The Development of Modular Building in China

Yan-juan HAN¹ and Wen-zheng ZHU²

¹College of Architecture and Urban Planning, Guangzhou University, Guangzhou 510006, China
²School of Civil Engineering, Guangzhou University, Guangzhou 510006, China

Keywords: Modular building, Module, Development situation, Technical advantages.

Abstract. Modular building is a new-type building structure, which has obvious benefits such as energy-saving, rapid construction, efficient manufacturing, and good quality, comparing with the traditional building. The technique can save Chinese construction industry from the dilemma of high pollution, high energy consumption and poor efficiency, and be of great scientific and engineering significance to transformation and upgrade of the construction industry. In order to let more people know about modular buildings, the development situation of modular building is discussed in the paper, and then the advantages of the technology is summarized.

Introduction

Modular construction refers to factory-built building units completely assembled or fabricated in a manufacturing plant away from the job-site, then transported and assembled on site. Modules are manufactured from a series of 2D panels, beginning with the floor cassette, to which the four wall panels and ceiling panel are attached. The walls transfer vertical loads and therefore the longitudinal walls of the upper module are designed to sit on the walls of the module below. At present, more and more modular buildings start to be used in China for their economic advantages and high construction quality. The development situation and the benefits of modular building are presented in the paper to demonstrate the construction method.

Development Situation

After nearly a decade of hard work, breakthrough innovation was made in terms of assembled-monolithic structure for China’s construction industry. Based on the traditional technique of frame-core wall structure, prefabricated assembled monolithic structure represented by Zhejiang Southeast space frame company, Hangxiao steel structure, and China construction steel structure Corp. Ltd., focuses on producing structural parts (Figure 1). Structural parts are produced in factories to reduce the welding and installation on-site, and 30-40% components of the buildings are made into parts. Prefabricated assembled monolithic steel structure represented by BROAD Group, manufactures the walls, roofs, cassettes, doors, and windows in the factories, and then sends to the site to assemble (Figure 2). The part ratio is probably 90%. In 2012, the BROAD Group had built a T30 hotel in 360 hours using this technique, and built a 57-story building in 19 days in 2015 (Figure 3). This mode belongs to component prefabrication in factories.

Figure 1. Century city by Hangxiao. Figure 2. Construction of T30 Hotel. Figure 3. The 57-store building by BROAD.
On the 7th China International Exhibition on Housing Industry in 2008, Zhejiang Taige Integrated Housing Co. Ltd. demonstrated a 2-story residential (Figure 4). The residential is composed with 3 housing modules and one lobby module, all the modules are made up of light steel frames and SIP wall panels. On China International Metallurgical Industry Expo in 2011, Shanghai Baoshan Iron & Steel Group Corporation presented a 2-story modular house composed with 13 modules (Figure 5), the modules are made of light steel frames and cold-formed steel walls. The modular house was installed in 12 hours by two rubber-tired cranes.

![Figure 4. Integrated residential by Taige.](image1)

![Figure 5. Modular house by Baosteel.](image2)

Lately, module buildings had developed in techniques and height. Atlantic Modular System Ltd., in Zhenjiang Jiangsu, had imported the module-concrete core system, and increased the height of the modular building in China (Figure 6). For lack of design and acceptance standards for high rise modular buildings, the demonstration project is the project of a public housing community in a new district of Zhenjiang. The community is composed with ten 18-story high-rise buildings made up of 3240 modules.

In 2005, China International Marine Containers (Group) Ltd. (CIMC) started to reform the used containers and research on container houses. At present, The company has about 40 standard containers including residential, offices, and public facilities, and the containers are used in mineral zones, hotels, schools, and scenic spots, such as the student apartment in the University of Amsterdam (Figure 7). Regrettably, the container houses only suit for low-medium rise buildings (Figure 8).

In 2011, Jiaozuo Quickform Industries Co. Ltd. started to research on the module technique, and introduced the sixth-generation manufacturing technology of modular building of Australia Hickory Group in 2014 (Figure 9). In 2015, the company displayed a sample house on the 15th International Integrated Housing Industry Fair in Guangzhou, China (Figure 10). For the difference in design philosophy and standards between China and Australia, the production are being exported to overseas. In 2015, the company cooperated with Hickory Group building the 43-story La Trobo Tower in Melbourne (Figure 11).

![Figure 6. Atlantic Modular System.](image3)

![Figure 7. Student apartment in UA.](image4)

![Figure 8. Container house by Xinhui CIMC.](image5)
Tianjin Architecture Design Institute and Tianjin University had carried out researches on the structural system and joints of modular buildings since 2013. In 2013 and 2014, Tongji University had promoted researches on containers and modular buildings. And since 2015, Guangzhou University has carried out researches on modular buildings based on the most advanced technique, which is the only technique can satisfy super-high-rise structural system, introduced from Hickory Group, Australia by Jiaozuo Quickform Industries Co. Ltd. A 18-story modular building designed as research and development centers of modular technology using the Hickory technology will be completed soon in Jiaozuo, Henan Province.

Technical Advantages of Modular Building

Low-carbon Energy
Comparing with the traditional residential, modular building can achieve more than 47% energy saving and 51% carbon emission reducing.

Fast Construction
Site work and module-manufacture in factory are carried out simultaneously, so the construction period can be shorten greatly. Modules are being assembled in streamlined construction process.

Efficient Manufacturing
Comparing with traditional construction methods, modular construction methods can achieve faster build speeds. With modern modular methods of construction, walls, floors, ceilings, and rafters are all built at the same time, and then brought together in the same factory to form a module. A fine decorated module can be finished in 90 minutes.

Affordable
Construction costs of modular buildings can be controlled by rapid construction, not by reducing the quality of materials.

Good Quality
Modular buildings are built by standard production using high-quality materials in factories. Standard production can avoid the impact of inferior materials and severe weather on construction quality as far as possible, while the construction quality and quality stability are guaranteed by standardized measures, modernized inspection methods, and industrialization production means.

Sustainability
Sustainability is one of the obvious advantages of modular construction methods comparing with traditional construction methods. Construction process of modular buildings can avoid environmental impact on the construction sites. When the needs change, modular buildings can be disassembled and the modules relocated for new use, and less material waste for material being recycled and better
protected. According to Lawson and Ogden (2008), modular construction of multistory buildings may result in 10-20% cost savings and 30-40% time savings.

Construction Safety

With most of the work of modular construction being completed in the factory, it is easier to control construction safety, while the risk of outdoor overhead working can be reduced significantly.

Summary

The modular construction is introduced to be material- and resource-efficient and greener. The advantages are mentioned to include less site disturbance, re-usability, less material waste, and fast construction. The development of modular buildings can not only upgrade traditional construction industry into standardized and industrialized manufacture, but also drive new system of building architecture, new method of construction and new building materials into application and made green building and its intelligent come into truth, which is significant for the transformation, escalation and sustainable development of national economy.

The modular technology can save Chinese construction industry from the dilemma of high pollution, high energy consumption and poor efficiency, and be of great scientific and engineering significance to transformation and upgrade of the construction industry. To make the new technology widely used in China, more information of modular building should be introduced to the people caring about the new construction method.

Acknowledgement

This research was financially supported by the cooperative innovation of major projects of Guangzhou Government.

References