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# A Review of Innovative Design Strategies for Prefabricated Green Buildings

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**Abstract:** Prefabricated green buildings are becoming a trend in the construction industry of China. The prefabricated components are made using modern technologies like green materials, artificial intelligence, and low-carbon and energy-saving techniques. This makes them an important aspect of the development of the construction industry in China, representing modernization and sustainable development. This article presents a study on the innovative design of prefabricated green buildings. This article serves to promote sustainable development on a macro level.

**Keywords:** Green prefabricated building; Monolithic residence; Waterproof and anti-seepage; Bathroom caisson

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## 1. Introduction

Prefabricated green buildings can significantly promote energy conservation, emission reduction, and maximum utilization of resources in the construction industry. In this way the sustainable development goals can be achieved and environmental pressures can be alleviated. Prefabricated green buildings align with ecological civilization, which is advocated by the country [1]. Therefore, engaging in innovative research on prefabricated green building design drives the development of the construction industry in China, elevating its status on the international stage in terms of building construction.

## 2. Overview of prefabricated green buildings

### 2.1. Prefabricated green building

The development of prefabricated green buildings is essential in the modern construction industry. The concept of prefabricated green buildings is built upon the core concepts of prefabrication and green buildings, which consider both construction efficiency and environmental friendliness [2]. Green design and the application of green technologies are important aspects of building prefabricated green buildings. This form of building construction serves to achieve energy conservation and emission reduction, thereby reducing pollution and achieving the maximum recycling of resources. By doing so, the negative impact of building construction on

the environment can be reduced [3].

## 2.2. Characteristics of prefabricated green buildings

Prefabricated green buildings are characterized by their high efficiency and energy-saving properties, sustainability of material and resource utilization, improvement of indoor environmental quality, intelligent management, etc., as shown in **Figure 1**.


**Figure 1.** Characteristics of prefabricated green buildings

(1) High efficiency and energy saving

The components of prefabricated buildings can be manufactured in a factory, which only improves construction speed and quality but also significantly reduces the problem of material waste.

(2) Sustainable materials and resource utilization

Prefabricated green buildings are made using renewable resources and low-pollution materials, which can significantly reduce their negative impact on the environment during the construction process, which in turn helps maintain biodiversity and ecological balance [4].

(3) Higher indoor environmental quality

The design of prefabricated green buildings emphasizes the optimization of indoor air quality, lighting, temperature, and humidity to create a relatively healthy and comfortable living environment for users.

(4) Intelligent management

The application of building information model (BIM) and the Internet of Things (IoT) can achieve intelligent resource management in the design, the construction, and the use of the building. Besides, the energy consumption of the building equipment (such as electromechanical and HVAC systems) and building maintenance costs can be reduced [5].

(5) Reduction of life cycle costs

The entire life cycle of the building is emphasized in the design of prefabricated green buildings, including the construction, use, and maintenance stages, and even the renovation and demolition stages. Therefore, compared with traditional cast-in-situ concrete buildings and prefabricated buildings, prefabricated green buildings reduce long-term operating costs and help achieve economic sustainability [6].

# 3. Advantages of prefabricated green buildings

## 3.1. Improving building performance

Prefabricated green buildings are usually made of materials with better thermal efficiency and structural stability.

Prefabricated building components are manufactured in a controlled environment, making the components produced more precise. Therefore, the components have better sealing and insulation effects, which reduces heat loss and energy consumption. Secondly, prefabricated buildings are usually made of lightweight materials, which can significantly reduce the weight of the building while still ensuring its safety and durability. Lastly, renewable materials used in prefabricated green buildings and the consideration of environmental friendliness during the design phase are highly beneficial to the physical and mental health of the residents.

### 3.2. Optimizing architectural design construction processes

By adopting a highly modular and standardized design concept, the entire project can be implemented more systematically, and uncertainty and risks during construction can be reduced. During the design stage, BIM can be used to simulate and analyze the building for further optimizations. BIM technology can create a four-dimensional model of the design to ensure a high degree of alignment between prefabricated components and on-site installation. Besides, refined manufacturing processes and technical standards allow high-quality construction and reduce rework and material waste [7].

## 4. Research on innovative design of prefabricated green buildings

### 4.1. Innovative design for integrated housing

Under the concept of reshaping future building construction, the innovative design of integrated housing in prefabricated green buildings can start from the four dimensions of system structure, modular design strategy, innovative application of integrated technology, and intelligent management system.

