

Application of BIM in the design and production of standardized components for residential products

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Abstract

With the industrialization of construction, China's fabricated buildings have developed rapidly. At the same time, BIM technology, as one of the important technical foundations for realizing the production management standardization, informationization and building industrialization of construction enterprises, has been fully valued and vigorously developed by the construction enterprises. With BIM technology, it is possible to comprehensively consider the degree of influence of architectural design, construction, assembly and other aspects on the design of building components. The requirements of building industrialization for the standardization and modularization of building parts and components provide a good opportunity for the application of BIM in prefabricated buildings. The organic combination of BIM and building industrialization can complement each other and realize the "building blocks" in the design stage. In the component design phase, the PC component BIM deepening design method can integrate various professional requirements, effectively avoiding the waste caused by the change, and pointing out a new direction for the prefabricated component design work.

Keywords

Building Information Model (BIM), residential product standards, prefabricated components.

1. BIM technology

Nowadays, various large-scale and super-large-scale construction projects are continuously promoted. How to effectively regulate and use other auxiliary projects of these large-scale construction projects has become a problem in the current construction industry. The birth of BIM technology has solved this problem well. The BIM technology mainly collects and organizes the information data of various enterprise units in the construction project, and then builds a simulated three-dimensional model based on these building data. Design data

It is embodied in the model, so that we can improve some of the loopholes in the project handover between the various related enterprises in the entire construction project through the three-dimensional model, and continuously provide construction efficiency from the overall project, and achieve the goal of maximizing the profit with the minimum resources[1].

2. The main advantages of BIM technology

BIM technology can establish an identical virtual model of simulation in the computer before the actual construction starts, and the wall, steel and skeleton in the building can be actually displayed through BIM technology. The simulation model is dynamically tested by the previous data information, and the actual survey data is also input into the model at the same time, and some changes of the model in the

data change are observed, and the improvement and adjustment are performed in time. This can greatly reduce some of the slight gaps in the design drawings and the actual construction process. In BIM technology, we can make real-time data changes to the established model. The traditional CAD drawing is only the graphic design of the design unit according to the overall requirements of the construction project. Some design standards and actual construction are If there is a certain gap, it will be reflected in the improvement of the drawings made by the design, which not only prolongs the construction time, but also wastes a lot of manpower and material resources. BIM technology can integrate data, and when many data are combined, it can be rectified in the model until all the data is unified, and on-site construction can not only reduce accidents during construction, but also improve the units. The tacit understanding [2]. Any changes in the data and drawings that appear in the entire construction project will affect the construction progress of the entire project. Since all the designs are interlocking, it is not easy to change the design data of any one place, but The actual construction site of the site is different from the design plan, which will lead to the shutdown of the entire project. The BIM model has a very good advantage, that is, the next step of the data can be carried out in the model. In short, it is the automatic handover of the work. By changing the data information in the BIM model, the data information of the entire construction project will occur. Change. This will ensure that all data information is correct after reviewing all the data. It is possible to print out the design drawings in accordance with the BIM simulation model and construct them according to the drawings.

3. Assembly Residential Combination

3.1 BIM design method research basic concept of combined design method

The combined design method refers to the detailed analysis of the functions of the system, and all the functions of the whole system are decomposed into independent modular units that can be exchanged according to different levels, and the modules are passed according to the needs of the user. The selection and summarization of the units quickly combines the modular unit combinations of different series, different functions and different uses.

In the combined design process. We need to classify each function space in detail, and the space with the same function will be organized in the same unit. The modular unit will be recombined to realize the conversion process of the building project unit to the whole. In many large buildings, such as apartment buildings, hotels, hospitals, and teaching buildings, there are many similar units. The combination of modular design and prefabricated technology is a suitable choice. The need can save design time to a certain extent and improve the efficiency of design and construction.

3.2 Assembly-style residential building design principles

Housing industrialization is to achieve the construction of residential buildings in the form of industrial production, which involves a variety of upstream and downstream industries. The lack of uniform standards in any key link will lead to the difficulty of docking between upstream and downstream industries. Therefore, the key issue for realizing residential industrialization is unified standards. Standardization is the basis for the development of residential industrialization, and a set of features suitable for prefabricated houses is established. The principle of modulus is the key [3][4]. It can make the house parts more versatile and interchangeable, and can also form a reasonable spatial relationship between the components of the prefabricated components. Housing industrialization is to follow the principle of modular coordination, to achieve optimal size coordination, to ensure that the housing in the process of construction, in terms of function, quality, technology and economy, the best solution is to promote the house from extensive to Intensive conversion. As the smallest basic unit of uniform component size, Module is widely used in many fields. In China's architectural design and construction, the "harmonized standards for building modulus" must be followed. The standard states:

(1) The value of the basic modulus is 100mm, the symbol is M, that is, 1M=100mm, and the modular size of the whole building or building component should be a multiple of the basic modulus;

(2) The expansion modulus is divided into horizontal expansion modulus and vertical expansion modulus, and the horizontal expansion modulus base is 3M, 6M, 12M, 15M, 30M, 60M, and the vertical expansion modulus base is 3M, 6M;

(3) The modulus is the integer divided by the value of the basic modulus, where the base is M/10, M/5, M/2, etc. [5].

