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Application of Sponge City Concept in Urban Waterfront Landscape Design

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Abstract: *Sponge city construction work is currently one of the focuses of all water ecological construction work in China's cities, and the urban waterfront landscape as the city adjacent to rivers, lakes, oceans and important landscapes, waterfront landscape planning and design work directly determines the actual charm of the city itself. In this paper, after sorting out the importance of the sponge city concept on waterfront landscape, according to the characteristics of sponge city, the sponge design of urban waterfront roads, squares and ecological corridor.*

Keywords: *Sponge City; Waterfront landscapes; Cavernous design*

1. Introduction

Cities are facing many problems such as traffic congestion, air pollution, water pollution and urban storm water disasters. Over the past 20 years, rapid urbanization has led to a dramatic increase in impermeable areas, altering the natural hydrological cycle and leading to serious urban flooding and environmental pollution problems. Many water problems, such as the yearly decline of the urban water table, localized waterlogging in heavy rains, poor water quality and insufficient water quantity, are seriously troubling people.

In order to better alleviate urban flooding, reduce urban runoff pollution, intensify the use of water resources, and protect and improve the urban ecological environment, the concept of 'sponge city' has emerged [1]. With the progress of social production technology and people's thinking, this concept is gradually applied to the field of landscape design. This has to a certain extent affected the attention of landscape design to stormwater management and the implementation of stormwater management concepts in the landscape.

2. Definition of theoretical concept

2.1 Concept of Sponge City

In the late 1990s, the state of Maryland in the United States developed Low Impact Development (LID) technology to achieve runoff and pollution control caused by heavy rain [2], mainly through decentralized, small-scale source control. After nearly 20 years of development, it has become the urban green rainwater infrastructure (GSI) technology most commonly used in the United States and many developed countries [3]. Similarly, Australia' s Water Sensitive Urban Design (WSUD) [4], New Zealand' s Low Impact Urban Design and Development (LIUDD) [5], and the UK' s Sustainable Urban Drainage System (SUDS) [6], are like-minded technologies.

In 2013, the Government of China launched a new integrated urban water management strategy called 'sponge cities'. Unlike traditional methods of rapid drainage, this concept focuses on increasing the water absorption capacity of cities through green infrastructure, based on a natural water recycling system that acts like a sponge. The aim is to control peaks in urban runoff and to temporarily store, recycle and purify rainwater. The sponge city concept is widely supported by the Government and academia and is seen as a breakthrough in China's sustainable urban planning paradigm, providing practical guidelines and policies for managing urban water systems more sustainably [7]. Sponge cities cover a wider area than similar water management solutions internationally and provide a more comprehensive system for developing innovative solutions to urban water problems, improving ecological conditions and thus

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reducing climate risks. Sponge cities are resilient in adapting to environmental changes and responding to natural disasters caused by rainwater, and can also be referred to as 'water resilient cities'. By improving the ability to infiltrate, store, purify, utilise and discharge rainwater, a virtuous hydrological cycle is achieved, thus maintaining or restoring the sponge function of the city. Urban 'sponges' include water systems such as rivers, lakes and ponds, as well as urban facilities such as green spaces, gardens and permeable pavements. The construction of urban drainage and flooding systems is imminent and will focus on 'sponge' urbanisation to effectively improve the recycling rate of urban water resources.

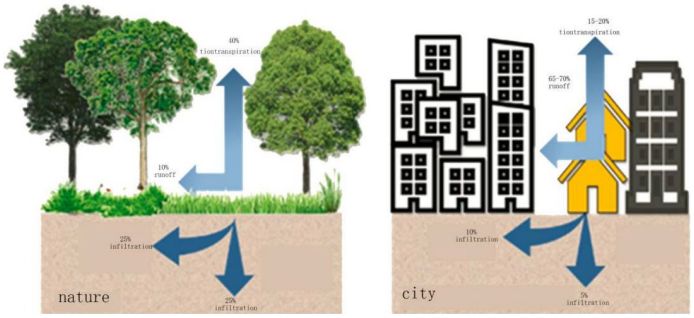

Figure 1: Concept of sponge city

2.2 Connotation of urban waterfront landscape

Human perception of the landscape is not a simple superposition of each landscape fragment, but a continuous display of the landscape in the multidimensional intersection of space and time. The linear and boundary characteristics of the waterfront space make it the most important part of forming the urban landscape character, and the continuity and viewability of the waterfront boundary are crucial and unforgettable. The purpose of waterfront landscape design is, on the one hand, to achieve spatial permeability through internal organization and to ensure a good visual corridor connecting with the water body; on the other hand, the waterfront area provides an open view of the water for the presentation of the urban cluster landscape, and it is also the best location for the formation of the city's overall iconic, gateway landscape.

