



Research on the Optimal Design and Quality Control of Prefabricated Components and Molds

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Abstract. This study aims to optimize the design of molds for prefabricated building components. By utilizing Revit software, a digital parametric model encompassing both prefabricated concrete components and their corresponding molds has been established. Through precise adjustments to mold dimensions and critical design parameters, an exact alignment between the components and molds has been achieved. The findings indicate that the optimized mold design significantly elevates the quality of components, ensuring their compliance with industry-wide quality standards. Additionally, it enhances production efficiency and facilitates the rapid generation of mold drawings. Furthermore, this study contributes to advancing the level of informatization management and accelerating the industrialization process in the prefabricated building industry.

Keywords: Prefabricated building; Optimal design; Revit parametric model; Quality control; Production efficiency

1 Introduction

Prefabricated buildings are highly regarded in the construction industry due to their efficiency, environmental friendliness, and flexibility. However, the industry still faces significant challenges in enhancing production efficiency and controlling costs while ensuring component quality. As the key link of the whole production chain, the design of component mold has a significant impact on the quality, production efficiency and cost of components. Traditionally, component manufacturers will entrust mold factories to carry out mold design, but this way is often due to the neglect of cost control and the lack of understanding of the characteristics of prefabricated components, which leads to the low size precision and complex structure, which affects the quality and production efficiency of components, and become a restrictive factor for the development of the industry.

This study aims to improve the quality of prefabricated components through optimized mold design, focusing on quality control indicators closely related to national and industry standards, such as cross-sectional dimensions, reinforcement specifica-

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Y. Qiu et al. (eds.), *Proceedings of the 2024 7th International Conference on Civil Architecture, Hydropower and Engineering Management (CAHEM 2024)*, Advances in Engineering Research 256, https://doi.org/10.2991/978-94-6463-650-5_10

tions, joint bar and sleeve positions, and joint surface roughness. To achieve this goal, this study utilizes Revit software to create a digital parametric model^[1]. By accurately adjusting the mold dimensions and critical parameters, it seeks to reduce production costs and enhance production efficiency while ensuring component quality. By doing so, we hope to contribute to the sustainable development of the prefabricated building industry and breathe new life into the process of construction industrialization.

2 Optimal Design of Prefabricated Component Molds

Prefabricated components the standardized design is a core element of prefabricated buildings. By unifying specifications and dimensions, standardized design significantly reduces production and procurement costs, facilitates mass production, optimizes production processes, and thus greatly improves production efficiency. In addition, it simplifies the assembly process, improves construction quality, and facilitates information management. The implementation of this design not only promotes technological innovation and industrial upgrading but also lays a foundation for more efficient information management^[2].

Component molds play a key role in prefabricated buildings, ensuring component accuracy, improving production efficiency, and guaranteeing component quality. However, traditional component mold designs have some problem, such as insufficient dimensional accuracy, complex structures, and lack of versatility and flexibility, which make it difficult to meet the efficient, flexible, and sustainable needs of prefabricated buildings.

To address these issues, we have optimized the design of component molds. Firstly, by precisely controlling the mold dimensions, we ensure the accuracy and consistency of the components. Secondly, we simplify the mold structure, making it easier for rapid assembly and disassembly, and improving the reusability of components. Finally, we select high-strength, wear-resistant materials for mold production and perform surface treatments to extend the mold's service life.

The implementation of standardized design not only standardizes component information but also facilitates information tracking and management, and improving managerial effectiveness. At the same time, the optimized mold design reduces production costs while improving production efficiency, further enhancing the market competitiveness of prefabricated buildings.

Overall, standardized design of prefabricated components and mold optimization are key to promoting the development of prefabricated buildings. They not only improve production efficiency and reduce costs but also enhance building quality and information management efficiency. In the future, we will continue to explore and innovate to promote the sustained development and progress of prefabricated buildings.

3 Engineering Case of Mold Optimization

Chongqing is an important city in southwest China which provides valuable architectural examples in its prefabricated rural housing construction atlas^[3]. This article statistics all prefabricated members based on six prefabricated concrete structure examples from the "Chongqing Prefabricated Rural Housing Construction Atlas." And using Revit software^[4], we building three-dimensional models and supporting component mold parameter models to construct a standardized and digitized component and mold library. The mold design is optimized through parametric methods^[5].

3.1 Statistics and Modeling of Prefabricated Components

This study conducted an in-depth analysis of six cases in the atlas and adopted Revit parametric modeling technology to systematically set family parameters and conduct coding statistics for prefabricated beams, columns, slabs, stairs, and other components. By utilizing Excel software for refined data processing, components with the same specifications were screened out, and universal molds were designed for them, aiming to enhance production efficiency and reduce costs. The research results indicated that beams and columns with the same cross-sectional dimensions could share the same molds, while slab components with the same thickness were classified based on their length and width to unify mold specifications. This approach effectively improved mold utilization, optimized production costs, and strengthened the quality control of prefabricated components. The statistical results are detailed in Table 1.