3.3 Structural selection and reconstruction

Compared to cast-in-place residential buildings, prefabricated homes require a more regular and uniform structural arrangement to provide a good integrity of the structure. The aspect ratio of the plane layout should not be too large. Try to be a regular plane such as a rectangle. If there is local unevenness, the size should not be too large [6]. The vertical direction of the structure should also follow the principle of regular and uniform arrangement. The load-bearing members should be aligned up and down, and the lateral stiffness of the structure should be as large as possible. The splitting of prefabricated structural members (walls, beams, slabs, columns) should be considered in terms of stress, connection, construction and other factors, and assembled into as many structural forms as possible with prefabricated structural members with as few dimensions as possible. The following principles should be followed in the structural selection and reconstruction of prefabricated houses:

(1) Increasing the diversity and variability of the support structure. At present, the structure of fabricated residential buildings in China is mainly based on shear wall structure. Compared with frame structure, there are obvious deficiencies in space flexibility and variability. However, due to the limitation of frame structure height and consideration of space aesthetics, this type of structure is rarely used in prefabricated houses [26]. For the shear wall structure, the flexibility of the shear wall structure can be increased by appropriately reducing the number of internal shear walls or leaving holes in the shear wall to meet the design requirements. Increase the diversity and variability of residential space.

(2) Reasonable selection of prefabricated and cast-in-place parts to enhance structural integrity and reduce construction difficulty. Due to the limitation of construction level in China, the on-site assembly process of prefabricated components has certain complexity. For those components with high functional integration and various shapes, such as exterior wall panels, stairs, laminated panels, etc., as far as possible in the factory as a whole, reduce on-site assembly. The number of them reduces the difficulty of on-site construction. Although the seismic performance of the fabricated structure can reach the same level as the cast-in-place structure. However, the cast-in-place joints between the prefabricated members or between the prefabricated members and the cast-in-place members are more susceptible to damage. Therefore, the "stretched beam weak beam" can be used to cast the shear wall or column and the beam is prefabricated. The location and practices of the cast-in-place nodes must meet the requirements of the relevant specifications.

(3) The type of load-bearing of the siding and the choice of construction methods. Due to geographical differences, the choice of weight-bearing methods for fabricated exterior wall panels varies from north to south. The southern climate is hot and humid, and the thermal insulation performance of the external wall is basically not considered. Therefore, the exterior wall panels of the southern area are mostly made of non-load-bearing external wall panels, which are thin and greatly reduce the weight of the structure. In the northern region, the climate is dry and cold, and the production of the outer wall must consider the heat preservation function. Therefore, the prefabricated outer wall panel is generally thick, and the use of the non-load-bearing plug-in method will increase the structural burden. Therefore, the northern region generally uses load-bearing sandwich insulation wall panels, also known as "sandwich siding panels". For the installation method of the external wall, the "post-installation method" and "pre-installation method" are commonly used in China at present [7]. The post-installation method is a technology introduced from Japan, that is, after the main structure is completed or some floors are completed, the installation of the lower outer wall panel is started.

The exterior wall panel installed by the rear loading method is a non-load-bearing external wall panel. The accuracy of the installation method is very high. Generally, mechanical connections such as bolts and embedded parts are used. If these connection positions are not properly handled during construction, it is difficult to avoid Waterproof, soundproof and other problems [28]. However, since the outer wall of the post-installation method can be constructed at the same time as the upper main structure, the construction speed is fast[8] [9]. The first installation method is to first hoist the outer wall panel and reproduce the node between the components to make it a structural whole. The first wall panel can be a load-bearing outer wall or a non-load-bearing outer wall. The advantage of the installation method is that the error adjustment can be carried out during the cast-in-place construction process, which greatly reduces the difficulty of on-site construction, and can improve the waterproof and sound insulation performance of the house due to the seamless docking formed by the cast-in-place between the components. For the time being, the first-loading method is more suitable for the current situation of China's prefabricated houses.

