Research on Prefabricated Structure Design Method Based on BIM Technology

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Abstract: In recent years, with the rapid development of computer technology and continuous technological progress, it has been widely used in various industries. In the field of construction, the state advocates the development of industrialized construction and vigorously promotes prefabricated buildings. BIM (Building Information Modeling) technology is integrated into advanced computer technology. With its powerful information management and interaction capabilities, the application of prefabricated building structure design has received increasing attention. The article expounds the application and development of new prefabricated buildings and BIM technology, proposes the application of BIM technology to prefabricated building structure design methods, and analyzes the theoretical basis and main technologies that can implement the method in detail. In the end, it has prospects for its development and application in the construction industrialization.

Keywords: building information model, prefabricated building, structural design

1. Introduction
With the continuous implementation of domestic construction industrialization, the construction industry has become an inevitable trend in the direction of green, environmental protection, high efficiency, industrialization and informationization. The emergence of new prefabricated building construction methods has just adapted to the development trend of this major situation. The vigorous development and promotion of prefabricated buildings is a major change in the construction industry from extensive to intensive production methods, and it is also an innovation in construction methods\textsuperscript{[1-2]}. The industrial production of the building production method, the component can be scaled and standardized production in the assembly line is a significant feature of the construction industrialization\textsuperscript{[3]}. The components are produced in a prefabricated component factory, and then
transported to the construction site for assembly, eventually forming a complete fabricated building structure. Compared with the traditional cast-in-place method, the use of this production and construction method can fully guarantee the safety of the operator's operation process, and can greatly improve labor efficiency, greatly shortening the production and construction cycle [4-5]. Therefore, vigorously developing and promoting prefabricated buildings will be the general direction and trend of China's construction industrialization development.

2. BIM technology and prefabricated building design and construction

BIM is the abbreviation of Building Information Modeling, that is, building information model. The technology is based on various related information data of construction projects, and adopts computer Lanwei digital technology to build a three-dimensional building model and simulate the real detailed information of buildings. The information contained is not only three-dimensional geometric shapes, but also incorporates many non-geometric shapes, such as parameters of building components, project progress, and material properties. Create a rich building model database through BIM technology. The database platform contains all the information of the building, so that project participants (such as construction units, design units, construction units, supervision units, etc.) can use this common platform. To share this building information model.

Compared with the traditional CAD drawing of flat graphics, BIM relying on computer software and 3D digital technology not only stays at the level of drawing building models, nor is it just a simple operation on geometric objects such as points, lines, and areas. Create three-dimensional models of building components such as walls, doors, and windows, and integrate the information of these models to make them relevant. The building model established by BIM technology is a building whole composed of various building components [Xi, instead of a bunch of unrelated points and lines. Each component of the entire building is objectified in the BIM platform, and the properties of each object are described by a series of parameters. These parameters are generally defined in advance or follow certain established rules. The properties of the building are composed of this parameter information. For example, a wall object is an object with all the properties of the wall. It contains information not only in terms of geometric dimensions (such as length, width, height), but also includes the specifications, cost, material, and surface of the wall. Handling and thermal insulation properties. Generally, in two-dimensional drawings drawn by CAD, the representation of the wall is achieved by drawing two parallel lines, and there is no correlation between the lines. BIM can provide visual and refined construction for the project, and it is an important technical tool for the informatization and refined management of construction projects.

BIM is a feedforward network with global convergence characteristics with fast learning speed and good approximation ability, and is widely used in the field of nonlinear function approximation, pattern recognition, etc. As shown in Figure 1, BIM input signal passes the input layer node to the hidden layer, and then each vector X is mapped to the corresponding target value Y by the implicit layer activation function, as shown in equation (1).

\[ Y = GW \]  

(1)

Where Y is the target matrix, G is the activation function mapping matrix of X, and W is the output weight matrix.
The conversion function of the kth node of the BIM network implicit layer is

\[ G_k(x) = \exp \left\{ -\frac{1}{2} \frac{\|x - c_k\|^2}{\sigma_k^2} \right\} \quad k = 1, 2, \ldots, q \]  

(2)

where \( x = (x_1, x_2, \ldots, x_n)^T \) is the center of the Gaussian function of the kth hidden layer node, the width of the Gaussian function of the kth hidden layer node, and q is the number of hidden layer nodes.

Prefabricated building is to prefabricate some or all building components in the factory, such as floor slabs, columns, beams, walls, etc., and then transport the components to the construction site for hoisting and assembling into a house through various transportation machinery. In the process of hoisting and assembling the structural parts, it is not just "lap up". After the prefabricated components are transported to the construction site, the reinforced concrete will be overlapped and poured during the assembly process to ensure the overall safety of the assembled building. "Integration" can be said to be the core of prefabricated buildings, informationization is the main line of "integration", and informationization reflected by BIM technology is the means of "integration". Traditional assembly design and construction are often due to the separation of design, production and assembly, and any link such as design and production is prone to irrational or error conditions, which will cause the normal application of components, resulting in a waste of time and resources. In the design and construction of prefabricated buildings, the integration of BIM technology can connect all aspects of the entire life cycle of the building, realize the "five-in-one" information management of design, production, construction, decoration and operation management, and give full play to BIM information integration. Advantages, not just "traditional component production + assembly" construction. Using the established BIM model to guide construction can effectively prevent errors and information mismatches from occurring. You can also use BIM technology to pre-assemble prefabricated components, perform simulation exercises on the BIM platform through 3D digital technology equipment, cooperate with work and test node connection simulation to provide technical support for the assembly building construction process.

