Method and Practice of Detailed Design of Prefabricated Buildings Based on Parameterized Design

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Abstract: This article aims to explore the methodology and practice of enhancing prefabricated building design through parametric design, addressing issues of inadequate design depth and low standardization in their practical use. It employs various research methods, including literature review, case analysis, and empirical research, to analyze the fundamental principles, characteristics, and potential applications of parametric design in prefabricated buildings. Practical project experiences are utilized to verify the feasibility and effectiveness of parametric design in refining prefabricated building designs, with corresponding improvement suggestions offered. The findings indicate that parametric design can notably enhance design efficiency and quality, fostering standardization and modular development in prefabricated buildings. The conclusion offers valuable insights and recommendations for refining prefabricated building design and anticipates the extensive application potential of parametric design in this field.

1. Introduction

With the advancements in science and technology and the ongoing evolution of the construction sector, prefabricated buildings have emerged as a novel construction approach, garnering significant industry attention due to their efficiency, environmental friendliness, and sustainability. Despite this, practical implementation challenges persist, notably inadequate design elaboration and limited standardization, which somewhat hinder their further progression [1]. The advent of parametric design introduces innovative concepts and methodologies for refining prefabricated building designs. Leveraging its robust data handling capabilities and adaptable design approach, parametric design offers substantial support for the standardization and modularization of prefabricated buildings [2]. Consequently, investigating the method and practice of enhancing prefabricated building design through parametric design holds both considerable theoretical importance and broad application potential.

This study primarily aims to delve into the application methodology and practical pathway of parametric design in refining prefabricated building designs, with the ultimate goal of enhancing design efficiency and quality while fostering standardization and modular development. Key research questions encompass: comprehending the fundamental principles and traits of parametric design and its implementation in refining prefabricated building designs; defining prefabricated buildings and their development trajectory, as well as their current position and role within the construction industry; and exploring the application potential of parametric design in prefabricated buildings and strategies to maximize its benefits.

2. Overview of Parametric Design and Prefabricated Buildings

(1) Basic principles and characteristics of parametric design

Parametric design is a design method based on parameters and algorithms. Its core idea is to decompose the design object into a series of controllable parameters, and adjust and optimize these parameters through algorithms to achieve the design goals. Parametric design is efficient, flexible

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and repeatable, which can significantly improve the design efficiency and quality [3]. In parametric design, designers can quickly adjust the design scheme by modifying parameters, without having to redesign from scratch, which greatly improves the flexibility and variability of design.

(2) The definition and development trend of prefabricated buildings

Prefabricated buildings constitute a construction mode where building components are prefabricated in factories and subsequently transported to construction sites for assembly and splicing (depicted in Figure 1). They offer benefits such as rapid construction, quality control, environmental protection, and energy efficiency, making them a significant trend in the evolution of the construction industry [4]. As science and technology advance alongside the progression of building industrialization, prefabricated buildings are poised to assume a more prominent role in the future of construction.

