Study on the Selection and Application of Environmental Protection Materials in Contemporary Architecture from the Perspective of Phenomenology

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Abstract. In order to analyze the selection and application of environmental protection materials in contemporary architecture from the perspective of phenomenology, this article takes advantage of data and theoretical analysis methods to explore the works of three contemporary architects, namely Wang Shu, Steven Holl and Peter Zumthor. This article also makes a comparative analysis of materials. It aims to explain that different types of materials show different ecological characteristics. According to the research, hypotheses can be made: one is to realize the ecology of traditional materials through recycling; the other is to realize the ecology of natural materials through obtaining materials from local sources; the third is to realize the ecology of modern materials through the combination of high technology. Additionally, the application of materials in construction is diversified, and it usually uses a variety of materials and construction methods in the same building. In terms of materials, architectures explored in this paper, on the one hand, reflect the place spirit and perceptual feeling of phenomenology; on the other hand, it is express the concern for the sustainable development of the environment.

1. Introduction and Objectives
As one of the most popular Western philosophical schools in the 20th century, phenomenology plays a pivotal part in architecture and many other fields. Husserl is currently regarded as the founder of phenomenology. The point of view that phenomenology has excellent inspiration for architectural theory and design research is “to the things themselves”. Martin Heidegger’s article Building, Dwelling and Thinking has also directly aroused the attention of phenomenology in the field of architecture. However, phenomenology's formal introduction into architecture is marked by a series of works published by Christian Norberg-Schulz in the 1960s. The existing research generally divides the architectural phenomenon into two branches. One is the existential phenomenology represented by Norberg-Schulz, who mainly studies architectural theory and accentuates the place spirit (Genius Loci). The other is the perceptual phenomenology represented by Steven Holl and Zumthor, who mainly develops in architectural practice. In fact, the epitome of phenomenology can be seen in Alvar Aalto and Louis I Kahn's works. Although they do not use phenomenology as their slogan, they have emphasized human space experience in architecture. Phenomenology undoubtedly stimulates dogmatist architects to reflect on architecture. It guides them to re-examine the relationship between architecture and human, which opens a new chapter for contemporary architecture development.

In the period of phenomenology development, influenced by the rise of “green movement” in the west, the ecological concept began to become the code of conduct for people to live in harmony with nature, which prompted people to reflect on the traditional architectural concept. With the aggravation
of the global ecological crisis and the popularity of sustainable development, the architectural industry has increasingly realized that it is necessary to implement the idea of sustainable development while emphasizing other creative principles.\cite{2} Therefore, two seemingly unrelated concepts have a profound impact on architectural design. Ecology expresses through the structure, technology and materials of architecture. However, this paper focuses on the material elements, and takes the architectural practice which embodies the phenomenological thought as an example. The objectives of this article are as follows:

(i) To reveal the ecological characteristics of materials in contemporary architectural practice under the influence of phenomenology.

(ii) To identify the correlation between phenomenology and ecological concepts in architectural practice, as well as the factors affecting the selection and application of building materials, to provide reference ideas for future architectural practice.

2. Methods

This paper selects three architects, namely Wang Shu, Steven Holl and Zumthor, to make a case study of their architectural practice. To some extent, architecture is an environment composed of space, materials, details, light and shadow and other elements. If we ignore those elements, it is equivalent to ignoring the space experience of architectures expressed. Whether the structure, details or lighting and other architectural performance are inseparable from the material elements, it can see that the material plays a fundamental role in architecture. On the one hand, from the perspective of phenomenology, for people in real architecture, materials act as a medium, and people can perceive its existence through their bodies in the process of movement. It also advocates using materials to enhance human perception, including hearing, vision, smell, taste, touch and synaesthesia. In the meantime, phenomenology highlights the establishment of place relationship between architecture and the specific environment through materials to arouse people’s historical memory of place. On the other hand, from ecological architecture, the definition of eco-environmental materials is still under study. It has three main characteristics: first, saving resources and energy; second, reducing environmental pollution and avoiding the greenhouse effect; third, easy recovery and recycling.

As an essential branch of the ecological environment, ecological building materials can coordinate with the ecological environment. The specific performance is that it only produces less resource consumption and environmental pollution, and has efficient use performance and recycling rate.\cite{3} This paper base on two points of view, trying to find the intersection of phenomenology and ecology in building materials. Therefore, in the process of case analysis, besides discussing the phenomenological characteristics of materials, it also involves the contribution of materials to environmental protection. Based on theoretical analysis, comparative study of materials will be carried out through data analysis in this paper.

