

Application of Energy-Saving Materials in Architectural Design

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Abstract: The conventional process of building construction is associated with issues such as the waste of construction materials and environmental pollution. Sustainable development highlights the importance of energy conservation and eco-friendly practices. It is essential to use energy-efficient and green materials in building designs to ensure the healthy growth of construction companies. This article discusses the advantages and principles of incorporating energy-saving materials in architectural design. It examines the strategies and critical control points for using energy-saving materials in architectural design, offering guidance for the sustainable development of the construction industry.

Keywords: Energy-saving materials; Architectural design; Advantages; Control strategy

Online publication: July 11, 2024

1. Introduction

As the energy crisis intensifies, countries worldwide have begun to emphasize improving environmental awareness and formulating green development indicators in various industries to achieve energy-saving goals. The construction industry is an industry that involves high energy consumption and severe pollution. However, it also demonstrates the most potential for energy-saving development. The energy-saving development of the construction industry will help improve the energy utilization rate in building construction, prevent energy waste, and reduce losses and environmental pollution. Therefore, energy conservation should be prioritized in current architectural design, which involves correctly understanding the advantages of energy-saving materials in architectural design and adopting scientific application principles to promote the healthy and sustainable development of the construction industry.

2. Advantages of energy-saving materials in architectural design

2.1. Reducing energy consumption

The application of energy-saving materials in buildings can effectively reduce energy consumption. In building design, various energy-saving materials and technologies can be applied to reduce the consumption of electrical and heat energy while ensuring warmth and sufficient lighting inside the building. For example, glass curtain

walls, solar photovoltaics, and other materials can be used to leverage natural resources for heating and lighting. Therefore, applying energy-saving materials in construction can ensure that building construction conforms to green environmental protection.

2.2. Improve material usage efficiency

The application of energy-saving materials in building design can not only effectively control energy consumption but also help improve the efficiency of building materials. For example, using ground source heat pumps can provide a more stable heat source for the building while reducing the materials used for combustion and insulation ^[1]. In addition, the indoor temperature and humidity can be adjusted based on the climate where the building is located.

2.3. Reducing construction pollution

Most of the energy-saving materials in architectural design are environmentally friendly, which reduces environmental pollution. For example, current energy-saving materials are required to meet low emission standards to avoid chemical pollution inside the building. In addition, installing drainage and air purification systems can reduce pollution and improve the environmental friendliness of the building.

2.4. Promoting the development of the construction industry

Applying energy-saving materials in architectural design can also promote the healthy and sustainable development of the construction industry. By designing energy-saving technology, harmful emissions can be reduced, thereby improving people's quality of life. Therefore, the construction industry should strive towards developing more environmentally friendly technologies, materials, and concepts to facilitate energy-saving building design.

3. Application principles of energy-saving materials in architectural design

3.1. Healthiness

The design of energy-saving buildings should also fulfill the user's needs. Traditionally, buildings are designed based on the designers' aesthetic preferences. However, energy-saving buildings should be designed based on the long-term use of the building, indoor performance, user comfort, and other aspects, while considering their impact on the environment ^[2].

3.2. Flexibility

Energy-saving building design is currently a popular concept in architectural design that emphasizes integration with the surrounding environment. Besides, designers must possess strong market sensitivity, keep abreast of new materials and processes, and strive to meet customer needs. In addition, design planning is carried out from a more macro perspective by combining social and economic aspects and clients' interests.

3.3. Economy

Energy-saving design of buildings serves to achieve energy-saving and environmental protection in building construction. Energy saving involves reducing the consumption of non-renewable resources and using clean energy to the greatest extent. Environmental protection emphasizes the careful selection of building materials in architectural design. The materials used should be green, pollution-free, and easy to decompose, which facilitates resource recycling and reduces environmental pollution. Besides, materials management must be

done with conservation being prioritized.

