# Research on the Application of BIM Technology in the Detailed Design of Prefabricated Concrete Beam Structures

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**Abstract.** Prefabricated concrete structures, with their high quality, efficiency, and resource-saving advantages, are widely used in the construction industry. However, traditional two-dimensional design drawings cannot meet the requirements of detailed design of prefabricated concrete structures, especially beam structures. BIM technology offers a new approach to the detailed design of prefabricated concrete beam structures. By analyzing the advantages of BIM technology, this paper proposes strategies for using BIM in component decomposition optimization, rebar detailed design, reserved embedded parts detailed design, and joint detailed design. Through case studies, the specific application process of BIM technology in the detailed design of prefabricated concrete beam structures is elaborated, aiming to provide a reference for the effective combination of BIM technology and detailed design of prefabricated concrete beam structures.

**Keywords:** BIM technology; Prefabricated concrete structures; Beam structures; Detailed design

## 1 Introduction

BIM technology can present a three-dimensional information model intuitively, carry out in-depth design inside the component, and realize the collaboration of different specialties. Compared with two-dimensional design drawings, BIM technology can more clearly express in-depth design information such as the internal reinforcement layout and node details of the beam structure. Therefore, the combined application of BIM technology and the detailed design of prefabricated concrete beam structures has received much attention.

Regarding the domestic research status, some scholars have analyzed the advantages of BIM technology in the detailed design of prefabricated concrete beam structures, such as improving design quality and efficiency, reducing modifications, and collaborative design. They have also proposed various application strategies and processes for the combination of BIM technology and the detailed design of prefabricated concrete beams to achieve effective integration. Some studies have verified and demon


D. Li et al. (eds.), *Proceedings of the 2023 9th International Conference on Architectural, Civil and Hydraulic Engineering (ICACHE 2023)*, Advances in Engineering Research 228,
https://doi.org/10.2991/978-94-6463-336-8_42

strated the application effect of BIM technology in the detailed design of prefabricated concrete beam structures through specific engineering cases.

Regarding the foreign research status, scholars have used BIM technology to optimize the design scheme of prefabricated concrete beams, achieve detailed design, and apply BIM technology to the internal reinforcement design and node detail design of prefabricated concrete beams. There is also research using BIM technology to realize the informatization management of the entire life cycle of prefabricated concrete beams.

However, there is still much room for the combination of BIM technology and the detailed design of prefabricated concrete beam structures. Based on the summary of previous research, this paper proposes application strategies for BIM technology in the detailed design of prefabricated concrete beam structures and verifies its application effect through engineering cases, hoping to provide a reference for the effective combination of the two[1].

## 2 Advantages of BIM Technology

With its information and intelligence characteristics, BIM technology powerfully supports the detailed design of prefabricated concrete structures, especially beam structures. Specifically, BIM technology can integrate information throughout the project life cycle, express project information in a three-dimensional digital manner, use collaborative platforms to prevent design errors, conduct various simulation analyses to improve the feasibility of schemes, and delve into the internal structure of beams for detailed construction design. BIM technology plays a vital role in information integration, three-dimensional visualization, collaborative work, simulation, and detailed design, providing comprehensive information support, intuitive display, collaborative work mode, scientific simulation analysis, and detailed internal construction expression for the detailed design of prefabricated concrete beam structures. With its robust technical advantages, it is an effective means to realize the detailed design of beam structures and is of great significance to the implementation of detailed design[2].As shown in Table 1 and Table 2,

**Table 1.** Application of Information Integration in BIM Technology

| Core Content | Application Scenario | Advantage Description |
|---|---|---|
| Data Aggregation | Data collection at various project phases | Through BIM technology, data from various sources can be integrated into a single platform, ensuring continuity and completeness of information. |
| Data Sharing | Collaboration among multiple parties | The BIM platform supports data sharing among multiple parties, ensuring all teams can access and update project data in real time, improving work efficiency. |
| Information Update | When project changes occur | BIM technology can update information in real time, ensuring all teams can access the latest project data at any time, preventing errors due to outdated information. |

