

Research on Rainwater System Optimization Design Based on LID Concept -- A Case Study of Sponge Landscape Design in Qian'an, China

Junfeng Cai*

Tianjin University of Technology, Tianjin, China

*Corresponding author e-mail: 851650025@qq.com

Abstract. The rapid development of urbanization in China brings convenience to people's lives, but it also faces the risk of water crisis. The effective resources such as rain, which is large in quantity and easy to obtain, are wasted due to poor management and become cities. The potential safety threats, out of consideration of the above issues, China proposed the concept of building a "sponge city", promoted the exploration and practice of solving storm water problems in cities and building low-impact rainwater systems in various fields, and also constituted an opportunity and basis for this study. . This article is based on low-impact development concepts and practices as the basis for research, focusing on its system construction methods and specific facilities in China's "sponge city" construction. Therefore, the design principles, design methods, and post-assessment methods of rainwater landscape based on low-impact development were proposed, and the design contents, methods, advantages, and disadvantages of the sponge landscape design case in Qian'an City in China were studied and studied.

1. Introduction

While the rapid development of Chinese cities has brought convenience, it has also created new problems for the living environment of human beings. With the expansion and concentration of urban expansion, replacing vegetation and soil, changing the environmental structure not only aggravates the urban heat island effect, but also prevents the infiltration of surface runoff, cuts off the natural hydrological cycle, and increases the pressure of the rainwater pipe network. At present, rainwater resources have not been fully utilized in China. Instead, it has become a hidden threat to the safety of people's lives and property during the rainstorm, which has caused the paralysis of urban public facilities and normal order. Based on the above issues, the Chinese government proposed a "sponge city" vision in 2014 and issued a "Technical Guide for the Construction of Sponge Cities." The central idea is to use the urban green space to build a low-impact rainwater system and distribute rainwater from the source. Pressuring control of water pollution, restoration of natural hydrological cycles, and transformative of disasters into sustainable resources [1]. This is not only a reflection on various water problems caused by urbanization, but also a top-down emphasis on rainwater management, which has greatly promoted the exploration and practice of rainwater flooding in cities and the construction of low-impact rainwater systems.

Low-impact development is the construction method and method of "sponge cities". Low impact development of rainwater systems is an important part of "sponge cities", while "sponge cities" are low-



impact developments that are more integrated, comprehensive, and systematic. The goal of building Sponge City, regardless of the level or means of construction, should coordinate with all aspects of urban construction and various departments to coordinate and deploy. It is a highly comprehensive system construction project. The final decomposition to the grassroots level is the design and comparison of various low-impact development technologies and facilities.

2. Basic situation of the project location

2.1. Design Background

Qian'an is a water-short city. The performance of water resources is extremely uneven, and groundwater is over-exploited. From the perspective of supply, the city's average annual available water resources amounted to 291 million cubic meters, but the average per capita was only 390 cubic meters, far below the national average of 2,200 cubic meters per capita in China. [2], Only 17.7%. From the demand point of view, in 2013, the city's total water intake was approximately 213 million cubic meters and was on the rise. The groundwater development intensity reached 76%-90%, accounting for more than 85% of the total water supply. The amount of groundwater mining was higher than its available amount. In over-production. [3] The contradiction between the shortage of water resources and the rampant urban environment has become increasingly prominent, and it has become a major cause of the restrictions on urban development. It is one of the important breakthroughs to adequately regulate and utilize rain and flood.



Figure 1. City status before the transformation

2.2. Design Plan

In the specific design process, we emphasize the integration of landscape construction and the construction of low-impact rainwater systems, and integrate the different design requirements of sunny and rainwater, and therefore pay more attention to the joint design of low-impact development facilities and sites and activities, in the plan of plan design. In the design of the project, important landscape spots include storm rain gardens, galleries and other series of venues, series of venues such as the Childhood Island, wild grasslands, flower marshes, flower fields, material gardens, series of venues, water curtain caves, plant gardens and other series of venues, water The low-impact development facilities used in the plaza etc. include permeable paving, green roofs, sunken green spaces, grass-planting ditch, bio-detention facilities, gravel vegetation beds, and wet ponds. Attractions and facilities are scattered in the park and integrated into the environment. The roads are connected in series to combine the change of topography and landforms and vegetation to achieve a good landscape effect. This will make the whole park more interesting and make visitors more entertained. Recognize the low-impact development and

the work process and effectiveness of the Sponge City, and achieve the purpose of demonstrating science popularization.