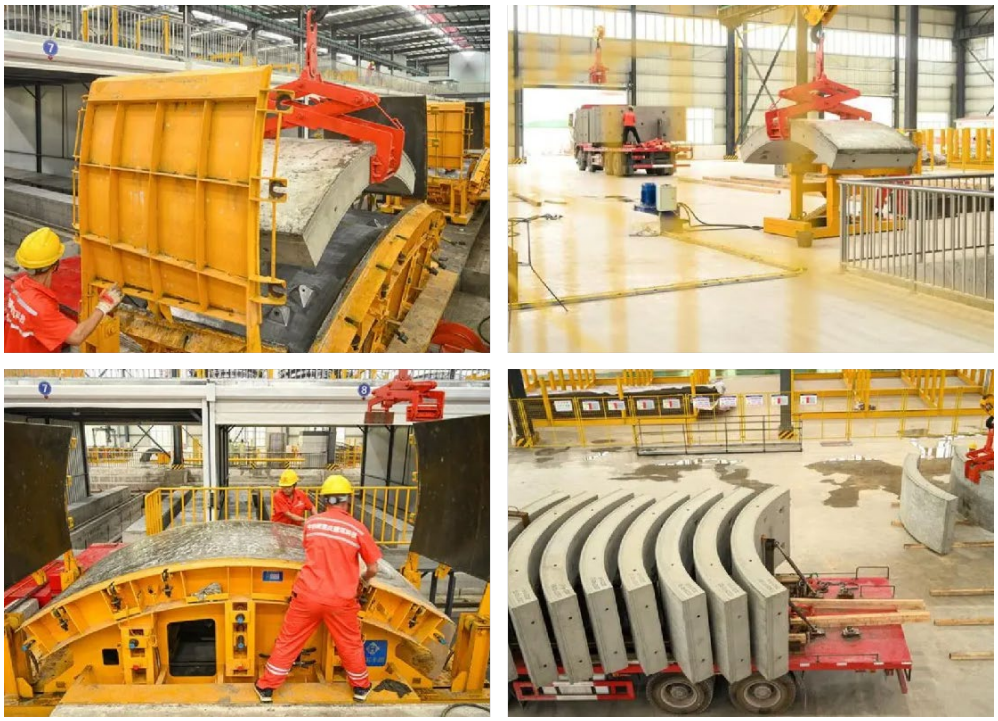

Figure 1 Prefabricated building

(3) The application potential of parametric design in prefabricated buildings

Parametric design has great application potential in prefabricated buildings. First of all, parametric design can realize the standardized and modular design of prefabricated buildings and improve the design efficiency and quality. Secondly, parametric design can optimize the structure and performance of prefabricated buildings and improve their overall performance and comfort. Finally, parametric design can also achieve personalized customization of prefabricated buildings to meet the needs and preferences of different users. Therefore, the application of parametric design to the in-depth design of prefabricated buildings is expected to promote the further development and innovation of prefabricated building industry.

3. Detailed design of prefabricated buildings based on parametric design

(1) Enhancing Design Depth and Specifications:

Deepening design constitutes a crucial phase in prefabricated building implementation, entailing the refinement and enhancement of the initial design plan to align with construction, production, and installation realities [5]. This process encompasses, but isn't limited to, detailed specifications of component dimensions, shapes, materials, and connection methods, as well as the formulation of construction details such as inter-component coordination and installation sequences [6]. It necessitates designers to possess robust professional expertise, extensive practical experience, and effective communication and coordination skills to ensure design accuracy and feasibility [7].

(2) Strategies for Integrating Parametric Design in Deepening Design:

In the realm of prefabricated building deepening design, parametric design strategies primarily encompass: leveraging parametric design's flexibility to swiftly adjust and optimize component parameters like size and shape to cater to diverse design needs; achieving component standardization and modularization through parametric design, thereby enhancing production efficiency and construction quality; and utilizing parametric design's visualization capabilities to intuitively present the deepening design scheme, facilitating communication and collaboration among designers, manufacturers, construction units, and other stakeholders.

(3) Core Technologies and Tools for Prefabricated Building Deepening Design:

The fundamental technologies and tools for prefabricated building deepening design primarily encompass BIM technology, CAD software, and parametric design software. BIM technology enables building information integration and sharing, providing comprehensive data support for deepening design. CAD software is utilized for creating detailed component and construction drawings, ensuring design accuracy and constructability. Parametric design software, on the other hand, facilitates automatic component design and optimization through algorithm and parameter control, ultimately enhancing the efficiency and quality of deepening design.

4. Practice of deepening design of prefabricated buildings

(1) Background and objectives of practical projects

This practical project selects a typical assembled residential project as the research object, which aims to realize standardized and modular production of components through parametric design, improve construction efficiency and quality, and reduce construction costs. The goal of the practical project is to apply the concept of parametric design to the actual project by deepening the design, verify its feasibility and effectiveness, and summarize the practical experience and lessons.

(2) Application of methods and technologies in practice.

