Research on the Application of Feature Modeling of Prefabricated Building Components Based on BIM

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Abstract. Building industrialization is a new trend in the development of today's construction industry, and prefabricated buildings have gradually become a hot spot in the construction industry. Prefabricated components are the core of prefabricated building management. The key points of prefabricated component management include component design, supply, installation, and operation and maintenance. BIM takes the whole life cycle of the building as the main line, links all links of the building through information, and realizes the integration of the whole life cycle information model of prefabricated components, which can solve the problem of backward production and management in the current construction industry. This paper proposes the realization method of the characteristic modeling system of prefabricated components. Based on the research on the design, production, construction and operation of prefabricated components, the functional requirements of parametric modeling and production management systems are analyzed, and the modular concept is applied. Divide the system into different functional modules and conduct research.

1. Introduction
The construction industry is in an extensive state of high-consumption and low-yield, and there is a large gap between it and the developed countries. It is difficult to meet the requirements of the modernization of the construction industry, and there is an urgent need to innovate the construction mode. Prefabricated buildings adopt a modern industrialized production model, which is conducive to changing the state of high consumption and low output in the construction industry, and promotes the further integration of the construction industry and informatization [1]. China's prefabricated buildings are still in the early stage of development. The construction mode is usually the design and construction drawings of the design institute [2]. The professional drawing unit will split the beams, slabs, columns, walls, stairs, air conditioning panels and other components for the second time, and order processing. Then the processed prefabricated components are transported to the construction site for assembly. Prefabricated components are the core of prefabricated building management [3]. A complete prefabricated building project includes a large number of prefabricated components. Prefabricated houses are mass-produced in factories, which improve efficiency and quality, and exclude design diversity due to emphasis on standardization.

BIM takes the whole life cycle of the building as the main line, and links all links of the building through information. BIM technology has changed the production method and management mode of buildings, enabling the sharing of information in the planning, design, construction, operation and maintenance of building projects, and ensuring the integration of information in each process. Applying BIM technology to prefabricated structural design, the W prefabricated component model is used to design the whole process, which can avoid the disconnection between design, production and
assembly, and use the detailed and accurate building information contained in the BIM model to guide prefabrication [4]. In the industrial production of prefabricated components, each component is coded uniformly and uniquely. Establish a four-dimensional BIM model through BIM technology to control the demand for components throughout the entire process, and manage components through the BIM model to prevent components from being lost or taken by mistake. BIM technology can facilitate the integration of information in the design, production, construction, and management of prefabricated structures [5]. At present, the most contacted BIM software in China is Revit. Revit has strong information modeling capabilities, which is of great help to the development of the construction industry. The BIM data model allows all participants in the construction industry to exchange information, and the entire industry is connected. Taking the application of BIM in the design and construction of prefabricated houses as an example, by establishing a data model, the structure and construction drawings of the prefabricated houses are integrated into the model [6]. The component data is directly extracted from the information model to guide the processing and installation of the factory, and the design efficiency of prefabricated houses has been greatly improved.

2. Feature modeling of prefabricated components in prefabricated buildings

2.1. BIM core technology advantages

The traditional construction industry has a huge overall scale but low efficiency. BIM technology is proposed and developed under this background. The core technical advantages of BIM technology are mainly reflected in the following aspects [7].

BIM can realize the three-dimensional visual design of the building, which is more intuitive and efficient. The BIM model has the information processing capability, so that the BIM model has higher application value than the traditional three-dimensional architectural model. The BIM parameter model breaks through the bottleneck that traditional 2D and 3D models are difficult to modify and synchronize, and exists as a real-time and dynamic multi-dimensional model [8]. The BIM parameter model is closely related to each system, and the overall model plays a role of coordination and synthesis.

Synergy is the core of BIM value. Under BIM technology, the project participants focus on the building information model. The model carries information. This information has the ability to interact and reuse. The project owner can dynamically update the information in the model, and the project participants can communicate with each other through the information in the model.

BIM realizes information sharing and creates a collaborative environment for information sharing, enabling information to be communicated, reused, and shared efficiently, while avoiding information loss or misunderstanding, helping all project participants to obtain the required information more easily and improving the efficiency and accuracy of decision-making.

2.2. Construct prefabricated component model of prefabricated building

The connotation of the features of prefabricated components in the BIM information model has different meanings at different stages, mainly including three categories: overall features, management features and entity features. According to the structural relationship and production process sequence of the features of the prefabricated components, the hierarchical model formed by the parent-child relationship is used to classify and manage the features [9]. Based on the hierarchical description of features, the feature information of the prefabricated component is described by coding, and the three-dimensional model information and production management process information of the prefabricated component can be read through the coded number. Using coding to describe component features is called feature coding of the feature.

BIM needs to classify features according to different application purposes, and the designed features cover the engineering content of the entire life cycle of the fabricated structure. The feature hierarchy is shown in Figure 1.

Encode various feature attributes on the basis of the feature hierarchical structure, that is, the code
uniquely identifies the feature, and the content of the feature is obtained by reading the code. The overall characteristics are used to describe the name, category, quantity, material information, geometric information of the component, the weight of the component, and the amount of steel used.

