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Research on Green Transformation of Campus Sponge and Energy Saving Facilities on Sloping Land

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ABSTRACT

Based on the renovation of sponge and energy-saving facilities in a middle school in Nanning, this paper systematically studies the overall elevation of the campus, the composition of the drainage system and the layout of space functions, and formulates a characteristic scheme for the renovation of sponge and energy-saving facilities according to the characteristics of the sloping campus. In order to control the total amount of rainwater runoff, the sponge transformation mainly adopts the transformation methods of partition catchment, upper storage and lower use, multi-stage detection and classification treatment. For the purpose of solar energy and wind energy utilization, solar photovoltaic panels and small-scale wind power generation system are adopted. The application effects of sponge and energy-saving facilities are estimated and evaluated.

1. Introduction

With the development of China's social and economic undertakings, there are many serious problems in cities, such as water shortage, water quality deterioration and frequent urban flood disasters, which pose a huge challenge to the sustainable and healthy development of urban and rural areas.

Sponge city is a comprehensive concept to solve urban water and ecological problems. Sponge city breaks through the traditional concept of "drainage as the main", takes buildings, roads and green space as the carrier, and constructs the urban low-impact development rainwater system through a variety of ecological technologies such as "infiltration, retention, storage, purification, utilization and drainage" [1]. The construction of sponge city will make the "steel city", which has been hardened gradually become naturally inhale and breathe. The city and the natural environment are no longer two independent individuals, human and nature live in harmony, shaping a healthy, complete and useful ecological civilization, so that water resources can be recycled [2].

In addition, in the context of green environmental protection, energy conservation and emission reduction, clean, safe, efficient and inexhaustible energy from the sun has become the direction of energy development in the 14th Five-Year and even the future. The development of distributed power supply is the combination of solar energy and architecture, which makes solar energy become an organic part of architecture. It is an important way to build low-carbon, energy-saving and environment-friendly green buildings by integrating mature solar technology

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products into buildings.

This paper studies and analyzes the natural geographical conditions and ecological environment of a sloping campus, discusses the feasibility of sponge and energy-saving measures, and completes the design scheme of sponge city and energy-saving facilities transformation of sloping campus. The design scheme will significantly improve the campus environment, save operating costs, and has good economic and social benefits.

2. Present Situation of the Campus

The total land area of a middle school campus is about 28 hectares, among which the roof area is about 37890 m^2, the course area is about 50430 m^2, the road area is about 11500 m^2, the parking area is about 7310 m^2,the green area is about 98830m^2, the water system area is about 4300 m^2. The campus is built according to the sloping land, and the whole campus is high in the north and low in the south. The vertical design of the building and site is more complex and changeable, forming a unique landscape environment of the sloping campus. The average annual sunshine of the campus is 1439~1596 hours, and the total radiation is about 4650 MJ/m^2, solar energy resources are relatively abundant. The campus has the following problems: 1) The current green space in the campus is mostly ordinary green space, which has a large area. The soil permeability is not high, and the water absorption and storage ability is poor, which is not conducive to the retention and drainage of rainwater. 2) The paving materials of the campus sports ground, track, road, parking lot and distribution square are mostly ordinary impermeable paving materials, without the function of rainwater infiltration. 3) The building roof and slope greening are not effectively used for rainwater storage. 4) The existing drainage facilities of the campus can not meet the overall goal of sponge construction in the region. 5) Some distribution plazas have severe heat island effect and poor thermal comfort.

