

Green Building Design Method and Green Material Application

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Abstract. In the context of global carbon emission reduction and low-carbon economic development, green building is a key measure to solve environmental problems. Through the application of green building design methods and green materials, the sustainable development of the construction industry has been significantly promoted. Green buildings aim to improve living comfort by saving energy, reducing emissions and using environmentally friendly materials, while minimizing environmental impact. The study covers all aspects of roof design, energy saving technologies, insulation measures, greening measures and the development of renewable materials, highlighting the importance of technological innovation, policy support and public awareness in the face of challenges such as high initial costs and technical barriers. Green buildings not only improve indoor and outdoor environmental quality, but also have long-term economic benefits, especially in promoting public environmental awareness and promoting green technologies. This research provides a theoretical and practical basis for promoting greener, environmentally friendly and sustainable approaches to building design and construction.

Keywords: Green building, sustainable development, energy efficient design, eco-friendly materials, low carbon economy.

1. Introduction

Low-carbon buildings under the goal of "double carbon" are an inevitable product of the development trend of global low-carbon economy [1]. Due to its potential to support sustainable development, green buildings have drawn interest from all around the world at a time when the environment is experiencing previously unheard-of issues. Green buildings try to reduce their negative effects on the environment while giving people a more comfortable and healthier place to live. They do this by implementing energy saving, emission reduction, and environmentally friendly design and construction techniques. Though the idea of "green building" is becoming more and more popular, there are still many obstacles in the way of its actualization, such as those related to technical execution, financial costs, legislative backing, and market awareness.

A thorough awareness of resource overuse, ecological environment degradation, and global climate change is the foundation of the green building idea. Since buildings are the primary locations for human activity, the environmental impact of these structures has gained prominence as urbanization and population expansion accelerate. Thus, the question of how to accomplish sustainability in the building industry has emerged as a pressing issue that requires attention. Green buildings are thought to be a good approach to address this issue because of its many benefits, which include reduced environmental impact, improved living standards, and energy and carbon savings. To make the transition from concept to broad application, green buildings still face a number of challenges.

The complexity, high cost and difficulty of the promotion and implementation of new materials and new technologies are the main manifestations of technical problems. From an economic perspective, green buildings offer long-term financial advantages. However, many investors are put off by the high initial cost. From the policy point of view, although governments at all levels have begun to introduce targeted relief measures, the specific effect of the implementation of these policies is still unclear. The market's ignorance and vague demand for green buildings have also caused great obstacles to the promotion process of green buildings. Therefore, the comprehensive application of innovation and traditional methods can play an important role in reducing the load of buildings on the environment, that is, saving energy and resources, reducing carbon emissions, providing safe,

healthy and comfortable living space, and realizing the harmonious coexistence and sustainable development of people, buildings and the environment [2].

This paper discusses specific design strategies for green buildings, including roof design, energy saving measures, insulation techniques and green practices. Evaluate the benefits of using environmentally friendly materials such as renewable building materials, low volatile organic compounds (VOCs), and highly efficient insulation. This paper aims to demonstrate the importance and practical results of green building in promoting sustainable development, reducing environmental impact and improving residential comfort, and provide theoretical and practical basis for sustainable development of the construction industry.

2. Green Building Structure Design

2.1. Roof Design

Roof design occupies the core position in green building, the key is to minimize the impact on ecological environment and maximize the welfare of occupants. An innovative roof not only collects and manages rainwater for use in the building's interior and surrounding greenery, but also improves the quality of natural lighting through design optimization. Using efficient materials and design, roofing can be transformed into an ecologically positive component, providing habitat for biodiversity and improving the microclimate of the city through a green layer [3].

The roof design also includes smart management of natural resources, such as the use of rainwater harvesting systems to reduce reliance on groundwater and municipal water supplies. Such systems not only reduce municipal drainage pressure, but also provide a model for sustainable urban water management [3]. In addition, through the carefully designed roof green space, the roof can improve the quality of the outdoor space of the building, providing an interactive environment for residents and urban wildlife.

In order to achieve these goals, the roof design considers the choice of materials, the technique of construction, and the coordination with other design elements of the building to ensure the durability and functionality of the roof. Every decision, from the slope of the roof to the choice of materials, is designed to optimize energy use and enhance the building's environmental adaptability.

