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Application analysis of green building technology in rural housing

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Abstract. In the process of construction and use of traditional rural buildings in China, the phenomenon of environmental pollution and resource waste is very serious. The introduction and use of green buildings can make natural resources more widely and rationally utilized through scientific overall design. This paper mainly studies the application of green building in rural housing. Firstly, the characteristics of rural green building design are analysed from three aspects: water saving and water resource utilization, energy saving and renewable energy utilization, material saving and greenhouse gas emission reduction. Then, through the detailed introduction of renewable energy utilization technology and clean energy heating and cooling technology, the application of rural green building technology is specified. Finally, the paper summarizes the green design, construction and use strategy system suitable for Chinese contemporary rural buildings. It is hoped that the research of this paper will provide effective reference for the design and use of rural residential green buildings.

Keywords: green building technology, rural housing, countryside.

1. Introduction

At present, the phenomenon of environmental pollution and resource waste is very serious in the process of construction and use of rural housing. Green buildings have been developing rapidly in recent years because of their great value in energy saving, carbon reduction, improving living environment and revitalizing economy, promoting ecological civilization construction and accelerating harmonious coexistence between man and nature. However, the construction and implementation of green buildings are mainly concentrated in cities, and their application in rural areas is still at a preliminary stage [1]. It can be said that green building has received unprecedented attention worldwide and become the general trend of the development of the world's construction industry [2]. Green building is different from traditional building. First of all, while traditional buildings consume a lot of energy, green buildings greatly reduce energy consumption. Secondly, most traditional buildings adopt commercial production technologies, and the standardization and industrialization of the construction process result in similar architectural features, while green buildings emphasize the use of local culture, local raw materials, and respect for local nature and local climate conditions [3].

Many countries have studied and practiced green buildings. In China, the stilted houses in Hunan and Xiangxi and the residential houses in the mountainous areas of Sichuan make reasonable use of local landforms and seasonal wind changes to achieve a good combination of site and architecture. Local rural houses can prevent moisture and be well ventilated, thus achieving greater comfort and higher

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efficiency, saving resources and protecting the environment [4]. In the United States, the Ecovillage in Ithaca, New York, co-housing community and Norris Community all make full use of green building technology [5-6]. Germany has explored the field of green building for more than 30 years, and achieved the effect of environmental and energy protection through energy-saving and water-saving measures suitable for building purposes, convenient operation, moderate price and regional characteristics [7]. The representative one is Bramwich Ecological Village.

Resource consumption and environmental pollution are serious problems in China's vast rural areas. To change all this, it is necessary to take the road of green development, especially to promote green building technology in rural housing construction [8]. This study is based on relevant works and literature on rural green building technology and theory in China, the United States and Germany, sorts out typical cases of green building practice in rural areas, analyzes and summarizes the existing common points and finds relevant laws by studying the theoretical research and typical cases of green building design methods in the above countries. In order to sort out the green design, construction and use strategy system suitable for China's contemporary rural architecture.

2. Rural green building construction concept

The concept of green building construction is manifested in the maximum conservation of materials, land, water, electricity and other resources. And throughout the whole life cycle of the building, it can effectively control the environmental pollution of the building, so as to realize the harmonious development of man and nature. Under the guidance of the concept of green building construction, green building materials have been widely promoted and applied, such as the use of environmentally friendly cement and wood plastic materials to reduce the loss of non-renewable resources and environmental pollution. By effectively controlling the energy consumption during the operation of the building, such as using solar energy to meet the energy demand of the building, using ventilation system to reduce the energy consumption of air conditioning and other equipment. In addition, some interior decorators equip houses with green plants, aiming to achieve the absorption and degradation of building pollutants and improve the rural ecological environment. All these are important manifestations of the concept of green building construction [9]. Countryside has its unique characteristics, and rural green buildings need to be rooted in the characteristics of the countryside to find a suitable road to serve the countryside [10].

