Enframed Scenery and Flowing Wind

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ABSTRACT

This article introduces a bamboo building constructed by the team from Tongji University in the Louna International University Construction Competition. It introduces the design strategies on how the building responds to the local natural environment.

Based on the study of ecological design, this article aims to discuss the value of bamboo and its ecological significance as a kind of building material. After analyzing this construction as the theme of “camping device” in Louna, Guizhou, China, it discusses the strategies and methods of architectural design from three aspects: regional building materials, terrain environment and regional climate. Under the guidance of the ecological design principles, it also wants to explore the design principles and methods of the bamboo materials.

Afterwards, combined with this camping equipment, this article not only shows the process of bamboo structure design from concept design to detailed study, but also has a brief study of bamboo structure, bamboo node and bamboo skin. In the design process, we think about the design itself, and thus to dig the role of bamboo construction in response to the natural environment in Guizhou province.1

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INTRODUCTION

Background

ENVIRONMENTAL CRISIS

In the past twenty or thirty years, due to intensifying human activities and global climate change, various types of ecosystems on the earth have undergone a great recession. A number of problems have emerged one after another, such as global warming, ozone depletion, energy depletion, acid rain, marine pollution, biological species reduction, forest area reduction, desertification, and so on. We have been able to feel the threats on our own health and safety due to the ecosystem disturbance and malignant transformation. If we had said many years ago that it was just a question of what we need to see, this is just the time for us to think about it.

RELATED CONCEPTS

For the convenience of later research, it is necessary to define and interpret the important concepts and vocabulary. These words include: “Response”, “Environment”, “Natural environment”, “Environmental response design”, “Ecological architecture”, “Bamboo construction”, etc.

(1) Response

“Response” means to actively respond and adapt to the environment. For the architectural design and the natural environment, response is a kind of answer how the natural environment is effected by the building. Under the premise of not destroying the natural environment, it asks the architecture to interpret, answer and respond to the base and the natural environment to seek the symbiosis of architecture and environment.

(2) Environment

The word interpretation of "environment" is "around the place, such as natural environment and social environment; surrounding areas." Environment is the situation and conditions around the places. The design of the building cannot be separated from its place, and is restricted by the surrounding situations and conditions.

(3) Natural Environment

The natural environment of human life includes certain ecological environment, biological environment and underground resource environment. It is the sum of all kinds of natural factors around the people, such as air, water, soil, plant, animal, mineral, solar radiation, etc.

(4) Environmental Response Design

In this article, environment response design is a kind of design strategy which architectural design responds to the natural environment, mainly divided into three aspects: in response to architectural design strategy of regional culture; in response to the ecological treatment strategy of terrain environment; in
response to technology strategy of climate conditions. And we carry out a more detailed analysis of these three aspects.

(5) Environmental Architecture

"Ecology" is from the Greek word "Oikos", meaning "home" or "shelter". The concept of ecology was first used by German zoologist E. Hackel in 1866, as the title of a science to study the relationship between organisms and external environment, which marks the birth of ecology.

“Ecological Architecture” uses the basic principle of ecology and building technology and means of modern science and technology, is reasonably arranged and organized the relationship between the construction and other relevant factors, which makes it become an organic combination between architecture and environment. At the same time, it has good indoor climate conditions and strong ability of biological climate regulation, which can meet the people living in the environment of comfort and make people, architecture and natural environment form a virtuous circle system.

Bamboo Construction

The concept of the "Bamboo Construction" design is to build the building with the logic of the construction of bamboo materials in the architectural design. The scheme "framed scenery and flowing wind" is to take the bamboo as the raw material, follow the characteristics of the bamboo material itself, and complete the process of construction in a reasonable way.

COMPETITION BACKGROUND

The project participated in the first international university construction design competition in Louna. As an important part of "International Mountain Building Art Festival in Louna", "International Mountain Building Art Festival in Louna" will be built in the architects’ commune in Guizhou Province. This is not a rigid implantation of construction, but the murmur in field of cultural mountains, the talk with the local culture, and an opportunity to meet with modernism and regionalism.

Born in Chinese rural renaissance background, the contest invited college students of architecture in China or abroad to discuss natural architecture relating to natural forests and fields in Louna. At the same time, it is important to rethink and experience for architects who try to involve in Rural Renaissance. The first session of the International University building design competition offered "camp device" as the theme.

