The Application of BIM Technology in Design Stage

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Abstract. Design plays a leading role in architectural design, which determines the quality of construction projects. At present, most of the prefabricated constructures are designed according to the principle of cast-in-place construction, and the structural system basically follows the mode of cast-in-place structure. The advantages of prefabricated industrialization have not been reflected in the system of prefabricated construction structure and design. Due to various factors, it has become highly difficult to design prefabricated buildings, making it impossible to complete the design with the help of traditional design tools. Instead, it needs to rely on BIM Technology to complete the prefabricated construction design so as to make the construction projects visible, controllable and informationalized. Moreover, the design information from various parties concerned can be highly integrated and coordinated, thereby improving the efficiency and quality of construction projects and enhancing buildings' quality [1].

1 Introduction

The design of prefabricated construction is different from the cast-in-place buildings. The characteristics of intergration, refinement and coordination determine that in the design process, from the vertical perspective, in addition to the factors to be considered for the traditional cast-in-place structures, such as the use function of the building, mechanical and electrical installation and pipeline layout, component processing, transportation and protection, construction and installation, quality supervision and detection, labor control and green construction, and many other factors. In terms of the design category, the restrictive factors are far more than those of traditional cast-in-place structure. Horizontally speaking, the participants of prefabricated construction design are not only the designers, but also the manufacturers, transporters, installers, and constructors of prefabricated construction. Besides, the formation process of the actual prefabricated constructions can be influenced by the production conditions of the components, mold dimensions, transport capacity of vehicle and the lifting capacity of cranes.

2 Application

2.1 Design framework model

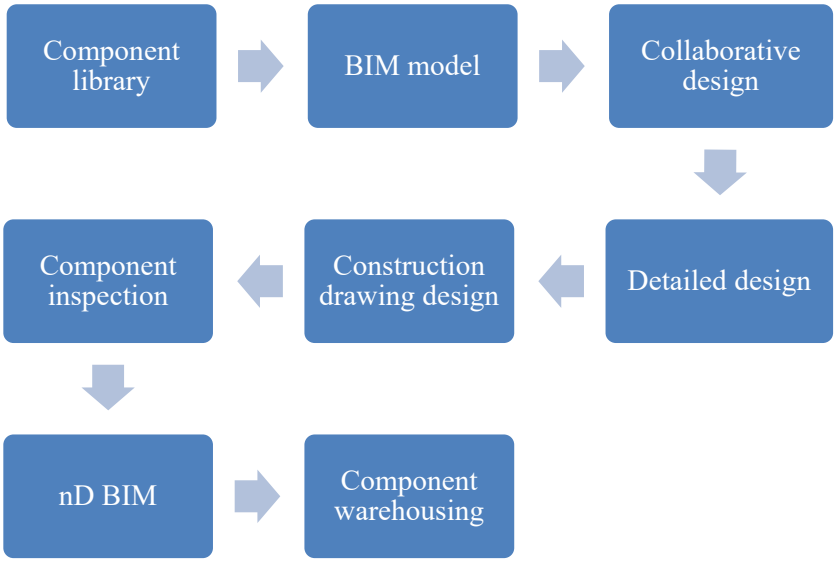

Figure 1. Framework model of the prefabricated construction design

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The framework model of prefabricated construction design is shown in Figure 1. In view of the characteristics of industrialized production, prefabricated construction and diversified functions of prefabricated buildings. The standardized component library is the premise of prefabricated construction design. The prefabricated component library is built by BIM model, coordinate the collaborative design of architecture, structure, water, heating and electricity, and take construction, transportation, production and other characteristics [2]. At the same time, the detailed design of the joint connection and the size of components are carried out, the prefabricated components in the BIM model are pre-assembled, and the dimensional coordination and connection of components are checked. After the components are checked correctly, the geometric information, physical information and functional information of the components are put into the BIM model to form the nD BIM model. Finally, the components are put into storage [3].

2.2 Component library

In order to achieve the diversification and serialization of building and components, the component library should be established according to the principle of "less specification, more combination" and the requirement of "standardization, normalization and diversification" [4]. In the design of prefabricated components, the limitations on the dimensions and specifications of components should be taken into account, so as to reduce the coordination difficulty among various stages of prefabricated buildings as much as possible. Prefabricated component information is an important foundation supported for design and analysis, which is crucial for prefabricated building design. BIM component library should ensure the information integrity of each component and provide complete information parameters for prefabricated building design.