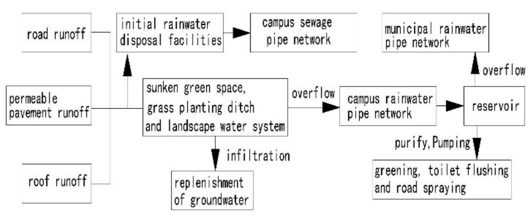

Figure 1. Schematic of Sponge City Design

Source: self drawn by the author

Campus is the main place for teachers and students to study and live. Closely integrate the existing problems of the sloping campus environment with the sponge city and energy-saving principles, systematically and reasonably complete the sponge transformation goal, and the campus landscape effect can be greatly improved. At the same time, distributed photovoltaic and wind power generation systems were installed on the roofs of teaching buildings, and diversified new energy utilization technology demonstrations were carried out to meet the power needs of campuses. At the same time as the green transformation of campus sponges and energy-saving facilities, students will be given sponge energy-saving demonstrations, cultural enhancements and environmental protection quality training to make the campus a base for sponge energy-saving science education.

3. The Reconstruction Measures and Benefit Analysis of Campus Sponge City

3.1 Measures for the Reconstruction of Campus Sponge City

The basic principle of sponge city design is to intercept and permeate rainwater runoff and replenish groundwater by taking measures such as sinking green space, planting ditches and landscape water bodies. The primary overflow is purified by the rainwater storage tank, and used for greening and watering, flushing and road pouring, so as to control the runoff pollution and make full use of water resources [3].

The sponging transformation construction measures include: green roof concave green space, permeable and water-cutting pavement, rainwater disconnection, grass planting ditch, water purification terrace and rainwater storage pond [4].

Combined with the sponge and energy-saving measures requirements and the actual conditions of the campus and other factors, the design of the main transformation measures are green roof, permeable and cut off the water pavement, sunken green space, rainwater storage pond, etc. Its design schematic diagram is shown in Figure 1 [5].

The scheme design covers most of the campus environment, and the overall layout of its transformation is shown in Figure 2.

3.2 Benefit of Campus Sponge City Reconstruction

The average annual rainfall of this campus is 1298 mm. According to the 75% runoff control rate, the corresponding rainfall is 26.0 mm, and the average annual rainfall frequency is 1298/26.0=50 times.

Rainwater recycling can save 300 m^3 water consump-

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tion of tap water greening each time. According to empirical data, excluding depreciation costs, the operating cost of rainwater collection, treatment and recycling is about 0.5 yuan per cubic meter, and the average cost of school water and tap water is about 3.10 yuan. Then, the project will save the inflow of water each year: Q=300×50=15000 m^3 per year. Save 39,000 yuan of water bill every year.

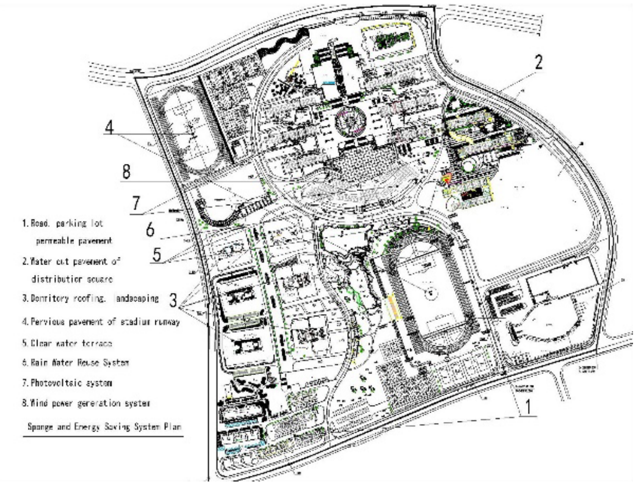

Figure 2. The overall layout of the campus sponge city renovation

Source: self drawn by the author

Roof greening can also alleviate the urban heat island effect. When the roof temperature is between 37℃ and 40℃ in summer, roof greening can effectively reduce the temperature by 3℃ to 6℃ . In addition, it can also absorb dust and reduce the amount of bacteria. Therefore, sponge modification will have a favorable impact on the environmental microcirculation and the reduction of heat island effect within the scope of this project [6].

