

Application of Green, Energy-Efficient, and Environmental Protection Technologies in Civil Engineering Construction

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Abstract: This article provides an overview of the application of green, energy-saving, and environmental protection technologies in civil engineering construction. It categorizes these technologies and introduces their application areas. The current status of energy-saving in civil engineering construction is analyzed, including the existing situation, challenges, and the assessment of the effectiveness of energy-saving technologies in use. While emphasizing the importance of energy-saving in civil engineering construction, the article puts forward strategies for the application of energy-saving technologies, aiming to provide references and guidance for the implementation of green, energy-saving, and environmental protection technologies in civil engineering construction.

Keywords: Civil Engineering; Green and Energy-Saving; Environmental Protection Technology; Building Energy Conservation; Construction Techniques

With the increasing prominence of global environmental issues and the reality of energy scarcity, the application of green, energy-saving, and environmental protection technologies in civil engineering has become increasingly important. Traditional construction and operation methods have had a significant impact on the environment, leading to energy waste and environmental pollution. To address this challenge, green, energy-saving, and environmental protection technologies have been widely introduced in civil engineering to achieve sustainable resource utilization, efficient energy use, and environmental protection.

1. Overview of Green, Energy-Saving, and Environmental Protection Technologies

1.1 Definition and Principles

Green, energy-saving, and environmental protection technologies refer to a series of techniques and methods applied during civil engineering construction, aiming to achieve sustainable development goals by reducing energy consumption, minimizing environmental pollution, and enhancing resource utilization efficiency. The core principles include energy-saving, environmental protection, recycling, health and comfort, and sustainability.

The energy-saving principle involves improving designs, adopting efficient equipment and systems, optimizing energy utilization efficiency, and minimizing energy consumption. The environmental protection principle emphasizes the use of environmentally friendly materials to reduce environmental pollution and damage, as well as lower carbon emissions and waste generation. The recycling principle encourages the use of renewable resources and recycled materials to decrease resource consumption and waste^[1]. The health and comfort principle ensure indoor air quality, lighting, and thermal comfort during the construction process, providing a healthy and comfortable working environment. The sustainability principle considers the entire lifecycle of civil engineering projects, ensuring sustainable development and long-term benefits through comprehensive planning, long-term management, and maintenance.

1.2 Relevant Policies and Regulations

The application of green, energy-saving, and environmental protection technologies in civil engineering construction is supported by a range of relevant policies and regulations:

- (1) National Energy Conservation Laws and Regulations: The country has established a series of

energy conservation laws and regulations, such as the "Energy Conservation Law of the People's Republic of China" and the "Regulations on Building Energy Conservation of the People's Republic of China," aiming to promote energy conservation and emission reduction efforts and provide legal basis for the application of green, energy-saving, and environmental protection technologies^[2].

(2) Building Energy Conservation Standards: Both national and local governments have issued a series of building energy conservation standards, such as the "Design Standard for Building Energy Efficiency" and the "Green Building Evaluation Standard," which stipulate the technical requirements and evaluation indicators for building energy conservation.

(3) Environmental Protection Regulations: The country has issued regulations such as the "Law on the Prevention and Control of Air Pollution" and the "Law on the Prevention and Control of Water Pollution," which specify the environmental protection requirements and limitations to be followed during civil engineering construction.

(4) Resource Utilization Policies: In order to promote rational and circular utilization of resources, the country and local governments have implemented a series of resource utilization policies, such as encouraging the use of recycled building materials and promoting the circular economy model, to support the application of green, energy-saving, and environmental protection technologies in civil engineering construction.

(5) Government Procurement Policies: Government procurement is an important market demand, and the government encourages the selection of products and services that meet the requirements of green, energy-saving, and environmental protection technologies during the procurement process.

2. Current Status of the Application of Green, Energy-Saving, and Environmental Protection Technologies in Civil Engineering Construction

With the increasing global population and accelerated urbanization, the construction industry plays a significant role in energy consumption. Despite making some progress in the application of green, energy-saving, and environmental protection technologies in civil engineering construction, there are still several issues.

