
Original Research Article

A Study on the Modular Design of Mobile Prefabricated Vacation Homes

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Abstract: With the rapid development of the tourism industry and the increasing demand for personalized accommodations, traditional vacation home design and construction methods no longer meet market needs. Compared to traditional vacation hotels, modular design offers advantages such as flexibility, shorter construction periods, lower costs, higher safety, and environmental sustainability. This approach is gradually becoming a new trend in modern tourism accommodations. This paper first outlines the current status of vacation homes and presents relevant exemplary cases, then reviews the theories related to modular design, and finally provides a design analysis from multiple aspects including space, construction, structure, and materials.

Keywords: Movable Buildings; Vacation Homes; Modular Design; Prefabricated

1. Introduction

With the rapid development of the tourism industry and the continuous improvement of living standards, the demand for personalized, comfortable, and convenient vacation accommodations is increasing. Traditional vacation homes struggle to meet these diverse needs. Modular design, based on the concepts of standardization, prefabrication, and reusability, offers numerous advantages such as sustainability, mobility, low construction costs, and reduced resource waste. This paper explores the application of modular design in movable prefabricated vacation homes, discussing various aspects such as the current state, concepts, design, and construction, providing valuable references for future vacation home design.

2. Current Status and Research of Modular Design in Movable Prefabricated Vacation Homes

2.1. Current Status

With the rapid development of the tourism industry, the demand for vacation homes continues to grow. Traditional vacation home construction methods face numerous challenges, such as long construction periods, high costs, and poor environmental sustainability. To address these issues, modular design, an emerging architectural concept, has gradually gained widespread attention and application in the field of tourism accommodation. Modular design not only improves construction efficiency and reduces costs but also offers flexible and varied design solutions to meet the market's demand for personalized, comfortable, and convenient accommodations.

However, there are still some issues with modular design in the vacation home sector. These include transportation limitations due to module size and weight, a lack of comprehensive design standards and quality inspections, negative market perceptions, and a general lack of understanding of modular design.

2.2. Case Analysis

Modular vacation homes are gradually being adopted worldwide due to their advantages of rapid

construction, environmental sustainability, and flexibility. By analyzing and summarizing the following typical cases (Figure 1), we can gain a deeper understanding of the practical application and effectiveness of modular design in vacation homes.

3. Modular Design Theory and Its Applications

3.1. Overview of Modular Design Theory





Name	Wikkelhouse	Port-a-bach	Farmhouse	Landscape Hotel
Structure	Cardboard Structure Module	Shipping Container Structure Module	Steel Frame Module Structure	Wood Frame Module Structure
Area	5 Square Meter Module Unit	36 Square Meter Module Unit	26.4 Square Meter Module Unit	24-30 Square Meter Module Unit
Function	Customizable based on needs, typically consisting of 3-8 module units	Bedroom, kitchen, bathroom, and open living room/balcony	Bedroom, kitchen, bathroom	Customizable based on needs
Features	Can be assembled in one day with no waste generated	Easy to transport Durable and sturdy	Eco-friendly Functionally adaptable	Independent modules Sustainable materials
Illustrative Image				

Figure 1. Analysis of relevant excellent cases

The concept of a module was first introduced by Starr, who defined it as “a component that can be designed and manufactured independently, and these components can be combined in various ways”^[1]. Modular construction is an architectural design and construction method that divides a building into independent modules, which are prefabricated in a factory and then assembled on-site into a complete building structure. This approach is characterized by fast construction speed, minimal pollution, and flexibility.

3.2. Equipment Modularity

Equipment modularity includes electrical devices, piping systems, furniture, and other interior facilities. The design and installation of modular equipment can significantly enhance the construction efficiency and quality of vacation homes.

Electrical Equipment.The modular design of electrical equipment can break down the electrical system into several independent modules, such as lighting modules, outlet modules, and control modules.

Piping Systems.The modular design of piping systems can decompose water supply and drainage, HVAC, and fire protection systems into several standardized modules. These modules are prefabricated and tested in the factory to ensure quality and performance stability. During on-site installation, the modules only need to be assembled and connected according to the design drawings to complete the system.

