

Research and Application of the Sustainable Architectural Design Theory

Xuan Dong^{1,*}

¹ Xiamen Academy of Arts and Design, Fuzhou University, Xiamen, Fujian, China

*Corresponding author. Email: 1937727017@qq.com

ABSTRACT

With the continuous development of China's current social economy, people's living quality has also been improved. Therefore, in the process of current architectural design, relevant designers begin to apply the concept of sustainability to architectural design in order to optimize people's living environment on the whole. The concept of sustainability is different from the traditional architectural design concept. It emphasizes not only the appearance and style of buildings, but also the design idea and the application of green technology, which is the only way for the development of the construction industry in the current era.

Keywords: Sustainable architecture, Design concept, Green environmental protection.

1. INTRODUCTION

With the proposal of the basic national policy of people-oriented and ecological civilization construction, the development of sustainable buildings and the construction of resource-conserving and environment-friendly society have become the fundamental goals of urban development in China. It is also the development direction of human society. In this process, how to design sustainable architecture and make the sustainable development of architecture become an important research topic.

1.1 The Origin and Development of Sustainable Architecture

In 1987, the World Commission on Environment and Development issued the report "Our Common Future", which defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."¹ [5]Constructing planned based on sustainable development is in the design, construction, maintenance, demolition of all kinds of buildings, the production, transportation and installation of

building materials, as well as the development, processing, transportation and use of energy, considering both the current needs and the future needs without sacrificing the interests of future generations to meet the present needs; not only improving people's living standards and promoting economic development, but also ensuring that a minimum adverse impact on the environment.

1.2 The Connotation of Sustainable Architecture

In the system of human sustainable development, sustainable architecture is supposed to achieve the "economy-environment-society" compound goal which is people-oriented. In some cases, the three aspects are contradictory and need to be compromised. For example, the rapid growth of economy sometimes comes at the cost of environmental deterioration; or, the rapid growth of economy may exacerbate the gap between the rich and the poor and bring about social instability. In some other cases, they promote and complement each other. For example, the vigorous development of cultural and creative industries is likely to promote excellent products, thus bringing great added value to the country and society. What sustainable architecture design should do is to seek a balance in these three aspects.[2] This paper will expatiate the connotation of sustainable building

1. World Commission on Environment and Development. Our Common Future [M]. Wang Zhijia Trans. Jilin People's Publishing House, 1977.

design from three angles of economy, environment and society.

Economically, it is necessary to comprehensively reduce the cost of the building. The building should be as efficient, multi-functional, multi-purpose and durable as possible, and create economic benefits as far as possible to promote the economic development of the local and even the wider region.

In terms of the environment, it is necessary to use a variety of ways to save the earth's resources, such as the saving of energy, material, land, water, etc., design maximized function and meaning of architecture, bring no harm to the environment in any period of architecture such as construction, operation, maintenance and demolition, and try to leave a positive effect on ecological restoration, and control the development of non-renewable resources to such extent that the investment will produce sufficient substitution effects in particular.

Sustainable architectural design pursues the combination of design with nature. "Design with nature" comes from the book "Design with Nature" by Ian Lennox McHarg. On the one hand, it puts forward the ecological thought that human beings and nature are an organic whole, thus setting up an ecological banner for the whole world. On the one hand, it puts forward the technical path that people can return to nature and make peace with nature through the design of the environment.²[4] This requires the consideration of integrating of the buildings with the surrounding environment and give priority to the natural renewable resources provided by the environment, such as solar, wind, biomass, hydrogen, geothermal, marine, hydroelectric power, etc. when designing buildings in order to achieve sustainable goals.

Socially, architecture can meet various needs of people and coordinate various interests comprehensively. Various social factors should be considered and carried as much as possible in the architecture, to deal with a variety of complex social problems, and promote the harmony and development of the region and the whole society. In terms of the "economic-environment-society" comprehensive goal, architecture is required to achieve the purpose that we are comfortable with both psychologically and physically, and not to have a negative impact on the environment due to

2. [UK] Ian Lennox McHarg. *Design with Nature* [M]. Translated by Rui Jingwei. Beijing: China Architecture & Building Press, 1992.

its low construction cost or the need to bring economic benefits to us, and not to have a burden on the environment due to the social value it brings, within the carrying capacity of the environment; to balance the interrelation of economy, environment and society, and promote the coordinated development of economy, environment and society that meets the needs of contemporary people as well as the needs of future generations.