When it comes to optimizing structural systems, the modularity and standardization of the building should be prioritized in the design. Architects can achieve a variety of component combinations and quick assembly through detailed component segmentation and universal interface design. Adopting this new systematic design model simplifies the manufacturing and installation process and facilitates maintenance and upgrades, effectively extending the service life of the building. In addition, the modular design strategy can also flexibly adapt to changes in the needs of users and owners during the design and construction phases, achieve flexibility in building space and layout, and meet the need for a personalized living space in buildings [8].

Second, the optimized design of the prefabricated green building structure can also be highlighted through integrating technology. In residential designs, designers can integrate new environmentally friendly materials and clean energy technologies. For example, solar panels can be installed on the roof to power the heat pumps to achieve energy self-sufficiency and reduce overreliance on external energy. At the same time, high-performance insulation materials can be used for doors and windows during the design stage to optimize the thermal efficiency of the building further and maintain indoor comfort and energy-saving effects.

Finally, integrating intelligent management systems can create an innovative living experience for integrated residential buildings. Real-time monitoring of indoor environmental parameters, including temperature, humidity, carbon dioxide, and PM2.5 values, can be achieved through built-in sensors and intelligent control systems. The building's indoor heating, ventilation, cooling, and air purification will then be automatically adjusted based on the values of the aforementioned parameters.

### 4.2. Innovative design for building waterproofing and impermeability

Innovative designs for waterproofing and anti-leaking in prefabricated green buildings can be achieved through integrated designs such as external wall insulation and waterproofing, as well as polymer waterproofing.

Integrated external wall insulation and waterproofing prevent leaking by combining insulation materials

with waterproof layers, forming a seamless and continuous protective layer for the exterior walls. The waterproof systems in traditional buildings often suffer from thermal bridging, which is caused by the separation of the insulation and waterproof layers. Therefore, the integrated design of the thermal insulation layer material and waterproof membrane can be constructed simultaneously to form an integrated organic protective layer. This strategy can improve construction efficiency and prevent leaking due to poor construction.

Polymer waterproof coatings are utilized in prefabricated green buildings for the waterhouse and underground garage areas, creating a highly elastic and strongly adhesive waterproof membrane. This waterproof membrane can adapt to minor deformation caused by thermal expansion and maintain the integrity and sealing of the waterproof layer for a long time. Besides, polymer coatings can compensate for the risk of leakage caused by tiny, uneven joints, especially for the joints of assembled components.

## 4.3. Innovative design for embedded parts

Embedded parts play a key role in prefabricated green buildings. They are an important link in connecting various prefabricated building components and significantly impact structural safety, stability, and construction efficiency. The innovative design of embedded parts can focus on improving project quality and construction speed while ensuring the long-term performance of the structure [9].

The corrosion of embedded parts is a key consideration during the installation stage of reinforced concrete components that would seriously affect the quality and stability of the building. To prevent corrosion of the embedded parts, red lead can be sprayed on the parts. Red lead is an effective protective material due to its good rust resistance and adhesion. It forms a protective layer on the surface of embedded parts, effectively isolating moisture and oxygen, which prevents them from being corroded by water vapor.

Round-head embedded nails should be used to further improve the stability of embedded parts. Compared to traditional flat-head nails, the arc-shaped head of round-head embedded nails can provide a larger contact surface and increase the anchoring force, strengthening the connection between them and the concrete.

## 4.4. Innovative design of prefabricated bathrooms

Prefabricated bathrooms mean that all components of the bathroom are prefabricated in the factory in advance and only need to be hoisted into place and connected on-site, thereby achieving rapid construction and excellent quality control.

(1) Modular design

The bathroom, as an independent spatial unit, can achieve highly integrated production through modular design, ensuring stability in construction quality and project duration. In the modular design stage, in addition to the fixed structural components of the prefabricated green building, it should also cover pipes, wires, and sanitary ware.

(2) Optimization of bathroom waterproofing and soundproofing performance

Waterproofing and soundproofing should be emphasized in designing toilets. Polymer waterproof coatings, sealing tapes, and materials with good sound absorption properties can be used to achieve those effects.

(3) Integrated design of bathroom structure and functions

The bathroom should be stable and equipped with intelligent equipment like smart toilet bowls, smart lighting, automated ventilation systems, etc. To ensure the smooth integration of various intelligent systems, designers should pay attention to reserving corresponding spaces and interfaces in the structure so that the equipment can be quickly installed during the construction phase and seamlessly

connected to the smart home system.