2.1 Problems in Building Layout Design

The layout design of traditional buildings often neglects considerations for energy utilization and environmental protection, leading to energy waste and inefficiency. Factors such as building orientation, shape, and layout are crucial for utilizing natural lighting and ventilation efficiently. However, many buildings fail to harness natural resources effectively and still rely heavily on artificial lighting and mechanical ventilation systems^[3]. For example, in areas with south-facing buildings, proper window placement and lighting design could maximize sunlight intake and reduce the need for artificial lighting, but many buildings do not fully exploit this potential. Additionally, traditional buildings often underutilize natural ventilation, requiring more mechanical ventilation during hot seasons to maintain indoor comfort, thereby increasing energy consumption.

2.2 Issues with Material Selection and Usage

High energy consumption is a primary concern with traditional building materials. The preparation and processing of materials like concrete and bricks typically involve substantial energy consumption. Furthermore, these materials have higher thermal conductivity, leading to poor insulation in buildings, necessitating additional energy for heating and cooling, thereby further increasing energy consumption. Additionally, traditional building materials contribute to environmental pollution, with concrete production generating significant carbon dioxide emissions, negatively impacting climate change^[4].

2.3 Problems with Energy Management and Usage

One of the most significant issues is the improper scheduling of equipment usage in many buildings, leading to energy consumption even during non-working hours or low-demand periods. This inefficient energy use results in wastage. Moreover, energy systems lack effective adjustments; traditional energy systems often operate in fixed patterns without considering actual demand and energy supply, resulting in surplus energy supply at certain times and possible energy shortages at others^[5].

3. Importance of Green, Energy-Saving, and Environmental Protection Technologies in Civil Engineering Construction

3.1 Resource Conservation and Environmental Sustainability

The application of green, energy-saving, and environmental protection technologies in civil engineering construction is crucial for resource conservation and environmental sustainability. These technologies can effectively save energy resources by improving building designs, optimizing energy management, and adopting efficient equipment, reducing energy consumption, and minimizing reliance on traditional energy sources. This helps protect limited energy resources and prolong their usage. The adoption of green, energy-saving, and environmental protection technologies aids in reducing emissions of pollutants. Traditional civil engineering construction processes often generate significant waste and emissions, negatively impacting the environment. However, the application of green technologies can reduce waste generation and minimize air and water pollution through the use of clean energy and low-emission materials. Furthermore, green, energy-saving, and environmental protection technologies promote sustainable development by emphasizing resource recycling and environmentally friendly principles. By employing practices such as material recycling, renewable energy utilization, and sustainable management, building projects can achieve long-term sustainability and availability.

3.2 Economic Benefits and Social Responsibility

In terms of economic benefits, the application of green, energy-saving, and environmental protection technologies can help reduce energy and resource costs. Optimizing energy management and using efficient equipment and materials can lead to lower energy consumption and reduced operating costs. Energy-saving measures can also extend the lifespan of building facilities, reducing maintenance and repair expenses.

Regarding social responsibility, the application of green technologies in civil engineering construction demonstrates a company's commitment to social responsibility. By reducing energy consumption and pollutant emissions, green technologies contribute positively to environmental protection, reducing damage to ecosystems and enhancing the quality of life in surrounding communities.

3.3 Enhancing Project Image and Market Competitiveness

As society increasingly emphasizes environmental protection and sustainable development, more clients and investors prefer to collaborate with companies that align with environmental values. By applying green technologies, companies can meet market demands, gain a competitive advantage, increase collaboration opportunities, and secure projects. The adoption of green, energy-saving, and environmental protection technologies also showcases a company's innovation capabilities. These technologies require companies to demonstrate technical innovation and implementation capabilities by introducing new green technologies and processes, highlighting their advantages in the technological field.

The application of green, energy-saving, and environmental protection technologies also supports a company's sustainable development. With increasing demands for sustainable development, governments and relevant organizations are promoting green construction and energy-saving environmental projects. By applying green technologies, companies actively respond to the call for sustainable development and maintain cooperation and consensus with governments and relevant organizations. This support and collaboration create broader market opportunities for companies, helping to expand their business scope and enhance market competitiveness.

4. Strategies for the Application of Green, Energy-Saving, and Environmental Protection Technologies in Civil Engineering Construction

4.1 Optimization of Building Design and Layout

In civil engineering construction, the application of green, energy-saving, and environmental protection technologies should focus on optimizing building design and layout to maximize their benefits.