In addition, sustainable development requires a balance between man and nature and between man and man. Man and nature must be in balance and harmony. Engels pointed out: "Let us not be too intoxicated with our human victory over nature, for every such victory, nature revenge on us."³[1] He was to remind us to follow the laws of nature, or we will be punished by the them. He also mentioned that "We must remember at every step that we do not rule nature as conquerors rule bariconas, not as men who stand outside it — on the contrary, we, with our flesh and blood and brains, belong to it and exist in it; all our power over nature lies in our ability to understand and apply the laws of nature better than all other creatures."⁴[1] Sustainable development also requires harmonious relationship between people. Marx and Engels pointed out: "Labor makes people form a certain social relationship in a certain way, and society is the intermediary of the relationship between man and nature, which links people and nature. The level of social development and social system directly affect the relationship between man and nature. Only by coordinating the relationship between people, can the contradiction between human and nature be fundamentally solved and the harmonious development of nature, society and human be realized."⁵[1] Therefore, it is necessary to always bear in mind that human beings should keep a balance by giving equal rewards to nature while taking from it; the interests of the present generation cannot be advanced at the expense of those of future generations; this region must not develop at the expense of other regions. In short,

3. [German] Friedrich Engels. *Dialectics of Nature* [M]. Central Compilation and Translation Bureau of Works of Marx, Engels, Lenin and Stalin, trans. Beijing: People's Publishing House, 1971.

4. [German] Friedrich Engels. *Dialectics of Nature* [M]. Central Compilation and Translation Bureau of Works of Marx, Engels, Lenin and Stalin, trans. Beijing: People's Publishing House, 1971.

5. [German] Friedrich Engels. *Dialectics of Nature* [M]. Central Compilation and Translation Bureau of Works of Marx, Engels, Lenin and Stalin, trans. Beijing: People's Publishing House, 1971.

we should carry out the sustainable design view into our architectural design throughout.

2. TECHNICAL DESIGN FOR SUSTAINABLE BUILDINGS

2.1 Natural Ventilation

Any indoor environment has a direct impact on our health, including our cardiovascular health, respiratory health and immune system health. According to relevant surveys, a healthy indoor environment can help us reduce the cost of health care, improve the efficiency of daily work and focus on study.

In fact, natural ventilation is an important passive green building technology measure, which can effectively save energy consumption of air conditioning and mechanical ventilation. The effect of natural ventilation is closely related to the local climate, type of building, function, design and control strategy. According to relevant research, natural ventilation can achieve energy saving effect of about 30%-70%. Many international and Chinese domestic standards and specifications have put forward clear requirements for the effect of natural ventilation of buildings, such as China's "Green Building Evaluation Standard" GB/T50378-2014 and "Heating, Ventilation and Air Conditioning Design Code for Civil Buildings" GB50736-2012, etc.

2.2 Natural Lighting

Natural lighting and electricity use are directly related, which is why it achieves energy efficiency. Among them, the most obvious is the relationship between natural lighting and artificial lighting. Natural lighting can reduce the use of artificial lighting, thus reducing the electricity consumption of artificial lighting. Here if the light sensor and artificial lighting can be effectively used through the automatic control system linkage, the effect will be more obvious.

Next, natural daylighting is still related with visual field directly. Architecture is about creating boundaries, and that's where the distinction between inside and outside comes from. People perceive information from the outside by the light coming in. Good vision helps people feel more satisfied, more focused and more productive. Richard Neutra once noted, "a large window that gives an unobstructed view of the surroundings" can create a feeling of "relaxation, satisfaction and relief." At the same

time, the visual field is qualitatively differentiated, which is more attractive and provides better visual relief when it contains natural elements. According to a 2003 study by the California Energy Commission, workers who sit in front of a computer, often with tired or dry eyes from hours of nonstop staring at a screen, can be relieved by the allure of the distant view. Another 2008 study by Ulrich Rodger showed that providing patients with natural views and access to nature in medical settings can shorten hospital stays, reduce stress, depression, and use of painkillers. There is no doubt that good vision is beneficial to human health. This is also required in many green building or sustainable building evaluation standards. For example, there is a requirement of excellent vision in the indoor environment quality part of the American LEED standard.

