

Research on the design of prefabricated buildings

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Abstract. In recent years, the traditional cast-in-situ construction is faced with many problems, such as construction quality relying too much on the level of construction personnel, design can sometimes increase construction difficulty, lack of construction of fine management, more and more high cost, serious material waste and so on a series of problems, this paper mainly discussed the prefabricated modular architecture compared to traditional cast-in-situ construction, Analyzed it in architectural design, construction, and some of the advantages on the building structure, this paper introduces the design of prefabricated modular building personalized, standardization, construction quality and construction of low cost, high material utilization, high construction efficiency, less waste and less pollution, and lists the specific application of prefabricated modular buildings, such as: Huoshen Mountain Hospital, Beijing Yizhuang blue Collar Apartment, Croatia Clark Stadium and Arab Jeddah port breakwater lights. This paper expects that the development of prefabricated modular building will be better and better. With the breakthrough of technology, the shortcomings of the construction industry will be completely changed, and the prefabricated modular building can break the shackles, the design mode and content can be more mature, and the degree of mechanization, information and individuation can be higher.

Keywords: Prefabricated building; modular design; design content; construction method; building structure.

1. Introduction

Over the years, traditional cast-in-place buildings have been faced with many problems, such as excessive reliance on the quality of construction personnel, the design scheme sometimes increases the difficulty of construction, the lack of fine management of construction engineering, increasingly high cost, serious waste of materials and a series of problems. With the acceleration of the development of science and technology, the degree of informatization in all aspects is getting higher and higher. As a traditional secondary industry, the construction industry has gradually fallen behind in capacity, and it is urgent to combine with high and new technology. Nowadays, modular technology and BIM informatization have provided a strong power for the reform of the construction industry. Prefabricated modular buildings are the products of the combination of traditional buildings and emerging technologies, which point out the direction and road for the development of modern construction industry. A building made of prefabricated parts assembled on site is called a prefabricated building. According to the form and construction method of prefabricated components, it can be divided into five types: block building, plate building, box building, skeleton plate building and rising plate building. With the development of modern industrial technology, building houses can be made in batches and sets just like machine production. Human must take the prefabricated building components, transport them to the site and assemble them.

With the promotion of the concept of intelligent engineering construction, countries have vigorously promoted the development of prefabricated buildings, making the construction industry show a trend of resource intensification and environmental friendliness, which is conducive to the innovative and healthy development of the construction industry. Under this background, the application of BIM technology to realize the prefabricated construction become the main development direction of prefabricated construction of modular design, the building informatization, parametric technology to modular design of prefabricated construction, can be in the building process will be fabricated accurate split at the same time, supported by the database system to carry out the construction management work, It is helpful to ensure the construction standardization of

prefabricated buildings, improve the efficiency of engineering construction while avoiding unnecessary cost input, and finally promote the long-term development of the construction industry.

The main purpose of this article is to analyze the advantages of prefabricated modular building under the existing technology and point out the importance of prefabricated modular building for the development of modern construction industry. Firstly, I made a brief lateral comparison between prefabricated modular building and traditional cast-in-place building, and analyzed the differences in design content, construction mode and building structure between them. Then, this paper enumerates the specific cases, using the Huoshen Mountain Hospital, Beijing Yizhuang blue collar apartment, Croatia Clark Stadium and the Arab Jeddah port jetty lighthouse as examples, to illustrate the advantages of prefabricated modular buildings.

2. Comparison between prefabricated buildings and traditional cast-in-place buildings

2.1. Design Content

First of all, the prefabricated architecture in the design process is the pursuit of personalized design, use of industrial technology to meet the needs of users, to skillfully combines technology and innovative ideas, showing a distinctive style characteristic, expresses the personality, reflects the culture of the construction industry, in order to achieve the enhancement purpose to the user experience [1]. However, traditional buildings pay more attention to the function and layout of buildings in the design process, unlike modular buildings, which generally pay more attention to personalized display, and their design content does not have high requirements for emerging technologies.

Secondly, prefabricated modular buildings also pay attention to structural design systematization in the design process. When designing buildings, a variety of schemes will be prefabricated first. If the architectural structure as a whole is regarded as a large system, then each room space in the building is a subsystem. Modular architectural design will consider the scheme from the subsystem, systematically design each subsystem, and finally select the most appropriate combination scheme for assembling. In the design process of traditional cast-in-place buildings, more attention will be paid to the overall structure and layout of buildings, not from small to large, but from whole to part of the way of design, which is different from modular building design.

Then in the aspect of modulus, the modular design of prefabricated building has very high requirements for modulus. The modular design of prefabricated building should ensure that its modulus is more conducive to ensure the quality of mechanized construction, and is an important content to ensure the development of building industrialization [2]. Traditional cast-in-place buildings also have high standard requirements for modulus, but they do not need to be specific in all aspects like prefabricated buildings. For example, a series of building components, such as column nets, do not need to be accurately modular in the design of traditional buildings, while prefabricated modular buildings do.

