Landscape applications of rainwater resources in urban green space: A case study of green space reconstruction along Riverside Street in Suzhou

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Abstract. The environmental problems exposed by the process of urbanization have become increasingly serious. At present, China has realized that rainwater is an important and valuable resource. Many cities have successively carried out the mode of rainwater resource utilization. This paper attempts to explore the design of rainwater management into landscape design, transforming from a single engineering technology level to a sustainable ecological level. From the source control, route transmission, terminal storage and storage, the three systems summarize the design of rainwater resources landscape application. Taking urban green space as the research object, and taking the reconstruction of the riverside green space in Suzhou as an example, the advantages and existing problems are analyzed. The feasibility of rainwater management is qualitatively analyzed and the rainwater runoff is quantitatively analyzed. The two measures of surface improvement and rainwater storage are used to explain how to integrate these design methods into specific cases, aiming for the future. Rainwater management in urban green space provides successful experience of others to go by.

1. Introduction

Rainwater is an important source of surface water and groundwater. In the 1970s and 1980s, in order to speed up the process of urbanization, China has developed a fast-food design for large-scale demolition and construction, with rainwater fast as the design requirement for early drainage systems. In recent years, the urban environmental problems exposed by such drainage systems have become increasingly serious. The phenomenon of shackles in major cities such as Wuhan and Fuzhou is serious. “The city is watching the sea” has appeared one after another. Excluding the influencing factors of abnormal weather in recent years, which reflects the changes in urban geographical conditions caused by urban construction and the construction of drainage systems in urban development. This problem has not only appeared in China, but can be said to be a problem arising from the process of urbanization in the world. Since the 1970s, many countries have begun to realize this problem. Many developed countries have begun to explore the ecological management and resource utilization of rainwater. They have proposed new design tools such as Best Management Practices, Low Impact Development. As the best carrier of rainwater runoff management in a city, urban green space has the potential of ecological benefits. When exploring the ecological management and resource utilization of rainwater in the world, a large number of local practices have been carried out on the basis of urban green space. Through the combined applications of various engineering
decentralized technical facilities, the role of stormwater runoff management is achieved. The landscape applications of rainwater resources should not only use the corresponding combination, but also the use of art and aesthetic concepts in the combination to achieve an artistic landscape effect that is integrated with all landscapes. It is a higher level of design and application. It is of far-reaching significance to build a green ecologically sustainable city and improve the status of urban stormwater management.

2. The impact of urbanization on urban water resources
From the beginning of the rain, nature's water cycle begins. For nature, runoff has three forms. One is surface runoff, which is used for absorption and filtration of plants. The second is soil infiltration and replenishment of groundwater resources. The third is inflow into the river. In order to maintain rainfall - runoff - the process of evaporation is endless, the three are in a stable and stable way. At the beginning of urbanization, there was no selective demolition of green space and a large amount of hard ground was built. Now the rainwater flows through the impervious road to the drainage pipe network and becomes a new type of runoff, breaking the balance mode. The impervious surface of the city has become the main area for the convergence, transit and distribution of urban stormwater runoff, and it is also an important source of rainwater pollution [1]. Results in Table 1 imply that comparison of traditional management and utilization of rainwater resources. Rainfall in most cities in China is uneven in time, with rainy season and dry season. In the rainy season, not only the runoff stroke greatly shortens the speed of water circulation, but also causes pressure on the water supply and drainage network. Moreover, the road surface pollutants washed under the rainwater also directly enter the pipe network, which increases the management difficulty in the later stage. In the dry season, the available rainwater is wasted, resulting in insufficient water base flow. In some northern areas, the water source can be shut down for several months. The ecological balance is destroyed. This will not only affect the water environment, but also closely related to water resources, including us, will be at risk of water ecosystems.

| Table 1. Comparison of traditional management and utilization of rainwater resources. |
|-----------------------------------------------|
| Traditional rainwater management concept | Rain water resources utilization concept |
| Drainage pipe network system | Ecosystem |
| Drainage pipe, no natural process | Simulating natural processes |
| Negative handling of problems | Actively respond to problems |
| Focus only on rapid discharge | Overall consideration |

3. Overview of landscape applications of rainwater resources in urban green space
3.1. Research objectives and significance of landscape applications of rainwater resources in urban green space
According to American Landscape Architecture Scholar Lewis P, the landscape construction 4E was proposed in 1969, namely education, ecological, esthetic, environmental. According to this principle, the urban green space rainwater resource design is designed. The natural power is used to make a new dynamic balance through artificial simulation, so that the land can be cleaned and stored. Through the design of the landscape, combined with low impact, ecological and artistic, all stages of rainwater management are taken as part of the urban landscape [2]. At the same time, join the non-engineering measures of science education, so that people can participate in the whole process. The purpose of this paper is to combine the requirements of rainwater management with the guidance of low impact development. This can infiltrate the content of propaganda and ideological education into entertainment activities. It can effectively use rainwater resources and maintain the stability of urban water ecology. It can also increase the water landscape in the city and satisfy people's mentality of
getting close to the water. Through the combination of theoretical and empirical research, the design method of rainwater resources landscape application is verified by taking the actual site as an example, which provides reference for future rainwater utilization in urban green space.

