

Literature Review of Outdoor Physical Environment Design of Green Campus

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Abstract—After reviewing the relevant literature on green campus, this study has analyzed the current design practice. It shows that there are shortcomings in the green campus design strategies for the outdoor physical environment. There are three aspects in the shortcomings: (1) the site planning, (2) the layout of buildings and micro-climate, and (3) the outdoor landscape and environment. This study recommends the following method be implemented so as to improve the design of the green campus outdoor physical environment. There are three parts in the method. First, the landscape system planning is the priority, that is to say, it is the terrain and hydrology and not the traditional man-made space forms that govern the planning structure and the overall plan. Second, use a computer simulation software set to optimize the layout of the buildings. Third, optimize the design of the walking space around the buildings so as to make the users feel more comfortable.

Keywords—green campus; outdoor physical environment; design strategies

I. INTRODUCTION

In 1995, the National Environmental Popularization and Education Work Outline initiated the concept of "green school" in China, and it was implemented between 1996 and 2010. In 2007, Tongji University played a demonstration role of a conservation-oriented campus in China. The technical guideline for the construction and management of the conservation-oriented campus was promulgated and implemented in 2009. In April 2013, the Evaluation Standard for Green Campus (CSUSGBC 04-2013) was implemented, which promoted the development of green campuses in China. The outdoor physical environment of the green campus has direct impacts on all the outdoor activities, which also affects the quality of the indoor environment. If the planning and design of the campus are already done, then there is little possibility of optimizing the physical environment. Further, the cost is high to achieve the same level of outdoor environment. Therefore, the outdoor physical environment design must start from the beginning of the campus planning stage. The site planning of a green campus affects the campus landscape system and the layout of the buildings directly. The layout of the buildings is an important factor of the outdoor micro-climate, which directly affects the sunshine, wind, and so on. The walking space around the buildings is the most active areas for human activities. Hence, in the design, it must take its effect on the people in account.

In view of this, this paper focuses on the design of the outdoor physical environment of the green campus. The shortcomings in the present design in three aspects are highlighted: (1) the site planning, (2) the layout of buildings and micro-climate, and (3) the outdoor landscape and environment. Based on the review, this paper proposes design strategies for the outdoor physical environment.

II. CONCEPT OF GREEN CAMPUS AND RESEARCH SCOPE

The Evaluation Standard for Green Campus (CSUSGBC 04-2013) defines a green campus as a campus which is in harmony with its natural environment. During its service life, it maximizes the conservation of the resources, such as energy, water, materials and land. It also protects the environment and reduces pollution thereby providing a healthy teaching, applicable and efficient environment for the teachers and students. Professor Hong-wei Tan, Secretary General of China Green University Network, developed a radar map, as shown in Figure 1. It shows that a healthy environment, green planning and environmental conservation are important components in the development of a green campus.

The diversity of campus functions determines the complexity of its spatial layout. A green campus is also a park. It includes green planning, green buildings and green landscape, of which the green buildings have to be certified according to the Assessment Standard for Green Building (GB/T50378-2014). Further, the campus can be divided into indoor and outdoor environments. For each environment, there are physical and cultural environments. The scope of this paper is focused on the outdoor physical environment, as shown in Figure 2.

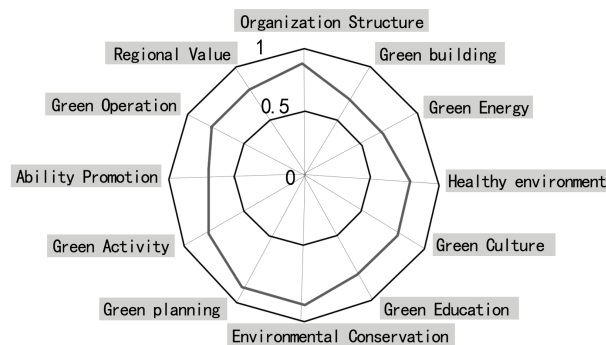


FIGURE I. RADAR MAP OF GREEN CAMPUS EVALUATION SYSTEM

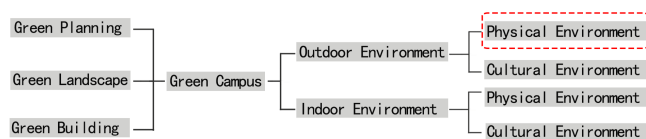


FIGURE II. RESEARCH SCOPE

III. CURRENT STUDY AND SHORTCOMINGS OF CAMPUS OUTDOOR PHYSICAL ENVIRONMENT

The green campus is an integration of green planning, green buildings and green landscape. These three components correspond to the site, the micro-climate and the walking space, respectively. With respect to the three components, the following is a review of the green campus outdoor physical environment design strategies.

A. Site Planning

Professor Tie-mao Shi highlights that for the site planning of a green campus, the ecological planning of buildings and landscape should be included. He emphasizes the need to merge the biological nature and the society's culture in accordance to the construction practice of Shenyang Jianzhu University. He further emphasizes the importance of understanding the characteristics of natural resources and natural environment before the overall planning of the campus area, so as to make full use of the existing natural environment. Professor Chong-jie Wang led the construction of Shandong Jianzhu University from the site selection, and developed a plan for design according to the local conditions, which include a stone factory with a gully, a pit, and the Xue-shan hill. With these conditions, it was difficult to build the campus, but through the ingenious incorporation of the natural terrain, the project was successfully completed without removing any earth from the site. During the development of the Meixihu middle school in Hunan province, Professor Biao Hu advised a reasonable utilization of the underground space, according to the topography and landscape. His advice was good for the buildings layout, because it reduced the quantity of earthwork that was removed from the site.