Table 1. Statistics of prefabricated components in engineering examples

Component Type	Component Size /mm		quantity	Component Type	Component Size /mm	quantity
	Section Size	length				
Pre-cast Beam	200x200	1520~3300	2		1020x1920x60	2
	200x250	1420~7820	22		1020x4020x60	1
	200x270	4220	1		1120x1920x60	3
	200x300	3320~4500	5		1320x3060x60	2
	200x350	2500~6670	28		1920x1020x60	3
	200x390	5100~5200	2		1980x3720x60	7
	200x400	1520~7820	94		2220x4920x60	1
	200x450	3670	1	Pre-cast	2240x3720x60	6
	200x550	6670	1	Panel	2520x2460x60	3
		total	156		3120x2460x60	4
Pre-cast Columns	300x300	2420~3620	59		3360x1620x60	2
	300x700	2420-3520	2		3420x1860x60	37
	300x400	2420-3520	10		3420x1920x60	1
	300x600	3520	1		3420x1940x60	3
	300x800	2420-3520	4		3420x2010x60	14
		total	76		3420x2310x60	10

----- Component Size /mm -----					
	projected length and width	step height	quantity		
				4020x1860x60	1
	4000×1180	150	6	4220x1320x60	2
Pre-cast Stairs	4000×1180	150	6	4320x1920x60	3
				4320x1620x60	1
				4320x1940x60	6
		total	12	4320x2460x60	6
				5220x2040x60	6
				total	125

3.2 Establishment of Component Mold Parameter Model

Based on the structural drawings of prefabricated components and using Revit software, we have precisely constructed three-dimensional digital models for both the prefabricated components and their corresponding molds. During the modeling process, design specifications were strictly followed to ensure that key parameters such as the geometric dimensions and material properties of the components and molds align with the atlas requirements, thus guaranteeing the accuracy and standardization of the components

According to the Technical Specification for Prefabricated Concrete Structures JGJ 1-2014^[6], molds for prefabricated components must strictly comply with bearing capacity and stability standards. In sure high-quality production^[7], of components, facilitates convenient assembly and disassembly, and allows for precise positioning of reserved holes and steel bars. At the same time, before pouring concrete, a comprehensive inspection of concealed parts in prefabricated components must be conducted. This inspection covers steel reinforcement specifications, connection methods, embedded parts, and ensures the accurate position and stability of the protective layer, insulation layer, and embedded pipelines.

By utilizing Revit's parametric 3D modeling technology, we can achieve a high-precision match of the mold and component models. It ensures the accuracy of the component's shape, size, quantity and position of embedded parts, as well as the precise positioning of the longitudinal connecting steel bars within the component. Additionally, this technology guarantees the accuracy of data related to mold assembly, fabrication, demolding, and lifting. Not only does this meet the relevant specifications for component quality inspection and evaluation, but it also further enhances the performance, fabrication quality, and apparent quality of the components, providing a solid guarantee for the overall quality of the components.

As shown in Figure 1, this is an example of Revit parametric 3D modeling. Modeling is based on the design drawings of prefabricated beam components, parametrizing the dimensions and specifications of both the components and the molds.

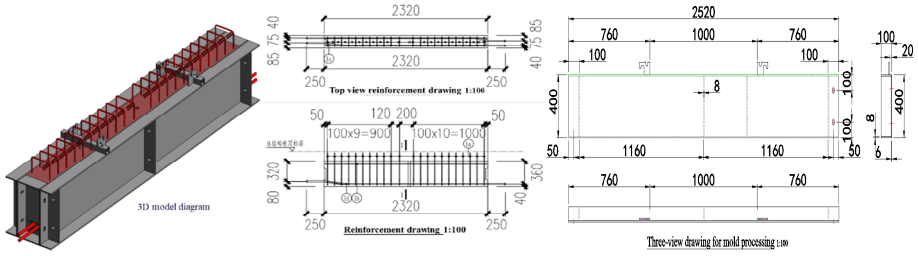


Fig. 1. Three-dimensional Model and Dimension Specifications of Prefabricated Beam Components and Molds

3.3 Digital optimization effects of mold design

The use of Revit software to build a digital parametric model can significantly improve the quality of components, and the relevant results are as follows:

Improving Dimensional Accuracy: Precisely controlling mold dimensions to ensure that components accurately meet design requirements. For example, in the production of prefabricated exterior wall panels, optimizing mold design and reducing problems such as misaligned steel bars for connecting grouting sleeves.

Optimizing Reinforcement Layout: Accurately setting the position, spacing, and specifications of reinforcement bars to ensure structural safety. For instance, precise layout of reinforcement bars can effectively prevent misalignment, omission, and other arrangement problems, ensuring the bearing capacity of the components.

Reducing Material Wastage: Precise mold design improves material utilization, reducing costs and environmental impact. For example, accurate calculation of material requirements can minimize waste and achieve more environmentally friendly and economical production.

Increasing Production Efficiency: Optimizing mold design to shorten the production cycle. By utilizing efficient parametric modeling, mold design can be quickly completed, and drawings can be exported promptly, thereby enhancing production efficiency.

4 Conclusion

This study successfully optimized the mold design by using Revit software to build a digital parametric model of prefabricated concrete components and molds, thereby significantly improving component quality, reducing production costs, and enhancing production efficiency. Specifically, by precisely controlling the mold size, optimizing the arrangement of steel bars, reducing material waste, and shortening the production cycle. These achievements not only inject new vitality into the sustainable development of the prefabricated building industry but also make a positive contribution to promoting the process of building industrialization. This study demonstrates that digital parametric modeling has broad application prospects in the field of prefabricated buildings and is expected to bring more profound changes to the industry.

Acknowledgment

Fund Project: Chongqing Construction Science and Technology Planning Project "Research on the Technology of Prefabricated Digital Smart Factory", Chengkezi 2023 No. 4-11.

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