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A Brief Analysis of Energy Conservation Ways by Building Materials for Ecological Architecture

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Abstract

The development of society and economy in China is bringing growth to all industries. In particular, the development of China's building industry has attracted much attention. Building materials are an important part of and widely used in the building industry. Energy conservation by building materials has become an inevitable way of sustainable development. Centering on the building industry, this paper mainly discusses in detail the energy conservation ways by ecological architecture and building materials.

Keywords

Ecological Architecture, Sustainable Development, Building Materials, Energy Conservation by Building Materials

1. Introduction

Affected by the rapid economic development in the early stage, the natural environment in China has deteriorated seriously, threatening the normal life of residents. Therefore, people begin to pay attention to the application of the concept of green and environmental protection in all kinds of work. In terms of architectural engineering, from the perspective of building industry, water resources, land resources and pollutant emissions have become our headache. Limited construction resources and excessive waste have turned on a red light. Ecological architecture has become the tide rider of the 21st century. How to make full use of ecological building materials to save energy and improve the validity of environmental protection on the basis of reducing environmental pollution and resource waste in the process of realizing ecological architecture is the key content of this paper.

2. Concept Interpretation

2.1. Ecological Architecture

Ecological architecture arises at the historic moment when ecological problems are extremely serious, and therefore it aims at environmental pollution and resource waste. It mainly means to coordinate the relationship between buildings and other factors with the help of modern architectural means and modern science and technology based on the local living environment in the development of architectural activities, and to build an organic combination under the harmony of various relations. On the basis of meeting the residential needs of residents, it builds a virtuous circle system of people, buildings and ecological environment [1].

For quite a long time, under the influence of the western philosophy of human-centered, human beings had built cookie-cutter "human living machines" for their own interests at the cost of sacrificing the environment [2]. In the later part of this century, when the problems of ecological environment and human beings themselves appeared constantly, human beings realized that the artificial environment they painstakingly built was inhuman and detached from history, leading architecture to crossroads. However, the proposal of sustainable development concept provides the ideological foundation for the future direction of architecture—from human-centered to equal importance to human and environment (the environment here includes both natural environment and humanistic environment). Following this principle, human beings should ask themselves in their construction activities whether their actions have caused damage to the natural ecological environment of the region and whether they have posed a threat to the ancient traditions of the region. Specifically, architectural actions include not only the consideration for material factors such as materials and structures, but also the attention to humanistic factors such as historical context [3]. With this as a starting point, ecological architecture design not only involves material requirements such as adopting ecological building materials and advocating ecological technology, but also spiritual needs such as combining regional characteristics and creating humanistic environment.

2.2. Energy Conservation by Building Materials

The so-called energy conservation by building materials mainly refers to the energy conservation and environmental protection by building materials. The application of energy conservation by building materials in construction projects can largely reduce the generation of construction waste in the construction, so as to save resources and energy, and thus reduce the environmental pollution caused by construction waste from the aspects of building materials, providing effective guarantee for the improvement of the ecological environment [4].

Generally, building materials used in the architectural activities can be divided into three types: 1) renewable resources; 2) reusable materials; 3) recyclable materials [5]. Among them, recyclable materials mainly refer to the use of certain

methods to change the form of the materials that cannot be reused to form another kind of materials that can be reused. Reusable materials mainly refer to the restoration or combination of the resources that can be used in the materials, so that they can be reused. In general, the original form of the materials will not be changed. Renewable resources mainly refer to the sources that can be renewed such as wind energy, water energy, geothermal energy, tidal energy and solar energy, which can be directly obtained from nature. No matter what kind of materials is used, they should be used effectively in the architectural activities to save resources and energy on the basis of reducing the waste of building materials.