2.3 BIM model and collaborative design

The components of prefabricated construction design should be assembled at the construction site into a whole. Therefore, compared with cast-in-place buildings, prefabricated buildings pay more attention to the cooperation of various specialties in the design stage and the participants' coordination at all stages of the project. Based on the prefabricated component library, BIM models of architecture, structure, water, heating, electricity and other professions are established, the design of the above professions is made and then the model is built [5]. On this basis, the collaborative design of pipeline collision, opening reservation and other disciplines is carried out to reduce the delay of the construction period and increase of cost caused by rework. These are the defects of traditional two-dimensional design. In addition, cooperation among the participants is also very important in all stages of prefabricated construction. They need to cooperate closely to ensure that the components can be put into production, meet the requirements of mechanized transportation and mechanized assembly.

At present, with the accelerating process of urbanization, people have higher and higher requirements on the quality of architectural engineering, which is more and more complex and involves multiple disciplines. Therefore, it is necessary to do a good job in collaborative design to ensure the overall quality of architectural design. However, in the development of the traditional 2D CAD era, although collaborative design has been applied to a certain extent, it lacks a complete technical platform in the actual operation [6]. In general, individual integrated software is used to carry out data exchange and transmission, which cannot reasonably solve the problem of collaboration between different specialties in design.

At the same time, in the project design phase, if the use of function or design for construction has changed, based on BIM information interaction model, we could be achieved in a short time, rendering and design results of update and modification, and the use of BIM model of additional dynamic display function, the design staff production could make a project in a short time. As a matter of fact, it can not only reduce the design difficulty, also can save the cost of design change.

2.4 Construction drawing design and review

Through scientific, accurate and reasonable construction drawing design, we can find design omissions and defects in advance, so as to avoid the impact of rework and slowdown on the progress, cost and quality of the project. The prefabrication rate of prefabricated buildings is considered in the Evaluation Standard of Prefabricated Buildings as the comprehensive proportion used in the main structure above the outdoor floor of a single building, enclosure wall and internal partition wall, decoration and equipment pipeline. Based on this standard, various provinces and cities have formulated policies on the depth of construction drawing design of prefabricated concrete buildings [7]. The Government of Shandong province has issued the Rules of Shandong Province on the Deep Design of Construction Drawings of Prefabricated Concrete Buildings (2018) to ensure prefabricated construction design quality and integrity. At present, different local governments have different requirements on the design depth of construction drawings, so they should formulate the unified standard as soon as possible.

2.5 Detailed design

In the detailed construction drawing design, BIM technology is used to optimize the design of various professional models such as architecture, structure, water heating and electricity, and other professions. At this time, the model depth is generally selected as LOD300 [8]. The main work is to complete the design of the processing drawing of the precast member, form the dimension control drawing of the precast member, determined the size, square, connection form, embedded pipeline, type

and location of the component and other basic information.

The node connection between prefabricated components is a very important aspect of detailed design. It is also the most difficult point in the process of the design. In this process, the designer should prioritize the basic performance requirements of the building. The node connections between prefabricated components should be designed in line with safety, building function and requirements, and draw reference from the relevant national technical standards and specifications to ensure the standardization, accuracy and rationality of prefabricated construction design, and thus improve the bearing capacity and seismic performance of prefabricated buildings [9]. For the design of complex structural nodes in key parts, the designer can use BIM technology to standardize the construction and installation nodes, which forms a three-dimensional visual node model diagram and includes relevant quality verification data and processing information.

In addition to collaborative design and dynamic effect display, in the whole design process of previous construction projects, it could be multiple sub-structural designs among different projects simultaneously. For example, commonly in large construction projects include building fire design, building the main structure design, construction machinery module installation design, hvac, engineering design, electrification system design and the communication network engineering design, etc [10]. In the traditional design mode, the contradiction between the different kinds of construction design and disputes are inevitable. It is hard to coordinate, and requires a lot of manpower and material resources. If the visual and integrated design is carried out based on BIM technology model, the design division coordination and system optimization among different projects and specialties can be realized in a three-dimensional model at the same time. Generally speaking, many designers lack of construction experience, so in the sub-project design of the project, they tend to only pay attention to the project design content within their own specialty, and easily ignore the coordination with other specialties, which would not only increase the design difficulty, but also cause problems such as design changes in the later stage. Therefore, in order to improve the feasibility of the late construction of the project, using BIM technology to assist and coordinate the design can strengthen the communication and communication between different professionals, so as to reduce design errors and loopholes, shorten the design time, and effectively eliminate or avoid design conflicts and contradictions.

