Sustainable Architecture Design

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Abstract. Sustainable development is the theme of the twenty-first century, and all industries are undergoing radical changes around this theme. The construction industry has also changed from the old-fashioned high energy consumption and high pollution type to the ecological and environmental protection type. Therefore, sustainable architecture has emerged. It is a new and innovative approach in many fields such as architecture, urban planning, civil engineering, and building environment and plant engineering. Building Information Modeling (BIM) allows architects to abandon traditional two-dimensional drawings, no longer limited by how to use traditional two-dimensional construction drawings to express the three-dimensional complexity of a space, thus expanding the implementability of architects' exploration of architectural form, and free-form is no longer a utopian imagination on a computer screen. In other words, BIM allows architectural design to move from two-dimensional to three-dimensional and to digital construction, which is a major transformation of architectural design methods.

Keywords: New materials, ecological Architecture, built environment, Building Information Modeling (BIM), urban development, sustainable development, architectural practices, architecture design

1 Introduction

Today, while modern buildings bring comfort and convenience to people's lives, their impact on the environment is also of great concern. In the United States, for example, commercial and residential buildings consume nearly 40% of total energy, 70% of electricity, 40% of raw materials, and 12% of fresh water, while emitting 30% of greenhouse gases and generating 136 million tons of construction and demolition waste [1]. With the rapid development of cities, the built and living environments have also improved, but the problems of urban development have also become more and more prom-

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inent. Noise pollution, light pollution, and other factors affecting people's living conditions have emerged, and in 1987 the United Nations World Commission on Environment and Development (WCED) first put forward the concept of sustainable development. "The so-called sustainable development refers to the development that can satisfy the present needs of human beings without jeopardizing the social and economic interests of human beings in the future." This is a new direction for mankind on the road to the future. The development of various industries is also centered on this theme. The construction industry is an important part of urban development. The sustainable design of buildings is also an inevitable trend in urban development [2].

In the 1980s, the concept of "green building" was finally developed through the integration of many disciplines. The meaning of "green" is to protect natural resources, regulate human activities and make nature enter into a virtuous cycle. The meaning of "green" is to protect natural resources, regulate human activities and bring nature into a state of virtuous cycle. On the economic level, it is to pursue economic and ecological equilibrium. In economic terms, it is to pursue a balance between the economy and the ecology, not only to promote sustainable economic development, but also to build a protective economy that is conducive to the natural ecology. Therefore, green building belongs to the category of sustainable development. Therefore, green building belongs to one of the links of sustainable development, and is the centralized expression of sustainable thinking in the construction industry. Sustainable development is the primary goal of promoting green building, and it is also the fundamental spirit of green buildings [3].

2 The Concept of Sustainable Architecture

2.1 Definition of Sustainable Development

Lester Brown defines sustainable development from the perspective of the "three-dimensional structural load system", i.e. sustainable development does not refer to economic or social development alone, nor does it refer to ecological sustainability alone, but rather to the sustainability of the natural and socio-economic load system centered on human beings. Therefore, from the perspective of a three-dimensional structural complex system, sustainable development is defined as the dynamic regulation of the natural and social complex system by the history of sustainable development, which enables human beings to promote economic development, maintain the resource cycle, and improve the quality of life while exceeding the carrying capacity of resources and the environment. Sustainable development is the process of human regulation of this complex system. There is no absolute standard for sustainable development because there is no end to the history of human social development. It reflects the state of functioning of the system and its overall trend. According to the above definition, firstly, the regulatory mechanism can promote economic development, secondly, development cannot exceed the carrying capacity of resources and the environment, and thirdly, the result of development is to improve the quality of life of human beings and create a better society for human beings [4].

2.2 Land Use Change Analysis and Development in Human Architectural Practices

Land use dynamics can quantitatively describe the rate of regional land use change, which is important for comparing regional differences in land use change and predicting future land use change trends. It plays an important role in comparing regional differences in land use change and predicting future land use change trends [6]. Here, a single land use dynamic attitude (1) is introduced to describe the land use change in Changsha City, and its expression is as follows:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \quad (1)$$

Where K is the attitude of a land use type within the study period; U_a and U_b are the number of a land use type at the beginning and the end of the study period, respectively; T is the length of the study period, and when the time period of T is set to be a year, the value of K is the annual rate of change of a land use type in the study.

The relative rate of change in land use can more accurately reflect the differences in land use change between different regions. The relative rate of change in land use can more accurately reflect the differences between different regions in land use change. Its expression is (2):

$$R = \frac{|K_a - K_b|/K_a}{|C_a - C_b|/C_a} \quad (2)$$

where K_a and K_b represent the area of a particular land use type in a region at the beginning and end of the study period, respectively; C_a, $C_b$represents the area of a particular land use type in the whole study area at the beginning and end of the study period, respectively. If the relative rate of change of a particular land use type in a region is R>1, it means that the change of this land use type in the region is larger than that of the whole region, which is a hotspot of land use change [4].

The study area has experienced significant changes in land use and cover over the years Table 1. Cultivated land, garden land, forest land, watershed and unutilized land have decreased, with cultivated land decreasing the most and grassland and built-up land increasing, with built-up land increasing the most.

