Abstract. This chapter highlights the significance of three-dimensional ecological architecture as a crucial direction for the development of green architecture in China. The design concept is centered around four main principles: green, energy-saving, user-friendly, and ecological circulation. This case analysis demonstrates the effectiveness of incorporating ecological elements and sustainable design strategies into building structures, resulting in reduced energy consumption, improved indoor environmental quality, and enhanced biodiversity. The chapter explores the development trends and insights derived from one case study, providing valuable references for China’s future advancement of green architecture.

1 Introduction

The rapid economic growth and the improvement of residents’ quality of life have caused society to put forward higher-level requirements for building quality and environmental standards. As my country further advances its goal of “carbon peaking and carbon neutrality”, the interconnection, influence, and importance between the ecological environment and urban development have become increasingly prominent. It is obvious that traditional architectural design concepts have limitations in meeting the urgent needs of contemporary society for sustainable and eco-friendly living spaces. In view of this, this study aims to provide a solid theoretical foundation for the field of ecological architecture. It will be of great significance to further explore the intrinsic relationship between the “double carbon goals” and ecological buildings. To this end, this study will start from the macro perspective of the residential industry and gradually refine it to the specific design principles and practices of three-dimensional ecological buildings to promote the smooth progress of this transition[1].

1.1 Green ecological, people-oriented design concept

The housing industry, green, ecological, and people-oriented design concepts have gradually become a development trend. These concepts emphasize the integration of urban planning, architecture, and ecosystems to promote a harmonious relationship between humans and nature. By utilizing this type of design, developers can build structures that not only meet the aesthetic and practical needs of residents, but also contribute to environmental sustainability.

1.2 Three-dimensional ecological footprint model

The three-dimensional ecological footprint model is an extension of the traditional ecological footprint model, which considers the area of biologically productive land, ecological carrying capacity, and biodiversity dimensions. Such models help to more comprehensively assess the impact of human activities on ecosystems. Natural capital accounting is a method of valuing natural resources and ecosystem services. In three-dimensional ecological research, natural capital accounting usually involves distinguishing and evaluating the flow and stock capital of ecosystems. Ecosystem services refer to the direct and indirect benefits that natural systems provide to humans. Three-dimensional ecological research focuses on how to integrate and enhance these services in urban planning and architectural design. Urban greening and ecological restoration are important components of three-dimensional ecological research, involving the ecological restoration of urban space and the construction of green infrastructure.

1.3 Purpose

This chapter aims to study the design ideas and practical applications of three-dimensional ecological buildings. By examining the benefits and difficulties of implementing these concepts, we attempt to provide a benchmark for the progress of green building in China. Research on three-dimensional ecological architectural design concepts will help promote the integration of...
ecological design and architectural design, and contribute to the construction of a more sustainable and humane urban environment.

1.4 Research Framework

2 Concept and characteristics of three-dimensional ecological architecture

2.1. Definition

Three-dimensional ecological architecture is an architectural design that harmoniously integrates various dimensions and elements of the natural environment. This design places special emphasis on the sustainable use of resources and the symbiotic relationship between man and nature. This is an innovative approach to address environmental challenges and promote ecological balance in the built environment[2].

2.2 Features

a) Space utilization

One of the primary features of three-dimensional ecological architecture is the effective use of space. This involves vertically integrating various functional areas such as living spaces, workplaces and recreational facilities within a compact footprint. This not only saves land resources, but also creates a more diverse and integrated living environment[3].

b) Ecological cycle

Three-dimensional ecological architecture emphasizes the importance of ecological circulation and biodiversity. It promotes the use of renewable energy, water-saving technologies and waste management strategies to minimize environmental pollution[4]. Furthermore, it encourages the creation of green spaces and the integration of natural ecosystems such as parks, gardens and wetlands to enhance biodiversity and provide ecological services.

c) Energy saving and emission reduction

The primary goal of three-dimensional ecological buildings is to minimize energy consumption and reduce greenhouse gas emissions[5]. Achieving this goal requires the implementation of energy-efficient systems such as insulation, lighting and HVAC systems, as well as the incorporation of renewable energy sources such as solar and wind. In addition, the design incorporates green building materials and sustainable construction methods to reduce the building's environmental impact throughout its life cycle.

d) Harmony between man and nature

The core is the concept of harmonious coexistence between man and nature[6]. The design strives to create a balanced relationship between the built environment and the natural world, aiming to promote biodiversity, clean air and water, and a sense of community. By integrating natural elements and sustainable practices into the built environment, three-dimensional ecological buildings foster a greater appreciation of the natural world and encourage residents to adopt environmentally conscious lifestyles.
3 Three-dimensional ecological building design concept

3.1 Green building design

Green building design fully considers natural conditions such as terrain, climate, water sources, etc., to achieve the integration of architecture and nature. This concept focuses on the significance of the harmony between man-made structures and surrounding environment[7]. By considering the unique characteristics of each site, architects can create buildings not only minimize the ecological footprint but also contribute to the overall sustainability of the landscape.