3. Energy Conservation Ways by Building Materials for Ecological Architecture

3.1. Passive Energy Conservation Ways in Ecological Architecture

1) Definition of passive energy conservation ways. Passive energy conservation way refers to the use of intervention means of non-mechanical electrical equipment to realize building energy consumption reduction. Specifically, in the planning and design of ecological buildings, it can effectively reduce the energy consumption of ventilation, air conditioning and heating through shading setting, openings designed to facilitate natural ventilation, rational layout of the building orientation, and thermal insulation technique of the building envelope, etc. Active energy conservation way refers to continuous energy input into mechanical equipment to maintain its continuous operation and to achieve antagonism with adverse internal environment and external climate condition change, thus creating an easy and comfortable indoor environment [6].

2) The realization of passive energy conservation for building materials for ecological architecture. In ecological architecture, thermal insulation doors and windows are essential building envelope, and aerogel glass is the building material to achieve this efficient thermal insulation structure. Aerogel glass is a kind of new building material with aerogel as the main raw material (see **Figure 1**), which can replace all kinds of glass. Aerogel glass has many advantages far outweighing the ordinary glass: for example, it is better than quartz glass in thermal stability and heat shock resistance. It will not burst even if it is put into water at a high temperature of 1300 degrees. Its specific gravity is very small, only 0.07 - 0.25 g/cm^3, which is one tens of that of ordinary glass; it has better thermal insulation properties than mineral wool; it is a good flame retardant and has good sound insulation property, which is more than 4 times better than common metal and glass. Besides, the intermediate product of aerogel glass is gas gel [7].

Another example of passive energy conservation in ecological architecture is the Tjibaou Cultural Center designed by Italian architect Renzo Piano. Inspired by the local hut, Piano extracted the essence of it, the wooden rib structure. The wooden rib structure of the local hut is made up of palm saplings (see **Figure 2**), which is covered with layers. The design of the cultural center imitates this structure. Each of its curved wooden ribs is connected with a vertical structure which

is used as the surrounding structure of the enclosed space. The wooden ribs are seamlessly connected horizontally and diagonally by stainless steel members. Different bending laminated wood, instead of the traditional palm seedlings, was used as the wood ribs connected into a cage framework by stainless steel, with two layers inside and outside. Each bent rib was tied and fixed by steel foundation and connected with a vertical structure in vertical direction [8]. These vertical structures were also used as peripheral structures of its enclosed space (see Figure 3 and Figure 4).

Figure 1. Aerogel glass for building.

Figure 2. Roof form of local houses.

Figure 3. Exterior view of Tjibaou cultural center.

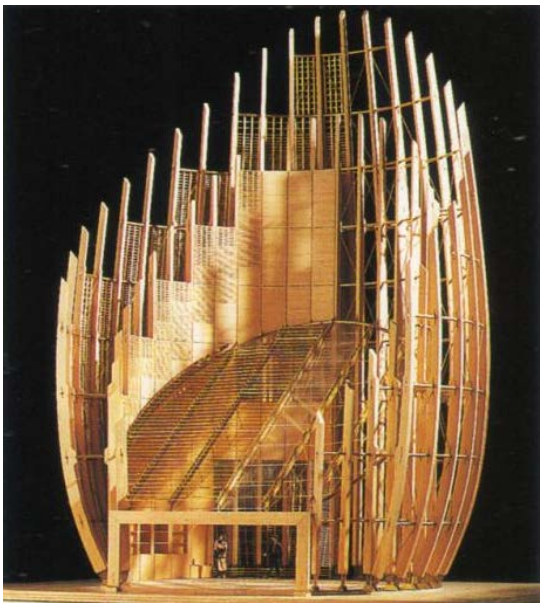

Figure 4. Schematic diagram of envelope structure of Tjibaou cultural center.

Passive ventilation system of the Tjibaou Cultural Center: basically, the passive ventilation system equipped with the unit is a very efficient system. Each curved external rib is connected into a vertical unified whole, and the structure forms the attached space around the unit. The curved ribs with strips with horizontal lines are used to correct wind direction. The interior is controlled by a passive system of shutters mounted at the bottom of the surrounding walls and on the opposite side of the structure. These shutters open or close according to the wind direction and wind force, and the air is discharged along the highest point of the roof as the breeze passes through (see **Figure 5**) [9].