In terms of cities, urban waterfront landscapes can be divided into two categories: physical and non-physical [8]. According to the theoretical analysis model of landscape ecology, the material landscape can be divided into three structural forms: patch, corridor and matrix. From the perspective of urban design theory, it can be further divided into three parts: landscape area, landscape axis and landscape node. Intangible landscape is the perceptual understanding formed through human activities with these three material landscapes as the carrier, which is the cultural traces in the material landscape, a high-level design concept goal, and the soul of the vibrant urban environment landscape [9]. The urban waterfront landscape area can be divided into three parts: water area landscape, transition area landscape and surrounding land area landscape.

2.3 The significance of the sponge city concept to the waterfront landscapes

2.3.1 Ecological values

The waterfront is the transitional link between the city and the water body and has good ecological value. The role of the sponge city concept is to prevent damaged water systems and pollution sources from entering the ecological hub to the maximum extent possible, and to give full play to its role in intercepting, purifying and recirculating polluted surface runoff, thereby effectively reducing the likelihood of runoff being polluted. Through the construction of sponge city systems, damaged water ecosystems can be restored to the maximum extent possible, promoting the establishment of more harmonious water ecosystems.

2.3.2 Social values

Sponge city construction carries out comprehensive consideration and planning for urban residential areas, roads, green areas, squares, etc., to beautify the urban landscape to a certain extent and provide a good ecological environment for the public. For example, in the construction of sponge city in Jiaxing, Zhejiang Province, the city's residential areas and roads are reasonably planned to expand the area of green space and increase the greening rate, to ensure that its 'sponge' role at the same time to allow people to enjoy the beautiful scenery, so that the city's humanistic atmosphere is more profound.

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2.3.3 Economic values

The traditional model of landscaping does not produce economic benefits, but rather more unnecessary capital investment and economic waste. The concept of urban stormwater in China is to achieve the fast drainage mode as much as possible, such as the construction of underground pipes in the city, and the investment cost of laying underground pipes in the old city or city center is higher. Rapid drainage of stormwater also causes waste of water resources, which is a problem that cannot be ignored. However, at present, most cities use rapid drainage for stormwater treatment, resulting in a waste of stormwater resources. Therefore, the full and rational use of these resources can maximize their economic value.

3. Specific application of sponge city concept in urban waterfront landscape design

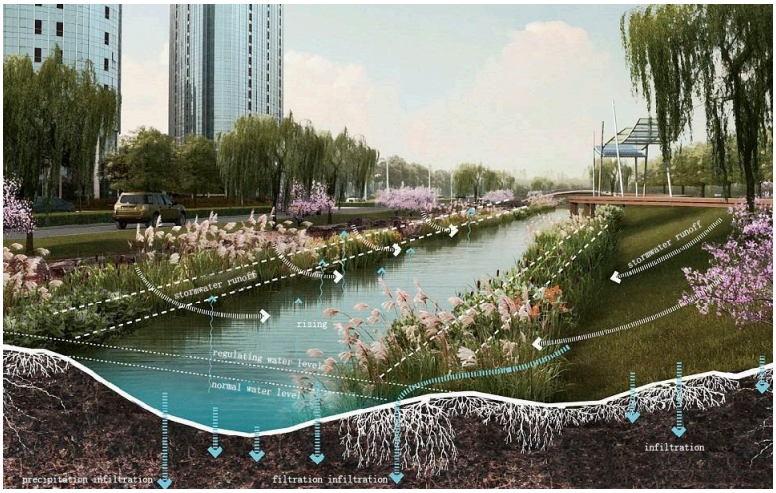

Figure 2: Waterfront green space in sponge city

The concept of sponge city provides new design ideas for the design of urban waterfront landscapes, effectively solves the problem of its water resources cycle, and achieves the protection of water resources in waterfront areas. The evaluation of good or bad waterfront landscape is actually essentially based on the results of human development of rivers. In order to better understand this concept, we must look beyond the surface composition of the landscape and study the relationship between the river and the ground surface.

