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ARTICLE

Research on External Space Design of Green University Campus in Lingnan Area Based on Climate Suitability

Wei Hu*

School of architecture, south China university of technology, Guangzhou, 510641, China

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ABSTRACT

With the rapid development of society and the continuous improvement of living standards, ecological environment and energy problems are becoming increasingly prominent, and university campuses are also facing many environmental problems. However, the green concept was not considered in the initial design of many university campuses, which resulted in the inability to effectively solve the environmental problems in the later stage. Campus external space design is an important part of campus design. The purpose of this study is to introduce the green concept into this link, implant "passive energy conservation" from the design source, and carry out climate adaptability design for green university campus. Green university campus in Lingnan area is explored at the level of urban design to achieve the optimization possibility of external space design strategy. Through the comparative study of the microclimate in the square, the courtyard and the street, the outer space of the university campus in Lingnan area is analyzed and sorted out to get a universal spatial prototype. Based on the advantages of traditional buildings in Lingnan, this paper deals with the hot climate in Lingnan by means of shading, heat insulation, ventilation and cooling.

1. Research Background

1.1 Green Campus

China has a large population base. With the rapid development of society and the continuous improvement of living standards, the overall per capita resources are lacking, and the ecological environment and energy issues are becoming increasingly prominent. Statistics show that 50% of the world's energy is used in construction. At the same time, more than 50% of the materials obtained by human beings from the nature are also used to construct various buildings and ancillary facilities. The emergence of green buildings has effectively reduced the amount of building energy used. Energy conservation is divided into "active" and "passive" green research. Active energy saving is achieved mainly through equipment and additional investment. Passive energy saving is achieved through building layout, space, structure, etc., without relying on equipment and requiring additional investment.

The university campus is an important part of today's society, which provides development and backup support for the country. According to the latest data released by

**Corresponding Author:*
Wei Hu,
School of architecture, south China university of technology, 1705, Chongli Building, Zone 5, Liede Garden, Liede Street, Tianhe District, Guangzhou, 510641, China;
Email: 490907008@qq.com

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the State Statistical Bureau and the Ministry of Education, there are more than 27 million college students nationwide in 2018. More than 190 million people have university education. As a large public building, university campus has a certain geographical range and spatial scale. It not only involves the functional requirements of teaching, scientific research, life and other aspects, but also carries the inheritance of culture and the expression of openness. However, as a major energy consumer, university campus still faces many energy-saving problems, which seriously restricts the development of green university campus. The main reason lies in the lack of comprehensive and systematic concept of sustainable development in most university campuses from the early stage of design.

1.2 Purpose and Significance

Campus external space design is an important part of campus design. The research purpose of this paper is to introduce the green concept into this link, implant "passive energy conservation" from the design source, and carry out climate adaptability design for green university campus. In the energy conservation design of green university campus, for buildings, the early stage of design has a great influence on the energy conservation results. In other words, the energy-saving effect achieved by spatial scale, building site, connection construction and other external spatial optimization strategies cannot be ignored. However, the concept of external space design is broad, so this paper focuses on the spatial relationship between the corresponding building and the external space. Both the site and the connector construct the external space of the green university campus. By analyzing the architectural prototype of place and connection in campus design, the passive energy saving principle is studied and corresponding green strategies are given to form a comfortable, efficient and pleasant external space of university campus.

Through the study of the design strategy of the external space of green university campus, the increasing ecological and energy pressure of the city is well alleviated. This has become a guide and model for comprehensively promoting ecological civilization. In addition, this kind of design strategy research can greatly play the role of cultivating talents in environmental education, and enable college students to accept the influence of green and low-carbon concept.

As a better component of the natural environment in the city, green university campus will effectively regulate the ecological function and provide a more comfortable urban microclimate environment for people. Through the climate adaptation strategy of the external space design of green university campus, the win-win results of urban function, spatial experience, building energy conservation and people-oriented can be achieved.

2. Climate Adaptability

2.1 Climate Adaptability Research

Lingnan is broadly understood as the south of five mountain (Dayu Mountain, Qitian Mountain, Yuecheng Mountain, Mengzhu Mountain and Dupang Mountain). It includes southern Fujian, Guangdong, Hainan, Taiwan, Hong Kong, Macao, and northeastern Guangxi. In the narrow sense, Lingnan refers to the Pearl River Delta and the Cantonese-speaking areas in southwestern Guangdong. Lingnan region has subtropical monsoon climate. Its characteristic is hot, stuffy, damp. The hot and humid weather is good for growing plants, and the abundant rain and dense river network make Cantonese accustomed to living with water.