The innovation of roof design is not only reflected in its function, but also in its contribution to architectural aesthetics. A roof with a roof garden not only adds to the visual appeal of the building, but also provides a unique urban oasis where occupants can find natural solace in busy city life.

In summary, an integrated approach to roof design helps shape a healthier and more sustainable built environment. By considering the maximum use of natural light, the proper management of water resources and the increase of ecological value, roofing becomes an integral part of green buildings and contributes to the achievement of sustainable development goals.

2.2. Energy Conservation Design

Energy efficient design plays a central role in the practice of green building, involving several key aspects such as building orientation, lighting and ventilation, with the aim of reducing energy requirements while increasing comfort and sustainability. The orientation of a building is key to energy efficiency and the use of natural resources. By optimizing the south-facing window layout, solar heat absorption can be maximized in winter, while overheating can be reduced in summer through shading design. North-facing Windows can be used to keep the interior cool and reduce reliance on air conditioning. Proper building orientation can significantly reduce the need for artificial lighting and heating, improving energy efficiency and residential comfort.

Daylighting design emphasizes maximizing the use of natural light. Reasonable window design and placement can improve the quality of indoor lighting and reduce the reliance on artificial lighting. Efficient daylighting not only saves energy, but also enhances people's living and working experience. The use of glass with high light transmission properties and appropriate window size can further enhance this effect.

Ventilation is designed to maintain indoor air quality through natural methods. The design takes into account the shape of the building, the position of the Windows and the proper layout of the vents, which can use the natural flow of the wind to regulate the temperature and improve the air circulation, thus reducing the reliance on mechanical ventilation. Proper ventilation strategies can reduce humidity, prevent mold growth, and create a healthy indoor environment.

The energy efficient design of buildings is not only concerned with reducing energy consumption, but also how to improve the comfort and health of occupants. This design direction has received significant attention in recent years. In the design, factors such as building orientation, lighting and ventilation are comprehensively considered in order to achieve the optimal use of natural resources, improve the indoor environment quality, and reduce the building's dependence on external energy. The orientation of the building is optimized to make full use of solar energy, reducing energy requirements for heating in winter and cooling in summer. Efficient use of daylighting design can significantly reduce the need for artificial lighting, while effective ventilation design helps to maintain indoor air quality and enhance the health and comfort of occupants. These design elements together form an overall energy conservation strategy, which has become an indispensable part of modern architectural design and provides a practical path for the sustainable development of the construction industry [4].

To sum up, energy-saving design in green buildings is not only a technical means to achieve sustainable development, but also an important consideration to improve the quality of life of residents. By effectively utilizing natural resources and combining with modern energy-saving technologies, green buildings provide a blueprint for energy saving, emission reduction and environmental friendliness for future buildings through innovative energy-saving design strategies [5].

2.3. Thermal Insulation Design

Thermal insulation design plays an important role in the energy-saving strategy of green buildings, which aims to reduce the energy consumption of buildings and improve the living comfort. Effective insulation can significantly reduce a building's heating and cooling needs, thus playing a significant role in energy consumption throughout the year.

In green buildings, the thermal insulation effect of external walls has a great impact on the overall energy consumption of the building. Materials with high insulation properties, such as polystyrene foam and rockwool, should be used in the design, which can effectively reduce heat conduction through the exterior wall, some of which are shown in Table 1. At the same time, reasonable building shape coefficient design is also a key strategy to reduce heat loss. By reducing the surface area of the building, unnecessary heat exchange can be reduced, thus reducing energy consumption.

Table 1. Material Heat Conductivity [6]

Material	Vacuum insulated panel	Foamed polyurethane	Rock wool board	Domestic extruded polystyrene board
Heat conductivity coefficient [W/(m·K)]	0.008	0.024	0.04	0.028~0.030

The window design of green buildings cannot be ignored, and high efficiency Windows, such as double or triple glazing, should be used with high insulation performance of the frame to minimize the heat loss of the window. In addition, the proper placement of Windows can not only optimize natural lighting, but also prevent too much solar radiation from entering the room, reducing the need for cooling. The application of hollow wall or composite wall structure is also an effective means to improve the insulation performance of wall.