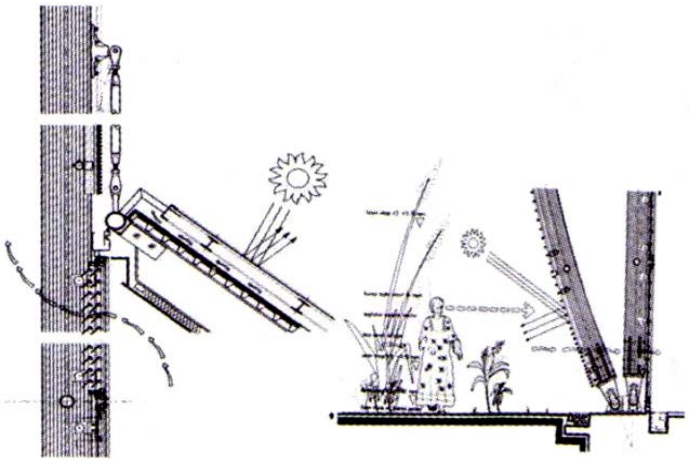

Figure 5. Schematic diagram of ventilation and lighting of Tjibaou cultural center.

In order to form passive ventilation inside the complex, Piano designed a double skin system. The outer skin of the building is divided into two layers, which are respectively composed of outer curved rib slats and inner vertical rib slats. Both rows of ribs are made of plywood. The double skin system allows the air to flow freely in the two-layer rib structure. The opening in the outer layer is used to guide the monsoon from the ocean, or to guide the required airflow. The skylight at the top is used to regulate the air flow. When there is a breeze, the skylight opens to facilitate ventilation. When the wind gets stronger, the skylight closes [10].

3.2. Energy Conservation Ways by Renewable Energy Sources in Ecological Buildings

1) Utilization of solar energy. In the current buildings, especially residential areas, more and more households use electric water heaters. The use of electric water heaters has caused serious waste of electric energy to a certain extent. Solar energy, as a renewable resource, can be said to be inexhaustible. From the perspective of international architecture development, the integration of photovoltaic and building has already appeared with a history of development, especially solar energy generation. In the domestic building industry, we can also learn from foreign architectural experience and fully apply solar energy, a renewable resource, into buildings. Although the use of solar energy has been extended from urban areas to rural areas to realize the effective utilization of solar energy resources, the realization of the integration of photovoltaic and building is insufficient in the current development, which requires vigorous promotion of the integration of photovoltaic and building in the development of ecological building industry. Photovoltaic power can be used to reduce the waste of resources in addition to meeting the electricity demand of households. The Low Energy Demo Building of Tsinghua University was taken as an example (see Figure 6 and Figure 7). Its floor fully uses the solar energy to adjust the indoor temperature. That is, a special phase-change material is used to store the solar energy in

the regular movable floor, which will be able to store the solar energy into the room in winter. At night when the temperature drops, it automatically releases the heat stored in the daytime, so as to ensure that the temperature difference between the morning and night in the room does not exceed 6 degrees Celsius [11]. Besides storing and releasing heat, the heat storage floor can effectively transfer the fresh air outside to the room with the small holes on its surface, thus ensuring the indoor air flow, so that people can breathe fresh air indoor.

2) Utilization of biomass energy. Biomass energy is a renewable resource that uses biomass as the carrier to convert solar energy and store it in biomass. This kind of biomass can be used to convert its stored energy into solid, liquid and other fuels under the help of technology, so as to meet people's living needs. Under the current development, the utilization of biomass energy is mainly reflected in liquefied garbage gas and straw. By doing so, biomass energy can efficiently provide heat for the lives of residents (see **Figure 8**). In particular, the use of biogas in this ecological building can provide not only abundant electric energy, but also heat energy to meet the needs of residents for cooking. It is important to note that when biomass energy is used, it is integrated with a variety of biomass energy in a comprehensive way, that is, joint use, to obtain low-carbon renewable resources [12].

