

Research on the Application of Bionics in Modern Architectural Design

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Abstract: Ecological bionic architectural design is one of the important means of ecological architectural design. In this process, the human thought plays a vital role on making architecture have its corresponding attributes, at the same time, it is more refreshing. Based on the author's learning and practical experience, this paper first analyzed the types and characteristics of architectural bionic design, and then put forward the application strategy of bionics in the modern architectural design.

1. Introduction

Bionics is a science that human beings imitate the principles of biological systems to design technological systems or to make artificial technological systems. Bionic design is one of the important methods of ecological architecture design, and the technical principle of ecological architecture can find prototype in nature. Organisms have adapted to the living environment after billions of years of evolution, and their survival mechanism is naturally reasonable[1]. Therefore, using bionic design to perfect and expand the design strategy is an efficient and scientific way. At present, the theory of ecological bionic architecture in our country is lack of systematic and in-depth research, and the successful cases of ecological architecture design by means of bionics are rare. Therefore, the study of ecological bionic architecture design has theoretical value and practical significance[2].

2. Types and Characteristics of Bionic Architectural Design

2.1 Structural bionics.

In architectural bionics, structural bionics is the most mature method, and most widely used. In order to obtain a better structure bionic phenomenon, we should not only understand the structure of the simulated object to a certain extent, but also understand the properties of the materials to be used, which will be reflected in the later design. Many realistic objects are designed considering the structure and material properties of objects accurately. Structural bionics is a very complicated theoretical concept and it is the result of perfect cooperation between architectural designers and structural designers. It can satisfy our maximum material life and its application degree in life is also the largest. The most special feature of bionic structural design is that it can save building materials with strong compressive and seismic resistance, and meet the requirements of aesthetics in terms of external shape. Dinosaurs were an amazing creature that lived in an earlier age than humans and it had an amazing weight, and the load on its limbs was enormous. After studying, we can know that the waist is the center of gravity of the dinosaur body, and the weight of the huge body is transferred to the thick limbs through the center of gravity. From the view of mechanics, the buildings that need to bear heavy loads can learn from its body structure. At the same time, this is the origin of the arch structure in architecture. For example, the Taiwan Center for Disease Control (figure 1), designed by Manfredi and Luca Nicoletti. Inspired by Nautilus shells, the exterior walls are interlaced with geometric sculptures that reproduce the DNA sequence of bacteria studied in the building.

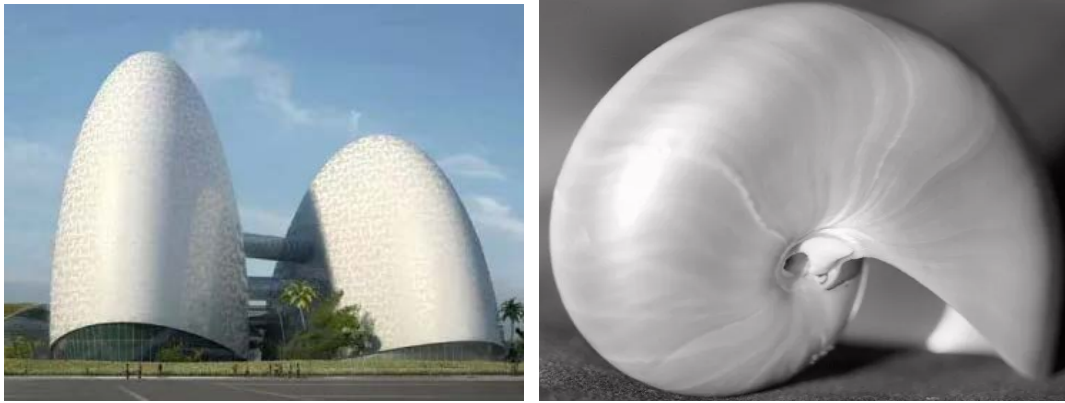


Fig. 1 Design scheme of Taiwan Centers for Disease Control

2.2 Functional bionics.

Bionic function is very weak, but of great value. As for the functional bionics, the functional principle of the natural object image is the basis of its research. Through the study of these knowledge, the products and objects with better performance are invented, and then the development of human society is promoted. Living things have life, but architecture does not. In the study of organisms, it is easy for humans to grasp the morphological characteristics of organisms and to analyze the structural characteristics of organisms, but the forms of organisms are extremely complex[3]. In the field of human biology, it is easier to grasp its morphological characteristics, and thus relatively easy to analyze the characteristics of its morphological structure. For complex functional features, it can only be a gradual understanding of the process, and sometimes misunderstandings or errors. Therefore, the architecture is relatively weak in the bionic direction, but it is also the most worthy of study and careful study of the design direction.

2.3 Morphological bionics.

Morphological bionics refers to a design technique that directly imitates the morphological characteristics of natural organisms and gives dramatic and artistic processing effects, which enables the people watching to play their own associative power and increase the affinity to use. For example, a temporary terminal building at New York's Kennedy Airport was designed by Schallin, which was also designed to mimic biological shapes (figure 2).