Furniture and Interior Facilities.The furniture and facilities inside the vacation home can be designed modularly, such as modular kitchens, bathrooms, and bedrooms. Given the limited space in vacation homes, multi-functional furniture modules can be used to improve space utilization and comfort.

3.3. Modular Exterior Cladding

Modular exterior cladding is an essential component of vacation homes, involving the building’s facade,

roof, and exterior walls. The design and installation of modular exterior cladding can enhance the building's aesthetics, functionality, and durability.

Facade skin.The modular design of facades can break down exterior walls and decorative panels into several standardized modules. These modules can be designed differently based on location, environment, and temperature. To install, the modular facade cladding is simply placed over the existing exterior walls of the vacation home.

Roof.The modular design of roofs can break down the roof structure, insulation layer, and waterproof layer into several independent modules. Using standardized connection methods and installation techniques, the roof can be quickly assembled and constructed, ensuring stability and durability.

Outer wall.The modular design of exterior walls can break down the wall structure, insulation layer, and decorative layer into several standardized modules. These modules are prefabricated and tested in the factory and then combined and assembled according to design requirements, providing an efficient solution for exterior wall construction.

3.4. Dimensional Modularity

Dimensional modularity is a crucial parameter in modular design, involving the size and shape of modules. Proper design and control of modular dimensions can enhance the construction efficiency and quality of vacation homes.

Typically, the length of modular units ranges from 6 to 12 meters, while the width is mainly constrained by transportation conditions, generally ranging from 3 to 4 meters^[2].

The design of module shapes must consider structural stability and functional diversity. Modules are primarily designed in rectangular or square shapes.

4. Modular Design of Movable Prefabricated Vacation Homes

4.1. Modular Assembly Methods

Vacation homes are constructed by combining multiple modular units to form a complete movable prefabricated structure. The assembly methods are categorized based on needs and area, including horizontal assembly, vertical assembly, and multidimensional assembly (Figure 2).

Horizontal assembly arranges the modules of the vacation home in a horizontal direction. Modules are laid out along the ground plane to create a horizontal structure, which can be arranged linearly along coastal lines, lake shores, mountain ranges, or according to natural or artificial landscapes.

Vertical assembly stacks or layers the modules of the vacation home in a vertical direction. The modules are arranged vertically to form a multi-story structure, which can be two, three, or even more stories high.

Multidimensional assembly combines the modules of the vacation home in both horizontal and vertical directions to create a complex structure with multiple layers and directions.

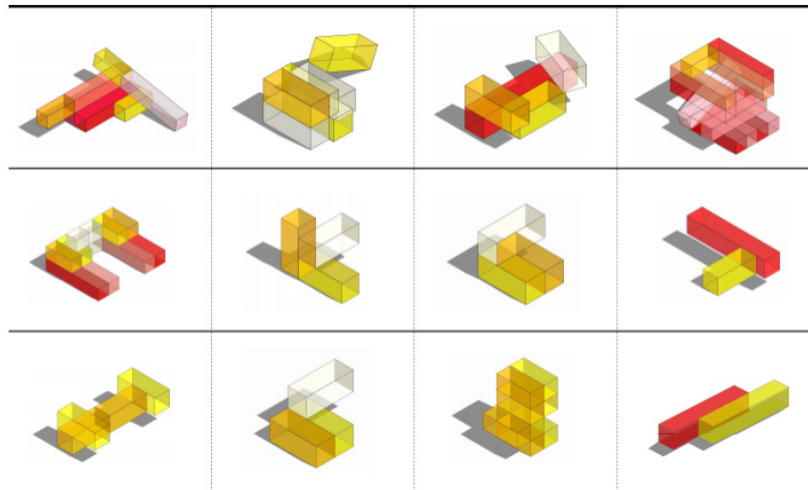


Figure 2. Module combination.