2.2. Construction content

Prefabricated construction will advance in a factory production system and all models, and then directly to install assembly at the scene, the scene construction mainly in a quick, simple, convenience, the site construction efficiency directly determines the construction progress and construction blueprint, will be to use the security and the use fixed number of year have a direct impact, high mechanization degree and building components, It can save resources to a certain extent and improve the efficiency of the use of materials, which is completely different from the traditional construction method [3]. In the construction of prefabricated modular architecture design is second, BIM information has a significant role on its, both at the design stage and construction stage, BIM technology will need to play a key role, establish a standardized construction of library, for example,

the pipeline comprehensive design and so on a series of work will depend on the BIM technology [4]. While the traditional architectural design or construction, do not need to rely on this advanced technology, its design depends more on artificial technology, construction efficiency and quality is directly determined by the technical level of the construction personnel [3]. In addition, the traditional cast-in-situ construction in construction will produce large amounts of construction waste, high cost of extravagance and waste, and will make a big noise in the construction, and the prefabricated modular construction cost far less than the traditional construction mode, high material also won't appear a lot of waste, its construction more energy conservation and emissions reduction, environmental protection [5]. Traditional cast-in-place building construction cannot achieve the material utilization rate of prefabricated modular building, not to mention the environmental protection degree of prefabricated building construction.

2.3. The Structure

Common prefabricated buildings generally have five types of structures, which are prefabricated concrete structure, prefabricated steel structure, prefabricated container house, skeleton plate building and prefabricated wood structure. First, prefabricated concrete structures are suitable for buildings of three to five storeys. Block construction has strong adaptability, simple production process, relatively simple construction, low cost, and can make full use of local materials and industrial wastes. In particular, small block, can be used to replace mortar dry laying method, reduce wet work. Secondly, the prefabricated steel structure has light dead weight, large span, good wind and shock resistance, good heat insulation and sound insulation effect, which is in line with the policy of sustainable development, high construction efficiency, and can expand the use area of the building, and is suitable for civil buildings such as villas, multi-high-rise residences, office buildings and building layers [6]. Then is the prefabricated container housing, with light weight, large span, wind resistance and earthquake resistance, heat insulation, sound insulation effect is good, in line with the policy of sustainable development, high construction efficiency, can expand the use of the building area, suitable for villas, high-rise residential buildings, office buildings and other civil buildings and building layers. Then there is the skeleton plate building, whose load-bearing frame can be heavy reinforced concrete structure or heavy steel structure, light dead weight, flexible internal separation, suitable for multi-story and high-rise buildings. The last is the wooden structure system, which is generally connected with mortise and tenon, teeth, bolts, nails, pins and glue. Wood is a kind of structural material which is easy to take and easy to process. Wood structure weight is light, wood structure is easy to transport, assembly and disassembly, can be used many times [7]. It is not difficult to see that, in fact, the structural characteristics required by prefabricated modular buildings are light weight and high strength, that is, flexible, easy to disassemble and assemble, and strong bearing capacity. However, these characteristics are not necessarily possessed by traditional ordinary buildings.

Traditional building common building structure forms are wood structure, masonry structure, concrete structure, reinforced concrete, steel structure, prestressed structure, brick and concrete structure. Among them, the common modern architecture is masonry structure, concrete structure, reinforced concrete, steel structure, prestressed structure, brick and concrete structure. First of all, masonry structure refers to the structure made of brick or stone in the building, which is one of the traditional architectural structure forms. It has created the peak of the development of China's masonry pagoda, with rich forms, diverse structures and progressive structural practices. From the plane, there are square, hexagon and octagon. After the middle of the Northern Song Dynasty in China, octagon was the main form, which could not meet the requirements of lightweight and high strength in prefabricated modular buildings. Secondly, concrete structure refers to the structure mainly made of ordinary concrete. General concrete structure can be seen everywhere in traditional cast-in-place buildings, but it is not suitable for all prefabricated buildings. Reinforced concrete structure refers to a structure made of concrete reinforced with steel bars. Since the tensile strength of concrete is much lower than the compressive strength, concrete structures cannot be used for beams

and plates subjected to tensile stress, which is far from precast concrete structures and cannot be well adapted to prefabricated buildings. Finally, it is brick and concrete structure, brick and concrete structure refers to the building center to the bearing structure of the building, column and so on using brick or block masonry, beam, floor, roof plate and so on using reinforced concrete structure. In other words, a brick-concrete structure is a structure with a small portion of reinforced concrete and a large portion of brick walls. It can be seen from the above that, in fact, most of the structures in the traditional cast-in-place building cannot be directly applied to the prefabricated modular building. Only after improvement can they be applied to the prefabricated modular building. In Table 1, the differences in design content, construction content and structure between prefabricated building and cast-in-place building are briefly summarized.