4. Strategies for applying energy-saving materials in architectural design

4.1. Energy-saving design for the overall structure of the building

The building's overall structure should be the primary concern in enhancing energy-saving design. This involves integrating the planning and design with the geographical and climatic conditions of the location. The building should be oriented and house types selected based on the local temperature and wind direction, ensuring the building can leverage the external microclimate to achieve energy-saving effects ^[3]. For example, when selecting a building's site, a comprehensive evaluation and consideration of the terrain, water quality, and other environmental factors must be carried out. It should not only meet the life cycle requirements of the building but also avoid damage to the overall ecological environment. Additionally, the overall planning of building energy conservation should be strengthened, and building materials should be selected according to the local climate.

4.2. Energy-saving design of building roofs and floors

The design of roofs is also a crucial aspect of building design. The roof of a building connects the building with the outside atmosphere, which plays a role in the exchange of indoor and outdoor energy. It is also the primary source of indoor energy loss. Therefore, energy-saving materials can be used in the design of the roof to conserve indoor energy. For example, insulation materials can be installed to avoid internal thermal diffusion. Different roofing models, such as planted roof systems, can be implemented depending on the environmental conditions in various regions. The design of the floor is also crucial for facilitating air exchange between the building and the outside environment, as well as for separating internal spaces. The design of the ceiling shape should be optimized. For example, circulating water pipes can be prefabricated in the floor slab; cold water can be injected through these pipes in summer to achieve a cooling effect, while hot water can be used in winter to keep the room warm, maintaining a comfortable indoor climate year-round. Given the extensive contact surface between the outer wall of the building and the indoor space, it is important to install moisture-proof and thermal insulation materials as part of the energy-saving design. These materials should be selected based on the specific requirements of different regions, enabling the building to fully utilize the external microclimate for optimal energy efficiency.

4.3. Energy-saving design of building doors and windows

The position and material of doors and windows impact building energy consumption. Statistics show that the main source of internal energy consumption in buildings in China is doors and windows, which can be up to 40% of the total energy consumption. Therefore, the design of doors and windows should be taken into account to reduce energy consumption. To achieve this, the first measure is to rationally design the number and position of doors and windows in different directions to maximize their lighting and warmth functions while minimizing heat loss. Summer ventilation issues must also be considered to ensure the circulation of internal air. Additionally, external shading can be incorporated into window designs to mitigate the increased cooling load caused by extensive glass curtain walls in summer ^[4]. In addition, the ventilation effect of doors and windows should also be emphasized to reduce reliance on electrical appliances such as air conditioners and fans, thereby reducing electrical energy consumption. Furthermore, selecting materials for doors and windows with high energy efficiency is crucial. Curtain walls, doors, and windows should be chosen based on their energy performance. Renewable sources like wind energy, solar energy, and other resources should be integrated

into the building. The gaps between doors, windows, and walls should be sealed with insulation materials. Understanding the properties of these materials in advance is necessary to avoid issues such as cracking, which can compromise the insulation performance. For buildings with exterior facades entirely made of glass curtain walls, the gaps between floor slabs, partition walls, and curtain walls must be filled with insulation materials to ensure optimal energy efficiency.

4.4. Building space layout design

Reasonable space layout design is also the key to energy saving in architectural design. Special partition boards can be used to divide the internal space of the building to avoid large-scale excavation in later construction. Besides, attention should be paid to indoor ventilation, insulation, lighting, and other aspects, and reasonable micro-structure adjustments should be made to enhance energy efficiency. Energy conservation should be the main concern in material selection.

5. Control points for energy-saving material design

5.1. Utilizing clean energy

Applying energy-saving materials in architectural design involves using clean, renewable energy sources such as solar and wind energy. By integrating these energy sources into building design, the consumption of heat and electrical energy can be significantly reduced. For instance, wind energy can be utilized through the strategic placement of doors and windows to ensure good indoor ventilation and promote air circulation without needing special materials. On the other hand, solar energy applications do require specific materials. For example, solar water heaters can be installed on the roof to collect heat via solar panels, converting it into thermal energy. This setup allows the building to use hot water without relying on gas or electricity, thereby reducing energy loss.