(4) The dimensions of the split components should be uniform. In the process of structural disassembly, in addition to the principle of modular system, factors such as production, transportation and installation of components should be fully considered. For prefabricated homes, the fewer types of prefabricated components, the smaller the number, and the lower the cost of construction. The most ideal is that the overall coverage of the prefabricated components is as large as possible, such as the overall prefabrication of the floor slab. However, due to the limitations of the molds, transportation conditions, lifting loads and other factors of the production components, it is necessary to rationally optimize the dimensions of the prefabricated components. For example, the split size of the laminate should be controlled within the range of 2900x7900mm. For areas with high waterproof requirements, the laminates in this area should be divided into one piece when splitting. The shape of the split member should be regular to facilitate the production of the member. For example, a precast wall is a post-watering node approach with a wing wall[10] [11].

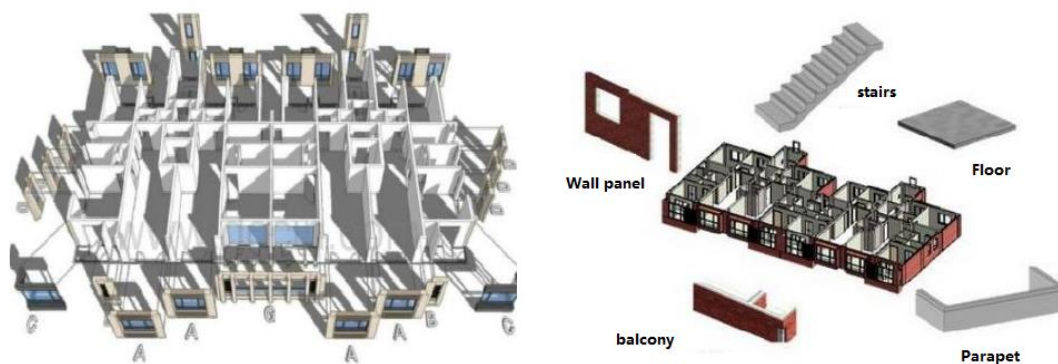


Fig.1 Prefabricated shear wall structure split concept map

4. Standardization of residential parts

A residential component is a collection of structural components consisting of building materials and individual products, and has relatively independent functions. The establishment of a series of processes from R&D, assembly and input to the market marks the formation of a mature residential system. Compared with the higher foreign residential parts and the mature residential system, China is still in its infancy at this stage, and the general parts only account for about 20%. There is still a big gap in standardization, industrialization and component modularization. To reduce this gap, China needs to adjust the housing system in terms of component versatility, standardization and component integration. First of all, it is necessary to unify the modulus of residential parts. This is the premise and basis for standardization. It actively implements the “Residential Standards for Residential Modularization” to achieve coordination and unification of design, production, construction, etc. Sex, matching and interchangeability; secondly, at the government level, we must establish a complete set

of parts certification system, evaluate and identify the standard, versatility, safety, durability, energy conservation and environmental protection of the parts, and actively guide the general parts. The production and promotion of housing quality; in the end, strengthen industrial cooperation, establish a cooperation mechanism between upstream and downstream enterprises, form an integrated industrial chain of production, learning, research, and use, and accelerate the transformation of scientific research results into actual productivity. We will use the advanced information technology such as BIM technology to accelerate the establishment of the general department storehouse and promote the improvement of the residential standard system[12].

5. Standardization BIM model library establishment

In order to speed up the establishment of China's prefabricated residential standard system, increase the standardization and serialization degree of prefabricated components, components and parts, it is necessary to standardize and standardize the design of the assembly house. With BIM technology, in many standard drawings Based on the set and multiple examples of fabricated residential projects, a standardized BIM model library is built, an open information platform is built, and the standardized residential model in the BIM model library is used as the material for the design of the assembly house. The BIM model is visualized. The advantages of information integration, optimize the design process and improve design efficiency. Standardized BIM type can also integrate commercial information such as product information and business information, which is conducive to the combination and promotion of upstream and downstream enterprises in the market. Guided by the design standards, the R&D design of new prefabricated components or component models, after expert review and design optimization, under the premise of meeting various specifications and standardized design requirements, into the BIM model library, to achieve the model library Constantly expanding and updating.

5.1 Classification of model libraries

The models in the standardized BIM model library are widely sourced, from the standard maps to the accumulation of engineering examples. Therefore, there are a large number of models in the model library, and it would be very confusing if they are not classified. In order to facilitate the maintenance and update of the model library and the use of the designer, it is necessary to classify and manage the models in the BIM model library. as the picture shows. Through the classification management of the model library, it is very convenient to maintain and update the model library in the future, as well as the designer's search and use.