3.2. Design method of landscape applications of rainwater resources in urban green space

3.2.1. Source control system. The traditional rainwater management method is taken from the end treatment and flows into the underground pipe network or rivers. The former provides pressure to the drainage system. The latter directly pollutes the urban water environment without treatment. The use of rainwater resources should completely change this state. In order to completely change this state, we need to start from the source and do resource and landscape treatment in urban green space. The rainwater will be infiltrated as much as possible to replenish groundwater. Or it can evacuate pollutants, get purified and filtered and flow into urban rivers, and then successfully protect the water quality of water resources.

3.2.2. Route transmission system. In the receiving conduction phase, the first step is to undertake and conduct excess rainwater from the source stage [3]. It reduces the flow rate of rainwater runoff and reduces runoff peak flow. Therefore, it is further prevented that the internal helium phenomenon is formed due to excessive pressure of the drainage system. The second step is to perform effective filtering. Use the graininess of the gravel or a certain size of holes to block larger solid contaminants. The small-molecule pollutants are filtered by the adsorption capacity of plants to achieve the purpose of collecting and utilizing stormwater runoff and controlling runoff pollution. And the plants are well matched and can form a good landscape effect. The third step is to use aeration technology if conditions permit. On the one hand, this technology can inhibit the eutrophication of water bodies. On the other hand, it combines with leisure and entertainment to increase people's participation.

3.2.3. Terminal storage system. The terminal regulates the storage of the rainwater that has been initially filtered, and is mainly used for purifying, regulating, storing the rainwater. During the dry season, the first two stages of rainwater are stored. Not only does it not short-circuit the water cycle, it also has water for irrigation in the green space and landscape. In the rainy season, the rainwater is stored to give it extra space, thus avoiding the phenomenon of urban shackles.

4. Greenland reconstruction near the riverside street in Suzhou

4.1. Site climate characteristics and location

Suzhou is located in the temperate zone and belongs to the subtropical monsoon and monsoon humid climate. It has four distinct seasons and abundant rainfall, with an average annual precipitation of 1099.6 mm. However, the rain is mostly concentrated in spring and summer, and the time and space are unevenly distributed. In addition, Suzhou itself has many inland rivers, which are prone to extreme floods. [4] The site is located in Suzhou Industrial Park. It is a relatively independent green space. Its northeast is the main road of the city. Songjiang Road is in the north and Xingtang Street is in the east.

To the east is the Auchan Commercial Center, to the south is the parking lot for urban road maintenance vehicles, and to the west is the urban river. Therefore, the location of the site is a green space next to the riverside street. If the polluted rainwater is discharged into the urban river channel without treatment, it will cause a series of derivative urban problems such as water pollution, which is a special existence in the urban green space. The overall terrain of the site is higher in the north, east and south, with lower depressions in the middle and west, with an area of about 3 hectares.
4.2. Advantage analysis

4.2.1. Water resources aspects. The site is located beside the urban river channel. There is already a small river in the interior, which is connected with the urban river channel. It does not need to waste manpower and resources to do the digging and diversion treatment, and it takes the lead in the project. At the same time, urban rivers as natural water sources, whether it is rainy season rainwater storage or dry season irrigation, have relatively good advantages.

4.2.2. Topographic aspects. Due to the water system inside the site, the rainwater can basically be discharged into the river through natural forces by means of the ups and downs of the terrain. There is no need to make major adjustments to the terrain. Moreover, there is a gentle slope micro-topography where plants are densely planted. As long as the plants are slightly configured, a good landscape effect can be created.