Water cutting brick pavement can reduce road temperature and alleviate urban heat island effect. The experimental results show that the measured temperature of the block can be reduced by up to 13℃ in the daytime and 3℃ in the evening, no matter in the daytime or at night. It takes 39.8 hours for the water level in the block to decrease from 4 cm to 1 cm [7].

4. Renovation and Benefit Analysis of Campus Energy-saving Facilities

The campus belongs to subtropical monsoon climate, wind and solar energy resources are rich, with the changing of renewable power and micro power grid technology, adjust measures to local conditions to build contains a variety of scenery energy micro grid power supply system, on the one hand, can be used as a renewable energy science base, on the other hand, self-sufficient in electricity, but also contribute to energy conservation and emissions reduction, low carbon environmental protection [8].

In this design, photovoltaic panels are laid on the roof of the flat roof of the teaching building, the administration building and the comprehensive building, and the laying area is 6150 m^2, the construction of photovoltaic microgrid, integrated into the campus power supply network. Small fans are installed at the wind crossings on the top floor of the building for 10 rack points to form a wind power microgrid, which is also integrated into the campus power supply network. The layout of photovoltaic and wind power (partial) is shown in Figure 3 [9].

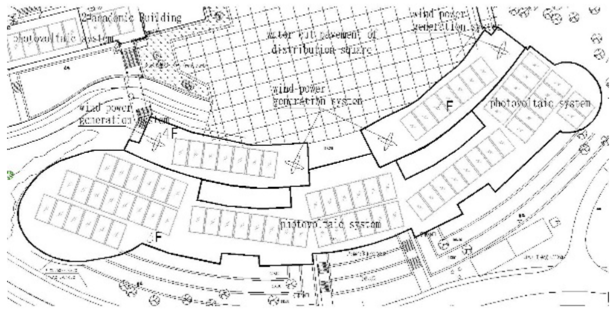

Figure 3. Photovoltaic and wind power system layout drawing (partial)

Source: self drawn by the author

For example, the photovoltaic panel parameter is 200W/1640 mm*670 mm, the module efficiency is 18.2%, and the area of the campus can be laid is 6150 m^2, the net installation amount is 633.5 KW. The photovoltaic utilization hours in this area are about 1500 h. Taking into account the effects of reduction factors, the annual equivalent photovoltaic full load hours are revised to 700 h, and the annual power generation is 443,450 h, which can save 221,000 yuan of electricity. If the small fan parameter is 1000W, then 10 AC permanent magnet synchronous wind generators are 10 KW. The annual utilization hours of wind power in this region is about 2000 h. Taking into account the effects of reduction factors, the equivalent annual full load hours of the wind turbine is revised to 900h, then the annual power generation is 9000 h, and the electricity cost can be saved by CNY4,500. The solar system can save electricity cost of 225,500 yuan a year. At the same time, its energy saving and emission reduction effect are remarkable. The energy saving and emission reduction of the solar system is shown in Table 1 [10].

5. Conclusions

According to the theory of sponge city and energy saving, a systematic combination design was carried out

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at the appropriate location of the sloped campus to solve the problems of rainwater ecology and energy-saving measures on sloped campuses, verify the theory of sponge city and energy saving, and realize the economic and social benefits of the campus. The improvement provides practical ideas for solving the sponge and energy-saving transformation of sloped campuses. The program design covers most of the campus environment, and the program practice will greatly improve the campus building and environment, and the effect of energy saving and emission reduction will be significant.

Table 1. Calculation of energy saving and emission reduction of wind and solar system

Comprehensive benefit analysis of environmental protection	Energy saving and emission reduction
Estimated annual power generation(MWh)	452.5
Standard coal (t)	162.9
carbon dioxide CO_2(tce)	451.1
Year Toner Dust TSP (t)	123.1
Sulfur dioxide SO_2 (t)	13.6
Nitrogen oxide NOX (t)	6.8
Purified water H_2O (m^3)	1809.8

Source: self drawn by the author

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