

# Research on the Design Principles and Embodiment of Eco-Build

Siupang Ho

The Attached Middle School to JXNU Binjiang Campus, China

1109501931@qq.com

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**Abstract:** Sustainable development has become a common theme for all countries in the world in the 21st century, and Eco-build has gradually become a mainstream development direction of the construction industry from an emerging architectural concept. Starting from the concept of Eco-build, this paper gives a brief overview of the basic features of Eco-build: recycling of materials; energy saving and use of renewable resources; waste reduction; environmental and cultural attributes. Also, it analyzes the principles of Eco-build design: integrity, efficiency, flexibility, functionality, and economy.

## 1. Introduction

Since the 20th century, with the continuous development and progress of economy and technology, human society has undergone radical changes. The oil crisis in the 1870s made people realize that the current high speed of social development at the expense of the environment is no longer sustainable (Hammond, G. P., 2000). Environmental pollution, energy shortages, and other problems have severely damaged our present living environment and have had a tremendous impact on future social development. People are beginning to realize that in the pursuit of economic development, they should also pay attention to the coordination with the environment ( ). Therefore, sustainable development has become a common development theme for all countries in the 21st century.

As the construction industry is the most energy-consuming, sustainable development requires a shift from the traditional high-consumption development mode to an efficient and green development mode. Since the 1960s, the concept of "Eco-build" and "Green building" has been put forward abroad until the 1990s, when the concept of "sustainable development" was proposed. After a long period of development, Eco-build has gradually become the mainstream development direction of the construction industry from an emerging architectural concept. The concept of Eco-build has gradually developed from a simple ecological consciousness in the early days into a comprehensive design theory system with systematic theory and practice. From the perspective of long-term development, Eco-build should also become the trend of the construction industry. A good building should be environmentally friendly and organically integrated with the environment (Day, C., 2017).

## 2. Concepts Related to Eco-Building

### 2.1 Definition of Eco-Building

ECO is the abbreviation of Eco-build, which is a rational arrangement and organization of the relationship between buildings and other relevant factors based on the local natural ecological environment, using the basic principles of ecology, building technology science and modern scientific and technological means, so that the relationship between buildings and the environment becomes an organic combination, and at the same time has good indoor climate conditions and strong bioclimatic regulation ability to meet the environmental comfort of people's living, to form a virtuous cycle system between people, buildings and the natural ecological environment (Moser, C., 2010).

Eco-build is a higher level of return to nature, which relies on the latest development of many relevant technologies and the best combination of these technologies according to specific conditions. No matter what technology is used, the building must be treated as a living organism to form a virtuous cycle system in balance with the natural ecology; the building must be treated as an ecosystem, and through the design and organization of various physical factors in the building's internal and external spaces, material and energy can be recycled and used in an orderly manner within the building's ecosystem to obtain an efficient, low-consumption, low-waste, low-pollution, and ecologically balanced building environment(Vona, F., & Patriarca, F. ,2011).

## **2.2 Basic Characteristics of Eco-Building**

### **2.2.1 Recycling of Materials**

The steel, cement, sand and gravel, masonry blocks, etc. commonly used in current construction are all taken from existing resources on earth, which is a waste of natural resources and prone to environmental pollution, while the building materials used in eco-building should not only not waste natural resources but also not pollute the environment. It is important to choose environmentally friendly building materials and to use recycled or recyclable materials and resources in everyday construction. For example, using recycled building materials and reducing construction waste in the building construction process, and Bamboo, straw bale, rammed earth, timbercrete, ferrock, and barn wood are great recyclable construction resources. (Naik, T. R., & Moriconi, G., 2005,).

### **2.2.2 Energy Saving and Use of Recycled Resources**

The technical principle of energy conservation is to reduce energy consumption through thermal storage and other measures, improving energy efficiency, and to make full use of renewable natural resources, including solar, wind, hydroelectric, ocean, and bio-energy, and meanwhile, to reduce the dependence on non-renewable resources (e.g., oil and coal). In the design of buildings with different climatic characteristics, according to the operation of the sun and the formation of wind, the use of sunlight and ventilation and other energy-saving measures to reduce energy consumption, the application of heat storage and insulation properties of materials, and the consideration of thermal insulation and thermal performance are adopted.

### **2.2.3 Reduce Waste Discharge**

Avoid the release of toxic and harmful pollutants to the outside environment and carefully dispose them by all means before release. At the same time, consider the impact of the building's surroundings on people's health and the health hazards of the building's indoor environment on its occupants. For example, decorative materials that do not emit toxic and harmful gases are needed to be used.

### **2.2.4 Environmental and Cultural Attributes**

Ecological and sustainable architecture in a broader sense also involves environmental and cultural spheres. The design should take into account the building's environment, such as the surrounding buildings, traffic, communication, school conditions, and other amenities. Cultural attributes should follow the local cultural and regional characteristics, and design buildings with certain regional characteristics to avoid uniformity of urban appearance( Williamson, T. J.,2003).

