13th Five-Year Plan emphasizes that it is necessary to study and promote the application of new steel structure systems in various types of buildings, and expand the application scope of steel structures. China’s steel structure design standards should be in line with international standards and China needs to improve steel structure design codes and standards. To provide complete sets of technology for the industrialization of residence with steel structure, it is necessary to develop economical, safe and reliable steel structure system with rapid installation and light steel structure floor, and apply them to affordable houses. We strive to make China's steel construction

account for more than 10% by 2020. *Outline for the Development of Modernization of the Construction Industry* of the Ministry of Housing and Urban-Rural Development has now completed the solicitation of opinions and is expected to be released in the near future. The *Outline for the Development of Modernization of the Construction Industry* clearly states that by 2020, prefabricated buildings will account for more than 20% of new buildings. By 2025, prefabricated buildings will account for more than 50% of new buildings. Judging from the background of the above times and the national development plan, the development of China's construction steel structure conforms to the background of the times, and is encouraged and supported by national policies. The market is very large. Houses with fabricated steel structure are fully in line with the industrialization of green houses and buildings. The needs are in line with China's guidelines for the industrialization of steel structured construction. It is a state-supported steel structure innovation technology and its development prospects are very broad.

4. Key Issues in the Development of Residential System with Fabricated Steel Structure

4.1 To break the limit of backward ideas.

Although steel-structured houses are mature and improved abroad, they are still new to the domestic people. Chinese consumers have long been accustomed to brick-and-mortar or reinforced concreted houses. To get used to and then prefer steel-framed houses, a gradual process is needed. Industrialized assembly production is the only way for the modernization of China's construction industry. On the road of high-rise steel structure industrialization, new ideas, new technologies, new systems and new processes must be promoted. We cannot be limited by existing normative standards and old-fashioned ideas. In addition, some of the major bulky steel structures waste steel, which will mislead the public. People mistakenly believe that steel structures are not suitable for general buildings, such as houses. People do not understand the advantages of great strategic position, fast construction speed and good seismic performance of steel structures.

4.2 To cultivate new technical and management talents.

On the road of industrialization of high-rise fabricated steel structures, we must have a series of standards and specifications for the design, manufacture, installation, construction and acceptance assessment, so that professional and technical personnel can follow the rules. In the process of formulating standards, a Steel Structure Housing Enterprise Alliance should be established, and scientific research units and enterprises should be organized. Production, learning, and research should be combined to develop new energy-saving walls and environmentally friendly low-carbon building system with high-rise fabricated steel structure houses as carriers. It is necessary to promote technological innovation in the construction industry and housing industrialization. We need to establish a high-rise assembly steel structure expert group to conduct professional evaluation of the reliability of new systems and new technologies to ensure that steel structure houses or products are economical and environmental friendly. The advanced technology should be in line with modular standards and be conducive to promotion. The group need to assess integration qualification of assembly-type high-rise steel structure design and construction of the company to provide reference for the relevant government departments. The timely placement of new technical talents and management talents is also a key step in promoting high-rise fabricated steel structures. At present, most of the construction workers in China's construction enterprises do not have specialized study and professional training. Apart from simple construction work, it is difficult for them to undertake industrialization and modern construction work. Migrant workers must be citizens, and they must become specialized workers in the construction industry to end the era of unskilled migrant workers in China's construction industry. China's construction industry can only achieve modernization by taking the road of industrialization. In order to realize the rapid installation and construction of standardized, modular and fabricated building components or parts like a construction aircraft, the relevant new construction industry technical talents and management personnel are indispensable.

4.3 To promote the construction of residential industrial chain with fabricated high-rise steel structure.

In order to achieve industrial production of houses with high-rise steel structure, we must have a sound industrial chain, starting from the materials, design, manufacturing, transportation, installation to property services. For each link of the operating mechanism, we need to propose corresponding industrial production and information management techniques and methods. The fabricated high-rise steel structure only involves the structure of the residential building. The complete industrial chain of the integrated building system needs to combine the architecture, plumbing, electric, decoration and other fields to provide complete commercial building residential products.

4.4 To break mechanism barriers in construction management.

At present, many construction general contracting enterprises do not have the professional assembly-type production and installation capabilities, while a few capable enterprises have no qualification for contracting. The project construction management system of the traditional construction industry has been deeply rooted in various enterprises, because it is easy to operate the system. However, it is outdated for the development of the industrialization of steel structure house. The self-upgrading of the system is urgently needed, which will help us to undertake the road of new -type industrialization and informatization.

5. Conclusion

At present, China's construction laws and regulations have to be further improved. The revision and new compilation of building standards are not timely, which lags behind the actual application level of construction engineering. The innovation is insufficient, the quality is low and the rigidity is not enough. Moreover, it is not implemented well. To perfect the building laws, regulations, standards and norms system, we must break the limits of backward concepts and standards, break the barriers in building management systems and cultivate new technical and management talents.

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