3. Ecological features of construction materials under the influence of Phenomenology

3.1. The use of traditional building materials

Wang Shu emphasized the spirit of place and declared that architects should not leave the various objects and space elements buried in human memory. In the construction process of Ningbo Museum, he used the old materials left in urban renewal, which span from the ancient bricks and tiles in Han and Qin Dynasties to the building materials of abandoned houses in the Republic of China and even modern times. Some of the bricks even have ancient inscriptions, preserving the history of urban changes. In this project, millions of recycled stones, bricks, and tiles build this building bearing historical memory.

As for the traditional building materials, they are not simply pasted on the building surface, but are built by the unique traditional masonry method (tile wall) in Ningbo. Tile wall is a kind of folk wall popular in eastern Zhejiang (Figure 1). It is mainly made of old bricks, old tiles and other waste building materials from local materials, with straw reinforced yellow mud or yellow mud plus lime as
auxiliary bonding materials. Furthermore, it is built by layer by layer. The recycling of traditional materials itself is low cost. On this basis, Wang Shu combined it with traditional technology, which explained energy conservation, environmental protection and sustainable development with a more localized approach. The wall made of waste materials is not only strong and beautiful, but also economical, environmental friendly and energy-saving. Wang Shu once said that recycling construction is not its original creation, but the grand tradition of Chinese architecture, which is being forgotten. The recycling construction of old materials has two primary meanings. One is the ecological significance, and the other is to wake up the memory of the city.

On the one hand, Wang Shu used many recycled materials, saving resources and extending the tradition of recycling construction. On the other hand, most of these building materials are recycled after the demolition of old buildings. It gives the building itself a sense of intimacy and evokes people's memories of the past buildings. In other words, people find the feeling of the past from the new environment, and the building virtually intervenes in people's life.

Furthermore, materials are presented in a specific environment. Phenomenology highlights returning to the connotation and authenticity of materials, which means that materials are not independent but related to the environment. The building's interior is made of bamboo formwork, which displays the texture effect of random cracking of bamboo. These materials' details are shaped from the overall environment's perspective, making Wang Shu's works blend with the environment naturally and create a specific spirit of place.
3.2. The use of natural building materials

Unlike Wang Shu's method of recycling old materials, the use of natural materials underlines the selection of materials from nature, that is, using local materials. In the Swiss Pavilion of World Expo 2000 in Hanover, Germany, Peter Zumthor used stainless steel components to fix the architectural form of tens of thousands of raw wood which has not been processed. It breaks the previous exhibition space concept, does not demonstrate the technical level, or introduces the latest machines; everything is primitive. He combines the sawn wood into the wood wall in the simplest way and forms a 9 meters high crisscross “maze” with 3000 square meters (Figure 2).

The pavilion penetrates the natural wind, providing a resting place for the audience. The silence of space in nature enables viewers to feel the rustle of wind blowing through the wood's cracks and the ticking of the rain. It is like entering a quiet forest to enjoy the ensemble of nature. Objects interact with each other in their way, and each sense is a comprehensive factor so that the five senses are inseparable. In addition to vision and hearing, touch, smell, and taste also play a significant role in people's perception of architecture. However, the influence is subtle and often associated with the audio-visual experience. The combination of wood and stainless steel in the Swiss Pavilion creates a natural sound and introduces the natural taste into the pavilion. The combined effect of hearing, smell and touch seem to bring the viewer into the Swiss natural environment. “What this kind of architecture brings us is not the visual stimulation, but the feeling that we need to listen and experience carefully. It mobilizes all of our body consciousness and confronts the 'image gluttonous' of this non-essential society.”[4]

Considering the “temporariness” of the Swiss Pavilion, Zumthor gave up all the connection methods that might damage the wood when choosing the construction method, only using steel poles and springs to complete the lap joint between the slats. Therefore, after the World Expo, the materials have been reused intact, which adequately reflects the architect’s sensitivity and ecology concern. In fact, the use of wood manifests the impact of materials on the ecological environment. Compared with life cycle environmental impact assessment of building materials, wood has incomparable advantages over other materials (Table 1). The most common natural materials include stone, wood, bamboo and others. It should be marked that these materials should be treated in such a way as to minimize overexploitation and damage of natural materials.