Fig. 2 BIM Model Library folder structure diagram

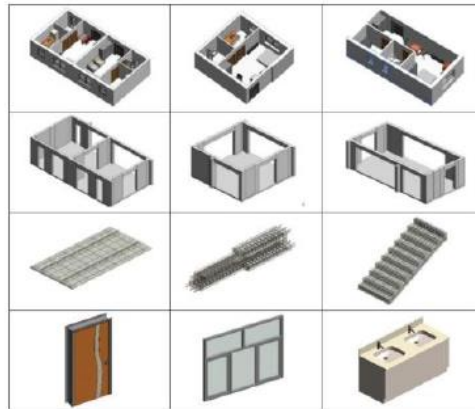


Fig. 3 Standardized BIM model sample

The BIM-based modular design approach is a new design approach for fabricated homes. Based on the principle of prefabricated residential design, the BIM technology is used to optimize the traditional assembly design process. Based on the idea of modular combination, based on the analysis of system function, the whole building is divided into modular units of different levels, different depths and different functions. Based on the standardized BIM model library, the standardization based on the BIM data platform is diverse. The combination design, after a series of subsequent calculations and analysis, to ensure the rationality and practicability of the design, form a BIM-based assembly structure design process, improve design efficiency, and promote the rapid development of residential industrialization.

5.2 Design overall process

At present, the design of fabricated residential buildings in China is based on the consideration of assembly-type splitting system, prefabrication and construction requirements. According to the architectural design drawings provided by the architect, the next step of the structural construction drawing design and the professional construction drawing design of the plumbing and electric power, etc., during the period of conflicts, can be solved through coordination. The structural design is firstly designed according to the traditional cast-in-place structure, and then the split design is carried out according to the split specification and requirements. Finally, the split components are further deepened, and the pre-made component processing drawings are sent to the factory for processing and production, and transported to the construction site. The construction company carries out on-site assembly and construction. This prefabricated design process adds component splitting and deepening to the traditional cast-in-place design approach.

The modular design uses the reverse design thinking. The designer directly assembles the design according to the assembly structure, from the apartment type to the living plane to the whole building, which is different from the traditional design. BIM technology runs through the whole process of modular design. The high integration of data increases the fineness of design, reduces the occurrence of design errors, solves the tediousness of assembly design, and greatly improves the design efficiency.

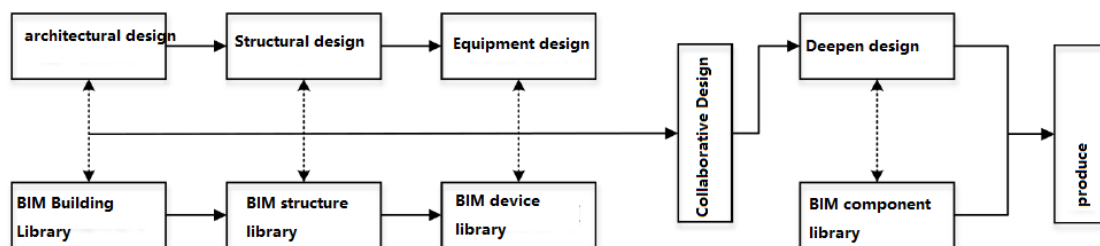


Fig.4 refabricated buildings combined design design process based on BIM

5.3 BIM modular design

The modular design method of fabricated houses based on BIM is the key to the degree of industrialization of residential buildings, and is the basis for better realization of factory production, assembly construction, integrated decoration and information management. In the design process, due to the application of BIM technology, information exchange between buildings, structures, plumbing and other majors is more convenient, and the information integration of buildings is higher. China's prefabricated houses are mostly based on shear wall structure system. Therefore, this section mainly analyzes the modular design method of assembled shear wall structure houses from architecture and structure.

6. Conclusion

The promotion and construction of prefabricated houses is an effective measure to promote the industrialization of residential buildings. The assembly construction method makes most of the work of the residential project ahead of schedule in the factory, which reduces the impact of the construction on the environment and improves the quality and quality of the house while improving labor productivity. On the basis of fully researching the application of assembly and BIM technology, the author explores the application method of assembly house based on BIM technology and the deepening design method of PC component.

Housing industrialization and BIM technology are the most concerned topics in the current domestic construction industry, and will develop rapidly in the future for a long time. The application of BIM technology in prefabricated houses can better utilize the advantages of BIM and promote the formation of China's assembly standard system. Through the establishment of the BIM model library, the application of the prefabricated residential design method is more standardized, the traditional design process is optimized, and the design efficiency is improved, which will reduce the cost of residential construction to a certain extent.

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