![Feature layered structure of laminated board components](image)

Figure 1. Feature layered structure of laminated board components

3. Design method of prefabricated structure of prefabricated building

3.1. Design method of traditional prefabricated building structure

In the construction process of prefabricated buildings, the construction party, the designer, the production party and the construction party need to cooperate closely and coordinate work to ensure the smooth progress of the construction process [10]. The design stage is mainly divided into five stages: technical planning, scheme design, preliminary design, construction drawing design and component processing drawing design. Foreign fabricated structures are designed using performance-based design methods, and domestically, they use design methods equivalent to cast-in-place structures. The prefabricated structural design mainly includes the overall calculation and analysis of the structure, the design of structural components, the split and merge design of the prefabricated components, the design of the connection nodes of the prefabricated components, and the in-depth design of the prefabricated components. The assembly structure design method is shown in Figure 2.

![Design method of traditional prefabricated building structure](image)

Figure 2. Design method of traditional prefabricated building structure

3.2. Design method of prefabricated structure of prefabricated building based on BIM

The BIM-based fabricated structural design method should unify standard and common components to form a library of prefabricated components. In the prefabricated structure design, there are corresponding prefabricated components available in the prefabricated component library [11]. The
prefabricated component library is shared by the prefabricated component production unit and the
design unit. The selection of prefabricated components during design can be limited to the scope
provided by the prefabricated component factory [12].

The prefabricated component library is the core of the BIM-based assembly structure design. The
construction of the BIM model and the production of prefabricated components are based on it during
design.

4. Parametric feature modeling of prefabricated building components

4.1. Parametric design process of prefabricated building components

The parametric modeling of prefabricated components aims to establish the constraint relationship
between the three-dimensional model of the prefabricated components and the size, and to change the
size of the three-dimensional model by defining constraints. In a parametric design system, designers
specify design constraints based on engineering relationships and geometric relationships. To meet
these constraints, it is not only necessary to consider the initial values of dimensions or engineering
parameters, but also to maintain these basic relationships and requirements each time these design
parameters are changed.

The steps for establishing the parametric model are shown in Figure 4. Firstly, the geometric and
topological model of the design object must be established. In the process of establishing the
geometric topological model, it is necessary to define the geometric constraint relationship between
the various pixels according to the requirements of the engineering and geometric structure. On the
basis of the geometric model, analyze its structural characteristics and control dimensions, define
variable parameters, and establish the relationship between parameter variables and engineering
relationships. In the prefabricated components, the variables must be calculated strictly in accordance
with the engineering relationship. The parametric geometric topology model and parametric
expressions are derived and compiled into a relational formula compatible with the CAD system to
realize parametric design.

Entity modeling is to describe real-world objects in the form of entities inside the computer,
making the CAD model more complete, clearer and more realistic. Realize accurate calculation of the
volume and quality of parts on the basis of solid modeling, and provide more reliable and accurate
geometric models for finite element method analysis, computer graphics simulation and automatic programming of CNC machining. Constructed solid geometry method refers to a modeling method of constructing complex solids by defining simple voxels. Basic voxel description is to describe the most common and simple three-dimensional geometry with a small number of parameters. The other type of voxel is a contour scanning voxel, that is, a voxel generated by scanning a cross-sectional profile along a certain spatial path.

4.2. Parametric design of laminated board

Through the analysis of the relationship between the parameters of the superimposed plate, the three-dimensional model is established and the relationship between the parameters of the model is given to realize the parametric design of the superimposed plate model.

To realize the parametric design of the geometric model, first establish the prototype of the parametric model, and then change its parameters to obtain the corresponding model. First, establish the prototype of the parameterized model. The system will define an internal identifier for each size in the model. The user will define some parameter variables and assign the variables to the internal identifiers. When you need to enter a value to create or modify a feature, enter the parameter name directly. Use the relational function of EWDraw to create a new relational expression, and associate the constraint parameter name automatically created by the EWDraw system with the design parameter.

Parameterization of the laminated board model. Considering the parameter conditions involved in the laminated board, constraints are used to express the geometric model of the component based on the three-dimensional control EWDraw, and the topological relationship of the geometric model is kept unchanged. Define parameter variables independently and modify their values to change the geometric model. The parametric design method of laminated board is shown in Figure 5.

![Figure 5. Parametric design method of laminated board](image)

5. Conclusion

The BIM-based fabricated structure design method applies BIM technology to the design and construction of fabricated structures, combining the characteristics of both BIM technology and fabricated structures. At present, the research of prefabricated structure mainly focuses on the development of structural system and the research of overall force analysis and joint bearing capacity to ensure the bearing capacity of the structure. The prefabricated component library is the basis for the BIM-based assembly structure design, and the creation and application of the prefabricated component library plays a pivotal role. The prefabricated components put into the warehouse need to be classified and established according to the assembly structure system, and assigned a unique code to distinguish them. The creation of prefabricated components is essentially the process of information creation, and the creation of information needs to consider the requirements of the information depth level. On the basis of BIM technology, this paper puts forward the realization method of precast component parametric modeling system and production management system, mainly focusing on the two parts of precast component parametric modeling and production management. Due to limited personal energy
and time, this article only realizes three-dimensional parametric modeling of some prefabricated components, and the parametric modeling of some complex components needs further research.

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