Application research on the design of assembled shear wall joint based on BIM technology

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Abstract. In response to the strategic slogan of sustainable development, China has intensified efforts to develop prefabricated buildings, so the node design of prefabricated buildings becomes particularly important. In this paper, a prefabricated residential building project in Shenyang is taken as an example. BIM technology is introduced into the design of prefabricated shear wall joints based on BIM visualization and parameterization features. The main purpose is to optimize the design of partial T-type and L-type shear wall joints, and to conduct optimization analysis through collision detection. The application of BIM technology can greatly improve the efficiency of shear wall joint design, promote the standardization of prefabricated shear wall joint design, further promote the modular design and production of prefabricated components, reduce project cost, ensure project quality, and give full play to the value of BIM technology in prefabricated construction projects.

1. Introduction
With the rapid development of China's economy, China is gathering towards developed countries in an all-round way. As the pillar industry of China's economic development, the construction industry has also been developing rapidly. However, looking at the development of the construction industry in the past decades, the construction industry in the past was largely labor-intensive development, which caused excessive waste of resources, produced a lot of pollution, and did great harm to the ecological environment, which was contrary to the slogan of "sustainable development strategy" put forward in the new era of China. With the continuous in-depth practice and development of assembly in China, it has been vigorously supported and implemented by the national government due to its advantages of short construction period, resource saving and less environmental pollution. In the process of prefabricated structure design, the node design between each prefabricated component and cast-in-place structure is very important, and the complex node design plays a key role in the quality and cost of the whole project. However, the emergence of BIM technology has carried out technical and management reform and innovation in the construction industry. For prefabricated buildings, BIM technology can be applied in the full life cycle and complement each other in the design stage of prefabricated nodes, playing a promoting role in promoting the development of prefabricated buildings in China[1].
2. Overview of BIM technology and characteristic

2.1. BIM technology
BIM is called Building Information Modeling. At present, it is well known that the BIM concept was proposed by Autodesk in 2002. The concept of BIM technology was first put forward mainly for information management and simulation analysis of building information. In recent years, BIM technology has been applied in engineering construction and become one of the important technical indicators of modernization and informatization in various engineering construction at home and abroad[2].

2.2. Characteristics of BIM
With the progress and development of the society, As a product of the development of modern science and technology, BIM technology brings unprecedented impact to the construction industry and is an innovation for design, construction, operation and maintenance in the later stage. the disadvantages brought by CAD and other traditional design methods gradually emerge. Compared with IT, BIM technology has huge advantages, which are mainly reflected in 3d visualization, simulability and information collaborative design.

(1) Three-dimensional visualization
In traditional engineering construction, most of the drawings are two-dimensional plane drawings. With the progress of The Times, the engineering is becoming more and more complex. Especially in the prefabricated complex node design, the design and management based on two-dimensional drawings are more and more difficult and inefficient for technicians at all stages. BIM technology can clearly and intuitively understand the specific conditions of each stage and position through 3d model and 3d visualization characteristics, reduce the working difficulty of technicians, and effectively improve the communication and collaborative work efficiency among professional technicians[3].

(2) Simulability
BIM technology can simulate the ventilation, heat transfer, lighting and construction process of the 3d model of prefabricated building as expected, and troubleshoot the problems in the simulation in time. At the same time, in the late operation and maintenance of the assembly project, the simulation can be carried out in advance to provide managers with a scientific program guidance.

(3) Information collaborative design
BIM model is the product of the collaborative design integration of various specialties. In the design process of the whole prefabricated engineering project, various participants such as structure, building, ventilation, water and electricity can input, extract, edit and modify information of BIM model, so as to better realize the collaborative cooperation among various specialties within the project. BIM technology provides a good platform for prefabricated design, strengthens the communication between participants at different stages, effectively reduces the design difficulty, reduces the design cycle, and improves the final economic benefit of the project[4].