## **3. Ecological Architectural Design Principles**

### **3.1 Integral Principles**

Due to the growing trend of ecological crisis, people are beginning to reflect on their own behavior and scholars are beginning to philosophize about it. Inspired by modern ecology, the idea of "ecological holism" has been proposed (8). The values of ecological holism emphasize both human dependences on society and human dependence on nature, which is a dual concern for

human sociality and human dependence on nature. Kathleen Mercer, a famous American historian of environmental history and science, suggests that holism views both humans and nature as components of the same organic cosmic system (Bakken, P. W., 1995).

Ecosystems are the material basis for human survival and development and can play a decisive role in the survival of human beings and the development of society (). Ecosystems not only provide people with the material basis and prerequisites for the existence of life forms but also provide opportunities for the social, intellectual, spiritual, and moral development of human beings, as the elements we obtain from them have a profound influence on our way of life and production. Therefore, the stability of ecosystems is crucial to the existence and development of human societies. If an ecosystem is destroyed, it can jeopardize the existence and development of human beings and society.

Eco-build is also an important part of the ecosystem. It is a large and complex system with many facets. Eco-build, broadly defined, encompasses a wide range of natural, social, human, and economic attributes. Rather, we should integrate the building and the area in which it is located into the surrounding natural and social environment on the premise of satisfying the owner's requirements and the function of the building itself. It is important to emphasize local and traditional cultural characteristics to promote the organic integration of technology and humanities and to consider all factors and weigh them to select the best solution. To make full and rational use of non-renewable land and other resources, to create efficient and reasonable development intensity, and to create a residential and urban environment that protects the regional environment, utilizes appropriate technology, and is humane.

Eco-architecture also necessarily requires us to establish a harmonious relationship between humans and nature, respect nature, and minimize the impact on the original natural environment [6]. To harmonize the natural environment with human behavior and development, and to focus on the integration and collaboration with nature, is the most basic connotation of ecological design. This requires architects to understand architectural works correctly, to realize that they are only one part of the environment, and to deal with the relationship with the environment with a humble attitude, giving more attention to nature and the environment. Local interests must be subordinated to the interests of the whole, and short-term interests must be subordinated to long-term lasting interests.

### **3.2 Efficient Principle**

According to the "Ecological Footprint", of Eco-build theory, Eco-builds should occupy as few ecological footprints as possible and consume as little material and energy as possible, just as ecological cities do. Therefore, the principle of efficiency must be followed in the design of Eco-builds based on the concept of territoriality(Assessment, M. E.,2005).

Efficient building design encompasses multiple meanings, mainly in terms of energy consumption, improved thermal performance, reuse, and recycling. For ecologically-based buildings, minimizing embedded energy is an important aspect of the efficiency principle. Most of the materials commonly used in modern buildings, such as steel, aluminum, and silicon, consume large amounts of energy in the production process, so natural and local materials should be used as much as possible when constructing Eco-builds. This not only reduces transportation costs but also significantly reduces the energy consumption and the energy content of the materials used in their production and fabrication.

Another important aspect of the efficiency principle is to improve the thermal performance of the building. The amount of heat transferred is directly proportional to the area of the building's exterior surface (building volume factor). At the same time, heat transfer is also affected by the airtightness of doors and windows. Therefore, improving the manufacturing and installation precision of building windows and doors, using strong sealing materials and various sealing measures can improve the building's thermal performance and reduce building energy consumption.

Reuse and recycling is also an important measure of efficiency. In Eco-build design, renewable and recyclable materials should be selected as much as possible. When disposing of construction waste, the possibility of recycling should also be considered as much as possible. The energy

consumption ratio over the building's life cycle should be analyzed and predicted at the time of building design, including the amount of energy consumed for construction, maintenance, operation, and final disposal. By analyzing the building's energy consumption, the factors that affect the building's energy consumption can be identified, and energy-saving design measures can be proposed following these factors so that eco and energy conservation can be carried out throughout all stages of the building's life cycle to achieve the ultimate goal of ecological energy conservation. We analyze the functional properties and environmental adaptability of various building materials and simulate the effects and energy consumption of their application to the building itself and the surrounding environment. Based on the above analysis, the most suitable building material for the area is selected, and the building material is chosen to maximize its efficiency in the local natural environment to achieve energy efficiency.

### **3.3 Principle of Flexibility and Adaptability**

The term "adaptive architecture" was coined in the mid-20th century with the birth of Eco-build. It advocates a friendly attitude that is responsive to and collaborative with nature, rational coordination of the relationship between architecture and the natural environment, architecture and society, and architecture and people, and limits today's predatory production and development methods.

Introducing the concept of adaptive into the field of architectural design is actually an extension of architectural activity, making the creative thinking of architectural design go beyond the building itself to the broader ecological and environmental thinking. Adaptive architectural design is a creative approach that integrates architectural, environmental, social, cultural, economic, and technological thinking, making architectural design activities systematic and making construction results more responsive to the specific needs of the natural environment and society.