It is a design practice with the material of bamboo, and it strives to make students deepen the understanding of the material, form, space, structure, and cognition in the process from design to construction.

Research Purposes

This article aims to explore some design strategies on ecological aspects of architecture through an actual practice of bamboo construction in Louna.
Firstly, we need to understand the relationship between architectural design and regional and natural environment. It can be analyzed and interpreted from three points of view.

From the humanistic point of view, the construction of building needs to take regional materials and folk activities into account. Coincidentally, it is rich in bamboo resources and folk culture activities in Guizhou. Through this construction competition practice, we can study how the local materials have actual effects on buildings in economy, environmental protection, construction and other aspects.

From the point of view of the terrain environment, there are different design strategies to meet with the local terrain, including earth covered construction, grounding construction and overhead construction, etc. But they may produce good or bad influences on environment. So this paper aims to analyze how the overhead strategic has an effect on natural environment.

Based on the analysis of the climate of Guizhou and local wind rose map, this article discusses on how this study can play a certain value in the design of climate response to the architectural space. In all, through the practice of the bamboo construction, it is an opportunity to explore the role of environmental response design in the architectural design.

PROJECT INTRODUCTION

Preliminary Study

FIELD INVESTIGATION

The project is located in Qianxi Prefecture in Xingyi City, Guizhou province. Qianxi Prefecture belongs to the Nanbeipan River Basin of Pearl River water system, which is in a typical low latitude and high altitude mountain region. Our base in the prefecture is undulating and complex. The climate of Qianxi Prefecture is in subtropical monsoon humid climate zone. Its rainfall is concentrated from May to September each year, in June at the most. But in recent years, the new rural construction in Guizhou has risen. Even though it has good natural resources, all of the new construction should be taken more carefully. Once the architectural design lacks the ability of protecting the environment, this will be a huge crisis of natural environment in Guizhou province.

SELECTION AND APPLICATION OF MATERIALS

In this project, the original bamboo is used as the main building material. China is in the center of the bamboo distribution in the world. It is the world's most important bamboo producing country, which also has a long history of bamboo utilization.

The area of bamboo forest is 22 million hectares in the world. There are more than 1200 kinds of bamboo, while the distribution of Moso Bamboo is
mainly in China. Besides, the area of bamboo in China is more than 7 million 200 thousand hectares. However, in our country, the utilization rate of bamboo material is low, and the original bamboo is rarely used in architectural design nowadays.

China has the world's largest bamboo resources, which has good advantage of developing and utilizing bamboo material. It also has a good prospect that using bamboo instead of wood. It is said that bamboo has the characteristics of fast growth and high yield. After building a bamboo forest, as long as the business is reasonably organized, the forest can be sustainable used. As to the application of Bamboo, it not only can be processed into food, arts and crafts, but used in construction, materials, chemical industry and other fields as well. If it is used as a building material, every 60 pieces of bamboo can be used as a substitute for one square meter of wood.

The advantage of bamboo is very obvious as problem of natural resources is well known. In fact, human beings should change their attentions from consumption of a large amount of resources to the efficiency improvement of the use of materials. Therefore, bamboo's advantage is greater than that of the wood in terms of the renewable resources, which has ecological significance to some extent.

Architecture Design

CONCEPT OF DESIGN

“Enframed scenery and flowing wind” is made from the original bamboo, as well as is a work to express the architectural space. It responds to the environment to the greatest extent, including to divert the wind flow, and to guide the water vapor, bamboo incense and other natural elements. At the same time, it also shows the regional environment of Guizhou.

Design is started from the point of view of man and nature, trying to combine the regional culture, regional environment and climate in Guizhou. The design wants to produce association between the folk activities of the bearing space and the natural elements, as well as produce interaction between building space and the external environment. Thus, it can be a greatest degree of response to the environment. Therefore our team would prefer use a suitable geometric logic to combine the architectural space with the external environment. Through analysis and research, we found that the ruled surface has an advantage in shaping the shape, guiding space and shaping the atmosphere. They are partly reasons why we finally chose the geometric prototype of the ruled surface as the main element in the interior space. The form of the ruled surface makes the device a flowing space.

Design was decided to use thermodynamics, ruled surface and other contemporary design practices and elements, thus to explore the relationship between architectural space and the environment, and to seek a new way to express the space of traditional architecture. The purpose of this is to provide a new idea for dealing with the relationship between architecture and nature.
Ultimately, the design should return to the people, return to the original life of the residents and return to the nature. The significance of the design is to bring the embellishment of life to original residents, and add a beautiful scenery line to the natural environment.