At the same time, the subtropical climate of Lingnan also belongs to the hot summer and warm winter climate zone. The buildings in this area must fully meet the requirements of summer heat, ventilation and rain protection. Winter protection and insulation are not considered. The key points of climate-adapted architectural design are shading insulation, ventilation and heat dissipation, environmental cooling, rain and moisture proof and typhoon prevention.

The green building strategy of Lingnan is greening, shading, ventilation and water. Urban microclimate was improved by greening, shading, ventilation and water [1]. Through the spatial strategy of “cold lane, patio, open hall, courtyard”, the corresponding cultural expression and climate adaptability technology is realized [2]. The climate adaptability characteristics of traditional Lingnan buildings are compared with the new building practices, and energy-saving design strategies are implemented from the perspective of architectural space and form [3].

2.2 Thermal Comfort Research

For the characteristics of heat, suffocation and humidity in Lingnan area, the experiment mainly studies the thermal comfort effect of human body in the summer solstice. Research on thermal comfort has been developed in foreign countries for nearly 100 years. Houghton and Yaglou from the United States proposed the first effective index (ET) for thermal comfort evaluation. The U.S. Navy has put forward the famous Wet Ball Black Globe Temperature Index (WBGT).In 1970, Professor P.O. Fanger of Danish University of Technology, based on the thermal comfort equation and the 7-point scale of ASHRAE, proposed two comprehensive indexes, PMV (Predicted Mean Vote) and

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PPD (Predicted Percentage of Dissatisfied), to evaluate the thermal environment.

The Predicted Mean Vote (PMV) index is based on the basic equation of human body heat balance and the level of subjective thermal sensation of psychophysiology. It considers the comprehensive evaluation indicators of many related factors of human thermal comfort. The PMV index indicates the average index of the group's vote for (+3~-3) seven grades of thermal sensation. In recent years, PMV values have been tested and debugged by scientists, and it can be used as a very scientific data processing method for urban external space micro-environment [4]. Through the simulation analysis of climate adaptability, PMV is selected as the evaluation index of thermal comfort correlation. The wind speed, temperature, humidity and sunshine radiation were compared and evaluated.

2.3 Purpose of Climate Adaptation Research

The climate adaptability of the Lingnan area was studied. Finally, in the perspective of urban design, through the comparative study of micro-environment in the three directions of square, courtyard and street, a series of optimizations are proposed in the urban design strategy of university campus. By analyzing and combing the external space of lingnan university campus, a universal spatial prototype is obtained. Based on the advantages of Lingnan traditional architecture, shading insulation, ventilation and heat dissipation, and environmental cooling are used to cope with the hot summer climate in Lingnan. Environmental conditions are simulated and analyzed by the ENVI-met model. The coupling relationship between the physical coefficient of the external space of the university campus and the micro-environment is studied to give advice on the design of the external space of the university campus.

3. Design of External Space of Green University Campus

3.1 Microclimate Improvement in External Space

Microclimate is a meteorological term. Compared with urban climate, the scope of microclimate is smaller. It pays more attention to the recent near-surface space climate in particular. The urbanization process has led to a large number of urban scale increase in China. Building density and height are increased. The physical space form of the city produced by this construction has completely changed the natural geomorphological conditions. It produces urban microclimates that are distinct from the natural climate.

In recent years, with the deepening of understanding of microclimate in big cities, the inseparable relationship between microclimate and urban form has been established [5].The form and combination of urban architecture directly affect the formation of urban microclimate. Urban microclimate should be represented by both physical index and comfort index, and linked by urban design index parameters [6].

The problem of urban microclimate is caused by the agglomeration of urban material space [7]. Therefore, the architectural community pays great attention to the correspondence between urban morphology and urban microclimate. They envisage the construction of a good urban exterior space through appropriate exterior space design and standard control. For the relationship between external space and urban microenvironment, domestic scholars have also conducted many simulation comparisons and quantitative analysis. All these research results play a guiding role in determining the research direction and scale of this paper [8].

If the building is considered to be a cavity with a defined shape whose main function is to accommodate human activities, the buildings that appear in a particular environment will change and affect the microenvironment and participate in the construction of the microenvironment. As a result, architecture, the environment and people form an intractable relationship.