The principle of flexibility and adaptability that Eco-build should follow is also determined by the spatial and temporal properties of Eco-build and the differences between different regions. In architectural design, adopting design strategies that can adapt to various changes, avoiding premature abandonment, and enabling reuse or multiple uses can greatly reduce the cost of repeated construction of new buildings. At the same time, adopting design strategies that can adapt to changes in various areas can make the building suitable for a specific environment by adopting the most appropriate techniques and measures according to the natural, social, cultural, and other characteristics and needs of different areas (MAIER, Jonathan RA, 2009).

### **3.4 Functional Principles**

When buildings were first created, their function was simply to shelter people from the wind and rain. Simply separating the physical rest and activities from the external natural environment is the original functional division of a building. The reasonable functional division is the most basic guarantee that a building can meet the needs of users, and it can also ensure the normal and orderly progress of all activities inside the building, which is the functional principle of architecture [9]. This principle includes the following three meanings.

(1) The functional zones of a building should be clearly delineated, with clear spatial boundaries between the zones. For a functional space whose main purpose is actual use, the internal function may not be single, but the space occupied by each function and the proportion of area should be determined.

(2) The space and location relationship between the functions in the building space system should be consistent with the needs of the building function and the connection between different building functions to ensure that there will be no contradiction between the functional layout and spatial form of the building, and people will not feel the same or be disturbed by other functional spatial factors in the process of use.

(3) The organization of building flow is an issue that cannot be neglected in the layout of building functions. The requirements for the traffic flow between building functions are generally simple, clear, and convenient. Under the condition that it does not adversely affect the building's function, it should ensure that users can more easily reach the space they want to use. At the same

time, the functional flow of the building should be in line with the industry's operating procedures.

Modern buildings should be designed to meet modern functions. Even if a traditional style is adopted, the importance of function should not be weakened or ignored. In today's rapid development of social culture and technology, people's living standards should also be improved. Compared with ancient buildings, modern buildings have more complex, more extensive, and more detailed functional needs. Meeting the functional needs of people's daily life, work, study, and entertainment is the main factor that architects should consider when designing, and it is also a major principle that should be adhered to.

### **3.5 Economic Principles**

Economic efficiency is the ultimate comprehensive indicator of all economic activities. For buildings, economic efficiency should be understood from two perspectives: first, the economic return on investment in construction capital; second, the utilization efficiency of social resources during the whole life cycle of the building (WALKER, Nathan L.,2020). At the same time, the efficient use and optimization of social resources are one of the necessary conditions for the construction industry to shift from an extensive development mode to an intensive development mode and achieve sustainable development. The two are mutually promoting and influencing each other.

In traditional Eco-build design, the economic principle is the 3R principle-Reduce, Reuse, and Recycle. They constitute a hierarchy of priorities from high to low, i.e., it is preferable to take measures at the source of production to reduce the use of resources. Resource conservation does not require that resources are not consumed, but rather that they are used as efficiently as possible and that their recycling possibilities are enhanced. The second is the use of discarded parts generated during the construction of the building. Modular design is one of the most common methods for recycling components. It can not only ensure the diversity of the building and make the building meet different and diverse user needs, but also reduce the construction cost of the building and facilitate maintenance, upgrading, and recycling. Third, when designing a building, the possibility of recycling building materials and parts should be considered, as well as the recycling methods and values of building materials and parts, and other related issues. Only when these issues are taken into consideration can the most efficient use of resources be achieved and the generation of waste be reduced. This will reduce the pollution of the environment (HAISONG, Wang,2009).

## **4. Embodiment of Eco-build in Architectural Design**

### **4.1 Scientific design of ventilation and lighting in Eco-builds**

As an important factor reflecting the level of the living environment, ventilation, and lighting plays a very important role in the process of improving the living environment.

To improve the comfort level of ventilation and lighting in the building space, the most basic means is to scientifically construct the building layout and design, through the building layout, three-dimensional system construction, and the rational design of the building structure to enhance the ventilation and light transmission in the building, to greatly improve the air circulation of the building itself. At the same time, the reasonable control of lighting conditions in Eco-builds can ensure indoor lighting requirements and improve the room's own temperature control ability. In the process of Eco-build design, we can make full use of the building's shape design, reduce unnecessary direct sunlight and reduce the adverse effects of light irradiation on indoor temperature by hanging shading and other building structures, and combine it with the actual climate of the building's location, and make necessary adjustments to the building's architectural structure through scientific analysis, to meet the building's lighting needs.

From the current development of solar energy technology in China, the most mature and advanced application is solar water heating technology, which is commonly known as the home solar water heater. On the other hand, passive solar rooms and solar air conditioning demonstration projects have been initially built, but the current solar photovoltaic technology is still in the

preliminary stage. Solar water heaters are more widely used in ordinary households due to their low price and convenience. In the design of green Eco-builds, architects should give integrated consideration to solar water heating systems on roofs to avoid problems of secondary installation and secondary investment.

## 5. Conclusion

Green, ecological, sustainable development has become only the trend of modern building development, this ecological philosophy throughout the living environment can not be separated from the development of science and technology, only people, buildings, and the natural ecological environment to form a benign system, to truly achieve the ecology of the building.

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