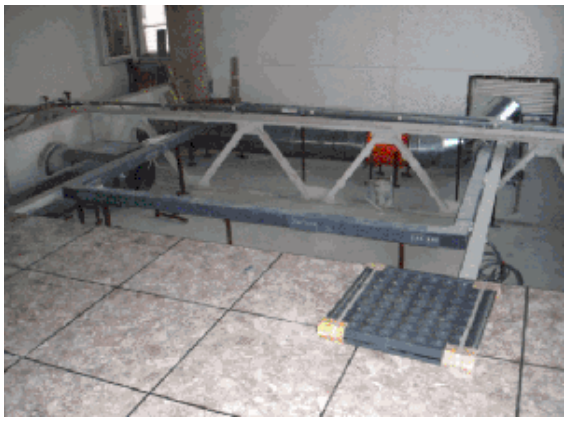

Figure 6. Real view of elevated raised floor.

Figure 7. Filling of phase-change material.

Figure 8. Outer wall of low energy demo building of Tsinghua university.

3) Utilization of geothermal energy. In ecological buildings, heat pump technology is indispensable for heating and cooling. Heat pump technology refers to a device that takes low heat energy from natural air, water or soil and provides high heat energy to people after electricity is used to do work. In some current new buildings, geothermal heat is often used for heating. The use of geothermal energy is confined to residential areas. Geothermal energy can also be applied to vegetable greenhouses to keep warm. In short, in the construction of ecological buildings with the help of geothermal energy, it is necessary to adapt to local conditions and choose geothermal energy according to local actual conditions. For example, in this industrial process, the temperature of the domestic heat pump can be increased to more than 4000˚C [11], so as to realize the full utilization of resources on the basis of meeting the needs of industrial development.

3.3. Energy Conservation Ways by Passive Ecological Building Heat Storage

In ecological building components, transparent aquifer can be fully used to improve the heat storage and thermal inertia of building envelope. The Low Energy Demo Building of Tsinghua University was taken as an example. The same material with the same color was used to construct the outer wall. This is because the north wall is facing the air outlet. The wall is made of transparent glass and thermal insulation composite material, which can reduce the erosion caused by the north wind and isolate the difference in temperature between inside and outside, so that the indoor temperature can be effectively maintained at a certain temperature. In order to reduce the heat loss caused by radiation and the influence of convection, the south wall adopts a double-layer curtain wall structure,

so as to achieve the effect of warm in winter and cool in summer. In addition, the ceiling of the energy conservation building is filled with water at a certain temperature by virtue of a plastic pipe with a diameter of 6 mm, giving full play to the function of water cycle, and heating or cooling the room as the indoor temperature changes with the water temperature [11]. In this way, the utilization rate of air conditioning can be reduced and natural resources can be used to meet people's demand for indoor temperature.

4. Conclusion

Through the study of energy conservation by building materials for ecological architecture, this paper indicates that, in traditional architecture, resource consumption is high, energy consumption is high, and environmental pollution is serious, which is contrary to the concept of sustainable development. However, in ecological architecture, renewable and reusable green building envelope and building materials are used to realize ultra-low emission and ultra-low energy consumption of ecological architecture. The long-term development of the building industry needs to be based on ecological protection. With the help of ecological architecture and the use of energy conservation materials, we should reconcile the contradictions between the building and the environment, so as to realize the green development of the building industry. Therefore, through discussion on energy conservation by building materials for ecological architecture, this paper analyzes the practical application of energy conservation by building materials in ecological architecture to bring the society and the market a more comprehensive and profound understanding of the economic benefits of green and energy-saving building materials, which is conducive to the development of green buildings in China, and lays a solid foundation for the rational development of China's building engineering.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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