3.2 Energy efficiency and environmental protection

Energy efficiency and environmental protection are important aspects of three-dimensional ecological buildings. By adopting green building technologies, architects can significantly reduce a building's energy consumption and minimize its environmental burden. Strategies such as insulation, natural ventilation and the use of renewable energy can help reduce energy consumption while maintaining a comfortable indoor environment.

3.3 Humanized design

Human-centered design focuses on the needs of individuals and families to enhance the comfort and quality of life in living spaces. This concept takes into account factors such as space layout, lighting, ventilation, sound insulation, etc. to create a healthy and pleasant living environment. By prioritizing occupant well-being, architects can increase building user satisfaction and productivity.

3.4 Ecological cycle

Ecological recycling refers to the creation of an internal ecosystem within a building to achieve resource reuse and environmental sustainability. This concept involves the integration of various ecological elements such as plants, water bodies, and waste management systems[8]. By promoting recycling of resources and minimizing waste, eco-cycling can contribute to a building’s overall sustainability and environmental performance. The three-dimensional ecological innovation building gives full play to the unique advantages of the "sky courtyard", perfectly fits the vertical greening theme, and maximizes the urban greening area on limited land. Green infrastructure such as urban forests, street trees, parks, green spaces, green roofs, gardens, and green walls can have a certain cooling effect on cities. In temperate climate areas, every 10% increase in green infrastructure can reduce the average urban temperature by 2.5 °C, thereby alleviating the frequency and radiation of urban heat island problems[9].

3.5 Innovation and practice

Innovation and practice are crucial to the advancement of three-dimensional ecological architecture. Architects and designers must continually explore new building forms, materials and construction techniques to reduce the environmental impact of buildings. By pushing the boundaries of traditional building practice, designers can create more efficient, sustainable and resilient structures that meet the changing needs of society.

4 Application cases analysis of three-dimensional ecological building design

Case: Fourth-generation ecological residential design in Fujian

a) Design Features: Fuzhou Jinshan Residential Project is a newly developed residential community in 2022. The project is located in Fuzhou City, covering an area of 17,463 square meters, with a total construction area of 47,359 square meters and a plot ratio of 2.0. The project plans seven secondary high-rise residential buildings with a building height limit of 50 meters. The architectural layout of the project is carefully designed to ensure the privacy of the residence while maintaining a good sight corridor with the surrounding park, allowing residents to enjoy the beautiful natural landscape. In addition, the single-plan design of the project adopts a wide layout with one staircase and two households, providing a spacious and comfortable living space. According to the project plan, Fuzhou Jinshan Residential Project also pays special attention to the construction of sky gardens and vertical greening. The setting of the sky garden not only provides residents with space for leisure and entertainment, but also increases the green area of the building and improves the ecological quality of the living environment. Vertical greening is the greening arrangement on the building facade, which not only beautifies the appearance of the building, but also plays a role in energy conservation and emission reduction. In addition, the project focuses on the sustainability and environmental friendliness of the building. In the selection of building materials, environmentally friendly, energy-saving, and low-carbon materials are given priority, such as green building materials, high-performance insulation materials, etc. In the architectural design, natural ventilation and lighting are fully considered to reduce reliance on air conditioning and other equipment and reduce energy consumption.

Overall, the Fuzhou Jinshan Residential Project is a high-quality residential community that combines comfort, ecology and sustainability. It not only meets residents’ needs for a high-quality living environment, but also embodies China’s commitment to green buildings and ecology. Pay attention to urban construction[10]. See Figure 1 for details.
Implementation:

In the Fuzhou Jinshan residential project, the design of the sky garden is a highlight. It not only provides residents with a leisure space, but also adds to the ecological function of the building. The following is a more detailed description of sky gardens, sky streets, building waterproofing and organizational drainage:

① Sky Garden

The sky gardens are designed to provide residents with a green space close to nature. The tree planting platform can be designed as a single or double layer, and the height of the overhanging part is at least twice that of the natural ground to ensure sufficient visual impact and sense of space. The design of the staggered tree planting platform is open but not closed, and there is no enclosure structure to ensure the continuity and permeability of the landscape. The green area on the platform should be no less than 60% of its horizontal projected area, so as to not only meet the greening needs, but also maintain a good landscape effect. See Figure 2 for details. The part of the balcony attribute, that is, the part with an overhang size of less than 1.8m, is calculated according to half of the horizontal projected area of the structural layer, while the part with a cantilever size of more than 1.8m is not included in the property area.

② Sky Alley

The sky alley is another innovative design in the project. It is an open public leisure and green platform with a height of at least two floors of the natural ground. Such a design not only provides space for interaction between residents, but also creates a shared green environment. Sky streets are not included in the floor area ratio or property area. It is a public space shared entirely by residents.

③ Building waterproofing

In view of the climate characteristics of Fuzhou, the building structure of the sky garden needs to adopt the "first-level waterproofing" standard, which means that there should be at least two waterproof layers, one of which is a root-blocking waterproof layer. During the design and construction process, a plastic film or geotextile isolation layer should be installed between the waterproof layer and the protective layer to prevent damage during construction. Such a design can effectively handle and extend the service life of waterproof materials, ensuring the long-term stability and reliability of the sky garden.