In addition to the above measures, green buildings should also utilize passive design strategies such as roof greening to further improve thermal efficiency. Roof greening can not only absorb

rainwater, but also reduce the temperature difference between indoor and outdoor, and increase the insulation effect of the building. At the same time, green buildings should utilize renewable energy technologies, such as solar panels, to reduce dependence on traditional energy sources and reduce operating costs.

When summarizing the thermal insulation design of green buildings, the emphasis should be placed on the use of efficient thermal insulation materials, the optimization of building shape coefficient, the scientific design of Windows, and the application of passive and active energy-saving technologies. The combination of these strategies not only helps to achieve the goal of energy conservation and emission reduction, but also provides a healthy and comfortable living environment.

2.4. Greening Design

As an indispensable part of green buildings, green design emphasizes the integration of natural elements in architectural design to create a harmonious living environment. In the context of modern urbanization, green design not only beautify the urban landscape, improve the quality of life, but also help to mitigate the urban heat island effect, increase biodiversity, improve air quality, and improve the urban microclimate has an irreplaceable role. The green design is also related to the physical and mental health of residents, providing a natural and friendly space for residents to rest and interact [7].

The key to green design is to create an environment that is both suitable for human habitation and harmoniously integrated into nature. The greening design should follow the principle of "people-oriented" and provide healthy, applicable and efficient use of space. In addition, the designer should take into account the importance of energy saving and consumption reduction in the greening design, and reduce the energy consumption of the building through reasonable greening, and promote energy saving and environmental protection. Greening design should not only beautify the building and provide a comfortable living environment, but also pay attention to economy in the design to ensure the economic applicability of the design scheme [7].

In the actual greening design, designers should optimize the layout of greening, pay attention to the selection and configuration of greening plants, and use native plants as much as possible to ensure the sustainability of greening. At the same time, the greening design should fully consider the overall layout and spatial function of the building, and realize various forms of greening design such as roof greening, facade greening, indoor and outdoor gardening, aiming to create a comprehensive green living environment. In this way, green design can not only provide aesthetic visual enjoyment, but also provide ecological benefits, such as improving air quality, providing leisure space, and increasing green space in the city [7].

Overall, green design should be a fundamental consideration in the building design process, which is closely linked to the building's energy efficiency, material use and environmental protection. Through the deep integration of green building technologies in design, green design is expected to become an important force driving society towards a greener, environmentally friendly and sustainable direction.

3. Green Building Materials

3.1. Renewable Building Materials

The concept of renewable building materials stems from the need for sustainable development in the construction industry, which includes a comprehensive consideration of the life-cycle impact of building materials. These materials not only require minimal ecological impact in the acquisition of their raw materials, but also embody a high degree of environmental protection and sustainability in every link of manufacturing, use and even final disposal.

The use of renewable building materials is expanding. For example, materials such as biobased plastics and biomass panels are used for walls and floors, often made from agricultural by-products or recycled fibers, reducing reliance on traditional petroleum-based plastics and reducing greenhouse

gas emissions. Wood derived from sustainable forest management, on the other hand, not only has a small ecological footprint, but also provides a durable aesthetic effect in architecture [8].

Another important direction of renewable building materials is the use of natural building materials, such as earth, stone, bamboo and wood. These materials are often able to be used directly with little or no processing, thus retaining their natural properties and environmental value. For example, the use of clay and adobe is back in vogue in some regions, not only because of their environmentally friendly nature, but also because of their unique comfort and aesthetics [9].

In modern green building design, the integrated use of rainwater recycling, solar energy and geothermal energy has become an important strategy to improve building energy efficiency and environmental standards. Rainwater recycling system collects rainwater from the roof and ground, and after purification treatment, it is used for irrigation and toilet flushing, etc., which not only relieves the pressure of urban water resources, but also reduces urban waterlogging caused by rainwater runoff. The process is shown in Fig. 1. Solar energy utilization, through solar collectors and photovoltaic panels, converts and stores solar energy to provide clean energy for buildings and reduce the need to rely on traditional energy. As shown in Fig. 2, geothermal energy is utilized through technologies such as ground source heat pump systems, which use the constant temperature characteristics of the underground to heat or cool buildings. The integration of these renewable energy technologies greatly improves the energy efficiency and environmental friendliness of buildings. Through these strategies, green buildings not only reduce operating costs, but also provide a comfortable living or working environment for their occupants, while also contributing to the sustainable development of the city.



