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STUDY ON SUSTAINABLE DESIGN OF RAINWATER LANDSCAPE IN EXISTING URBAN RESIDENTIAL COMMUNITY

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ABSTRACT

With the rapid development of Chinese cities and the increase of hardstand areas, the existing urban residential communities are faced with serious problems such as flood disaster and water pollution, the engineering measures adopted in China in the past are to the disadvantage of environmental protection and sustainable development of ecology. By consulting relevant documents and combining with practical cases, taking the existing communities in Qian'an City of China as an example, analysis the problems of existing communities with current situation. Starting from the perspective of the landscape and using the technical measures of the Sponge City to carry out the landscape renovation design, this thesis puts forward the sustainable design strategy of landscape in the existing urban residential communities. In order to provide reference for landscape reconstruction design of other cities in the north of China, and furthermore, to promote the sustainable development of the whole social environment.

Key words: Sustainable design; Rainwater landscape; Existing urban residential community; Ecological view.

INTRODUCTION

Due to the fact that people’s activities deviate from the law of ecological development, environmental pollution, waste of resources and other phenomena become more and more serious, which put off the sustainable development of urban landscape. Therefore, we should reflect on how to maintain harmonious coexistence and development with nature. Carson’s *Silent Spring* reveals that humans are punished by nature for destroying the environment, making people aware of the importance of natural environment. McHarg also proposed in *Design with Nature*, that landscape design should take the sustainable development of natural ecology as the guiding principle. In ancient Chinese philosophy, it is always emphasized to conform to nature, respect nature, and live in harmony with nature, that is, the idea of “the unity of nature and man”, which contains the meaning of sustainable development. This paper aims to solve the rainwater problem of existing urban residential community in northern China by applying sustainable design strategies such as natural ecological methods, Sponge City technical measures etc., in order to restore the circulation process of natural system, to achieve the harmony and unity of human, society and nature, and to promote the effective utilization of resources the sustainable development of the whole social environment.

1. PROBLEMS AND RESEARCH STATUS OF URBAN RAINWATER LANDSCAPE IN CHINA

The development of Chinese cities is always at the cost of the environment, the urban fabric that can absorb and storage water has been replaced directly by hard roads, undermining the ability of cities to cope with the natural flood cycle. The existing urban residential communities refers to the communities built in recent years, with many obvious problems such as high development intensity, high building density and large water consumption [1]. There is a large area of hard ground in the existing urban residential community, a lack of green space, a large amount of rainwater runoff, which can easily lead waterlogging phenomenon in the residential community during rainy season, and cause water shortage during dry season. According to relevant data, 154 cities in China suffered from waterlogging in 2015, affecting 255 people and causing losses of nearly 8.1 billion RMB, causing great hardship to people’s lives. At the same time, the increase of hard ground leads to the lack of green area, which makes the landscape environment of the city worse and worse, and cannot meet the leisure and entertainment needs of people.

In 1987, in *Our Common Future*, the United Nations Commission on Environment and Development defined “sustainable development” as “development that meets the needs of the present generation without jeopardizing the ability of future generations to meet their needs” [2], then sustainable design can be seen as a way to solve the relationship between man and nature from the perspective of overall interests. The sustainable development of cities cannot be separated from good water resources and water ecology. Other developed countries have studied the management of urban rainwater as early as in the 19th century, and carried out natural retention, infiltration, collection and reuse of rainwater, thus creating a good landscape effect, and realizing the sustainable utilization of rainwater resources. In the 1990s, China began to study the management of urban rainwater and other aspects. The concept of sponge city in 2014 was just suitable to solve the landscape problem of the city, and China carried out a pilot project of Sponge City construction in many cities. Qiu Xingbao, chairman of the China Urban Science Research Association, gave the definition of Sponge City in his paper “The connotation, ways and prospects of Sponge City (LID)” [3], Sponge City refers to a city like a sponge and has flexibility in adapting to environmental changes and coping with natural disasters. China should absorb more excellent foreign practical experiences, and according to the actual situation in China, create rainwater landscape treatment measures that are consistent with national circumstances.