The concept of green building construction has been widely used in the construction of rural housing in China. According to the 2022 Research Report on China's Building Energy Consumption and Carbon Emissions, China's housing stock in 2020 will total 55.3 billion square meters, of which 32 billion square meters will be urban, accounting for 58%, and 23.3 billion square meters will be rural, accounting for 42%. From the change trend of building energy consumption, the comprehensive carbon emission factor of building operation decreased from 2.3tCO2/tce in 2005 to 2.0tCO2/tce in 2020. It can be seen that China's building energy structure is gradually optimized, and building energy consumption shows a downward trend.

3. Characteristics of rural green building design

3.1. Water saving and water resources utilization

In China, water conservation and water resources utilization have shifted from a single water supply or sewage treatment to a comprehensive water recycling, and from a single technical process of simply removing pollutants to the realization of sewage resources. The technical measures adopted are as follows: firstly, water-saving appliances are adopted. secondly, sewage is purified and rainwater is recycled and used in landscape greening, floor washing and road pouring.

At the Hamburg Bramwitsch Eco-Village in Germany, As shown in Figure 1, a closed loop ecosystem is simulated in nature through biological decomposition and purification. Thus, it replacs the traditional chemical treatment and speeds up the sewage nutrient diversion, so that it is returned faster and presented in nature. Sewage treatment uses low-end ecological technology, plant purification makes water treatment simple and effective, and composting toilets save the cost of toilet water and sewage pipeline

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laying. The kitchen and bath water in the house are collected into the artificial seepage pool inside the community through sewage pipes. In the vertical direction, the sewage is filtered through three layers of soil, sand and stone. Finally, it is naturally purified by the sand and reed roots planted in the seepage pool. The purified water flows into adjacent waters or underground water system. The introduction of biological purification technology is an essential change in the ecological suitability design of residential areas. It changes the traditional way of chemical treatment of waste, and reduces the cost of related construction equipment, while improving the community's energy efficiency and reducing the cost of construction. At the same time, biological purification technology has the characteristics of small scale, simple and convenient, easy maintenance, suitable for small-scale residential applications, and close integration with residents' daily life.

Figure 1. Bramwich Village [11].

In the New Norris community in the United States, the integrated water resources management system is adopted in water conservation and water utilization, so that the wastewater can play different roles through different treatment systems. As shown in Figure 2, the design utilizes the slope of the site to treat wastewater and rainwater directly in situ using gravity flow, which is a simple on-site treatment system. The soil water retention, infiltration and collection have been carefully designed. After being sterilized by ultraviolet light and carbon filtered, rainwater can be used as non-potable water in residential and outdoor courtyards. When the tank is full, the water overflows into a reservoir for watering vegetables. When the pool is full, gravity pulls the water through the holding pool, the tank, and the overflow point before reaching the lowest pool. If the rain is heavy, the water will spill into the swamps in the forest. However, lightly polluted domestic water is discharged from underground to the highest treatment pond for treatment and filtration [12].

3.2. Energy conservation and renewable energy utilization

Nowadays, the consumption of energy resources has become a prominent problem in sustainable development. Ecological imbalance, resource depletion and climate warming are all serious challenges at present [13]. In China, energy conservation and renewable energy utilization implement the system energy conservation integration of roof, exterior wall, doors and Windows, and floor integration. Widely used solar energy technology, water source heat pump technology, water reuse technology. And fully carry out solar energy, wind energy, geothermal energy, biogas and other renewable energy development and utilization.

In the rural environment, solar energy is the most abundant and inexhaustible natural resource in nature. Therefore, solar energy should be fully utilized to form an active technology system with solar energy as the core. Thus, the use of fossil energy is reduced, and pollution is reduced and energy is saved. The solar active technology system mainly includes the new solar heating and cooling technology of heat-activated wall coupling cross-season energy storage and direct energy supply, solar hot water technology, solar photovoltaic power generation technology.