In conclusion, the design of natural lighting should be the intentional and controlled use of natural light to achieve a specific goal. That is, the aim is to maximize natural light, but at the same time attention should be paid to avoiding visual problems caused by excessive light.

2.3 Water Resources Recycling

The goal of water resource recycling is to realize water conservation — flood control and ecology, water saving — water resource utilization and water purification — sewage treatment. Water conservation can be achieved through the recycling of rainwater by designing green spaces, permeable paving and permeable pipelines. For example, the green space designed can make rainwater penetrate into the soil, which can help the microbial activities of the soil and contribute to the green photosynthesis to a certain extent; at the same time, the roots of plants can activate the soil, increase soil porosity, and help to conserve rainwater. They are a mutually reinforcing process. Rainwater on the roof of a building or around the building can be recycled through the designed permeable pipeline and be used for greening water after treatment.

The purpose of water saving can be achieved through the design or use of water-saving equipment, for example, all the sanitary appliances in the building can be water-saving equipment, water-saving toilets can be used, water-saving faucets and other water-saving equipment can be adopted in public kitchens.

The aim of water purification can be achieved through the establishment of reclaimed water

system. The daily sewage in the building can be discharged into the sewage pipe set up in the city for unified treatment, and the rest of the sewage will be collected and recycled for miscellaneous domestic water after being treated by the equipment, such as toilet flushing, landscape and greening water, with a reuse rate of 42%.

3. DESIGN PRINCIPLES FOR SUSTAINABLE BUILDING DESIGN

3.1 Being Environmentally Friendly

Today, it is very difficult to achieve 100 percent sustainable architecture with no negative impact on the environment today. In most cases, the design must be environmentally friendly. In this sense, the construction of the external environment and the internal environment play an equally important role in different aspects. The internal environment mainly considers the reduction of pollution, while the external environment mainly considers the possibility of ecological restoration. It is important to use more natural materials, renewable energy, environmentally friendly equipment and avoid the use of materials that cannot be naturally degradable, phase out traditional energy sources, avoid site damage; great efforts should be made to minimize the adverse impact on the natural environment in terms of building materials, air, soil, water, biodiversity and other aspects and reduce the burden of ecological restoration; to abandon the so-called "reducing environmental damage and ecological compensation is environmentally friendly" view, the first is to minimize interference and damage to the natural environment and the second is to try to make ecological compensation for the damaged and polluted site environment to help it restore the ecological balance.

3.2 Resources-conservation and Efficiency

Designers should save the limited earth resources in a low-cost, recycling and efficient way under the rational attitude of moderation and enough. Natural energy, low processing natural materials, recyclable materials, environment-friendly high performance materials high performance materials and generalized materials and components should be considered first; it is necessary to make rational use of building structure, environmental performance simulation technology and construction methods to reduce the

consumption of land resources, water resources, building materials and energy; it is also important to make careful use of scarce and rare resources, and strive to improve the efficiency of all resources in the whole life cycle of the building. The service life of the building should be extended as far as possible, and the cyclic utilization of the old building and the recycling of the old equipment, components, materials and furniture should be realized. The building should be localized as far as possible. The ideal existence process and state of sustainable building is: local resources — local production — local sales — local circulation. However, in the era of globalization, the interconnection of the world has become a whole that promotes and influences each other. Such localization is difficult to be implemented on a large scale and is a bit too idealistic, but it is an idea, an orientation of goal and a meaningful practice. The cost can be strictly controlled in the design of the building scheme and the cost of the construction, operation, maintenance and demolition of the building should be estimated to calculate the proportion between the cost required by the building and the benefits it will bring in the future, so as to maximize the benefits of the building.

