

The Development and Application of Prefabricated Buildings

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Abstract. This essay will start at the development of construction area, including the detailed introduction of the meaning and features of prefabricated buildings, as well as its general situation and requirements and policies relating to prefabricated buildings development in part of provinces in China. In the second half of this report, detailed introduction to advantages and disadvantages of main prefabricated components like precast reinforced concrete composite slab which are applied for domestic constructions and combination characteristics of commonly used concrete sandwich wall. This essay may offer some references to related workers and students studying in related majors.

Keywords: Prefabricated Building; Prefabricated Unit; Composite Floor Slab; Sandwich Type Wall Panel.

1. Introduction

Construction industry is one of the most important pillar industries in China, which means that it is the leading area to support national economy. However, in the past developing process, there exist several problems including low efficiency of work efficiency, high construction cost, high energy consumption and serious pollutions. These factors seriously limit the rapid development in construction area in view of the current situation of Chinese fast urbanization process. Outline of the national medium- and long-term science and technology development program (2006-2020) clearly points out that current situation of traditional industrial development needs to be changed and take full advantage of technology progress to build a benefit prior, resource saving and environmentally friendly society. Prefabricated building is a vital part of industrialization of construction that could improve the efficiency of construction and reduce the cost, resource consumption and energy consumption, which indicates that prefabricated building may offer some help to solve problems caused by traditional construction methods. Prefabricated building (Figure 1) refers the building assembled by prefabricated components in construction site. In other words, prefabricated building is a type of buildings whose part or all components are produced in factories and then transported to and assembled by reliable connecting methods in the construction site. Therefore, it has a significant meaning for engineering personnel to precisely learn and master prefabricated building, as well as development and application characteristics of main precast units, which may be helpful for Chinese prefabricated building industries to develop healthily.



Figure 1. Prefabricated buildings

2. Meaning of prefabricated building development

National government points out a vital development goal which is to build environmentally friendly and resource saving society in the sixth chapter of The Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China. Prefabricated concrete buildings satisfy this requirement, which indicates that promoting the usage rate of prefabricated concrete buildings is an effective approach to realize energy conservation and emission reduction for buildings and housing industrialization. It not only can promote the work efficiency, but also can reduce labour costs, energy consumption and environmental pollution. Therefore, promoting the usage rate of prefabricated concrete buildings is beneficial for integral development of Chinese construction industry under the circumstance of aging of population. According to the 7th census of China, there exist 246.02 million human beings who are older than 60. This number take a proportion of 18.70%, giving a rise of 5.44 percent comparing its counterpart in a decade ago. A series data shows a fact that aging population is inevitably increasing. Due to less requirements exist in construction area for people, large amount of rural labour forces where the middle-aged and elderly take a larger proportion are triggered to work in this industry. These factors make the phenomenon of aging of the population relatively obvious [1]. The decrease of labour resource may cause the increase of human resource cost, while the application of prefabricated buildings could solve economic problems and the problem of lack of workers led by aging of the population.

3. Characteristics of prefabricated building

The most significant characteristic of the prefabricated building is that they are assembled in the construction site by using different precast units. Comparing with other traditional construction patterns, the method to fabricate prefabricated architectures has several relative outstanding advantages. Firstly, it would save large amount of money compared with commonly used building approaches. Because major parts of prefabricated buildings' components are manufactured in factories and they only require connection and installation in the construction site, which make the construction period of the prefabricated building shorter. Therefore, constructing prefabricated buildings can save the invested cost. Moreover, making prefabricated buildings has a lower labour force demand compared with the requirement of cast-in-suit concrete structures, which alleviates pressure generated by the decrease of workers and gradual increase of labour cost under the situation that urbanization is developing rapidly. There are some data to suggest that if industrial mode of production is taken, construction crews working in site can be reduced by 89% and the construction cycle can be shortened by 70%. Economic benefits caused by the change should not be ignored. Secondly, as integral concrete structures are mechanized production made in industries, and processing quality and accuracy of precast concrete can be guaranteed due to modern technologies and have been very mature. Data show that finished product error rate can be lowered to 0.01% and the accuracy deviation is accounted in millimeters if the Industrial mechanized production is taken. Thirdly, prefabricated reinforced concrete structures equip with excellent earthquake performance. Because precast units are connected by cast-in-place sections that equip the ability of consuming energy generated by earthquake through deformation. Hence prefabricated reinforced concrete buildings can maintain good stability in earthquakes. Finally, compared with the way to construct buildings whose components made in suit, he way to construct prefabricated buildings has lower negative impacts on environment. As assembly integral structures require less wet operation in construction sites, and materials used on site like formworks, scaffolds, steel bars and concrete are reduced obviously, which indicates that usage amount of corresponding wastage will be reduced greatly. In the construction site of precast structures, material wastage can be reduced by 60% while rubbish will be lowered by 83%. At the same time, buildings can save 50% energy consumption and recyclable materials take a proportion of 66%. Data above demonstrate that industrial production system meets the long-term goal of sustainability. However, disadvantages exist mainly in price and technology. Compared with traditional construction systems, the cost to build prefabricated buildings