Table 1. Differences between prefabricated buildings and traditional cast-in-place buildings

	Cast-in-situ construction	Prefabricated building
design content	The overall design	Individuation and systematization
form of construction work	labor control	Information technology and Mechanization
structure	multitudinousness	Fewer types, light weight, high strength

3. Application of prefabricated building

3.1. The Miracle of Huoshenshan Hospital

With technological innovations, prefabricated buildings have become more common in recent years, notably the Huoshenshan Hospital in Wuhan, China. Vulcan hill hospital is just spent 10 days Chinese people build up the hospital, the main structure is a box shack, vulcan hospitals use mountain is modular packaging box of modular steel structure building, its characteristic is the modular design standard, factory assembly line production, packaging folding transportation, modular assembly at the scene, bolt connecting removable, for repeated use. In 2020, due to the impact of the epidemic, the construction of the makeshift hospital is imminent. After the drawing is sorted out by Wuhan CITIC Design Institute, the construction will start immediately. Huoshenshan Hospital adopts the prefabricated construction technology to maximize the use of assembled industrial finished products, prefabricated all components in the factory, and then to the site for overall hoisting, interspersed with the site construction, to save time. In the whole design and construction project of Huoshenshan Hospital, it can be seen that the biggest characteristic of prefabricated modular building is high efficiency, and more dependent on computers, and a high degree of industrialization and information technology [8]. Fig. 1 shows the construction process of Huoshenshan Hospital. The whole hospital blocks are assembled. One block is lifted by a crane and then assembled step by step.



Fig 1. Huoshenshan Hospital [8]

3.2. Beijing Yizhuang Blue Collar Apartment

Beijing Yizhuang Blue Collar Apartment is located in Beijing's south Sixth Ring Road, the size of a medium-sized community. The construction site is clean and clean, without the noise of a traditional construction site. The whole wing has been pre-produced in the factory and only needs to be hoisted like building blocks on the construction site. The entire construction period takes six months and is much more energy efficient than traditional buildings. Beijing e-town blue-collar apartment the whole assembly at a rate of ninety-two percent, construction relying on the global initiative for zhongjian technology of prefabricated construction wisdom to build platforms and cohesive body of BM plate connecting technology, and lightweight technology, mobile data center, plus point cloud scanning technology and health detection hut intelligent building technology, to develop the whole assembly, the whole chain, Fully integrated technology management demonstration application. During the completion of the project, designers set up digital twin buildings on the platform, so that procurement, manufacturing, construction and operation and maintenance can advance the project construction tasks in accordance with the plan, breaking through the limitation of traditional construction which can only be carried out in sequence according to the process [9].

3.3. Kerke Stadium, Croatia

Croatia to the stadium wall is used by the original stone and precast concrete members build by laying bricks or stones, which uses a old technology called "terrazzo", the precast concrete is through the stone into a wooden mold, then use PVC membrane covered in them, finally pouring concrete, and the production of such a simple but has a distinct visual impact. The characteristic walls and components needed for Croatia's Kerke Stadium were prefabricated in the factory before being assembled and assembled. Croatia's Kerke Stadium is also one of the world's most famous prefabricated buildings [10]. Fig. 2 shows a real view of the stadium, which shows the sharp edges and corners.



Fig 2. Kerke Stadium, Croatia [10]

3.4. Lighthouse of Arabian Jeddah Port Breakwater

Jeddah Harbour Breakwater Lighthouse, the tower is made of 187 hexagonal precast concrete components, each of which has several shapes that are not repeated. The sun shines through the small honeycomb holes in the tower, leaving dappled shadows. The spacious inner atrium is full of sunlight and can also be used as a gathering place for local resident. And the lighthouse itself cools itself naturally, with the structure pumping out hot air and bringing cool air from the ocean. The whole tower is lit up at night as a beacon for ships in the sea [11].

4. Conclusion

At present, prefabricated building is a powerful way to save energy and reduce energy consumption in the construction industry. The development of prefabricated modular buildings can promote energy conservation and emission reduction in the construction industry, greatly reduce the extravagance and waste of materials, and reduce costs. Compared with cast-in-place buildings, prefabricated buildings can greatly reduce the consumption of wood, insulation materials, cement mortar, water and electricity and other resources during the construction phase, and can reduce the discharge of construction waste by 80%. The construction efficiency of prefabricated buildings is also completely ahead of that of cast-in-place buildings. Compared with the traditional construction mode of extensive management and excessive reliance on the level of construction personnel, the mechanized information construction mode of prefabricated modular buildings can significantly ensure the construction speed. In addition to shortening the construction period, being efficient and reducing waste, prefabricated buildings can also improve construction accuracy. To sum up, traditional architectural design and construction have too much reliance on artificial technology, construction efficiency and quality directly depend on the technical level of the construction personnel, and will cause a lot of waste, many constructions waste and other limitations. Modular assembly building design has the advantages of personalization, standardization, high construction quality, low construction cost, high material utilization, high construction efficiency, less waste, less pollution and so on. The combination of high technology and traditional construction manufacturing industry has become inevitable. In the future, prefabricated buildings will be essential if the construction industry is to make breakthroughs.

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