5.2. Recycling old materials

In some projects, buildings would need to be demolished before the construction takes place. The materials from the demolished buildings can be collected, processed, and redesigned to be used in new buildings. Recycling old materials not only helps save construction costs but also reduces waste emissions during demolition, contributing to energy conservation and environmental protection. Recycling old building materials is an important strategy for creating green and energy-saving buildings. Using renewable materials from old buildings, such as metal guardrails and fiber insulation materials, can effectively mitigate the environmental impact caused by the excessive consumption of new materials and resources. This approach promotes sustainability and helps maintain ecological balance ^[5].

5.3. Reducing the impact on the environment

While reducing energy consumption in the design of energy-saving buildings, it is also essential to strengthen the protection of the natural environment, avoid environmental pollution, and minimize the impact of various forms of waste and pollutants generated by buildings. To achieve this, materials with a relatively low environmental impact should be selected whenever possible in architectural design ^[6]. Construction activities typically involve high energy and resource consumption and can cause significant environmental pollution. Therefore, designers must consider ecological and cost factors when selecting materials to meet performance requirements while reducing energy consumption and pollution. For example, using high-performance and long-lasting materials, ecological cement, or prefabricated components can help reduce waste and material loss during construction. Additionally, environmental impact should be thoroughly considered in both architectural

and process design to minimize energy consumption.

5.4. Utilizing renewable resources

New energy-saving materials should be used in architectural design. For instance, current building construction often incorporates thermal insulation materials to enhance energy efficiency. There are many insulation materials available, including polystyrene boards and rock wool. Selecting appropriate insulation materials based on the architectural design requirements and specific insulation locations can significantly reduce heat loss. This approach helps to minimize the need for extensive use of air conditioners or other heating equipment, thereby conserving energy in the long term ^[7]. Applying thermal insulation materials in building design offers several benefits such as improving thermal insulation, reducing the exchange of hot and cold air, and ensuring comfort indoors. It also helps prevent issues like frost formation on floors and walls. Some advanced insulation materials are environmentally friendly and can even absorb harmful substances. However, the use of insulation materials needs careful consideration due to potential drawbacks. Some materials may occupy room space, reduce ceiling height, or release harmful substances that can affect residents' health. Therefore, it is crucial to comprehensively evaluate thermal insulation materials in building design ^[8]. Photovoltaic materials integrated into the external architecture of buildings can harness solar energy, converting it into electrical energy to provide heating and other services, thereby reducing energy costs. This application leverages renewable resources, offering flexibility with photovoltaic panels that can be customized in various specifications and shapes to suit building structures and specific needs. Despite these advantages, photovoltaic panels are expensive and susceptible to weather conditions, which can limit their effectiveness ^[9]. In addition, the structural characteristics of the building also need to be considered when installing photovoltaic panels. Finally, the application of rainwater collection materials in architectural design. Another aspect of sustainable architectural design involves rainwater collection systems. These systems utilize natural precipitation for tasks like swimming pool flushing and plant irrigation, reducing reliance on potable water sources and minimizing water pollution. While beneficial, rainwater collection materials can occupy significant space and increase construction costs. Additionally, materials used in high-efficiency doors and windows play a vital role in energy conservation. These materials, often made from metals, aluminum, or plastics, enhance insulation and comfort while reducing heating consumption. However, their initial cost and potential for future replacement should be carefully weighed when selecting materials suited to the construction site ^[10].

6. Conclusion

Applying energy-saving materials in architectural design plays a crucial role in reducing both construction and operational energy consumption, thereby achieving energy conservation and emission reduction goals. This approach aligns with the principles of sustainable development and contributes to minimizing environmental pollution. When incorporating energy-saving materials, it is essential to adhere to corresponding principles and strengthen control over design considerations. This includes prioritizing the use of raw materials sourced from clean energy whenever possible. Additionally, there should be a focus on recycling old materials, minimizing construction waste, and conserving limited resources throughout the design and construction phases. Architectural design should adopt a holistic approach that innovates in materials and technologies. This involves reducing energy inefficiencies commonly found in traditional buildings while fostering the development of new energy-efficient models.

Disclosure statement

The author declares no conflict of interest.

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