is relatively high, which requires larger budgets to support. Moreover, specific factors such as insufficiency of degree of standardization, uneven workers' level and the immaturity of connection techniques may lead safety problems.

4. The current situation of development of prefabricated buildings in China

Compared with the time when foreign countries started to develop prefabricated structures, the time in China is later. application proportions of integral precast concrete structures in civil engineering industry in developed countries are as followed: 35% in America, 50% in Russia and from 35% to 40% in Europe. The usage of prefabricated prestressed concrete structures account for more than 80% of the total prestressed concrete consumption. Chinese civil engineers started to study prefabricated structures since the 1950s. They primarily learnt the construction method of prefabricated structures from Union of Soviet Socialist Republics [2]. By 1977, 30% concrete buildings were houses made by prefabricated concrete in Beijing and this number in Shanghai was 50%. In the 1970s, precast concrete hollow floor slabs were extensively used. In the end of 1970s, Yugoslav system of prefabricated prestressed concrete slabs and columns was introduced to Chinese relative departments.

Since 1999, China Vanke Co. Ltd. showed a great interest to research and develop precast buildings. This company established a modern industrial park in 2004 and they did some researches and development with some authoritative research institutes in the same year. A large number of projects about prefabricated architectures were promoted on a national scale, which was beneficial for accumulation of valuable experience.

Take Hefei City in Anhui Province as an example. Based on publicized information given by Hefei government, Hefei Economic and Technological Development Area has been listed as a national demonstration base of housing industrialization. From 2008 to 2011, the government showed a great concern about development status of buildings in Hefei and combined measures were taken to promote the development. Since 2011, provincial government several relevant guidance successively such as Guiding opinions of General Office of Anhui Provincial People's Government on accelerating the modernization of construction Industry and Notice of Anhui Provincial Government General Office on vigorously developing prefabricated buildings. Up to now, technologies of constructing prefabricated buildings have notable progress.

Shanghai government compiled some standards named Shanghai standard system – tables of engineering construction based on Standardization Law of People's Republic of China, Standard for assessment of prefabricated building and industrial standard called Technical Specification for Precast Concrete Structures. In this specification, uniform standards and basic terminologies related to precast units are cleared and matched design atlas was enacted to clarify technical requirements during designing in the following procedure. So far, Shanghai prefabricated building standard system has significant progress. It should be noticed that existing standard content will be completed continually according to development status [3].

The development of prefabricated building in Hong Kong began earlier, and its rapid development benefited from promotion in many aspects. In aspect of policy, Hong Kong government has introduced a preferential policy that awarding a plot ratio of 3%, which is substantial given the housing price is quite high in Hong Kong. In the aspect of development thoughts, the development of prefabricated buildings in Hong Kong is mainly oriented by goals about how to solve construction problems, which supports the rationality and convenience of construction technologies of precast buildings. in the aspect of human resource, due to the lower price of labour force in Chinese Mainland, the constructing pattern in Hong Kong is gradually transformed from traditional pattern to the pattern that producing prefabricated components in mainland area and transporting them to construction site to assemble.