Fig. 2 A temporary terminal building at New York's Kennedy Airport

The whole building form is a wing-expanding bird, fully integrated with the building's architectural purposes. One of the habits of design thinking expressed in the early modern architecture of Sarinen was the introduction of its own design into an unprecedented field of sculptural styling. There are numerous examples of architectural bionics, mostly in the form of a relatively simple bionic architecture, or as a simulation of the physical characteristics of the external

forms of other organisms in the architectural design. This application is more evident in children's palaces, kindergartens and other buildings with special use.

3. The Application Strategy of Bionics in The Modern Architectural Design.

3.1 Intensive design.

Intensification is the use of the least amount of material to achieve as many effects as possible. The long evolutionary process of biological species is a process of survival of the fittest, in which organisms gradually abandon the redundant and unreasonable parts of the organism and constantly optimize their own functional mechanisms. The structure supports, connects, protects and divides the organism. The structure of the organism uses its own resources as little as possible to achieve the maximum effect. According to experiment, the external pressure of the snail shell is 2200 times that of its structural weight. Similarly, building structures should be high-strength, light-weight, economical and safe and as long-span as possible. At present, there are shell structure, fiber structure, aerated structure, membrane structure and space skeleton structure for intensive design[4].

3.2 Succinct design.

Organisms usually achieve the highest efficiency in the most concise way, mainly manifested in the simplicity of materials and structure. For example, the tensile strength of shells is as high as 1,000 kg/cm², much higher than that of cement materials. Its ingredients are only 95% calcium carbonate and 5% protein, and they bond into a solid whole without processing. It enlightens people to develop new building materials with simple chemical composition, simplified technology, to reduce energy consumption and environmental pollution. A high strength polymer cement made of furfural alcohol water soluble binder has been developed by the National Laboratory of the United States, which can quickly repair roads, bridges and airport runways, reflecting the simplicity of materials and construction. The structure of organisms is characterized by the simplest form, the least energy consumption, the most stable durability, and the most functional. Therefore, simplifying the epidermal structure of ecological buildings can reduce the cost of construction, operation and maintenance. The complex structure of the epidermis of high-tech ecological building, the high precision construction technology requirement and the easy wear and tear of the components lead to the high construction cost. As a result, hi-tech ecological buildings usually require a long construction cost recovery cycle, which some experts have denounced as "a waste of savings"

3.3 Integrated design.

The tissues of organisms have many physiological functions. For example, polar bear fur has the dual function of heat preservation and sunlight absorption. Its basic structure is a light-colored transparent skin and a thick endothelium. Inner leather converts light energy into heat energy, while outer leather prevents heat dissipation in the body. The hair between the two layers is to divide the air layer into smaller volume hollow tubules, ensuring high air content and ideal thermal insulation. The skin design of China's National Swimming Pool embodies integration: the ETFE air pillow unit and the foam space frame structure, similar to the cellular expansion and pressure principle, are divided into outer air pillow, air sandwich and inner air pillow, while satisfying the thermal insulation of the venue.

3.4 Adaptive design.

Adaptive design is mainly divided into adaptability to growth and adaptability to climate. The adaptability to growth means that the ecological bionic architecture is similar to the growth characteristics of animals and plants and has the ability to meet the functional changes and spatial topology in the whole life cycle of the building. The metabolic theory represented by Dan Xiagin and Jizhang Kurogawa advocates that building clothes should be metabolized as living things do in the basic laws of the biological world[5]. They emphasize the growth, renewal and decline of things, compare cities to the growth and cell division of organisms, and advocate the life and organization

of the development in human society. Nakagin Capsule Tower is a prefabricated building conceived from growth (figure 3). The building consists of 140 hexahedron compartments that can be added or subtracted according to the user's wishes. As the main function space, the equipment and storage space are unitized, embodying the adaptability of cell division and regeneration.



Fig. 3 External and internal scenes of Nakagin Capsule Tower

3.5 Self-organizing design.

The main characteristic of living body is self-organization, that is, self-selection, self-regulation, self-protection and self-rehabilitation. Self-organizing design is mainly reflected in the response to the internal state of the building and the external environment, and it can adapt to the environment through perception and adjustment. Botanists found that sunflowers were positive during the period between germination and blooming, with leaves and disks following the sun during the day. After sunset, the disk slowly turned eastward, reset to east about 3 am and waited for sunrise. A computer-controlled sun-tracking house designed by German architect Tudor Thostre can always follow the direction of the sun like a sunflower in order to make full use of solar energy.

4. Summary

Ecological bionic design is not limited to ecological architecture, and ecological problems are the common concern of contemporary architecture. Therefore, ecological bionic architecture design research has more far-reaching and universal significance. On the level of architecture technology, ecological bionic architecture design is mainly based on electronic, chemical, computer and other professional fields, and the narrow sense of architecture does not seem to have a direct relationship. However, as an architect who applies bionics principles to the design of ecological architecture, he must understand and master the research results in the field of bionic science because ecological bionic architecture design has been an important trend.

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