Based on the life of the original residents, internal activities were accepted in the building. On the one hand, it is the extension of the residents’ life, bearing the basic life activities such as rest, communication, playing and so on. On the other hand, it is a container of folk activities in Guizhou, serving as the frame of the scenery that human and nature are intertwined.

![Activities combined with environmental conditions.](image)

Figure 1. Activities combined with environmental conditions.

The expansion of activities need to be combined with environmental conditions. As is shown in Figure 1, the space sequence of the building is expanded in a square frame with three faces. The internal space of the frame needs to undertake the responsibility of building activities with the theme of "camping device", including: sleeping, resting activities, folk customs, channels, etc.

Through the simulation and analysis of the thermodynamic performance, the structure frame of the interior space chose the best form of ruled surface as the final form of structure. On the one hand, through folding the space, we lead the wind, guide the water vapor and the bamboo incense, block the rain water to respond to the natural environment. On the other hand, when it rains, the design of single slope roof could turn the background into a water curtain, which brings comfortable and romantic camping experience to users.

In addition to responding to the climate, the response of the building to environment is also able to build a three-dimensional square frame with original bamboo, which is able to form a large finder frame. It is a conversation between
internal space and external space, not only showing the external natural environment in Guizhou, but also the ongoing folk activities of the frame.

APPLICATION OF THERMODYNAMICS

Ruled surface is a kind of strongly constructive geometry prototype. In our design, the prototype of the building is based on two different scales of the ruled surface as the main space elements. Through folding the surface, the structure is connected with two overhead activity platforms, so as to achieve space extension and coherence.

As Figure 2 shows, the prototype shapes the ruled surfaces and forms spatial forms to adapt to the natural environment through thermodynamic simulation. Specifically, it can be divided into the following three points: firstly, to meet the connectivity of the active paths, stairway trails along the curved surfaces connect the two elevation platforms. Secondly, the prototype can maximize the flow of wind, which allows the air to flow in the interior space. At the same time, the platforms can bring the most comfortable feeling for the residents. Thirdly, the effect of the surface density should be combined with the frame of sight platform openness and personal activities to achieve the balance in the density between the best sensory experience for users (as is shown in Figure 3.).

Figure 2. Flow stimulation.
ACTUAL CONSTRUCTION PROCESS

The base of the whole competition is located in Dachong village, which was four kilometers away from Louna. As Figure 4 shows, Dachong village is surrounded by mountains. The only way reaches the village is a small artificial tunnel. The village is like a land of Utopia with beautiful scenery.

Our base is located in a slice of ginger land (as is shown in Figure 5). There are peaks in the Northeast southwest direction, forming the open visual corridor. The main stream of people is a cement road to the northeast.
Due to local site conditions, we need to have a good environment in the construction of laying the foundation before the start, which is aimed to improve the construction conditions and pave the way for the final design of the surrounding environment. Our final site is a square block of 4.5m*3.3m, with the 10 meters distance to the cement road. Because of the height difference between the ginger land and the cement road is about 1 meter, we need to consider site design in the construction process as well.

After discussion, we use a step by step way to build a path, which is connected with the internal path of the building, the path also extends to the cement road. At the end of the connection, we build 7 steps as a guiding role to strengthen the direction of the entrance (as is shown in Figure 6).
Foundations

Foundations are the most basic and important link in the process of actual construction. Taken full consideration of the environmental conditions, we determined to build steel pile and brick based way to complete the foundation.

According to the architectural design process, side walls play a role of the main load-bearing structure. So in the foundation design (as Figure 7 shows), we lay a 6cm diameter steel pile in each 4 to 6 column position of the side walls. The steel column will serve as the main bearing point, and the bamboos will be emptied in order to be able to insert into the steel column. The steel column will be buried underground digging pile steel by measuring the location, artificial beating and auxiliary equipment.
Construction of Sidewalls

The combination of the side wall and the roof beam constitutes the basic framework of the work. Through the connection with the sidewalls, roof beams and the foundation can be well resisted. This can avoid the situation that the frame is tilted to one side.

The bottom of the wall is mainly fixed by screws. The bamboos with the steel column are connected with the steel columns through a screw rod, and the bamboos without the steel column on both sides are fixed and connected with each other by screws, so that the two side walls can be integrated into a whole.