5. Introduction of main prefabricated components used in domestic architecture

Prefabricated components can be roughly classified as prefabricated slab, prefabricated column, prefabricated wall, prefabricated beam and prefabricated staircase. Up to now, prefabricated slabs and prefabricated shear walls are commonly used in domestic construction industry.

5.1 Prefabricated slab

Prefabricated slab (Figure 2) refers to slabs made in precast yards and assembled on construction sites. Prefabricated floor slabs can be roughly divided to solid slab (beamless slab, one-way slab, two-way slab), ribbed slab, composite slab and hollow slab, while composite slab is the most commonly used prefabricated slab.

Composite slab (Figure 3) is a type of precast units made by layers upon layers of prefabricated panels and cast-in-situ reinforced concrete layers. It is produced in factories and cured in curing kilns. After the curing process is finished, composite slabs will be transported to construction sites to be assembled. In practice, composite slab has a lot of advantages which are listed as followed:

The integrity of composite slabs is good, which will enhance the earthquake resistance of buildings.

Upper and lower surfaces of slabs are smooth and this characteristic is useful for external layer to be decorated, which may save indoor working time and the construction speed can be increased.

Construction wastage can be reduced by applying composite slabs, which meets the requirement of “sustainability”.

In practice, composite slabs are extensively used in developed countries like France, the United States and Germany. They are also applied experimentally in some first-tier cities in China such as Shanghai and Beijing.



Figure 2. Production site of prefabricated slabs



Figure 3. Composite slabs

5.2 Prefabricated wall

Prefabricated wall means a type of prefabricated plane components that are made in factories supplied for assembly buildings. According to used materials, prefabricated walls can be classified into single-material walls and compound-material walls. Materials of the single-material wall could be sintered clay bricks, hollow blocks. Compound-material walls [4] include walls composed with internal thermal insulation, walls composed with external thermal insulation and concrete sandwich walls. According to the current state of usage, single-material wall is more suitable to be interior panels while compound-material wall is more suitable to be used as exterior walls. Many cities in China have started researches and promotion about compound-material walls.

Walls composed with internal thermal insulation are a category of prefabricated walls which are made by compounding insulation materials on the inner side of exterior walls of buildings, with a series of advantages like sound insulation, thermal insulation and high strength. Moreover, as insulation layers are constructed indoor and scaffoldings are not occupied, operation period can be shortened. However, heat loss when applying this type of walls is relatively more and indoor space is occupied.

Walls composed with external thermal insulation are a category of prefabricated walls which are made by wet construction uniformly on the outer side of exterior walls of buildings, with outstanding advantages that thermal-insulating performance is excellent and the function of insulating layers can be fully used. Nevertheless, disadvantages cannot be ignored. All work is required to be finished on scaffoldings, which will occupy expected construction period. Also, operation quality cannot be guaranteed.

Heat insulation materials of concrete sandwich walls (Figure 4) are placed inside walls, relying on connection among concrete inner lamellas, outer lamellas and insulating layers. This type of precast walls has comprehensive advantages of both walls composed with internal and external thermal insulation, as they have good performance of insulating heat and insulation materials are effectively protected. Up to now, many cities have conducted researches about concrete sandwich walls. In Shanghai, researchers from Tongji University cooperated with Shanghai Urban Construction Company to develop a new type prefabricated inorganic concrete sandwich wall which is suitable for industrial production. It can effectively reduce the heat bridge effect, which will lead the decrease of building energy consumption. Furthermore, it has high strength and fire resistance, so safety of buildings can be ensured [5].



Figure 4. Concrete sandwich walls

6. Conclusion

Compared with traditional technologies of concrete architectures, prefabricated buildings have advantages in various aspects. In recent years, the Chinese government aims to develop a resource

saving and environmentally friendly society. Constructing prefabricated buildings could not only save investment, but also reduce negative impacts on environment. In a specific future period, Chinese construction industry will develop rapidly. As the promotion of prefabricated buildings will be beneficial to drive the increase of variety, safety and speed, this measure accords with current strategic goals in China.

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