In practice, we first established the building information model of the project by using BIM technology, which provided comprehensive data support for deepening the design. Then, with the help of CAD software and parametric design software, we designed the components in detail in terms of size, shape and material, and realized the standardization and modularization of the components. At the same time, we also use the visualization function of parametric design to intuitively show the deepening design scheme, which is convenient for communication and cooperation with all parties.

(3) Challenges and solutions in practice

In practice, we have encountered some challenges. For example, due to the complexity of parametric design, designers need to spend more time and energy on learning and mastering; At the same time, due to the high degree of standardization and modularization of components, higher requirements are put forward for the production capacity of manufacturers and the construction capacity of construction units. In view of these challenges, we have adopted corresponding solutions. For example, through training and learning, improve the parametric design ability of designers; Communicate and cooperate closely with manufacturers and construction units to ensure that they can meet the requirements of deepening design.

(4) Evaluation and reflection on practical achievements

Through this practical project, parametric design has been successfully applied to the in-depth design of prefabricated buildings, which has realized the standardized and modular production of components and improved the construction efficiency and quality. At the same time, it has accumulated some practical experience and lessons. For example, we realize that we need to pay more attention to the importance of communication and cooperation with all parties in the process of deepening design; At the same time, it is necessary to further study and explore how to give full play to the application potential of parametric design in prefabricated buildings. Table 1 shows the summary of this practice.

Table 1 Design practice of prefabricated buildings

Category	Description
Project Background	A typical prefabricated residential project aiming to achieve standardized and modular production of components through parametric design, enhancing construction efficiency and quality, and reducing building costs.
Project Objective	Apply parametric design concepts to practical projects through detailed design, verify feasibility and effectiveness, and summarize practical experience and lessons learned.
Methods & Technologies Used	1. Utilize BIM technology to establish a building information model, providing comprehensive data support for detailed design.
	2. Leverage CAD software and parametric design software for detailed component design, achieving standardization and modularization.
	3. Utilize parametric design visualization features to present the detailed design scheme intuitively, facilitating communication and collaboration with all parties.
Challenges Encountered	1. The complexity of parametric design requires designers to invest more time and effort in learning and mastering it.
	2. High standardization and modularization of components pose higher requirements on the production capabilities of manufacturers and construction capabilities of contractors.
Solutions Implemented	1. Enhance designers' parametric design capabilities through training and learning.
	2. Maintain close communication and collaboration with manufacturers and contractors to ensure they can meet the requirements of detailed design.
Evaluation of Practice Outcomes	Successfully applied parametric design to the detailed design of prefabricated buildings, achieving standardized and modular production of components, and improving construction efficiency and quality.
Reflection & Lessons Learned	1. Greater emphasis on communication and collaboration with all parties during the detailed design process is necessary.
	2. Further research and exploration are needed to better leverage the potential of parametric design in prefabricated buildings.

Future research will continue to explore the application methods and practical paths of parametric design in prefabricated buildings, in order to promote further development and innovation in the prefabricated building industry.

5. Conclusions

This study delves into the methodology and practical implementation of in-depth design for prefabricated buildings, leveraging parametric design principles. Through a blend of theoretical analysis and real-world case studies, we've identified notable advantages of parametric design in this context, specifically in achieving component standardization and modularization, which subsequently enhance design efficiency and quality. Additionally, we've summarized the challenges encountered during practical application and proposed corresponding solutions.

Our findings offer valuable insights for advancing prefabricated building design. We recommend designers harness the benefits of parametric design during the deepening design process, emphasizing component standardization and modular design to elevate production efficiency and construction quality. Moreover, we underscore the importance of maintaining close communication and collaboration with manufacturers, construction units, and other stakeholders to ensure the feasibility and constructability of the deepening design.

Prospectively, parametric design holds immense potential in the prefabricated building sector. As science and technology advance and building industrialization progresses, parametric design is poised to further propel the standardization, modularization, and individualization of prefabricated

buildings, ultimately introducing more efficient, eco-friendly, and sustainable construction solutions to the industry.

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