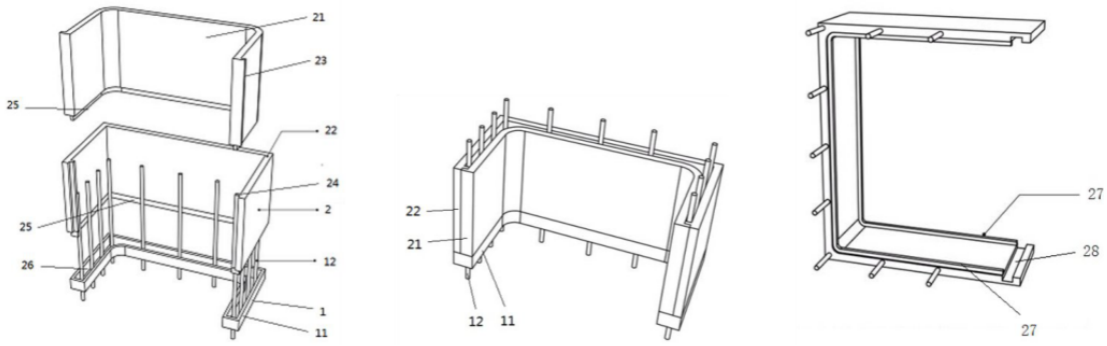
(4) Strengthening the overall style design

The appearance of the bathroom should also be consistent with the overall design of the building. The prefabricated bathroom caisson should also be seamlessly integrated into the overall system of the building. This requires a proper selection of materials and colors, and the functional layout, indoor layout, and user habits should also be considered during the design stage [10].

## 4.5. Innovative design of modular grouting mold

The main purpose of designing modular grouting tools for prefabricated green building construction is to address the shortcomings of previous prefabricated building wall panels, such as low modularity, poor workmanship, high prefabrication costs, and long production cycles.

The base and modular mold can be designed from bottom to top based on the modular grouting mold. The base would adopt a U-shaped design and a part of the steel bars would be embedded in the base. The modular mold includes an inner wall and an outer wall. The shape of the mold is the same as that of the base. The steel bars will be encapsulated within the inner wall and outer wall of the hollow wall (**Figure 2**).




Structure breakdown Overall structure The second and third grove

**Figure 2.** Schematic diagram of modular scratch-off mold

As shown in **Figure 2**, Part 2 of the prefabricated base would be processed through casting. The 12-part combination has both the advantages of steel bars and concrete. The concrete can be manufactured using sand and gravel or concrete wastes to reduce costs and material waste. The 12 steel bars are wrapped in a concrete protective layer, which is not prone to rust and has good corrosion resistance. The base and the modular grouting grinding tool are both detachable structures. Parts 21 (inner wall) and 22 (outer wall) of the grouting mold are also detachable structures. On Part 21, there are 23 horizontal grooves. The horizontal edge of Part 22 is designed to be similar to groove 21 on the inner wall. Part 24 (corresponding clips) is designed to fit into the bottom of Parts 21 and 22, as well as Part 25 (outer edge), to lock into base 11. The upper surface of base 11 is designed with Part 26 (grooves) corresponding to the protruding outer edge of Part 25. Two opposite inner walls of Part 27 are designed. A third groove (Part 28) is designed along the grouting direction to be inserted into the support plate during the operation stage.

Modular molds can be created based on user needs. Walls, columns, and beams are connected through grouting to form prefabricated wall components. During the pouring and molding of wall components, functional components such as internal lighting, doors and windows, and thermal insulation walls can be added based on built-in multi-functional channels. Using this module for prefabricated green building wall panel

construction ensures not only aesthetically pleasing structures but also easy operation, high recyclability, and flexible installation. This approach can greatly reduce the construction costs of prefabricated components.

## 5. Conclusion

Prefabricated green buildings have become an inevitable trend in China's construction industry. These types of buildings combine the advantages of prefabricated construction and green building practices. They can achieve ecological sustainability and cost savings while significantly improving construction quality and performance. Therefore, construction companies and architectural design firms should actively explore design innovations for prefabricated green buildings. New technologies should be integrated into the design and construction processes to better meet residents' needs and enhance environmental and economic benefits. Lastly, prefabricated green buildings allow the fulfillment of personalized user requirements and contribute to the overall green and sustainable development of China's construction industry.

## Disclosure statement

The author declares no conflict of interest.

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