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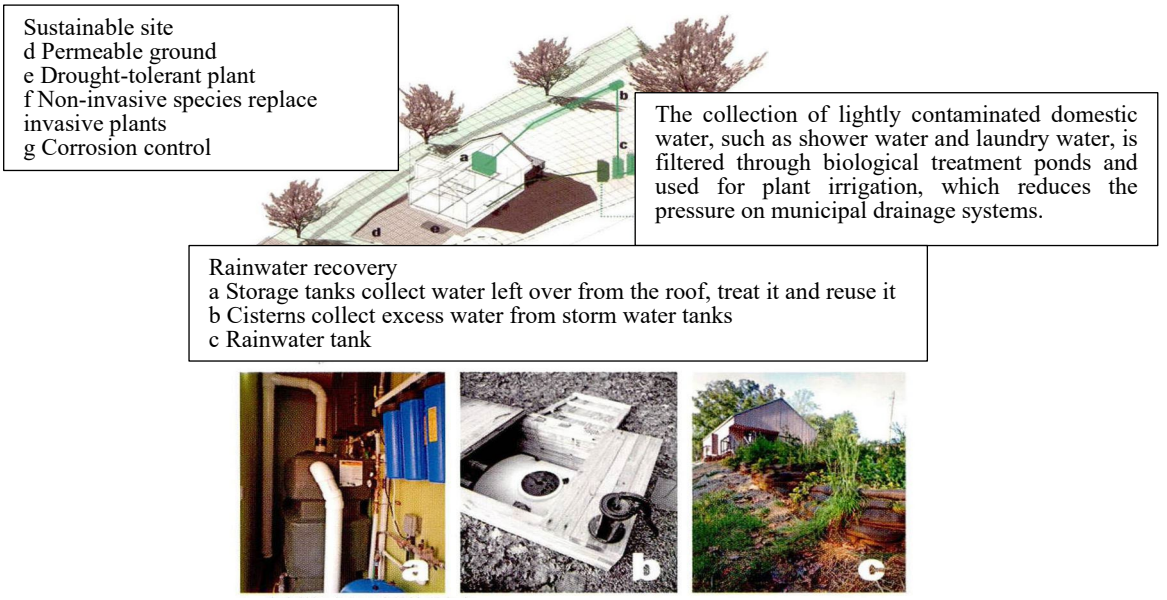

Figure 2. Treatment of indoor and outdoor sewage and rainwater [6].

Table 1. Comparison of masonry material properties [11].

Name of masonry material	Performance characteristics	Pictures
Sintered non-clay porous brick	With shale, coal gangue, fly ash as the main raw materials, the brick made from roasting, the cavity rate ≧15%, the hole size is small and the number is large. Compared with solid brick, the raw material consumption is reduced, the building wall weight is reduced, and the thermal insulation performance and seismic performance are enhanced.	
Fired non-clay hollow brick	With shale, coal gangue, fly ash as the main raw materials, the brick made by roasting, the cavity rate ≧35%. The hole size is large but the number is small. The hole is rectangular strip hole or other hole type, and parallel to the large surface and strip surface.	
Ordinary concrete small hollow block	It is characterized by cement as a cementing material, coarse aggregate such as sand, gravel or pebble, heavy slag, adding appropriate admixtures, admixtures, etc., and mixing with water.	
Aerated concrete block	Compared with ordinary concrete blocks, it has a large number of microporous structures, light weight and high strength. It has good thermal insulation performance and can be used as thermal insulation material.	

The wall of green building is an important energy-saving construction, which can consider the sintered non-clay porous brick, sintered non-clay hollow brick, ordinary concrete small hollow block, aerated concrete block, etc. The comparison of masonry material properties is shown in Table 1. The arrangement position of the hollow brick needs to be carefully determined, fully considering the problems of painting cracking, wall heat value and leakage, and comprehensively analyzing the wall insulation, earthquake resistance and heat value and other factors affecting the wall, so as to ensure its

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energy-saving effect.

Manage the roof energy saving, the first is to ensure that the selected density cannot be too high, heat consumption coefficient cannot be too high, to prevent the roof pressure limit. Second, the water absorption capacity of the selected roof insulation material should be as small as possible, so as to avoid the water absorption of the material to reduce the heat insulation effect. Through the use of highly efficient thermal insulation material with the roof, and through the form of building overhead insulation house surface to be treated, the basic principle is to reduce the heat consumption coefficient to achieve heat insulation and insulation.