Fig. 1 Rainwater Recovery System [3]

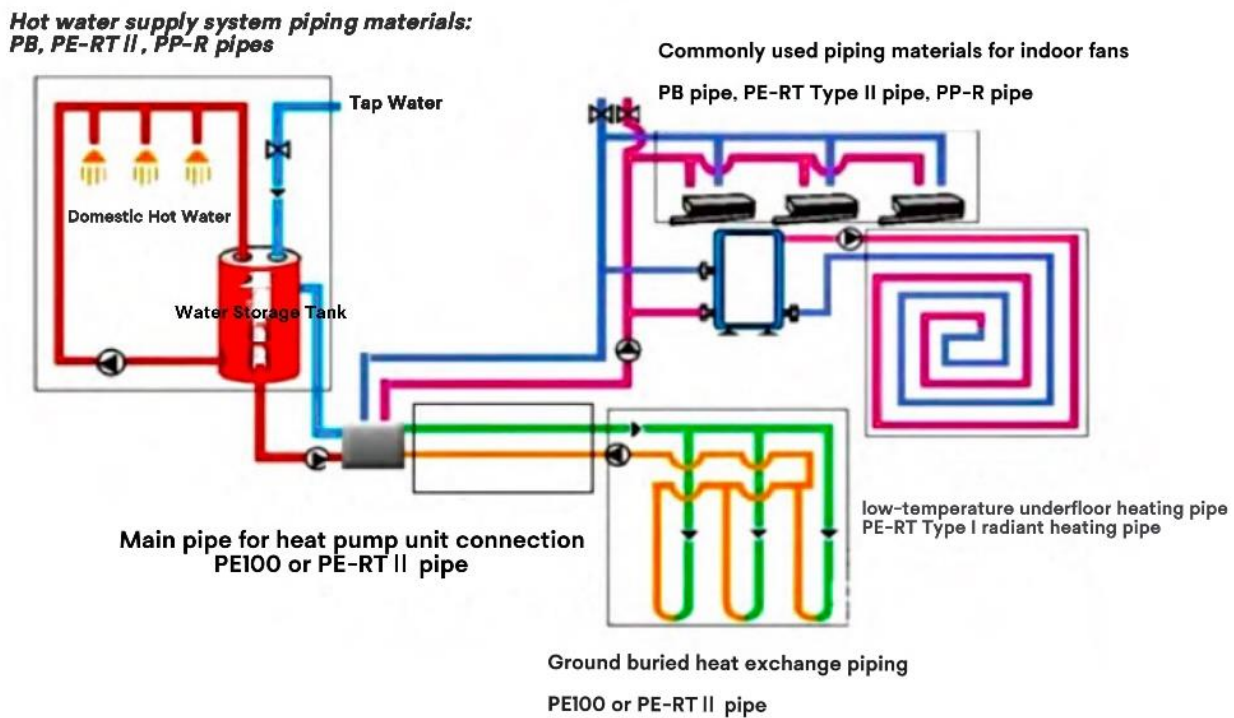


Fig. 2 Operation principle of ground source heat pump system [3]

The development of renewable building materials is not limited to the environmental benefits of the materials themselves, but also how to use these materials to create a healthier, more environmentally friendly indoor environment. For example, the use of non-toxic or low-toxic materials can improve indoor air quality and avoid harmful chemicals that can be released by traditional building materials [9].

In the future, the development potential of renewable building materials is huge. With the adoption of green building standards and certification systems, it is expected that the construction market will see widespread use of renewable building materials, which will bring significant benefits to the sustainable development of the construction industry, the health of occupants and the global environmental protection goals.

3.2. Low VOCs

The management of low VOCs is an important consideration in the selection of green building materials. These compounds are commonly found in traditional building materials, such as paints, adhesives and cleaners, and in high concentrations in indoor air can pose a health risk to occupants. Therefore, green building aims to reduce indoor pollution and improve air quality, which requires strict control of VOCs emissions in the selection and use of building materials [10, 11].