From the green planning perspective, the three mentioned cases are for specific campuses, and they are located in different climatic regions. Shenyang Jianzhu University is in the severe cold region. Shandong Jianzhu University is in the cold region, and Mei-xi-hu middle school is in the hot-summer and cold-winter region. While the three campuses have been operating well, general planning design methods for a campus were not developed.

B. Layout of Buildings and Outdoor Micro-climate

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Bao-xin Li, hosting the designs of a university campus in Guangzhou City, and a middle school campus in Shaoyang, emphasized the design of a green campus should focus on the "wind" and "water" thereby achieving the "hiding of the wind" and the "inflowing of water". With such a design, the campus is in harmonious coexistence with nature. Using a computer simulation software Yu-kun Zhang has optimized the outdoor environment of Shijiazhuang Jingji University. Also using computer simulation, he has developed a planning and design method for green campuses. Yu Zhang has developed passive technologies for the enclosing form, path design, plane form, roof design and ventilation, which can determine the building height, depth, construction spacing and enclosure type. The use of a suitable enclosure type can reduce the negative effects of adverse weather in a severe cold region. Using the Southern Science and Technology University as an example, Peng Liu and Hong-wei Mao analyzed the landscape and physical environment digitally can thereby refining and quantifying the wind, sound, light, heat and other physical environmental factors of the campus. This analysis can improve the campus outdoor physical environment quality, and reduce costs. Guo-hua Tian recommended that the regional airflow constraints be taken into account in the overall planning of a campus and the layout of buildings. This is not only useful to the insulation and energy-saving of the buildings, but also to improve the summer and winter outdoor wind environments at the campus.

There are many studies on the layout of green campus and the design of outdoor physical environment. There is a consensus that the physical simulation software can be used to design the layout of the buildings and to optimize the outdoor physical environment. However, in practice, the green environment simulation analysis is only carried out after the conventional planning and architectural design are completed. Hence, the results of the simulation analysis and the optimal design are only for show and not used in the planning design, building groups design and landscape design. This planning and design process cannot be good for a green campus.

C. Landscape and Environment

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Tie-mao Shi recommended that campus ecological landscape be integrated into the overall greening system. The greening system can be divided into two parts, i.e. the green space system, and the water system. In the design, it is recommended that the two parts be considered as a single system, thereby forming an ecological corridor. Guo-hua Tian considers the protection of the existing ecological environment around buildings is the primary method to improve the outdoor micro-climate. Only with this method, the wind around the buildings can be made to feel comfortable, and the plant can play the role of carbon fixation fully. Zhang Yu shows that by incorporating water, the waterfront treatment and water shape in the design, they can reduce the effects of the unfavorable climatic factors. Combining with the campus energy system, the water can play the role of temperature regulation in the cold region. By combining the designs of the landscape and the building groups, Bao-xin Li shows that using the computer simulation technology can achieve ecological rainwater

management. Concave green grass, rain garden landscape can solve the problem of rainwater utilization and excretion. Using the landscape planning of Tianjin University as an example, Yu Hao and Lei Cao have developed a low impact development strategy in the green campus landscape design. The landscape design based on the principle of landscape ecology can control the runoff of rainfall from the source.

The campus landscape design practices are based on the completed campus planning, whose start and end points are not at the macro level, namely, not from the source. Although Yu Hao recommended that the source of rainfall at the site be controlled so as to achieve low impact development, it was not carried out at the initial stage of the campus planning. Therefore, these landscape designs cannot optimize the outdoor physical environment at all.

IV. SUGGESTIONS ACCORDING TO THE ABOVE STUDY

The outdoor physical environment of a campus is closely related to its geographical location, terrain and hydrological condition. That is to say, the positives and the negatives of the green campus outdoor physical environment are already affected at the planning stage. In the preceding discussed campus outdoor physical environment design methods, there are three common characteristics. First, at the planning stage, the focus is on the space form for the land use, but there is no outdoor physical environment design. Second, the design is carried out before or concurrently with the simulation and optimization. Third, there is no design for the walking space around the buildings.

Hence, this study has developed a design method for the campus outdoor physical environment, which starts at the planning stage. There are three parts in the method. (1) The planning should start from the landscape system because the environment is governed by the existing landscape. Then, it makes rational use of the terrain topography, hydrological conditions, which forms the foundation for the subsequent planning and design. (2) After the entire campus landscape system is basically planned, use a physical simulation software set to optimize the layout of the building groups so as to form the best outdoor micro-climate. (3) At the late architectural design stage, the walking space around the buildings is optimized by making full use of greening, shelf, building components to form large shading area.

V. CONCLUSION

With the Green Action, the outdoor physical environment design of a green campus can be achieved with fruitful results. However, based on the literature review in this paper, it shows that there are shortcomings in the current practices on the design of the physical environment of the green campus. This study has developed a design method in which the design of the green campus outdoor physical environment starts from the planning stage. It then advances the design of the campus outdoor environment to the planning level. The green campus, suitable for certain climatic characteristics and geographical conditions, is a low-cost design strategy for a campus outdoor physical environment.

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