3. Low impact development rainwater system design

In the design of specific projects, the emphasis was placed on integrating the construction of landscapes with the construction of low-impact rainwater systems, and integrating the different design requirements of fine weather and rainwater, and therefore paying more attention to the joint design of low-impact development facilities and sites and activities. In the design of the project, important landscape spots include storm rain gardens, galleries and other series of venues, series of venues such as the Childhood Island, wild grasslands, flower marshes, flower fields, material gardens, series of venues, water curtain caves, plant gardens and other series of venues, water The low-impact development facilities used in the plaza etc. include permeable paving, green roofs, sunken green spaces, grass-planting ditch, bio-detention facilities, gravel vegetation beds, and wet ponds. These attractions and facilities are scattered among the parks and integrated into the environment. They are connected in series through roads, combined with the changes of topography and landscapes and vegetation to achieve a landscape effect that makes the whole park more interesting and better. Recognize the low-impact development and the working process and effectiveness of the Sponge City in an entertainment tour.

3.1. Rainwater Control Range and Runoff

According to the requirements for the construction of sponge city, in addition to absorbing the rainwater on its own and on both sides of municipal roads, the project should be combined with the rainwater drainage zoning of the surrounding urban areas. Considering that the rainwater in the neighboring residential areas and educational and scientific research areas will be connected to the project area to achieve stagnation. According to the area statistics of rainwater drainage zoning divided according to vertical conditions, the storm water runoff control scope to be solved at the site includes the site itself and the surrounding catchment area, a total of 216.01 hectares.

According to calculations, when the rainfall is 42.6 mm (once-once-yearly), the site's total internal and external flow volume to be solved is 21167.5 cubic meters. The annual total runoff control rate is 85%. When the corresponding rainfall is 29.3mm, the site's internal and external flow volume is 14558.87 cubic meters to achieve zero outflow. At the same time, the design should consider the problem of excessive rainwater discharge and promptly exclude rainwater from the site that exceeds the design rainfall. That is, when the designed rainfall is 42.6mm, the emptying must be ensured within 24 hours and no flooding disaster should be formed.

3.2. Construction of Low Impact Development Rainwater System

Specifically, the low-impact development of rainwater system covers the three stages of source reduction, midway transmission, and end storage. The use of facilities is based on the principles of "efficiency, aesthetics, and interactive display."

The source reduction mainly relies on permeable paving, green roofs, initial waste flow devices and sunken green spaces. Since the beginning of rainfall, infiltration, diversion and abandonment have been carried out, reducing rainwater entering the middle of the site. Pervious paving covers first-grade roads, second-grade roads and some general sites, accounting for 70% of the hard paving area; all building roofs are remodeled and designed as green roofs, and the roofs are available for the roofs and gardens with sufficient loads and larger areas; The initial waste flow device is arranged on 4 entrance squares, which screens and discards the rainwater that cannot reach the standard of the reservoir, ensuring the cleanliness of the impounded water; the sinking green space is set at the end of the intercepting ditch or low-lying At the rainwater collection point, the depth of sinking is 3 meters, which mainly plays the role of infiltration and regulation.

The transmission in the middle mainly relies on vegetation buffer zone, grass-planting ditch, biological retention pool and gravel vegetation bed, and plays a role in transmission, retention and purification. Vegetation buffer zone includes all vegetation coverage areas with a slope of 2%-6% and

a width of more than 2 meters. Some of the planting grass trenches are reconstructed from the current intercepting ditch, and some of them are laid along the road, and they are rainwater from high-altitude green areas and roads and sites. The interception and organization of transfusions are carried out so that the next step can be collected and the subsidence can be designed to a depth of 3 meters. The bio-residual pool is mainly composed of gabion retaining wall, wetted plants and osmotic soil. At the same time, due to the strong landscape, so much more. In combination with the layout of the event venue, the parallel section of the human and vehicle also appeared as a separation zone, with a sinking depth of 3 meters, and the depth of the biological retention pool in the middle of the parallel road between people and vehicles was 3 meters; the gravel vegetation bed utilized the pebbles and wetness on the site. Plants and microorganisms play a role in purification, both wet and dry, with a design depth of 0.2-0.5 meters.

At the end of the adjustment, it mainly relies on wet ponds, reservoirs, and rainwater tanks to regulate the amount of water and reserve reserves. The wet ponds are mainly used for purification and temporary storage of rainwater, and need to be impervious. The design depth includes 0.45 m permanent volume and 0.45 m regulation volume; there are a total of four reservoirs distributed on the northwest side and the southeast side. The entrance is a closed underground facility; there are 6 rainwater tanks, and the main basis for the deployment is the location of the municipal storm water pipe network access site and the location of the buildings nearby use. It is also a closed underground facility.

3.3. Related Calculations

Judging whether the design can reach the target of rainwater control, mainly refer to the three values: seepage of rainwater, storage capacity of the facility, and unresolved surface runoff.