**Table 2.** Application of 3D Visualization in BIM Technology

| Core Content | Application Scenario | Advantage Description |
|---|---|---|
| Model Construction | Initial design phase | Through BIM technology, designers can create high-precision 3D models, which provide clear and detailed guidance for subsequent design and construction. |
| Real-time Rendering | Client presentations or team discussions | BIM software typically has high-quality rendering capabilities, capable of generating realistic images in real time, making communication with clients or teams more intuitive and efficient. |
| Interactive Experience | Design review or construction preparation phase | 3D models support interactive experiences, allowing users to navigate freely within the model. This helps to better understand the design intent and discover and address potential issues promptly. |

# 3 Application of BIM Technology in the Detailed Design of Prefabricated Concrete Beam Structures

## 3.1 Component Decomposition Optimization

In the BIM detailed design of beam structures, the maximum weight of a single block is calculated based on transportation conditions and hoisting capabilities. Taking into account room layouts and structural grids, BIM technology is used to optimize the design by segmenting the beam, controlling the weight of each segment, and minimizing the number of segments to meet transportation and hoisting requirements. During segmentation, the reinforcement joint treatment at the nodes is thoroughly considered to ensure node strength and rigidity. An optimized modeling scheme is developed, from which a BIM model of the beam segments is generated, and structural calculations are then conducted for validation. This design not only outputs a clear list of beam segments but also provides data support for transportation, hoisting, and construction, making it a crucial step in the detailed design of beams[3].As shown in Fig 1.

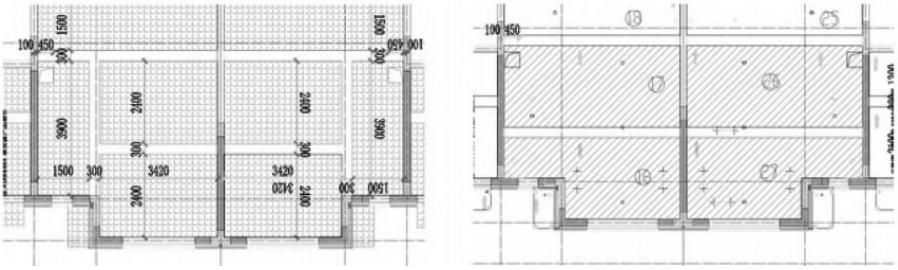


**Fig. 1.** Component Decomposition Optimization Diagram

### 3.2 Reinforcement Detailing

In the BIM detailed design of beams, the cross-sectional dimensions and the quantity of reinforcement bars are determined based on design loads and code requirements. Within the BIM software, a model of the beam cross-section is established. Different shapes are used to represent different reinforcement bars, constructing a three-dimensional digital model of the internal reinforcement of the beam. Reinforcement bars are thoughtfully spaced to avoid overlap and intersections. The design precisely represents the shape of the reinforcement, anchorage, and joint treatments. Calculations for critical construction parts are conducted to ensure rationality. Based on the three-dimensional reinforcement model, detailed drawings such as beam cross-sections and reinforcement unfolding diagrams are generated, providing comprehensive fabrication data. This design avoids reinforcement overlap, ensures accurate calculations, offers strong guidance, and guarantees the rationality and safety of the beam structure[4]. As shown in Fig 2 and Fig 3,

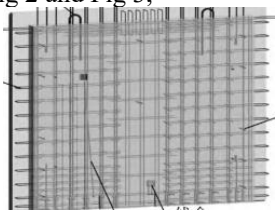

**Fig. 2.** Optimization of Rebar Layout in Prefabricated Components

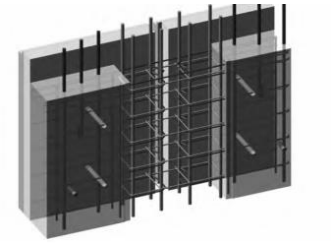

**Fig. 3.** Rebar Layout in Cast-in-situ Joints of Prefabricated Components

### 3.3 Detailed Design for Reservations and Embedded Parts

In the BIM detailed design of beams, requirements from various disciplines for openings are compiled, including dimensions, locations, and directions. Within the BIM software, openings are designed as per requirements, and collision detection is performed with the rebar model, marking conflict zones. The location of the openings is further optimized to avoid interference with the rebars, ensuring the rationality of reinforcement while meeting the requirements for openings. Detailed layout drawings and axonometric diagrams of reserved and embedded parts are produced, providing comprehensive information on the openings. This design ensures that pipelines smoothly pass through the beam, avoiding rework and modifications during construction, thereby enhancing quality and efficiency. As shown in Fig 4.