3. Application and research of BIM technology in the design of assembled shear wall joints
Prefabricated buildings will be split into whole reasonably can be prefabricated, such as prefabricated external walls, prefabrication composite plate, the balcony, prefabrication stair, precast beams and precast column, the air conditioning board, in which precast file for industrialization, standardization production and processing, and then will be prefabricated product transportation to the construction site hoisting by reliable nodes are connected by combination of a new type of building model. This paper will mainly study the joint design between precast shear walls. In the design of precast shear wall joints, post-casting belt connection, bolt connection and sleeve connection are mainly used in practical engineering.

At present, various problems caused by information mismatch often occur in the production and processing of components of prefabricated shear wall structure and in the field construction and installation operations, which will greatly affect the overall project schedule and cost budget. The
main reason for these problems lies in the lack of standardization and modularization of prefabricated components and nodes, which leads to errors in the split design of components and further affects the processing, production and construction in the later period. In addition, in the design of shear wall joints, the number of reinforcing bars and connectors and so on are very complex, and they are prone to collision. In the traditional design mode, it becomes very difficult to solve such problems.

BIM technology, with its huge advantages and features, can not only carry out standardized, modular and unified design of shear wall dimensions and joints, but also conduct batch design operations, greatly improving the design efficiency. At the same time, BIM technology makes use of its 3D visualization characteristics and automatic collision detection function to carry out collision detection and optimization for complex shear wall joints[5].

3.1. Optimization of horizontal joint of assembled shear wall based on BIM technology

(1) Manifestation of horizontal nodes

For prefabricated shear walls of prefabricated buildings, horizontal joints are mainly divided into the following three forms: 1-type node, L-type node and T-type node. Through BIM technology, the specific parameters of three types of nodes are carefully controlled, including shear wall thickness, post-cast belt length, reinforcement anchorage length. Meanwhile, the standard modular design is carried out to promote the standardized design of shear wall, so as to meet the requirements of easy construction, economic safety. The three different forms are shown in Figure 1.

![Figure 1. Three different nodes are introduced.](image)

At present, the horizontal joint construction of assembled shear wall is mainly divided into the following two ways: (1) the edge wall is partially cast-in-place, and the horizontal reinforcement ring is inserted and connected; (2) all the edge walls are cast-in-place, not wall edge precast[6].

This paper will mainly study the method(1). The specific method is to first install the prefabricated shear wall in place, set up temporary support support, lay reinforcing bars and anchor rings on the joint position, and finally cast the joint position support mold[7].

(2) Existing problems and solutions

During the construction of traditional prefabricated shear wall, a series of problems are found as follows. In the construction and installment of L-shaped shear wall joints, it is difficult to install prefabricated PCF plates for shear wall due to the narrow location of L-shaped joints, such as filling of foaming agent and casting of cast-in-place concrete, which affect the construction schedule and quality. For shear wall T nodes, the joint than L, type 1 nodes is more complex, many complex between steel bar and fittings, most of the horizontal shear is assumed by the edge of the component, prefabricated shear wall force transfer is mainly rely on the vertical transmission, has violated the original cast-in-place structure design train of thought, and T shape node in concrete shear wall inside and outside all need to build templates support, construction process and complex.

In view of the above problems, this paper will optimize the design of T-type and L-type shear wall joints based on BIM technology. On the basis of ensuring the stiffness stability and seismic
performance of shear wall, in the BIM model, by changing the resolution parameters of shear wall, part of T-type nodes and L-type nodes can be converted into 1-type nodes through reasonable resolution. Through optimized node design, the number of L-shaped and T-shaped nodes can be reduced to make the shear wall structure more explicit. Meanwhile, the number of reinforcement bars for the optimized type 1 node can be reduced to simplify the construction process and effectively improve the construction efficiency and quality.

3.2. Collision detection of assembled shear wall joints based on BIM technology

In the process of prefabricated building structure design, the node connection between each prefabricated component has always been the difficulty and focus of design. Failure in the early design will lead to rework, work slowdown and design changes in the later construction, which greatly affects the overall construction schedule. In the traditional design mode, designers optimize the overall building structure and pipelines by collision detection based on two-dimensional CAD drawings, which is not only a huge amount of work, but also very easy to miss and make mistakes. Higher requirements for professional and technical personnel. For collision detection based on BIM technology, not only can save a lot of complex work, at the same time using BIM technology automatic collision detection can be detailed collision information, professional and technical personnel can be found on the 3d model accurate collision point position, and use the visualization, parametric characteristics of BIM technology reasonable optimization, can effectively reduce the unnecessary loss in the actual construction, save resources.