Passive design is a method that utilizes building layout and structure to make the best use of natural energy and reduce energy consumption. For example, designing balconies and windows facing south can maximize the use of solar energy for indoor heating during the winter. Strict requirements for building insulation and airtightness can achieve efficient energy utilization and a comfortable indoor environment. Green roofs and vertical greening can lower a building's energy consumption, improve the surrounding environment, and reduce the indoor temperature through plant transpiration, thereby reducing the load on air conditioning systems. These designs not only provide beautiful landscapes but also improve the air quality in cities.

Optimizing natural ventilation and daylighting through appropriate building layout and window design can reduce the need for mechanical ventilation and artificial lighting. For example, the Beijing National Stadium (Bird's Nest) adopts an open design that allows for natural ventilation and good airflow through the shape and ventilation openings, reducing energy consumption. Moreover, installing solar panels in the building layout can reduce reliance on traditional energy sources. For instance, Apple Park headquarters incorporates extensive solar panels to achieve self-sufficiency in energy supply. This application not only reduces greenhouse gas emissions but also saves energy costs for the company.

4.2 Selection and Use of Energy-Saving Materials

In civil engineering construction, the selection and use of energy-saving materials are crucial strategies for green, energy-saving, and environmental protection.

Opting for materials with excellent insulation performance, such as polystyrene boards, rock wool, and silicate boards, is essential. These materials have low thermal conductivity, effectively isolating indoor and outdoor heat exchange, and reducing energy consumption. Using these materials in buildings significantly decreases heating in winter and cooling in summer, leading to energy savings. Choose high-efficiency insulation materials like aerogels and composite insulation boards. These materials have low thermal conductivity and excellent insulation properties, reducing heat transfer and energy loss. Applying high-efficiency insulation materials to exterior walls, roofs, and floors can significantly enhance a building's energy efficiency.

From an environmental perspective, select materials with eco-certifications, such as eco-label products and low-VOC (volatile organic compounds) materials. These materials have minimal impact on the environment and human health during production and usage, improving indoor air quality and creating a healthier indoor environment.

From a sustainable development perspective, choose renewable materials like bamboo, straw boards, etc. These materials come from sustainable resources and have lower energy consumption and environmental impact. The use of renewable materials in civil engineering can reduce the consumption of finite resources and promote a circular economy and sustainable development.

4.3 Energy Management and Optimization Strategies

One common strategy for energy management and optimization is establishing an intelligent energy monitoring system. This system utilizes sensors and monitoring devices to real-time monitor the energy consumption data of buildings, including electricity, water, gas, and other energy sources. By analyzing and evaluating these data, energy waste areas can be identified, and corresponding measures can be taken for optimization. For instance, adjusting the temperature and humidity settings of air conditioning equipment, optimizing the brightness and timing control of lighting systems, and managing the energy consumption of elevators and electronic devices can effectively reduce energy consumption and improve energy utilization efficiency.

Another strategy is utilizing renewable energy. Renewable energy sources like solar and wind energy have abundant resources and environmentally friendly characteristics. In civil engineering construction, solar photovoltaic systems or wind power systems can be adopted to utilize renewable energy. By installing solar photovoltaic panels or wind power devices, renewable energy can be converted into electricity supply, reducing reliance on traditional energy sources and decreasing carbon emissions. This strategy not only helps lower energy costs but also provides sustainable energy sources for buildings. For example, in a certain civil engineering project, a green, energy-saving, and environmental protection technology of water resource management and recycling was applied. Through detailed water resource management and innovative recycling schemes, efficient water

resource utilization was achieved, reducing reliance on tap water. In the building design phase, water-saving equipment such as low-flow faucets and water-saving toilets were used to effectively reduce water usage. Real-time monitoring of water consumption was enabled through the installation of water flow sensors and intelligent control systems, allowing for intelligent regulation of pump operation to ensure reasonable water usage. Additionally, rainwater collection systems and graywater recycling systems were implemented. The rainwater collection system collects rainwater through drainage pipes and storage containers, treating it for non-potable water purposes such as garden irrigation and road cleaning. The graywater recycling system collects graywater generated from sinks and bathtubs, treating it for flushing toilets and cooling equipment. This water resource recycling not only reduces the demand for tap water but also lowers wastewater discharge and water resource consumption.