As is shown in Figure 8, the construction process of side walls is difficult. Since each bamboo is not completely vertical, they do not fit well when placed side by side. Finally we fix the bamboos by the connection with the foundation. Each side wall and horizontal stacked bamboo are connected together to achieve a good solution to the problems of construction. Moreover, the bamboo density arrangement will cast a good lighting effect.

Figure 8. Construction of sidewalls.

Construction of Ruled Surfaces

Ruled surface is the most critical component to connect the two active surfaces. So after we complete the construction of the whole framework, we can move into the construction of surfaces. The surfaces need to be supported by the structure of the roof beam and the side walls. Therefore, after we set the position of the curved surface and the side wall by marking and fixing the bamboo which is connected with the ground.

In the process of constructing the ruled surface, the difficulty lies in how to present the effect of the surface and the angle between the bamboo and the side wall. Therefore, we repeatedly debug the effect of the building, with the physical model comparing with the building at the scene and the computer model to approve for more accurate ruled surfaces positioning.

The construction of ruled surfaces are more loosely arranged and combined with the more dense arrangement of side walls. With the selection of 6cm diameter’s bamboos to build a ruled surface compared with the side walls of 8cm
diameter’s bamboos, that ruled surfaces will reduce weight and bear itself in the building at the same time.

Figure 9. Ruled surfaces.

Structure of Bamboo Nodes

From the beginning of the overall design concept, through a series of spatial relations, the organization and collaboration of materials, structure, form and scale are gradually developed: a gradual change in scale (from large to small), spatial order and hierarchy, the material which is determined by shape, density and form. Therefore, the node details are regarded as the products of the whole design process, resulting in the closing phase of the design.

As is shown in Figure 10, the joint structure of this work is mainly connected by screws. It takes different forms in different parts. On the basis of the fixed foundation, platform and other parts, the use of screw connection plays the main role of fixation. The connections of the side walls and the curved surfaces, the roof beams, the side walls and so on, which is mainly composed of the positioning, the bearing and the coupling, use the screw rods, so that they can be better connected.

Figure 10. Bamboo Nodes.
The main connection form of bamboos is by screws. It can show the connection between the original bamboo structure clearly, highlight the charm and entirety of original bamboo as well. The screw forms can expose connections at the same time. It is difficult for the screw forms to become deformed because of damp, exposure problems. But ropes, bamboo nails and other connecting members probably cause structural changes due to changes in the environment.

CONCLUSIONS

The building cannot be completed satisfactorily without the sacrifice of each members in the team of Tongji University, from the initial design to the entity construction of "Enframed scenery and flowing wind". The significance of the entity construction lies not only in the real reappearance of an ideal design, especially inspiring us, as a dream come true, but also in a change of identity for architects. Leaving empty talk, entering a real battlefield, contacting the construction, all of these make us realize the importance of consideration of construction details and strengthen our understanding of the construction technology and materials.

Moreover, the environmental conditions tend to "change the plan". We need to consider how to implement each step of the scene to be completed on schedule. When we actually put ourselves in the response of nature, we realized the design is no longer stay in the theory, but seriously related to the local environment. Therefore, the architectural design needs to consider the adaptation to the natural environment, and can complement each other and interact with each other at the same time. To integrate architecture and nature, to improve the surrounding environment comfort without destroying the natural environment, that is the value of this architecture.

In the aspect of the response to the natural region environment, it has played a good role in the natural environment of Guizhou in the process of the construction of the "Enframed scenery and flowing wind". “Enframed scenery and flowing wind” responding to the design strategy of regional culture is
considering the local residents life style and folk activities, so as to design the original fusion living building space. The responding to ecological strategy of terrain environment is the site design in line with the Guizhou topography and built as far as possible without damaging the existing environment. The responding to technology strategy of climatic conditions is the use of overhead type movable platform and double ruled curved surface to guide the airflow way. Through a series of these ways, from the beginning of the design to the final construction, "Enframed scenery and flowing wind" is to extract the Guizhou mountain view show to promote and embellish the indigenous inhabitants' life, which gives perfect feeling back to people with combination of nature and environment. Therefore, this bamboo construction provides a chance for us to explore the design of environmental response and the effective way to achieve ecological building (as is shown in Figure 11).

REFERENCES