2. PRACTICE AND APPLICATION OF SUSTAINABLE DESIGN OF URBAN RAINWATER LANDSCAPE

Country	Time	Rainwater Management measures	Function
The United States	1970s	The Best Management measures BMPs	Reduce non-point source pollution of rainwater through source control and treatment
The United States	1990s	The Low Impact Development model LID	Maintain the same hydrological characteristics after urban development as before, and reduce the damage to natural environment.
Australia	1990s	Water Sensitive Urban Design WSUD	The functions from three aspects: rainfall and flood control, water quality control and rainwater reuse.
Japan	1980	Rainwater Infiltration plan	The use of a large area of permeable materials to increase urban rainwater infiltration rate.
Germany	1996	Decentralized Rainwater Management DRWM	Collect rainwater by using roof rainwater system, purify and recycle rainwater.
Britain	1999	Sustainable Urban Drainage System SUDS	Establish good water circulation and drainage system, and carry out sustainable management of groundwater and surface water.

China	2014	Sponge City theory	When it rains, it will absorb water, store water, seep water and purify water. When necessary, the stored water will be “released” and used.
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[Table 2.1] Management Facilities and Functions of Rainwater

Foreign rainwater management measures emphasize the maintenance and promotion of urban natural hydrological processes by protecting landscapes and utilizing natural landscape ecological measures, and pay attention to the symbiosis between urban landscape environment and construction and development [4]. The practice of urban water resources utilization and management in the United States, Japan, Australia and Europe started earlier and produced many excellent cases. These management measures of rainwater have provided a good reference for the promotion and development of Sponge City in China.

2.1.Source control of rainwater resources

The concept of Low-Impact Development(LID)technology is mainly based on the improvement model and design principles put forward by unreasonable land development and utilization in the United States. The natural hydrological process is taken as the design concept in High Point community of Seattle, USA, and the problem of rainwater is solved from the source by using ecological design method. Water permeable pavement is used in the site to reduce surface runoff and relieve drainage pressure of urban pipe network, set up a rain garden to handle excessive rainwater. Roof drainage system and water pipes are used to bring rainwater to ground greenery, reduce ground erosion, and also add interest for the residential landscape design [5]. The current land development intensity in China is large and the ecological environment is more sensitive, the LID technology in the United States provides theoretical guidance for the landscape design of rainwater in the existing urban residential communities in China, which can promote the sustainable development of ecological environment in China, and maintain the urban hydrological environment.



[Figure 2.1] Plot Roof Rainwater Scattered Layout



[Figure 2.2] Residential Area Roof Rainwater Scattered row



[Figure 2.3] Plot Glassed Swale

Source: SVR design company

2.2.Promote recycling of rainwater resources

The Sustainable Urban Drainage System(SUDS)in Britain mainly through source control, rainwater transportation and rainwater collection, some legal systems have been formulated to form the integrated management system for rainwater collection and utilization. The Agilent community in Britain installed a buffer storage tank for a variety of integrated development projects. During torrential rain, the water tank provides water storage function, after the rain, the water tank can be controlled by water valves, so that the water storage can be slowly discharged into the soil, and through certain treatment, all water tanks are placed underground, thus not affecting the design of any above-ground space and can effectively use rainwater resources [6]. This measure has guided the application of impounding reservoir in China’s Sponge City theory which is used to collect the surplus rainwater and avoid waste of water resources.



[Figure 2.4] Community Surrounding Environment Map



[Figure 2.5] Total Plan Map



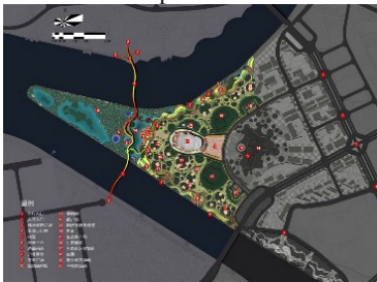
[Figure 2.6] Site Effect Map

Source: EMA architects office

2.3.Create Multi-functional elastic landscape

In 2015, Chinese President Xi Jinping proposed at the meeting to build a sponge city with “natural accumulation, natural penetration, and natural purification”, and requested to protect nature, conform to nature, and solve the problem of urban rainwater with the concept of sustainable development. The design of the Yanweizhou Park in Jin-

hua City, Zhejiang Province was guided by the concept of “making friends with floods” and adopted a design strategy of water elasticity, which uses submerged terraced planting to provide alternative engineering flood-resistant hard revetments, combining flood prevention with ecological conservation and recreation [7]. Through minimum engineering methods, the original vegetation was reserved. The urban park is used as an ecological infrastructure, and it is combined with the protection and utilization of water resources to realize ecological, social and cultural flexibility of the landscape.