The most critical stage to control the project cost is the design stage. The focus of the project cost is mostly placed in the construction stage. Now the common work habit is to emphasize that the technical industry has specialized, and the design business is separated from the cost business, thus missing a good opportunity to control the cost at the design stage. The application of BIM technology in the design stage of general contracting project makes it possible to control the cost in the design stage of the project. In addition to the space and geometric structure of the building, the BIM model also includes the material information of the components, and the engineering quantity of the corresponding specifications for the components could be calculated in the specialized engineering quantity calculation software based on the material information of these components. The full application of this function could realize the optimization of the cost control in the design stage of the general contract project [11].

2.6 Component inspection

For the prefabricated components of prefabricated buildings, dimensional errors between adjacent assembled components can be checked to avoid the waste of prefabricated formwork and assembly mismatch problems during engineering installation. BIM technology is used to conduct internal inspection of components and simulate the splicing between components, cast-in-place parts, and construction facilities. The component inspection includes the following aspects:

1) Internal inspection and optimization of components

BIM technology should be used to check the important parameter information of prefabricated components, such as the geometrical size of components, the type and diameter of internal reinforcement, the spacing between reinforcement and the thickness of the protective layer of reinforcement. Using the collision detection function of BIM Technology, the collision rules between steel bars, pipelines, and embedded parts can be set to optimize the internal conflict parts [12].

2) Inspection and optimization between components

The inspection of components is mainly to check the cohesion between the component connections and the collision of steel bar. Using the visualization of BIM Technology, we can eliminate the potential risk of assembly conflict between prefabricated components, improve the accuracy of design, and reduce the waste of labor, materials, machinery and other resources in the installation process. The steel bar at the joint connection between components is also prone to collision. The collision rules are set using the collision inspection function of BIM technology to optimize the joint connection.

3) Inspection and optimization between components and cast-in-place structures

At present, most of the prefabricated buildings are not completely prefabricated, and some prefabricated parts are cast in place. In this case, we should check the steel bar collision between the prefabricated component and the cast-in-place part, set the collision rules, run the collision inspection, analyze the collision structure and optimize the design.

2.7 nD BIM

Prefabricated construction design contains geometric information and other non-geometric information such as physical and functional information. BIM Technology is used to integrate geometry, physics, function and other

information of prefabricated components to form a prefabricated nd BIM model. In this way, it can provide a foundation for the production of prefabricated components, the prefabricated building construction and later operation and maintenance [13].

2.8 Component warehousing

The "library" here has two meanings: one refers to the component library, and the other refers to the model library. The richness of the component library directly affects the efficiency of prefabricated design. For each new project, the new component model can be put into the component library after processing to avoid the repeated design. For each project, the optimized BIM model can be put into the model library, which can provide information for the production and develop a model library exclusive to the enterprise, and also enriched the experience of prefabricated construction design [14].

3 Conclusion

The advantages of prefabricated industrialization have not yet been reflected in the structural system and structural design of prefabricated buildings. The reasons are as follows: Firstly, the standardized and modular design of buildings needs to be further studied and practiced. Secondly, the node connection design is not mature enough to meet the requirements of the overall performance of the building. Thirdly, prefabricated construction designers are insufficient, and those with a global vision and rich experience in the field of design are rare, etc. For many reasons, the design of prefabricated constructures has not been able to have good concepts or modes which can suitable for the industrial buildings. In additon, the idea of cast-in-place structure restricts the performace and development of prefabricated buildings [15].

With the continuous development of the construction industry, the level of computerization is constantly improving. The application of BIM technology has brought undeniable convenience to construction industry in China. Although there are still some obstacles and problems in the application of BIM technology in China, as time goes by, the efforts of governments, companies, institutions and other aspects have promoted the development of China, and the application standards of BIM technology software are also gradually improving. Finally, BIM technology standards will be implemented for the need of development of construction industry in China.

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