④ Organizational drainage

The drainage design of the garden floor is the key to ensuring the long-term use of the hanging garden. It is recommended that the sinking plate be designed with an inclination of 2% to 3% of the structure, which can reduce the structural load while ensuring effective drainage of water. Set up a drainage outlet and balcony drainage pipe every 3 to 5 meters, and organize downspouts to ensure the dryness of the garden ground. Pipes should be hidden in the interior corners of the building and combined with the exterior decoration or landscape of the building. Climbing plants should be the main ones, and the consistency of color, space size and shape should be maintained to achieve a harmonious and beautiful effect.

b) result:

In the fast-paced life, people long to find a quiet oasis in the hustle and bustle of the city and enjoy a slow life in harmony with nature. Three-dimensional, ecological and sustainable organic architecture was born to meet this demand. This architectural form can not only improve the quality of life of urban residents, but also shape a new image of the city. Taking the Jinshan residential project in Fuzhou as an example, it creates a three-dimensional, ecological and sustainable living environment through design elements such as sky gardens and sky streets. These designs not only beautify the urban landscape, but also provide residents with a leisure space close to nature. Here, people can stay away from the hustle and bustle of the city and enjoy a quiet and slow life. This organic architecture also embodies respect for nature and is eco-friendly. By setting up root-blocking waterproof layers, organizing drainage and other designs, the project not only protects the ecological environment, but also ensures the long-term stability and reliability of the building. This architectural form not only helps reduce energy consumption and environmental pollution, but also improves the city's adaptability and resilience to cope with environmental challenges such as climate change. In the interior space design, the project fully considers traditional architectural elements such as lighting and ventilation to provide residents with a comfortable and livable space. This organic architecture also embodies the spirit of
innovation. By adopting new technologies, new materials and new design concepts, the project provides a new possibility for urban architecture. This innovation is not only reflected in architectural form and function, but also in thinking about urban development and concern for the ecological environment.

In short, three-dimensional, ecological, and sustainable organic buildings, such as the Fuzhou Jinshan Residential Project, not only meet people's needs for material and spiritual life, but also shape a new image of Fuzhou as the provincial capital, opening the door to urban prosperity, respect for nature, and ecology. A new chapter in friendship and continuing the tradition. This architectural form will become the trend of future urban development, creating more beautiful living spaces for people.

5 Three-dimensional ecological building design trends and insights

5.1 Trends: green, intelligent, and sustainable development

The development of three-dimensional ecological buildings follows the three major trends of green, intelligent and sustainable. The green trend emphasizes integrating natural elements into architectural design, aiming to reduce the negative impact of human activities on the environment. The smart trend involves the application of advanced technologies such as artificial intelligence and building information modeling (BIM) to improve the energy efficiency and environmental performance of buildings. Sustainable trends focus on the long-term viability of construction projects, taking into account economic, social and environmental factors.

5.2 Insights

a) Strengthen policy support and promote the development of green buildings

The government should formulate and implement policies to encourage and regulate the development of green buildings. This includes providing incentives for developers and builders to adopt environmentally friendly design principles and imposing stricter regulations on energy consumption and environmental impact.

b) Improve the technical level of the construction industry and innovate design concepts

The construction industry must continuously improve its technical capabilities and adopt innovative design concepts that prioritize environmental sustainability, such as the development of new building materials, energy-saving technologies and smart building systems.

c) Popularize green building knowledge and raise public awareness

Education and awareness campaigns should be launched to increase public awareness of the importance of green buildings and associated benefits. This will encourage greater demand for eco-friendly buildings and promote a more sustainable built environment.

d) Strengthen international cooperation, learn from advanced experience, and promote the development of green buildings in our country

China should actively participate in international exchanges and cooperation and learn from other countries’ advanced experiences in green building development. By adopting mature technologies and design concepts, China can accelerate the development of its own green building industry and contribute to global sustainable development goals.

6 Summary

This article highlights the key role of three-dimensional ecological buildings in the development of green buildings in China, especially in addressing environmental challenges and promoting sustainable development. The design concept of the three-dimensional ecological building focuses on the four core principles of greenness, energy saving, humanization and ecological recycling, aiming to minimize the impact of the building on the environment while improving resource utilization efficiency and occupant comfort.

In Chapter 3, the practical application of three-dimensional ecological architecture is demonstrated through case analysis, proving the effectiveness of integrating ecological elements and sustainable design strategies into building structures. These strategies help reduce energy consumption, improve indoor environmental quality, and enhance biodiversity.

The chapter concludes with a discussion of the development trends and insights from the case studies, which provide a valuable reference for the future development of green buildings in China. Key insights include the integration of advanced technologies, active stakeholder engagement, and policy implementation to drive green building practices.

Overall, research on three-dimensional ecological buildings reveals their potential in solving environmental problems and promoting sustainable development in China. The design concept emphasizes the importance of integrating green and sustainable practices into building design and operations. The case study provides valuable insights into the practical application of three-dimensional ecological buildings and points out a promising direction for the future development of green buildings in China.

References