4. Application Examples

4.1. Overview of project

This project is located in a residential building in Shenyang, Liaoning Province. The structural system of this building adopts prefabricated integral frame-shear structure, with a structural height of 51.6m and a total of 16 floors. The precast components in this project mainly include precast beams, precast columns, precast composite panels, precast PB panels, precast PCF panels, precast air conditioning panels, precast stairs, precast shear walls.

4.2. Optimize the design of local shear wall joints

(1) Modeling the overall structure of the project

First of all, based on PKPM-PC, we carried out the overall modeling of the building structure, PKPM-PC, an assembly-type design software based on BIM platform, has very rich and diversified modeling methods. The PKPM-PC modeling process in this paper are Import 2d drawing, Establish standard layer, Bim-based prefabricated component repository layout components, floor assembly, overall structural model, structural calculation of the model, optimization and adjustment, complete the overall modeling; the overall structural model of the project is shown in Figure 2.
(2) Optimize the design of local horizontal joints of shear wall
For local shear wall nodes in this project, the following optimization was carried out based on PKPM-PC software: T-type to 1 node, L-type to 1 node; according to our country "technical specification for concrete structures of prefabricated" (JGJ1-2014) for shear wall design specification requirements, the nodes in type 1 node structure edge artifacts range should be greater than 200 mm, up casting range should be greater than 300 mm, parameter Settings, as shown in Figure 3. In this paper, local shear wall optimization is carried out on the second floor of the building structure model, Among them, T-type to 1 node includes 5 T-type nodes converted to 1 in the middle of the south shear wall, l-type to 1 node includes L-type nodes on both ends of the south shear wall and 4 L-type nodes converted to 1 on the north side, as shown in figure 4, yellow circle: T-type to 1 node, red circle: L-type to 1 node.

4.3. Collision detection and simulation optimization for shear wall joints
In prefabricated shear wall node, collisions between the main collision point is reinforced, fittings, collision between steel bar and fittings such as entity belongs to the collision detection of the collision, in the project, the use of BIM software such as Navisworks for collision detection, the node of the collision of steel bar, need to go back to deepen the design phase of the split relevant optimized design and reinforcement design, choose reasonable avoid the way according to design requirements. After the further design of the prefabricated structure, it is necessary to design the temporary support of the
shear wall. Collisions are likely to occur at the corners of the shear wall, and BIM technology can be used for collision detection optimization.

Example 1: The collision occurred at the transverse and longitudinal stirrups at t-type joints of prefabricated shear walls. In the overall structure model, the position of the collision point is X=-15.171, Y=4.103, Z=2.916. The specific optimization scheme is to adjust the joint stirrup parameters and shift the horizontal stirrup upwards by 50mm, as shown in FIG. 4.

![Image of collision detection sites](image.png)

Figure. 4 Detail drawings of two types of node collision detection sites

5. Conclusion
At present, under the promotion of the concept of sustainable development in China, the development of prefab buildings has been advancing by leaps and bounds. For prefabricated shear wall node design, this article first for BIM technology and prefabricated shear wall an overview to the node design, meanwhile analyzes the BIM technology in the application of prefabricated shear wall node design, through the BIM technology, in the engineering example, guidance and optimization of prefabricated shear wall node design, mainly on the level of shear wall node optimization applications, collision detection for the shear wall node optimization.

Although with BIM technology optimize the prefabricated shear wall node design, can promote the standardization of nodes, but in considering the prefabricated shear wall rigidity and whole structure seismic performance. On the basis of this paper, the optimization method has some limitations, and can not be applied to all of the shear wall node, hope subsequent can improve the optimization method, strengthen the BIM technology and modular structure design direct contact, further to ensure the design quality and efficiency of the fabricated structure, effectively promote the development of modernization and informatization of prefabricated construction.

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