3.1 Cavernous design of road landscape

Road landscapes are an important part of urban landscapes, accounting for 10 to 25 per cent of the entire urban area. Therefore, when designing waterfront landscapes, the design of sponge roads should be addressed first. In the city, the value of the road landscape should not be ignored, and designers should start the design work from the special characteristics of the waterfront area. The sponge road in the waterfront area adopts permeable pavement. Due to the large gaps in the permeable pavement, when it rains, rainwater can quickly penetrate the surface asphalt and flow into the drainage system on both sides of the road from the surface of the lower waterproof structure, preventing water on the road. Laying stones in the soil layer of the road surface can accelerate water diversion and filtration, greatly improving the infiltration effect of rainwater in the road surface, in addition to the use of plastic pipes with good diversion effect. Drainage holes should be set up before concrete paving to create growth conditions for different microorganisms, achieve circulation throughout the city, and stabilize the urban ecological balance. Waterfront landscapes based on the sponge city concept can choose from a variety of permeable paving forms, such as grass tile paving, embedded grass tile paving, and permeable asphalt paving. Sponge design includes road organization design, permeable paving, sunken green space, rain garden and many other elements. Landscape designers should carry out sponge design according to the actual situation of the site. For some special waterfront areas, special sunken green space can be set up to improve the utilization rate of rainwater and obtain better ecological benefits. Sunken green space needs to be regarded as a space below the building ground level. Rainwater and surface runoff can flow into this sunken green space for further purification.

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3.2 The cavernous design of the square

Cities tend to set up more plazas in the planning and design process to meet the spatial needs of residents for outdoor communication and collective activities. The form of the square is not only limited to the ground, but also can be extended downwards to form a sunken square, which not only solves the problem of water storage in the rainy season, but also improves the quality of the square space and working and living environment, and creates different levels of landscape effect according to the size of the rainfall and water storage. In order to facilitate residents to walk and leisure, its ground is generally made of hard paving material, which is less permeable to rainwater. As a place for our citizens to carry out political, economic and cultural activities, the city square often has the characteristic of covering a large area in the construction process. Based on this feature, the relevant departments and personnel in the process of promoting urban 'sponge' landscape design, the need to use a large area of permeable tiles or permeable concrete for the plaza floor paving operations, to achieve the effective conservation of water resources. The main reason for adopting this measure is that, on the one hand, the ornamental and artistic nature of the square can be enhanced through various forms and color of tiles; on the other hand, it can also play the role of rainwater infiltration to avoid the emergence of urban waterlogging. In addition, in the process of designing urban squares as 'sponges', the relevant personnel also need to strengthen the design and construction of sunken plazas and bioretention areas, and to enhance the water storage and infiltration capacity of these areas.

3.3 Planning and designing of ecological corridor

The main function of ecological corridors is to realize the connection and isolation of various ecological patches in the waterfront space. Through the installation of different ecological corridors, effective integration between different ecosystems is realized, forming a large-scale and diversified ecological environment system, and facilitating the migration of organisms and the circulation of water resources. River runoff, ponds and low-lying areas are utilized as wetlands, which are incorporated into the overall rainwater storage and purification system to alleviate urban flooding, recharge the river landscape water body and form a stepped rainwater purification wetland. Secondly, it combines urban open space and recreation with the ecological construction of rivers in parks, establishes a continuous slow-moving network, and transforms the cross-section pattern to create more water-friendly spaces. Combine riverfront land development with river improvement, using river landscape as an opportunity to guide internal urban renewal, enhance land value, strengthen urban vitality, and promote synergistic development of wetland landscape and livable urban environment. Through the construction of natural barges on the river, the ecological condition and self-purification ability of the river will be restored, and the vitality of the river will be reshaped. The water quality around the river will be purified and buffered. Combined with the spatial organization of the woodland within the river, the river will form a good intermingling relationship with the surrounding urban environment, creating an urban sponge green lung and a central ecological base.

4. Conclusions

From the perspective of sponge city, the city should combine its own situation, optimize the road landscape and square landscape design, do a good job of water system collation, improve the design of water bodies, and reduce water pollution and water damage. It is necessary to do a good job of vegetation restoration, construct artificial wetland plant pools, improve urban waterfront landscape design, strengthen coastal landscape construction, and achieve harmony between man and nature. The construction of sponge cities is an important component of measures to achieve the harmonious ecological development of cities, human beings and nature. It is necessary to focus on methods such as source reduction, ecological restoration and natural storage, as well as policy and financial protection, technical research and exploration, etc. In the short term, the construction of demonstration cases will be used as an accumulation of technical experience; in the medium term, accelerate the formulation of relevant laws and norms, require new buildings, green spaces and other facilities to have rainwater storage functions, strengthen the research and application of permeable engineering materials, and promote in-depth research by the government, enterprises, universities and research institutions to conduct in-depth research; and open up the industry to competition to improve construction and operation. In the long run, it will enable all people to participate in monitoring, enhance environmental and ecological awareness, and comprehensively build and improve sponge cities.

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