In Hamburg Bramwych Eco-Village in Germany, the regional energy saving thinking of suitability technology overturns the energy saving method based on individual and family. It takes the community level as the starting point for the overall system design, which is far more economical and efficient than the application of solar energy and environmental protection measures as a unit. Moreover, it is more unified and beautiful in the visual expression of community building appearance. The effect of this overall system design is often greater than the sum of its parts. Secondly, the establishment of a standardized system for low energy consumption housing tests the energy-saving effect of suitability technology, so that the effect of technology energy-saving can be quantified. The establishment of energy conservation system and the application of ecological technology develop in parallel and complement each other, which is conducive to the further innovation and development of suitability technology and its standardization process, and easy to popularize in the ecological community.

3.3. Material saving and greenhouse gas reduction

At present, China's new rural construction and development progress is getting faster and faster. The rural construction and development are first reflected in the improvement of residential living environment. However, in the current use of rural building materials, too much use of urban eliminated equipment, and these materials more or less have some defects, thus affecting the development of rural construction. This requires the development strategy of appropriate technology as the starting point, closely around the core of new rural construction, make full use of local building materials, so as to coordinate and unify rural architecture and local characteristics.

As far as the current situation is concerned, advanced materials are usually unable to adapt to the economic conditions of the local towns, so it is necessary to focus on the economy of the selected building materials. In the development of rural building materials, practicality and economy should be taken into account. Develop characteristic building materials according to local conditions. This can not only reduce the production cost of materials, but also save the transportation cost of consumables. The most important thing is that local materials can be better integrated into the local climate environment to build a pleasant residence [14]. Practicability should be considered in the development of building equipment, and the idea of adapting to local conditions is the best embodiment of practicability. Local materials, raw materials from the natural environment, and then through scientific and technological means to develop cost-effective and adaptable new energy-saving building materials, can fundamentally solve the problem of the use of rural green building materials, comprehensively improve the overall level of rural buildings.

The construction method of the new Norris house in the United States is designed to achieve full industrialization, components are produced in the factory, and the finished prefabricated modules are shipped to the site for assembly. The prefabrication saves 17.5 percent of wood production, while the prefabrication of built-ups and modules reduces construction waste by 70 percent. This construction mode can integrate design, production, construction, operation, maintenance and other links to form a complete industrial chain, and realize the industrialization, intensification and socialization of green housing.

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4. Rural green building technology application

4.1. Renewable energy utilization technology

Under the guidance of green building design concept, renewable energy utilization technology can be rationally used to effectively control the energy consumption during building operation.

(1) Wind energy

Wind energy is not only renewable resources but also green and clean energy. The application of wind energy technology in construction projects will not cause irreversible pollution to the environment. At present, the application of wind energy technology in the construction industry is mainly reflected in two parts: first, the use of local natural wind energy through the design of reasonable window orientation and door openings. Second, the conversion of building energy through wind energy technology to convert wind energy into other energy. Due to the limitation of scientific and technological conditions, the application of wind energy technology is interfered by many external factors at the present stage, which leads to the failure of the technology to fully play its due application value, and it still stays at the superficial technical application level, with insufficient thinking on the subsequent development [15].

(2) Water resources

In order to effectively reduce dust pollution, in the actual construction, reasonable collection of rainwater, rainwater purification treatment, to be widely used in other construction links. Construction units strengthen technical personnel to use advanced environmental protection technology to apply water resources and promote the multi-dimensional application of green building technology in actual building construction.

(3) Solar energy

The use of solar photovoltaic technology to generate electricity, reduce the use of non-renewable energy, reduce the degree of pollution of greenhouse gas emissions. At the same time, the solar photovoltaic power generation technology has the characteristics of stability, safety and no noise, so the development and application of it should be strengthened in the future.