| Materials | Greenhouse effect | Solid waste | Water contamination | Air contamination |
|-----------|------------------|-------------|---------------------|-------------------|
| Bamboo/Wood | 1               | 1           | 1                   | 1                 |
| Steel     | 1.47             | 1.37        | 120                 | 1.44              |
| Cement    | 1.88             | 1.95        | 0.9                 | 1.69              |

3.3. The use of modern building materials

In addition to using traditional building materials to create place spirit or using local natural materials to build space perception, modern materials also play an important role in creating space experience. Its ecological performance is often achieved by combining with high technology. Taking Steven Holl's
Wanke center in Shenzhen as an example, as a demonstration of the first batch of energy-saving buildings in Shenzhen, it is awarded LEED (Leadership in Energy and Environmental Design) certification, relying on the comprehensive coverage of green building technology measures. In terms of material utilization, the project adopts steel and aluminum alloy, bamboo and other renewable building materials(Table 2). And, in the early stage of material selection, plenty of building materials produced by local and surrounding areas are scheduled.

Wanke center adopts aluminum alloy shutters on a large scale, perfectly combining the adjustable external shading system with the building façade (Figure 3). According to the image of bamboo leaves, the aluminum alloy shutters are designed as curved perforated aluminum plates. Under the premise of ensuring indoor light and temperature, they combine with different curtain wall systems to enrich the building's facade texture. Additionally, it displays the variegated light and shadow on the building's inner surface under the natural light. Holl is inspired by the light and shadow effect of leaves, and this performance interprets the form of light and shadow in Chinese architectural culture from a new perspective. Furthermore, These sunshades are also part of the whole office building's rotary facade system, which can automatically adjust the sunshades' opening range horizontally from 0 to 90 degrees according to the sun height angle and indoor lighting index. The data manifest that when the sun shines strongly, the solar transmittance of 15% when the sun visor is closed can reduce 70% of the solar radiation heat and satisfy 75% of the space lighting needs, without artificial lighting. For the warm area all year round, building shading has made an outstanding contribution to energy saving. It not only realizes the various changes of light and shadow, but also optimizes the building energy consumption, reflecting the design concept of green building.

Moreover, fair-faced concrete is used in the construction of exposed walls in restaurants, swimming pools and other areas. And bamboo is used as a template in the concrete pouring process to create a unique texture with regional characteristics on the surface. This pouring method reduces the pollution caused by the use of artificial materials. By simplifying the process, the concrete is cast at one time, so excessive construction treatment in the later stage is omitted. In terms of furniture, doors and tables are made of bamboo. The reason is that bamboo products with good quality can be used for 15 years, and bamboo belongs to fast-growing wood, which has high economic benefits. A large number of renewable materials are used in the construction of Wanke center, and local materials within 500 miles are used as far as possible, which dramatically reduces the energy consumption in material transportation. Holl believes that the “detail” shown by the building materials directly faces the human perception, enabling us to go beyond the keen vision to reach the tactile field. Through the detailed treatment of building materials, he interprets the place. The space atmosphere is no longer monotonous because of the details, showing specific and rich spatial characteristics. His works have both the memory of tradition and the perception of modernity, and eventually “anchoring” in specific places.

4. Conclusions
In construction, architects are always restricted by social, economic, cultural, environmental and other conditions; thus, architects should comprehensively consider many factors when they design. The selection and application of building materials are also affected by diverse factors. Starting from the place spirit and perception in phenomenology, we can draw a conclusion through the analysis of the above cases. On the one hand, some architectural works use materials to reflect the spirit of phenomenology. On the other hand, they also use materials to express their concern for the sustainable development of environment.

First is the reuse of traditional materials, through recycling old building materials, which saves resources and stimulates people’s memory of history. Second is the natural materials adapted to local conditions. The ecological performance of building materials is reflected in the high economic benefits and should put attention to the long-term benefits of sustainable development. Zumthor, through the local wood as a medium, attaches great importance to human perception and reflects the ecological properties of natural materials. Third, the combination of modern materials and technology. In
architecture, the application of materials is not single, but often a variety of materials and construction methods work together. Holl’s Shenzhen Wanke Center reveals the contribution of various materials in environmental protection.

It has become an urgent problem to protect the human living environment and natural ecology and create a material environment suitable for human survival. Moreover, The application of low pollution and recyclable materials, as well as the treatment of demolished building materials, have always been a major problem of urban ecological environment. In the construction process, architects consider the ecology of materials from the material properties and consider the construction of the spirit of place and perceptual experience from the perspective of phenomenology. It is helpful for architects to reflect on ecological building materials' role by analyzing the selection and application of building materials affected by phenomenology.

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