4.2. Basic Functional Modules

Essential modules include sleeping spaces and bathroom spaces, meeting the basic physiological needs of occupants. The sleeping space is the primary usage area, typically designed as a bedroom. It is used for longer periods and can be designed as a single-room suite, double-bed room, or family suite, depending on the number of guests and their needs. Comfort, privacy, and safety must be thoroughly considered in the design. Furniture such as beds should be ergonomically designed to ensure guest comfort, with adequate lighting and ventilation, oriented towards the best views to enhance interaction with nature.

The bathroom space includes functions such as toilets, showers, and sinks. It requires high privacy and should be designed with functionality, hygiene, safety, and comfort in mind. Suitable bathroom fixtures, good ventilation, and drainage systems are essential. Typically, these are prefabricated in the factory and directly placed in the vacation home. In vacation home design, the bathroom space is usually adjacent to or concentrated near the sleeping space (Figure 3) to facilitate use and improve efficiency.

Optional modules refer to additional components or parts that can be selectively added based on different needs and scenarios to enhance the functionality, comfort, and aesthetics of the vacation home, meeting diverse living requirements. These mainly include dining and kitchen spaces and leisure and entertainment spaces.

Dining and kitchen spaces are crucial in vacation home design, especially for coastal or scenic areas where simple food preparation is often needed. Therefore, basic cooking equipment and utensils should be provided. Typically designed as open spaces, these areas connect the kitchen and dining room (Figure 4) to increase spatial transparency and interaction.

Leisure and entertainment spaces usually extend outward, providing outdoor relaxation and gathering areas. Alternatively, the living room can be designed with floor-to-ceiling windows to serve as a relaxation space outside of sleeping hours, improving space utilization and reducing waste.

Additional modules primarily provide service functions, focusing on storage space. These can include wardrobes, shelving units, and custom or built-in storage cabinets and rooms. The design should maximize space usage and improve space efficiency, enhancing the overall living experience for guests.





	Name	Description	Illustrative Image
Optional Module Units	Living Room	Positioned in the middle	
		Positioned at both ends	
	Dining Room and Kitchen	Co-designed with bathroom	
		Co-design with the corridor	

Figure 3. Location diagram of the required module unit.




	Name	Description	Illustrative Image
Essential Module Units	Bedroom	Positioned in the middle	
		Positioned at both ends	
	Bathroom	Located centrally	
		Positioned at the top	

Figure 4. Location diagram of the required module unit.

4.3. Functional Space Organization Patterns

The functionality of movable prefabricated vacation homes can be as simple as providing only a sleeping space, or as complex as traditional residences with full living and entertainment facilities [3]. The organization patterns are generally divided into single units and unit combinations. A single unit typically consists of a sleeping space and a bathroom, fulfilling basic needs. Unit combinations, on the other hand, offer various space organization patterns (Figure 5) to meet diverse requirements.

A sleeping space combined with a bathroom is a common layout in vacation accommodations. This design typically features 1-2 bedrooms with the bedroom directly adjacent to or connected to the bathroom, suitable for 2-3 people for short-term stays, fulfilling the basic needs for sleeping and bathing.

This combination allows for flexible design based on space size and primarily uses an open-plan layout. The living room, kitchen, and bathroom are integrated without clear partitions. This open design enhances spatial flow and transparency, making the entire space appear more spacious and bright.

This spatial pattern focuses on larger spaces and is more suitable for family stays and long-term occupancy. The bedroom serves as a private space, separated from the living room, kitchen, and bathroom to provide privacy and comfort. The living room and kitchen are connected, facilitating interaction and communication among guests, while the kitchen is separated from the living room and bedroom to prevent cooking odors from affecting other areas, maintaining cleanliness and comfort. The bathroom is connected to the bedroom for convenience. This layout is flexible and adaptable to various unit types and needs.

In addition to the above organizational patterns, there are many other combinations. Since modules are prefabricated in the factory, they can be assembled according to specific needs, allowing for highly flexible and convenient layouts.

Name	Spatial composition	Illustrative Image	Interior renderings
Functional Space Combinations	Bedroom + Bathroom		
	Two Bedrooms + Bathroom		
	Bedroom + Living Room (Top Position) + Bathroom		
	Bedroom + Living Room (Middle Position) + Bathroom		
	Living Room + Bathroom + Kitchen		
	Bedroom + Living Room + Dining Kitchen + Bathroom		

Figure 5. Functional space combination.