(4) Biomass energy

According to the geomorphic characteristics of the region, the local water resources, land resources, climate conditions, sunlight, air and other natural conditions can be fully utilized. On this basis, an ecological farm housing area integrating farmland planting, aquaculture, animal husbandry, garden planting and house planting is built. Thus, production and life are integrated into an organic whole, the waste and animal feces in life are fermented, the biogas produced is used for power generation, cooking, etc., and the sediment is used as farm fertilizer. This not only saves energy, reduces waste discharge, but also protects the environment.

To sum up, solar energy, wind energy and other clean energy should be actively applied. Thus, the consumption of non-renewable resources during the operation of the building can be effectively reduced, the goal of energy conservation and environmental protection can be achieved, and the perfect integration of construction and environmental protection can be achieved.

4.2. Heating and cooling technologies that use clean energy

In China, for example, coal burning furnaces, electric heaters, local heating and other traditional heating methods are often used in rural areas in cold and bleak winter. In recent years, due to economic and geographical factors, the use of air conditioning cannot be promoted in rural areas. In addition, due to the current situation of energy shortage in China, clean energy heating will be the development direction of rural heating in the future. In rural areas, the main clean energy sources that can be used for heating are solar energy, geothermal energy and biomass energy. Solar energy is highly affected by the weather and the initial investment in solar heating systems is high, so solar energy is generally used as an auxiliary heat source combined with air source heat pump or ground source heat pump, and sometimes combined with biomass energy to form a complementary heating system. The buildings in rural areas have large yards and are mostly bungalows. It is convenient to arrange solar collectors and is conducive to solar energy collection. Therefore, solar assisted heating system is a very suitable rural heating

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technology. In the non-heating period, adding a heat exchanger to the solar assisted heating system can also provide domestic hot water. In refrigeration, the common split air conditioning is the main way of refrigeration in hot summer and cold winter areas. If it is vigorously promoted in the countryside, it will cause great energy consumption. The solar assisted heating system can also be used for summer cooling. For the solar-assisted ground source heat pump heating system, which is widely studied at present, the choice of cold source can not only use the buried pipe in the soil, but also use the groundwater in Wells that can be seen everywhere in rural areas [16].

Photovoltaic building integration, as a traditional rural building application, not only more beautiful, energy saving, but also can create more than 25 years of power generation benefits, with residential comfort, economic living and other multiple advantages. Nowadays, the cost of photovoltaic building integration industry is constantly decreasing, and its economy, cleanliness and energy attributes all determine that it can become the main choice for rural green buildings.

5. Conclusion

After years of development, China's rural green buildings have made gratifying achievements. However, compared with western developed countries such as the United States and Germany, there is still a big gap in architectural concept, design characteristics and technology application. Therefore, in addition to learning from the advanced experience of other countries, it is also necessary to combine China's reality and promote the application of rural green buildings in China according to local conditions. In summary, the following three suggestions are put forward.

(1) In terms of energy saving, the outer area and window wall ratio of rural residential buildings should be reduced, and the size coefficient should be reduced in cold areas. The design of the window should avoid the dominant wind direction in the local winter, and the outer window should not be too large. At the same time, the roof should be set up insulation layer, doors and Windows should have good sealing. Warm areas should increase the use of solar energy, such as solar water heaters. Windows face south, reasonable design of shading devices, make full use of natural conditions to adjust indoor air and temperature. For example, water is stored on the roof to cool down, and the external wall can be ventilated and clamped to facilitate heat dissipation.

(2) In terms of water conservation and water resource utilization, it is suggested to establish a reasonable and perfect water supply and drainage system and adopt water-saving appliances. People can collect and use rainwater, treat and reuse wastewater and so on.

(3) In terms of material saving, safety and environmental protection building materials with light weight and high insulation efficiency should be selected. Local materials, design should conform to regional characteristics, architectural modeling should be simple, reduce decoration, pay attention to the recycling of materials.

Building a green, ecological, livable and beautiful countryside is an important part of promoting green development and building a beautiful China. It is necessary to achieve all-round green development, improve the quality of rural areas, and make the living environment more beautiful.

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