Table 1. Land use and cover changes in the study area, 1995-2005 (〖hm〗 ^2/%) [4]

Land use type	Area	1995 the share of land	Area	2005 the share of land	Area of change	Rate of change
Farmland	13065.43	23.485	10004.07	17.982	-3061.36	-2.34
Garden land	2631.07	4.729	2390.14	4.296	-240.93	-0.92
Woodland	10115.52	18.182	8578.61	15.42	-1536.91	-1.52
Grassland	1.97	0.004	8.04	0.015	6.11	31.02
Water	8544.48	15.358	8027.35	14.429	-517.13	-0.61
Building land	19282.18	34.659	24800.94	44.579	5518.76	2.86
Unutilized land	1993.43	3.583	1824.89	3.28	-168.54	-0.85

3 Digitization in Sustainable Architecture Design

Driven by a wave of data, today's architects and engineers are designing buildings using software tools that offer far greater functionality than traditional design tools. With these tools, architects and engineers can easily access information on material properties, energy performance, lighting quality, site disturbance, and hypothetical comparisons between new construction and renovation projects. This approach to building design is so different from using traditional CAD software that the industry has given it a new name: Building Information Modeling (BIM). BIM allows architects to abandon traditional two-dimensional drawings, no longer limited by how to use traditional two-dimensional construction drawings to express the three-dimensional complexity of a space, thus expanding the implementability of architects' exploration of architectural form, and free-form is no longer a utopian imagination on a computer screen. In other words, BIM allows architectural design to move from two-dimensional to three-dimensional and to digital construction, which is a major transformation of architectural design methods. This is a major transformation of architectural design methods, especially for special and complex projects [1].

When the architect's design work is transformed from a two-dimensional to a three-dimensional environment, and when the whole design process becomes visualized, simulated, and analyzed, many design errors can be discovered and corrected in advance, many design ideas can be tested and decided in advance, and many material costs can be analyzed and adopted in advance, which invariably reduces the human, material, and financial costs of the final design results. In the construction industry, many people associate these changes brought by BIM with sustainable design. Sustainable design is the incorporation of the concept of sustainable development into the design process. This concept requires the ability to predict the performance of a design, compare different options, anticipate environmental impacts, and simulate the implementation process during the development phase of a design to avoid damaging and wasting the environment and resources, and to ensure that green resources are developed, cleaner production is carried out, and the ecological environment is continually improved and optimized, thus ultimately harmonizing and facilitating the interaction between the population, resources, and the environment. Nowadays, the concept of sustainable design has begun to be deeply applied to almost all design fields such as architecture, urban planning, production and industrial manufacturing [1].

3.1 Wooden Houses that Stay Warm in Winter and Cool in Summer

Improving the thermal performance of the envelope can significantly reduce the building's cooling and heating load. Nanjing is located in a region with hot summer and cold winter, so it should not copy the thermal system of the envelope structure in cold or cold regions, areas, the thermal system of the enclosure structure should not be copied from the cold or cold areas, but should be analyzed by combining with the specific building characteristics. The performance analysis should be carried out with specific building characteristics. From the relationship between the envelope structure and the indoor load of the building, it can be seen that with the improvement of the thermal insulation performance, the marginal benefit of reducing the load of the building is decreasing. When the heat transfer coefficient of the external wall reaches about 0.4 W/($m^2 \cdot K$), the thickness of the external thermal insulation will increase significantly if the thermal insulation performance is improved, which will lead to a significant increase in the cost and construction difficulty, as shown in Table 2 [5].

Table 2. Comparison of envelope heat transfer coefficients W/(m^2 · K) [5]

Part	Material	Project	Energy Efficiency Design Standard for Public Buildings	Near-Zero Energy Consumption Building Technical Standard	Shanghai Ultra Low Energy Consumption Guideline
Roof	140 mm thick XPS insulation	0.24	≤ 0.4(D ≤ 2.5) ≤0.5(D>2.5)	0.15~0.35	≤ 0.3
Exterior	140 mm thick rock wool insulation	0.38	≤ 0.6(D ≤ 2.5) ≤ 0.8(D > 2.5)	0.15~0.40	≤ 0.4
Exterior slab	140 mm thick rock wool insulation	0.38	≤ 0.7	-	-
Exterior windows	high performance warm edge triple-glazed two-cavity hollow tempered glass: 6 mm high-transparency Low-e+12Ar +6+19Ar+6	1.6	≤ 2.4	≤ 2.2	≤1.4

4 Conclusion

At present, in the field of architectural design, there are some popular design concepts related to sustainable development, such as "green building", "ecological building", "healthy building" and so on. All these concepts contain the idea of sustainable development to a greater or lesser extent. These concepts are gradually accepted by architects and especially by owners. Compared with traditional architecture in the past, sustainable architectural design pays more attention to prior consideration of the building's respect for and adaptation to the environment, and how to reduce the use of non-renewable resources, use renewable resources more efficiently, and at the same time create a more comfortable living and working space. Therefore, the development of sustainable architecture in China is an inevitable trend in the development of the construction industry. Architecture is a product of human will and also influences human behavior and attitude. The project hopes to convey a green and low-carbon living attitude to the public through the low-carbon design language of the building. For example, the design of the hanging ladder and staircase in the atrium makes the interior space more bright and interesting, so as to encourage people to climb up the stairs and use the elevator less and take the stairs more.

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