![Diagram of BIM platform integration](image)

**Figure 1.** Integrated industrial chain integration of prefabricated building on BIM platform
3. Application of BIM in the design phase of prefabricated buildings

3.1. Standardization design of prefabricated components can be realized, and design efficiency is improved

The application of BIM technology to the design phase of prefabricated components can better achieve the integration and sharing of component model information. Compared with traditional two-dimensional graphic design, BIM technology uses 3D as the basis for modeling. The information resources and libraries of prefabricated components are established in a parametric design method. Designers can perform component material types and sizes on the platform. The integration of information builds a "family" library of various types of prefabricated components (such as doors, windows, etc.). Designers of various specialties can filter and optimize the same type of "family" and add it to the "family" library of the component resource library. As the "family" library continues to be enriched, the standard shapes and modulus dimensions of prefabricated components will become more standardized. The "family" library of prefabricated components created in this way helps to improve the scientificity and rationality of general design specifications and design standards for prefabricated building components.

The use of BIM to build a model can be roughly divided into three processes: first, setting standards, then building models, and finally applying models. Any graphic unit in the BIM model covers the related parameters such as the size, type, and material of the component. All component models are set by parameters, which makes the sub-modules in the BIM model related to each other. If the designer modifies and improves any parameter in the component model, all the components associated with it will be updated accordingly, which effectively avoids errors and inconsistencies between drawings. After the BIM model is created, you can export 2D CAD drawings and the quantity table of each component according to the actual work needs, which is fast and efficient. BIM also has the characteristics of three-dimensional visualization. The design unit communicates with the builder, constructor, component manufacturer, etc. through the visualized three-dimensional model, finds design contradictions and blind spots in advance, and adjusts and improves the design plan in time. The coordination of the participating units in the subsequent stages provides convenience. Designers can use a variety of standardized "family" libraries to provide a construction simulation environment for the project site, various types of work and construction machinery to increase the design of prefabricated buildings, in order to achieve the purpose of saving the manpower and time for the design and adjustment of the plan. It can make the specifications of prefabricated buildings more abundant and changeable, and better meet the diversified needs of the owners.

3.2. Collaboration among various disciplines to reduce design errors in prefabricated buildings

The structural components in prefabricated buildings must be prefabricated, then transported, hoisted and spliced to form a whole building. From the design of prefabricated components, to the prefabrication in the factory, to the completion of assembly, and finally to complete the various stages of decoration, the overall collaborative design of the building is required. There are two main parts in the overall collaborative design of the building: one is to optimize and deepen the design within the professional, that is, the collaborative design within the professional; the other is the collaborative design between the professional, that is, the collision detection between the professional and its subsequent Design adjustment. The
former is designed in accordance with design specifications and can meet the functional needs of various disciplines such as architecture, structure, equipment, etc., while the latter is in accordance with the relevant requirements of construction specifications and design to meet the functional requirements of the owner. From the component design, component production, assembly construction to operation and maintenance of the prefabricated building, many professional designers are involved in each stage, such as component design, HVAC, electrical and mechanical engineering, water supply and drainage engineering, and decoration. Designers of various professions need to coordinate and work closely on a platform with smooth information to better complete the entire assembly building.

A major feature and advantage of BIM technology is that it can realize informationization and collaborative management, and provide a three-dimensional visual design information interaction platform for the participating units of the project, so that different professional design models can be interactively combined on the same platform. Provide convenient channels for the collaboration of professional designers and participating units. The prefabricated prefabricated design and construction collaborative platform based on BIM technology is a library of BIM model resources using the IFC standard. In order to better realize the accurate transmission of information between upstream and downstream of various majors, the design team coordinated and coordinated the parametric design of the BIM building model on the BIM platform, and timely found the problems and defects in the design process. It can effectively prevent and avoid design errors between components, significantly improve design efficiency and quality, and can provide technical support for the entire process of construction. Figure 2 shows the characteristics of BIM technology modeling.

![BIM Technical Characteristics](image)

**Figure 2.** BIM technical characteristics

The use of BIM technology for collaborative design and construction in prefabricated buildings is a design method oriented to prefabricated components, which fundamentally changes the traditional design thinking of whole to component separation. This method attempts to create a standardized, general-purpose library of prefabricated components and use it to design assembly structures. After
inspection, adjustment, and optimization of the prefabricated component model, a reasonable design plan is finally formed, and the BIM model is used to guide the production, transportation, and assembly of the prefabricated component.

4. Conclusion
Applying BIM technology to the various stages of prefabricated building structural design, structural model optimization, component transportation, and guidance on-site construction can give full play to its advantages and functions. This technology enables the design and construction of prefabricated buildings to be visualized through the parametric design of the three-dimensional model, which greatly improves the quality of assembly component splitting and deepening design, and can also guide the prefabricated component factory in the production and processing of components. BIM technology is an important technical support for the current transformation and development of the construction industrialization. When applied to the design and construction of prefabricated buildings, it will greatly accelerate the development of construction industrialization and informationization. At the same time, we must also be soberly aware that although the BIM technology has been used in the prefabricated building design and construction phase, progress has been made, but there are still many problems and deficiencies, such as the problem of node processing of prefabricated assemblies and incomplete technical specifications. Etc. To achieve seamless integration of prefabricated buildings and BIM technology, further exploration is needed.

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