Research shows that the main emissions of building VOCs come from building decoration, architectural coatings and architectural wood materials. Therefore, green buildings are increasingly choosing products labeled with low or no VOC when using these materials. For example, use water-based paints instead of traditional oil-based paints, or choose wood and flooring that have been specially treated to inhibit VOC release [10].

In addition, the study of VOCs emission reduction behavior in residential buildings provides important insights for understanding residents' environmental behavior intentions and actual behaviors. For example, improving residents' environmental awareness and sense of behavioral control can significantly increase their intention to reduce the use of high VOCs products, thereby actually reducing the level of indoor VOCs. This behavioral shift is of great significance for promoting the participation of the whole society in the emission reduction of building VOCs, which can significantly improve the quality of the living environment.

In summary, low VOC building materials not only improve the indoor environment and reduce potential hazards to human health, but also support the long-term sustainability goals of green buildings. With the increasing awareness of consumers and the construction industry on healthy living environment, it is expected that the demand for low VOC products in the market will grow, which will promote the development and application of green building materials [12].

3.3. Environmental Protection Materials

The choice of environmentally friendly materials plays a pivotal role in the construction of green buildings, not only in terms of minimizing the environmental impact of the materials, but also in terms of their positive contribution to the environmental quality inside the building. Environmentally friendly materials can significantly reduce the temperature difference between indoor and outdoor due to their low thermal conductivity, such as polymer foam insulation materials and inorganic materials, which effectively reduce the exchange of hot and cold air, improve indoor comfort, and reduce energy consumption [13].

The use of environmentally friendly materials in green buildings means selecting materials with minimal impact on the environment and human health. These materials are often sourced from sustainable sources, such as wood produced using certified sustainable forestry or products made from recycled materials. They have the potential to be recycled, reducing the need for raw materials while also reducing the production of construction waste. These environmentally friendly materials also include non-toxic or low toxic options, such as paints and coverings made using natural or bio-based materials that contain no or only very low amounts of hazardous substances, ensuring the safety of the indoor environment and avoiding the potential risk of harmful chemicals.

Future trends in green building materials will place greater emphasis on the use of renewable raw materials, such as bamboo and wood, recycled metals and degradable plastics, to reduce dependence on limited resources. In addition, the recycling and reuse of building materials will also be more promoted to reduce the generation of construction waste and maximize the use of resources. The choice of materials will pay more and more attention to the health and comfort of the occupants, avoid the use of materials containing harmful substances, such as formaldehyde, VOC, etc., while the maintenance and cleaning of materials will become easier to ensure the health and hygiene of the indoor environment.

To sum up, the wide application of environmentally friendly materials plays a vital role in the practice of green buildings, not only because of its advantages of energy saving and emission reduction, but also because of its significant contribution to improving the quality of the living environment. With the continuous progress of technology and the improvement of public awareness of environmental protection, it is expected that the use of environmentally friendly materials will become the standard configuration of building design and construction, and promote the development of the construction industry in the direction of more binding input equipment and more environmental protection.

4. Conclusion

In this paper, the methods and challenges of green building design are comprehensively discussed, and the innovative practices of green building in structural design, material selection, and utilization of renewable resources are deeply analyzed. It can be concluded that while green buildings may face high initial costs and technical barriers, these challenges are worth overcoming given their significant contribution to promoting sustainable development, reducing environmental impact, and improving living comfort. Green buildings can not only reduce operating costs, but also bring broader benefits to society, such as raising public awareness of environmental protection and promoting the development of green technologies. The development of green buildings will depend on technological advances, policy and regulatory support, cost reduction and public awareness. Technological innovation, including more efficient energy use and more advanced building materials and

construction techniques, will be key to driving green buildings forward. At the same time, governments need to develop more incentives and standards to promote the widespread use of green buildings. Increasing public awareness of the value of green buildings and increasing market demand are also indispensable. With the continuous improvement and advancement of these aspects, green building is expected to become the mainstream of the construction industry and make an important contribution to achieving more sustainable social development.

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