3.3 Adjusting Measures to Differing Conditions

The design should be closely combined with the actual conditions of the region and the overall environment background, using favorable conditions and positive factors to avoid adverse effects and sensitive issues. It is important to develop sustainable building schemes according to local conditions, protect regional uniqueness, carry forward and inherit regional culture, and show the regional style of the times. The adaptation strategy and the focus of environmental issues can be determined according to the physical geography and climate conditions; the general requirements and the main needs of users can be determined according to the social development level and the human environment; and then the design strategy suitable for the local actual situation and real needs can be formulated combined with resource conditions, technical level and economic conditions. Focus should be put on analyzing, summarizing and absorbing the design, construction, operation and waste disposal strategies of local traditional architecture in using resources and dealing with environmental problems, and the use of local materials and local

construction technologies should be put at priority, to explore design elements that can be used for reference as much as possible, in order to activate the style and spirit of local traditional architecture. Sustainable design scheme should not only seek the unity of regional and contemporary architecture, but also highlight the local regional characteristics in this unity.

Kengo Kuma's Chokkura Plaza ("Figure 1" and "Figure 2"), for example, is a typical place that integrates with the local area. He mentioned that, "The holes are used not only for light and ventilation, but also to give the building a gentle and intimate feeling. Thick walls built with only stone might be better suited to warehouses and churches. It was a bit too heavy for the station square in front of a field station. Countless holes in the wall, and the sedimentation of the stains of decades have experienced wind and rain together. The Oya tone is near its development site, perfectly playing to its advantage of being "full of holes". The stone "full of holes" perfectly matches the local landscape, producing a wonderful atmosphere."⁶[6]



Figure 1 Chokkura Plaza.

a The picture is from Kengo Kuma's book "The Voice of Architecture", Mu Dian Trans, Beijing: New Star Publishing House, 2017, p. 85.



Figure 2 Chokkura Plaza.

a The picture is from Kengo Kuma's book "The Voice of Architecture", Mu Dian Trans, Beijing: New Star Publishing House, 2017, p. 90.

3.4 Using Suitable Technology

Designers should start from the local actual conditions and the actual situation of building construction and operation, find an integrated technology strategy most suitable for the local natural environment characteristics, social development level, economic conditions and general, and achieve the architectural purpose in the simplest way. There is no need to blindly pursue high technology, and the accumulation of "high, expensive and new" technologies should be avoided to reduce the initial investment of the building, as well as the difficulty of construction and maintenance. If the ideal effect can be achieved through simple technical means, high cost or advanced technology should be avoided. Since the traditional technology is not inappropriate and it contributes to the sustainable purpose, efforts should be made to achieve low investment and low environmental impact of the building and the maximum "technology-function" transformation.[7]

3.5 Green Construction

At present, human beings are still using energy which will pollute the environment on a large scale. Therefore, saving energy consumption will inevitably reduce pollution and is conducive to environmental protection. Greening is an important measure to protect the environment and ecology, and saving construction land can provide more green land. Yet the development of three-dimensional greening without directly occupying land for greening can further save land use. This is the relationship between land conservation and environmental protection. Construction workers who devote themselves to improving human living environment should pay close attention to energy saving and land saving.

Sustainable building design in the construction process should try to use environmental protection and energy saving materials, as environmental protection and energy saving materials can reduce the pollution to the environment, and avoid harm to human body to a certain extent. At the same time, it can provide pollution-free recyclable materials, in order to ensure that building materials can be recycled, further achieving the purpose of sustainability.[3] In short, it is necessary to implement the concept of sustainability into every aspect of design and even life. For example, outdoor landscape lighting in architectural design

6. [Japan] Kengo Kuma. Natural Architecture [M]. Chen Jing Trans. Jinan: Shandong People's Publishing House, 2010.

uses solar photovoltaic system, which can convert solar energy into electricity.

Dutch designer and architect Raimonddehullu have come up with the idea of "using trees as building materials to transform cities into forests" and is now implementing the project, called OASIS. OASIS introduced a new building typology to world architecture design, which is considered to be the first building in modern history to be 100% "green". Using vertical greening technology, skyscrapers and mid-rise buildings will be shrouded in natural vegetation, and on the basis that the ecosystem can maintain a self-sustaining balance, the densely populated area can restore the natural living environment without interfering with the existing residents. Unpractical as it may sound at the concept stage, it is actually easier to implement than sceptics think. The construction materials include wood, organic insulation, green plant walls and glass, each of which is ecologically friendly and does not produce any pollutants. Moreover, the sustainable development of the building can reduce the environmental load, connect with the environment, and benefit the health of the occupants. Its purpose is to reduce energy consumption, save water, reduce pollution, protect the environment, ecology and people's health.