[Figure 2.7] Yanwei State Park Plan



[Figure 2.8] Aerial view of Yanwei State Park



[Figure 2.9] Yanwei State Park Recreation ground

Source: <https://www.turenscape.com/en/home/index.html>

3. SUSTAINABLE DESIGN OF RAINWATER LANDSCAPE IN EXISTING URBAN RESIDENTIAL COMMUNITIES OF QIAN'AN CITY, CHINA

There are few studies on rainwater landscape of residential communities in China, and a lot of landscape measures have been widely used in parks. The Shanghai World Expo Houtan Park, Zhejiang Jinhua Yanweizhou Park, Haerbin Qunli Rain Flood Park etc, designed by Professor Yu Kongjian of Peking University, have all adopted technical measures of Sponge City. In my opinion, these measures are also applicable in existing urban residential communities. Applying Sponge City measures to the rainwater landscape design of the existing urban residential community, in accordance with climatic and hydrological conditions in different areas, and adapting to local conditions, will help to solve the flood problem, promote the recycling of rainwater resources, and improve landscape quality of the community.

3.1 Background analysis of existing residential communities in Qian'an City

Qian'an City is located in the north of China, the climate is warm temperate sub-humid continental monsoon climate with four distinct seasons, and the dominant wind direction in summer is southeast wind and in winter north-west wind. Rainfall is concentrated and most of the rainfall occurs from June to September, occupying more than 80% of the annual rainfall. Every summer there are heavy rains or continuous rains, which is easy to cause floods. According to the data of feasibility research, the average rainfall in Qian'an City is 672.4 mm, maximum annual rainfall 1070.9 mm (1959), and minimum rainfall 393.4 mm (1982). In the meantime, Qian'an City is also lack of water, due to groundwater overexploitation, resulting in the imbalance between supply and demand of water resources.

3.2 Rainwater landscape design method of existing residential community in Qian'an City

In the landscape design of rainwater in the existing residential community of Qian'an City, the key of solving the landscape environment and rainwater problem in the community is to change the traditional transformation mode of the existing urban residential community. Mainly based on the concept of Sponge City, use the control principle of “Infiltration, stagnation, storage, purification, use, drainage”, increase green facilities and reduce grey facilities. In accordance with the actual needs of residents, measures such as Permeable pavement, Sunken green space, Grassy ditch, Rain garden etc., are adopted to ensure the infiltration of rainwater and reduce the accumulation of water on the road. To carry out the construction of Sponge facilities and upgrading of landscape upgrading at the same time, and to provide a beautiful and convenient living environment for the residents, as well as promote the recycling of rainwater resources.

1). Using permeable pavement to ensure the infiltration of rainwater

Due to the large proportion of hard ground area in the existing residential community in Qian'an City, rainwater cannot infiltrate in time when rainstorm comes, resulting in accumulation of water on road surface and affecting people's travel. In the designing process of residential community, permeable paving is adopted to control rainwater from source to reduce the formation of rainwater runoff, and make rainwater naturally infiltrate, maximize the retention of rainwater and replenish groundwater resources in a timely manner.

2). Collect surplus rainwater by using sunken green space

The landscape effect of the original site of the existing residential community in Qian'an City is not good and the height difference is not handled properly, resulting in uneven land in the community. In the low-lying area of the residential community, a sunken green space is set up to collect excess rainwater on the road surface and reduce the non-point source pollution of rainwater. At the same time, enrich landform by filling and digging and increase

water space for residents and children. This helps to improve people's living conditions and strengthen communication between each other, and it also plays an important role in promoting the construction of ecological civilization.

3). Transmission of rainwater by planting grass ditch

It is quite common that there is less green area in the existing residential community in Qian'an City, and the overall environmental quality is not adequate enough, and cannot meet people's spiritual needs. Planting grass ditch in the community not only increases green space of the area but also can be used to collect and transport runoff rainwater, and then transport rainwater to green spaces and gardens to supply water for the landscape. Planting grass ditch can be well combined with other single facilities, urban rainwater drainage systems and over-standard rainwater runoff drainage systems. The combination plays a more important role in transporting rainwater, promoting the effective use of water resources and maintaining ecosystem balance.