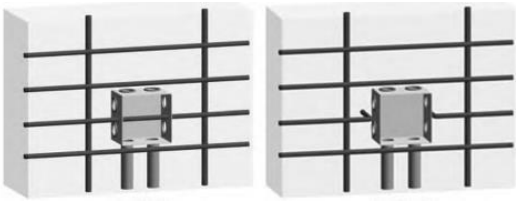


**Fig. 4.** Detailed Design for Embedding Conduit Boxes in Prefabricated Wall Sections

### 3.4 Detailed Design of Joints

The detailed design of beam joints is a challenging and crucial aspect of the construction process for prefabricated concrete beam structures. Utilizing BIM technology allows for a clear representation of the complex construction of these joints. Initially, based on the design load and the configuration of the structural frame, the position of the joints and their load-bearing requirements are determined. Subsequently, by using BIM software like Revit, a three-dimensional model of the joint is established. Within this model, the rebar cage of the joint is meticulously designed, along with the steel plates, pouring tubes, and other components of the joint. It's crucial to set a reasonable staggered spacing for the rebars to prevent collisions between them. The model also represents details like the bending of the rebar, its extension, bolt connections, and more. The force distribution at the joint is calculated, leading to refined joint mix designs. Finally, detailed design drawings of the joint are produced, which include expanded rebar diagrams and detailed construction diagrams of the joint. This detailed design clearly defines the construction components of the joint, guiding its fabrication, ensuring smooth assembly of the beams, and enhancing the quality of the joint[5-6]. As shown in Fig 5.

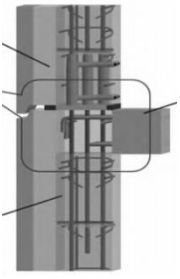

**Fig. 5.** Detailed Design of Prefabricated External Wall Connection Joint

## 4 Case Study

### 4.1 Project Overview

This case pertains to the detailed design of a prefabricated concrete beam structure for an office building project. The building area of the project is approximately 20, 000 $m^2$,

with a structural system consisting of a frame-shear wall structure. The project uses prefabricated concrete beams and prefabricated concrete slabs to form the frame system. Among them, the beam span is generally 6-8 meters, classified as medium to long-span beams[7].

### 4.2 BIM Detailed Design

The beam's detailed BIM design was conducted by using Revit. Based on the span and lifting restrictions, the beam was segmented, ensuring each segment's weight was within 3 tons. Joints were reserved for segmentation, and the design included hinge treatment for reinforcement at the joints. Building upon the beam block modeling, the internal reinforcement was designed, encompassing the main longitudinal bars, vertical stirrups, stressed bars, and tie bars. By using hole-opening technology, embedded parts, and pipeline openings were designed to prevent conflicts with the reinforcement. Node modeling was undertaken to design connection components such as bolts and steel connecting plates and express the combination relationship between beam blocks. Based on the BIM model, outputs included beam block tables, reinforcement drawings, hole detail drawings, and node diagrams, among other assembly production and construction materials[8].

### 4.3 Application Results

The detailed BIM design clarified the segmentation plan of the beam, reinforcement layout, hole-opening design, and nodal details, producing a complete set of construction drawings. This provided a reliable technical basis for prefabrication and assembly, guiding the assembly process to ensure quality. Compared to traditional design, BIM design avoids frequent modifications and reinforcement conflicts, improving accuracy and efficiency. The detailed BIM design achieved a precise representation of medium to long-span beams, effectively addressing key transportation and assembly issues, and ensuring the smooth implementation of the project. This validated the technical advantages and application effectiveness of BIM technology in the detailed design of prefabricated concrete beams[9-10].

## 5 Conclusion

BIM technology provides crucial technical support for the detailed design of prefabricated concrete beam structures. By employing BIM technology, one can engage in three-dimensional modeling, design optimization, reinforcement layout design, and detailed expression of nodal constructions. Compared to traditional two-dimensional designs, BIM technology achieves a more precise, comprehensive, and in-depth design of beam structures. BIM's detailed design not only allows for the output of standardized design drawings but also offers precise three-dimensional information model support for the fabrication and assembly of beams. This ensures a true zero-error alignment between design schemes and fabrication assembly, effectively enhancing

project quality and efficiency while saving costs. In summary, BIM technology offers an advanced technical approach and methodology for the detailed design of prefabricated concrete beams. Its vast application potential makes it worthy of widespread adoption.

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