3.6 Reasonable Space

In his book "Space, Time and Architecture", architectural historian Giedion divides the history of human spatial relations into three eras: "In the first age, which can be called submission and use of outer space but no inner space, the Neanderthals used outer space instead of building inner space; true architecture, such as the Pyramids of Mesopotamia and Egypt, and later the statues, columns, and obelisks of Greek and Roman city squares, also show compliance to outer space and attempt to control it for the use of human. The second era, can be called the separation of internal space and external space. In A.D. 100, the Pantheon in ancient Rome saw the first artificial interior space, allowing humans to separate the interior from the exterior. Architectural space is a physical place defined by certain elements in nature, so that human beings can become an independent existence independent of the external nature. The space concept and its philosophical significance of the dualistic opposition between man and nature have influenced and even dominated the development direction of the western and even the

whole human society for a long time. The third era is marked by the German Pavilion at the Barcelona International Exposition designed by Mies Van der Rohe in 1929. The emergence of "flowing space" breaks the boundary between inside and outside space, liberating human beings from the closed walls they built and returning to nature." ⁷ [8] Today, to reduce the buildings' impact on the surrounding environment, when using the concept of sustainable architecture scheme in the design process, the related design personnel should strengthen the investigation of the surrounding environment, make scientific and reasonable use of the site of the construction site according to the actual requirements of construction engineering and construction needs, and make scientific and reasonable space arrangement combined with requirements of the user to the house type under the current era. At the same time, green construction technology and construction materials should be used in the design work. Relevant designers in the design work should strengthen the communication and exchange between the site construction personnel and technical personnel and comprehensively understand the natural environment and geological conditions of the construction site, the construction site of the natural environment and geological conditions, so that these natural resources can be fully utilized.

4. CONCLUSION

Both the environmental problem and the resource problem have become the worldwide topic. It can be seen that sustainable buildings are likely to replace ordinary ones in the future. The development of sustainable architecture or green architecture and ecological architecture started earlier in the West, and now a complete industrial system has been formed. Although China has made some progress in recent years, it is still not advanced enough in many related technologies. In the future, it is still necessary for China to learn the advanced ideas of the West in the development of sustainable architecture, and the unceasing efforts of relevant technicians and scholars are needed to constantly find and solve problems in practice, so as to make a breakthrough achievement in the construction industry.

7. Siegfried Giedion. *Space, Time and Architecture* [M]. Wang Jintang and Sun Quanwen Trans. Wuhan: Huazhong University of Science and Technology Press, 2014.

AUTHORS' CONTRIBUTIONS

This paper is independently completed by Xuan Dong.

REFERENCES

- [1] [German] Friedrich Engels. *Dialectics of Nature* [M]. Central Compilation and Translation Bureau of Works of Marx, Engels, Lenin and Stalin, trans. Beijing: People's Publishing House, 1971.
- [2] [USA] Tom Lass. *Sustainability and Design Ethics* [M]. Chongqing: Chongqing University Press, 2016.
- [3] [USA] David Bergman. *Sustainable Design: A Critical Guide* [M]. Xu Xinlian and Chen Ran Trans. Nanjing: Phoenix Science Press, 2019.
- [4] [UK] Ian Lennox McHarg. *Design with Nature* [M]. Translated by Rui Jingwei. Beijing: China Architecture & Building Press, 1992.
- [5] World Commission on Environment and Development. *Our Common Future* [M]. Wang Zhijia Trans. Jilin People's Publishing House, 1977.
- [6] [Japan] Kengo Kuma. *Natural Architecture* [M]. Translated by Chen Jing. Jinan: Shandong People's Publishing House, 2010.
- [7] Qian Yi. *Environmental Protection and Sustainable Development* [M]. Beijing: Open University of China Press, 1999. (in Chinese)
- [8] Siegfried Giedion. *Space, Time and Architecture* [M]. Wang Jintang and Sun Quanwen Trans. Wuhan: Huazhong University of Science and Technology Press, 2014.