4.4. Modular Design of Indoor Furniture

Modular design of indoor furniture is not only applicable to vacation homes but is also a trend in modern decor, offering users greater flexibility and customization. Furniture is designed as independent modules that can be combined according to needs, fulfilling various functional requirements. Modular design helps save production and transportation costs for vacation homes, adapts to different spaces, and maximizes space utilization.

The functional needs of vacation homes vary over time. During the day, more living space is required, while at night, more sleeping space is needed. Modular furniture can be easily adjusted and reconfigured to meet the changing needs at different times.

Furniture modularity can be categorized into single-function modules and modules that integrate multiple functions. Considering that vacation homes often have limited space, multifunctional furniture modules are commonly used. For example, stair storage cabinets combine the staircase structure with storage functionality, utilizing the space underneath the stairs. Similarly, multifunctional sofas integrate seating, storage, and sleeping

features (Figure 6).

To optimize space and reduce waste, using modularly determined furniture has significant advantages. Statistical analysis of major furniture items shows that expanding by integer multiples of 150mm aligns with the dimensions of most furniture^[4]. Therefore, the basic modular setting for furniture design in vacation homes is set at 150mm, with expansions based on usage needs.



Name	Illustrative Image
<p>Staircase Storage Cabinet</p>	
<p>Multi-Functional Sofa</p>	

Figure 6. Multifunctional Furniture Combination Methods.

4.5. Inter-Module Connection Methods

The connection methods between modules significantly affect the structural performance of modular buildings, such as lateral stiffness and load-bearing capacity^[5]. Typical inter-module connection methods include bolted connections, mortise and tenon connections, and interlocking connections.

Bolted connections use bolts, nuts, and bolt holes to securely join modules together. By adjusting the tightness of the bolts, the degree of firmness between the connecting components can be flexibly controlled, adapting to different installation requirements and working conditions. Compared to welding, bolted connections are easier to install, require less on-site work, and are suitable for various materials used in vacation homes.

Mortise and tenon connections are a classic method inherited from traditional Chinese architecture. This method involves creating corresponding tenons and mortises on the connecting components, allowing them to fit precisely and form a strong connection. This technique is known for its high precision, structural stability, and aesthetic appeal, and is mainly used in wooden modular vacation homes.

Interlocking connections involve components fitting together through interference or deformation, and can be connected after the construction of partition walls or other building elements. This method supports modular operations at the building level but requires careful attention to minimize precision errors.

5. Design and Construction Integration—Application of BIM Technology

BIM technology, with its features of visualization, coordination, simulation, and lifecycle management,

aligns well with the “five-in-one” requirements of prefabricated building design, production, construction, decoration, and management ^[6]. Design teams can engage in real-time collaborative design within the model, quickly adjust design plans, and improve design efficiency and quality.

During the design phase, BIM technology is used for clash detection to identify and resolve conflicts and interferences between building components early on.

In the construction phase, BIM technology aids in developing construction plans and managing construction schedules. The construction team can simulate and optimize the construction process using BIM models.

After the vacation home is built, a digital operation and maintenance management system is established, recording and managing maintenance records, update schedules, and operational data of building equipment. This extends the lifespan of the vacation home and reduces operational costs.

6. Conclusion

The modular design of movable prefabricated vacation homes injects new vitality and innovation into the construction industry. By dividing buildings into modular units and utilizing factory production and on-site assembly, construction can more flexibly respond to different needs and scenarios. Compared to traditional vacation hotels, modular vacation homes offer advantages such as higher efficiency, faster construction speed, environmental sustainability, and greater personalization. These features align with the development trends in the construction industry and adhere to the principles of sustainable development. As the construction industry continues to evolve, modular vacation homes are expected to have a brighter future. We can look forward to more intelligent and digital vacation home designs that leverage smart systems and digital technologies to provide a more convenient and comfortable living experience for vacationers.

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