The selection and use of energy-saving materials are one of the essential strategies for energy management and optimization in civil engineering construction. By choosing materials with low thermal conductivity, such as polystyrene boards and rock wool, building insulation performance can be significantly improved, reducing heat transfer and energy loss. These energy-saving materials have high thermal insulation properties, which can reduce the temperature difference between indoor and outdoor environments, thus reducing the reliance on heating or air conditioning systems and saving energy consumption. A well-designed building can make the most of natural daylighting and ventilation, reducing the need for artificial lighting and mechanical ventilation systems. Designing large windows and using transparent or translucent materials allows more natural light to enter the interior, reducing reliance on artificial lighting. At the same time, considering the airflow path in the building layout and setting up appropriate ventilation openings and air ducts can promote natural ventilation and reduce the use of mechanical ventilation systems. For example, in a certain civil engineering project, polystyrene boards were used as exterior wall insulation materials, and large glass windows were designed to maximize the use of natural light inside the building. Additionally, suitable ventilation openings and air ducts were incorporated into the building layout to ensure effective indoor air circulation and reduce the operating time of mechanical ventilation systems. These measures enable the building to reduce energy consumption while ensuring comfort, achieving green, energy-saving, and environmental protection goals.

4.4 Application of Intelligent Control and Monitoring Systems

Intelligent control and monitoring systems play a crucial role in the energy-saving application of civil engineering buildings. One typical case is an intelligent energy management system implemented in an office building. The system uses advanced sensors and data analysis technology to monitor the building's energy consumption in real-time. By analyzing energy consumption data and building usage patterns, the system can identify energy-saving potentials and optimization opportunities. For instance, during non-office hours, the system automatically shuts down unnecessary equipment, adjusts lighting brightness and temperature control to reduce energy waste. The system also provides remote monitoring and control functions, allowing engineers to monitor energy consumption and make adjustments and optimizations at any time.

The intelligent control system can automatically adjust the building's energy equipment based on real-time data and predictive results to achieve optimal energy utilization efficiency. Through the installation of sensors and smart meters, the system can monitor real-time energy consumption data of electricity, water resources, and air conditioning systems. This data is transmitted to the central control center and processed through data analysis and algorithm models to generate energy consumption reports and forecasts. For example, a commercial complex automatically reduces the air conditioning system's intensity during low-occupancy periods or adjusts the brightness of lighting equipment based on indoor temperature and natural light conditions. Moreover, the system can automatically monitor and control water resource usage, such as automatically closing leaking faucets or adjusting the irrigation system's operation. The application of an intelligent building energy management system has achieved significant energy-saving results in the commercial complex. Real-time monitoring and precise control of energy consumption significantly improve energy utilization efficiency and effectively curb energy waste. According to preliminary assessments, energy savings exceeded 20%, resulting in substantial energy cost savings for the company and reduced carbon emissions.

For instance, in a public building of a large civil engineering project, an intelligent lighting control system was applied as part of green, energy-saving, and environmental protection technology. The system uses advanced sensors and automation control to achieve intelligent control of lighting equipment, improving lighting effectiveness while reducing energy consumption. By installing human

body sensors and light sensors, the system can accurately perceive human activities and natural light conditions. When someone enters an area, the sensors automatically activate the lighting equipment. When there is no one or sufficient natural light, the system automatically turns off or dims the lighting equipment to save energy in unoccupied areas.

5. Conclusion

This article comprehensively explores the application of green, energy-saving, and environmental protection technologies in civil engineering construction. By optimizing building design and layout, selecting energy-saving materials, managing energy, and utilizing intelligent control systems, it is possible to achieve resource preservation, reduce energy consumption, improve economic efficiency, and minimize environmental pollution. The application of green, energy-saving, and environmental protection technologies not only contributes to achieving sustainable development goals but also enhances the image and competitiveness of engineering projects in the market. Given the current situation and challenges in building energy efficiency, the application of these technologies becomes a crucial solution.

The introduction of relevant policies and regulations provides policy support and standardization, while the establishment of industry standards and certification systems promotes the widespread adoption and supervision of these technologies. However, there are still challenges in their application, such as high costs and technical difficulties. Thus, it requires joint efforts from the government, businesses, and academia to strengthen cooperation and innovation, advance research and development, and promote the widespread application of these technologies.

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