In different regions, from the perspective of historical evolution, due to the different climatic characteristics, the shape and space of the building will produce some adaptive changes. These changes are all aimed at creating better microenvironments and more livable spaces. The chamber of architecture will be restricted by invisible forces, and there is some magic in its form and composition, which should adapt to the climate, the environment and guide people's behavior.

3.2 External Space Design Parameters

The design of outer space of university campus is divided into place and connector, which constitute the design of outer space of university campus [9].Through the above analysis and research, it is finally determined to divide the design of the external space of the university campus into square space, courtyard space and street. This is the goal of the external space design for climate adaptation.

(1) At the level of square space, this paper first analyzes several square spaces of Lingnan university campus and summarizes the spatial prototype. Based on the location relationship of several spatial prototypes corresponding to the square and individual buildings in the campus, a qualitative strategy is obtained. Meanwhile, the quantita-

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tive relationship between the shading coverage of buildings around the square and the micro-environment of the square is obtained by ENVI-met simulation calculation. Finally, the concept of square enclosure degree is introduced to reprocess the simulated data, and the optimization strategy of enclosure degree is obtained.

(2) At the level of courtyard space, the prototype of courtyard space is also established. The single prototype of university campus is relatively unified. Through the setting of spatial scale and open orientation to the control group, the relationship between the scale and orientation of the courtyard and microclimate was studied, and the qualitative strategy was proposed. At the same time, the prototype of the courtyard was analyzed, and the contact area of the courtyard surface and the vertical ventilation rate were taken as research variables. ENVI-met was used to explore the subtle relationship between yard physical properties and environmental changes.

(3) At the street level, due to the convergence of university campus building facade scale, the influence of campus street orientation and scale on outdoor microclimate can be studied by using the control variable method. According to the influence, the general rule of spatial arrangement of streets and lanes is discovered. At the same time, the data concepts of bottom overhead rate and windward area ratio are introduced, and the approximate relationship between them and human thermal comfort is obtained by comparing several schemes.

According to the building density, height, spacing and other indicators, the corresponding sky-view factor can be obtained. The calculation results of urban roughness can also be obtained according to the density, height, orientation and shape parameters of buildings. By dividing several space prototypes of campus external space design, the simulation and comparative analysis of each space prototype are carried out, and several optimization strategies are obtained. It provides clear methods and approaches for future green university campus urban design. At present, the following design methods of combined parameters have been obtained:

(1)The urban square climate adaptability design strategy uses architectural shadows to reduce solar radiation and control enclosure to ensure natural ventilation.

(2)With the use of streets and alleys, the microclimate in the vertical block with 30° intersection angle due to its different trend is relatively uniform and stable. This is most conducive to the improvement of the overall microclimate within the block layer gorge in summer.

(3)The shape, aspect ratio and depth ratio of the enclosed courtyard are related to the climate.

(4)The windward area ratio is defined as the ratio of the windward area to the maximum possible windward area. The product of the building density and the average windward area ratio of residential areas in different climatic zones is the ventilation blocking ratio of residential areas.

(5)The optimal solution of bottom overhead is continuous overhead at the end of row houses adjacent to wide air ducts.

Based on architecture, the main work in the early stage of architectural design is to study the rules of architectural form layout, space combination, density and scale, so as to adapt to the needs of specific climate and human demand for architectural functions. It plays a vital role in the improvement of building performance. Architectural design is an important stage in which all possibilities are mobilized to make the decision of architectural form space scheme under the premise of relevant limiting factors. In this process, spatial patterns and important spatial parameters are determined. On the one hand, these design languages form the surface characteristics of buildings; On the other hand, it is also the key to affect building energy consumption, natural ventilation, lighting, shading, insulation and other physical environmental performance.

4. Conclusion

The research and discussion on the design of the exterior space of green campus at home and abroad are referenced, and the theoretical and practical achievements of green building design at home and abroad are combined. On the basis of these theories and urban design methods, a deeper and more specific exploration of the external space design issues of the green university campus in Lingnan area is carried out. The coupling relationship between external spatial parameters and microclimate of university campus is studied by using thermal comfort evaluation standard. Some suggestions on the design of university campus exterior space are put forward. Finally, a series of optimization strategies are obtained in the design strategy of the external space of green university campus. Through the climate adaptation strategy in the external space design, the win-win results of urban function, spatial experience, building energy saving and people-oriented can be achieved.

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