3.3.1 Underwater seepage. Underwater seepage depends mainly on the permeability of low-impact development facilities such as permeable paving, sunken green spaces, grass-planting trenches, bio retention ponds and gravel vegetation beds. Permeability depends on infiltration. Factor, surface area, etc. According to the relevant regulations, the permeability coefficient of surface permeable pavement should not be less than 1×10^{-4} m/s. According to the experimental research in the relevant papers, it is determined that such permeable pavement can be cut at most when the rainfall exceeds 25mm. 23.7% of the runoff.[4] The infiltration of other low-impact development facilities based on green space can be calculated by the following formula:

$$S = \frac{K(d_f+h)A_fT}{d_f} \quad (1)$$

Among them, K is the permeability coefficient, m/s; d_f is the total depth of the facility, generally includes the planting soil layer and the filler layer, m; h is the average depth of the aquifer design, generally 1/2 of the maximum depth, A_f is the facility The area, m^2 ; T, is the calculation time, min, which is usually calculated as a rain 120 min.

From this, we can calculate the rainwater seepage of the low-impact development facilities with water permeability in the design, as shown in the table below. In these facilities, the total amount of 927.11 cubic meters of rainwater seepage within 2 hours after rainfall.

3.3.2 Facility water storage capacity. According to the engineering practices of various low-impact development facilities in the design, the maximum amount of water that can be stored in low-impact development facilities with storage capacity can be calculated as shown in the table below.

Table 1. Table of storm water infiltration.

Facilities (new)	Area(m ²)	Permeability coefficient(m/s)	Total depth(m)	Designed average water depth(m)	Infiltration(m ³)
Permeable pavement	20328.70	1×10 ⁻⁴	-	-	378.14
Sunken green space	9757.00	2×10 ⁻⁴	0.60	0.15	292.71
Plant grass ditch	6788.00	6×10 ⁻⁴	0.60	0.15	61.09
Bio retention pool	5053.00	2×10 ⁻⁴	0.80	0.15	144.01
Gravel vegetation bed	1911.00	2×10 ⁻⁴	1.30	0.15	51.16
total					927.11

Table 2. Table of storm water storage in LID facilities.

facility	Area(m ²)	Average maximum depth(m)	Water storage capacity(m ³)
Sunken green space	9757.00	0.30	2927.10
Plant grass ditch	6788.00	0.30	1018.20
Bioretention pool	5053.00	0.30	1515.90
Gravel vegetation bed	1911.00	0.30	573.30
Wet pond (regulation volume)	3306.00	0.45	1983.60
Total surface storage facilities	26815.00		8018.10
Reservoir	-	-	6292.00
Rainwater tank	-	-	1500.00
Total underground storage facilities			7792.00
total			15810.10

The statistical water storage capacity of the facility includes two parts: surface facilities and underground facilities. The total water demand of these low-impact development facilities on the above-ground parts totals about 8,018.10 cubic meters. When the local area is partially full, rainwater will overflow and be collected through pipelines or grass-groove ditches. In the underground reservoir and rainwater tank, the underground facility requires 7792.00 cubic meters of water. All these facilities have a total of 15,810.10 cubic meters of rainwater storage.

3.3.3 Facilities water storage capacity.

Table 3. Rate of controlling surface runoff at 29.3mm.

Rainfall =29.3mm	volume(m ³)	Runoff control rate
Underwater seepage	927.11	6.37%
Surface water storage	8018.10	55.07%
Underground water storage	5613.68	38.56%
Surface runoff	0.00	0.00%
Total runoff	14558.87	100.00%

Table 4. Rate of controlling surface runoff at 42.6mm.

Rainfall =42.6mm	volume(m ³)	Runoff control rate
Underwater seepage	927.11	4.38%
Surface water storage	8018.10	37.88%
Underground water storage	7792.00	36.81%
Surface runoff	4430.29	20.93%
Total runoff	21167.50	79.07%

According to the calculation results, when the rainfall is 29.3 mm, the design can achieve zero outflow of rainwater, reaching a total control rate of 85% of annual runoff. When the designed annual rainfall is 42.6 mm, the design requires a runoff control rate of 79.07% for the site and can be discharged within 24 hours without flooding.

This provides reference and support for the realization of the annual runoff total control rate target in the surrounding areas, and effectively plays an important role in rainwater management.

4. Conclusion

The design of the low-impact development and demonstration park in Qian'an City was based on the analysis of the natural conditions of the site. The research on the concept and technology of the low-impact development of the Sponge City has basically reached the previously established urban park recreation function and the ecological function of the riverside greenery. And storm water management functions. In the design, the low-impact rainwater system was developed to solve the storm water runoff on the site and surrounding areas. Through the special design of roads, terrain, water bodies, and plant landscapes, the rainwater system and landscape effects and ecological benefits were taken into account, and the specific node design was adopted. Low-impact development facilities are integrated into the process of excursions and leisure activities to achieve the purpose of an interesting science show. We will strive to realize the construction of an ecological rain-collecting belt-like park that will be built on the basis of the construction of a public recreational greenery and low-impact rainwater system development.

However, there were some confusions and regrets in the design process. For example, how to coordinate the technical aspects of rainwater harvesting management and the artistic nature of landscape design, and whether the local site has a larger depth or a larger area to meet the target of rainwater control, although the safety requirements are met and balanced by planting, the landscape perception is estimated. These issues need to be further explored in the next study.

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