4). Set up a rain garden to purify and store rainwater

There is not enough leisure space in the existing community to provide a good place for residents for entertainment and communication. Setting up rain gardens can help to enrich landscape types in the site, collect and purify rainwater. Using landscape treatment to combine these facilities with rainwater landscape measures and leisure seats can be designed at the edge of the rain garden to provide people with a place to rest, not only can control environmental pollution but also has the function of aesthetic recreation and the recycling of rainwater is realized.

4. SUSTAINABLE DESIGN STRATEGY OF RAINWATER LANDSCAPE IN EXISTING URBAN RESIDENTIAL COMMUNITIES

4.1 Guided by Sponge City theory

Sponge city is realized through low-impact development technology. Follow the basic principles of ecology, maintain the hydrological characteristics before and after land development and coordinate the relationship between nature and people. Sponge facility is an ecological infrastructure based on landscape and natural processes. Rainwater landscape design is carried on with the facilities of Permeable pavement, Roof garden, Rain garden, Planting grass ditch, Sunken green space, Artificial wetland, Ecological pond etc. Use "sponge" to create an ecological residential community with elasticity, natural accumulation, natural infiltration and natural purification, making the existing community with leisure function and full of vitality, and making the city a suitable place for people to live.

4.2 Use natural ecology method

The purpose of sustainable design is to restore the cycle process of natural system, achieving the purpose of protecting nature and conserving resources. In the landscape design of rainwater in the existing community, it is necessary to combine the present situation of the site environment and take ecological priority as the principle, make full use of the process of natural circulation system to collect, purify and reuse rainwater resources, and reduce the impact of human activities on the site, maintain the natural state of the landscape within the existing community and maintain the original benign water cycle. The sustainable ecological rainwater landscape design can not only reduce flood disaster in the existing community, but also adjust the microclimate of the whole city and alleviating urban heat island effect.

4.3 People-oriented and adapt to local conditions

The sustainable design of rainwater landscape in the existing urban residential community should be people-oriented, taking into consideration of people's needs for leisure activities, in accordance with the standard of people's habits and user-friendly, make the natural ecological restoration and cultural ecological reconstruction organic combination. The ancient Chinese gardening scientist Ji Cheng proposed in the Yuan Ye that "made by human beings, but like a masterpiece of nature". He proposed to respect the natural characteristics of the site and adapt measurements to local conditions. In the design of rainwater landscape in the existing community, various technical indicators shall be determined in accordance with the current situation of the site and by choosing appropriate sponge facilities. Environmental protection materials and clean energy shall be used to promote the recycling of waste, and to achieve the goal of low impact development with minimal cost.

4.4 Strengthen community management

For a long time, laying emphasis on construction while neglecting management has been an important reason for restricting the sustainable development of residential areas. In the design of the rainwater landscape in the existing urban residential community, we should draw lessons from foreign excellent theoretical and practical cases, strengthen social propaganda and education, let residents participate in community landscape design of rainwater and improve people's awareness of water saving. The government should improve relevant laws and regulations, adopt sewage discharge charge system and collection and reward system of rainwater, enhance residents' sense of responsibility and realize nationwide coordination of rainwater resource management. Only with this, can we achieve ecological sustainability of real urban rainwater resources.

5. CONCLUSION

The sustainable design of rainwater landscape in the existing urban residential community is a kind of ecological design strategy for the deterioration of the urban environment, which requires human activities to conform to the laws of the natural environment and people should live in harmony with nature. Through sustainable design methods and strategies such as technological facilities of Sponge City and natural ecological measures, rainwater landscape problems in the existing residential community of Qian'an City, China, have been well solved. And it has increased rainwater infiltration rate and reduced non-point source pollution caused by surface runoff. Improved the landscape quality of the community and integrated rainwater recycling of the existing urban residential community with the landscape and humanization. "Sustainable design" is undoubtedly an inevitable way and a fundamental strategy for human beings to achieve sustainable development. With the continuous progress of human society, people gradually realize the importance of protecting the environment. In the landscape design of rainwater, the strategies of "sponge" elastic design, ecological design and humanized design should be comprehensively applied to solve urban rainwater problem effectively and maintain the balance of ecosystem. Create a beautiful living environment for people to achieve "return to nature" and wish of coordinated development of natural environment, and achieve the sustainable development of the urban environment as a whole.

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