The Structural Design Method of Prefabricated Buildings based on BIM Technology

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Abstract. Prefabricated building is the direction of the construction industry’s transformation, and BIM technology is an effective means to promote the development of prefabricated buildings. This paper firstly explains the connotation of BIM technology and its advantages in Prefabricated buildings design, and proposes a new structural design method of fabricated buildings based on BIM Technology. Secondly, finite element analysis is used to analyze and recheck the formed BIM model, and the comparison of analysis results with the specifications are helps to make some adjustments to the BIM model when necessary. Finally, the algorithm design for analysis and optimization is realized.

Keywords: Prefabricated Buildings, BIM, Structural Design Method

1. Instruction
At present, the traditional construction of cast-in-situ concrete structure is widely used in our country. Some problems exist in the construction industry such as Low degree of industrialization, high energy consumption of buildings, inconsistent with national policies on energy saving, emission reduction and environmental protection. Therefore, construction industrialization is the only way for the development of China's construction industry. At the same time, BIM (Building Information Modeling) based on three-dimensional digital technology, which integrates various related information of construction projects, enables informationized structural design to be realized in advance. The change in the method of structural design is a promotion for the development of building industrialization.

2. BIM Technology and its Advantages in Prefabricated Building Design
Building Information Modeling (BIM) has the characteristics of visualization, parameterization, and integration [1]. It has been widely accepted by the industry and regarded as the "best solution for building informatization" by the construction administrative department [2]. It has been used in Chengdu Financial City and Shanghai Disneyland, Shanghai Center and other construction projects. At present, in prefabricated buildings, detailed design is a key link, which plays a role in integrating the whole information in design and construction.

In prefabricated building design, a database can be established when using BIM modeling, and there are more information records in the database. In the construction of the project, it can also be adjusted according to the actual project, and needed information can be found quickly and accurately.
in the database [3, 4]. So the efficiency of decision-making and the quality of the can be greatly improved.

3. The Structural Design Method of Prefabricated Buildings based on BIM Technology

3.1. Main Idea
The BIM-based fabricated structural design method should unify common components to form a library of prefabricated components. The prefabricated component library is shared by the prefabricated component construction company and the design company [5]. The selection of prefabricated components in the phase of design can be limited to the scope provided by the prefabricated component factory to ensure the coordination between the two. The prefabricated component library is constantly improving, and should contain some special prefabricated components to meet the special architectural layout requirements.

Therefore, it is necessary to change the design thinking from the overall design analysis to the splitting of the prefabricated components, and the BIM-based prefabricated structural design method for the prefabricated components is proposed.

3.2. Designing Process
This structural design method is divided into four steps: the formation and improvement of prefabricated component library, BIM construction, BIM analysis and optimization, and BIM construction and application, as shown in Figure 1.

Among them, the most important step is the BIM model analysis and optimization, The pre-designed BIM model needs to be analyzed and rechecked to ensure the safety of the structure. When the the safety check fails, the prefabricated components should be re-selected to replace the one that can not meet the requirements, and the safety check shall be performed again until the requirements are met. The structural analysis can be carried out according to the analysis method of the cast-in-place structure, or it can be dealt with according to the connection of the nodes. The latter method also requires construction practice and experimental research as supporting evidence. Compare the analysis results with the specifications to determine whether the safety check meets the requirements [6].
4. BIM Analysis and Optimization

**4.1 Process of Analysis and Optimization**

The process of the Prefabricated buildings’ BIM is shown in Figure 2. It is mainly divided into two stages: finite element analysis, and the comparison of finite element analysis result with specifications. The former is mainly to convert the BIM model into the analysis model required for structural analysis, and perform finite element analysis based on the corresponding load combination. The latter is mainly to compare the results of the finite element analysis with the specifications [7]. When the requirements
are not met, all components that do not meet the requirements need to be replaced with higher-level components, and the analysis and optimization process is recycled until the requirements are met.

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**Figure 2.** The Process of analysis and optimization

4.2 Algorithm Design for Analysis and Optimization

Take prefabricated floor slab as an example. The algorithm design module should include the finite element analysis module, the review module of different types of components, and the design of a few cast-in-place components should be considered. As shown in Figure 3, the specific design steps are as follows.

4.2.1. **Finite element analysis**. The finite element analysis module should enable the BIM model to be easily converted into a structural analysis model for finite element analysis [8, 9]; the finite element analysis results should be easily extracted and used for calculation of the module, and the marked components after the calculation should be able to be quickly found and replaced.

4.2.2. **Safety Recheck for Prefabricated Floor Slab**

Prefabricated floor slab consists of input, function realization and output parts. The input part refers to the data input for safety recheck, which mainly includes the finite element analysis results of the prefabricated floor slab, the code of it, and the information data used to judge the material characteristics in the comparison [10]. The safety recheck is composed of judgment and comparison, circulation, and marking functions. The judgment and comparison function refers to judging whether the finite element analysis result of the prefabricated floor slab meets the index requirements in the specification. The circulation function refers to the ability to make circular judgments for different types of prefabricated floor slab, the marking function refers to the ability to mark prefabricated panels that do not meet the requirements. The output part is mainly able to output the marking information such as the code of the prefabricated floor slab, which is used for component replacement in the BIM.
5. Conclusion
The BIM-based prefabricated building structure design method can effectively avoid the conflict and incoordination between design and construction, and improve design efficiency. In this paper, the BIM model of the fabricated structure obtained by the pre-design of the prefabricated component library needs to be analyzed and rechecked, the finite element analysis method is applied, and the analysis result is compared with the current specifications, and the BIM model is adjusted according to the result. The review process can be completed by a program algorithm which includes Finite element analysis, safety recheck for prefabricated component.

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