4.3. Problems analysis

4.3.1. Rainwater treatment aspects. The surface runoff formed by urban roads on both sides of the site is mainly excluded through the urban pipe network, and excess rainwater is discharged into the site. Studies have shown that urban road rainfall runoff is about 25%, but it produces 40%-80% of pollutants, mainly due to frequent traffic activities [5]. Some of the surface runoff formed by the southern parking lot is discharged into the site, and some of it is directly discharged into the urban channel of the west side. The hard paving in the site is mostly impervious to water paving, which is easy to form surface runoff. In the flood season when the amount of rain is heavy, water is often collected on the impervious surface. Or it is discharged into urban rivers. The former caused inconvenience to passers-by, and the latter caused water pollution in the river. The rainwater in the site is directly discharged through the pipe network, maintaining the traditional fast-discharging mode. The green space in the site was not used for rainwater management. It caused it to lose its water storage capacity and the ecological benefits were not developed. Moreover, the rainwater runoff is directly discharged into the rainwater pipeline to increase the pipeline pressure. Therefore, the main catchment area of the whole site includes four areas of buildings, hard squares, roads, green spaces and urban rivers. According to the calculation statistics, the construction area is about 325 square meters, the hard square area is about 6553 square meters, the road area is about 2862 square meters, and the green area is about 17818 square meters. Through inquiring the rainfall in flood season and non-flood season in Suzhou city, quantitative analysis and calculation of rainwater runoff are carried out according to relevant engineering technical specifications. Results found that the ratio of the impervious surface runoff to the total runoff is nearly 70% in both the flood season and the non-flood period. The permeable surface has a large proportion of runoff. Results in Table 2 imply that non-permeable water surface runoff ratio.

4.3.2. Other aspects. Through interviews and investigations, it is known that although the surrounding areas are scattered throughout the residential areas, shopping centers and other places with high traffic, the utilization rate is low. The reason is that the planning of the waterfront area is unbalanced and improperly managed. The waterside plants are single and the habitat is poor. Its surface debris floats. The water quality is poor and it also gives off a pungent smell. Only the nearby residents will stay in the square, but there is a lack of infrastructure that can appeal to people. When people stay, they have a single form of activity and stay for a short time.
Table 2. Table of non-permeable water surface runoff ratio*.

| Type of water surface | Flood season runoff (m³ s⁻¹) | Proportion of impervious surface runoff in flood season (%) | Non-flooding runoff (m³ s⁻¹) | Proportion of impervious surface runoff in non-flooding season (%) |
|-----------------------|-----------------------------|----------------------------------------------------------|-----------------------------|----------------------------------------------------------|
| Building              | 179.0                       |                                                          | 116.4                       |                                                          |
| Hard square           | 2122.5                      | 68.9%                                                    | 1380.7                      |                                                          |
| Road                  | 1535.0                      |                                                          | 998.5                       | 68.9%                                                    |
| Green space           | 1731.4                      |                                                          | 1126.3                      |                                                          |

*Formula for calculating total rainwater runoff: W = hψF.

h - rainfall (the unit is mm.)
ψ - runoff coefficient (the basis of calculation is GB50400—2006[s].)
F - catchment area (the unit is ha.)

4.4. Design goals

We must consider how to achieve the balance of rainwater runoff emissions before and after site development through effective management of the surrounding catchment area and its own rainwater. It is envisaged that the surface runoff on the roads around the site and the parking lot will be introduced into the site, and the rainwater will be utilized in a step-by-step manner. Through the transformation of micro-topography and plants, the rainwater retention capacity of the original green space will be improved. And the buffering capacity and dissipation capacity of the urban green sponge will be fully utilized. Before the rainwater is officially discharged into the urban river, the water quality is improved by the rainwater purification device in the site. The purified rainwater can be used as green landscape water or parking lot vehicle cleaning to realize rainwater resource reuse. The people-oriented concept runs through the entire design to meet the spiritual needs of the crowd. It is worth paying attention to the landscape applications of each process to create a multi-functional place.

4.5. Specific design

4.5.1. Surface improvement measures. Starting from the source control, the surface improvement measures will be taken first when the rain falls. Increase the time of rainwater collection by reducing the flow of the peak of the rainfall. Before the rain enters the site, the sidewalks on both sides of the site are provided with a 30-60mm gap at the broken curb. The purpose of this is to prevent deformation of the road surface and prevent large debris such as leaves, stones, and garbage from entering. Rainwater enters the permeable infiltration tank from the gap, and the elevation of the gap is slightly lower than the curb. Rainwater flows through the permeable infiltration tank and is fully infiltrated, and excess rainwater flows into the site. The permeable pavement has a certain functional diversification. Exercising the same functions as squares and roads when there is no rain, it meets the needs of flexible design. Figure 1 shows the application profile of the permeable infiltration tank. There is a building gallery inside the site to carry out the treatment under the armpit. That is, an permeable belt is arranged below the edge of the truss to introduce the rainwater of the roof into a specific path, and the filling requirement for the interior is not high. Due to the isolation of the underlying surface of the inner plaza, most of the rainwater cannot be infiltrated to form runoff, increasing runoff flow. The permeable pavement is mainly used for the reasonable use of various permeable materials to minimize the area of impervious paving. This can slow down the surface runoff flow rate, allowing the rainwater to have enough time to stay and penetrate, thus increasing the chance of rainwater retention and infiltration. Before entering the urban river, the dry creek is set according to the shape of the natural stream, showing a natural linear layout. The use of pebbles, vegetation, etc. constitutes a rainwater landscape facility. Planting ditch refers to the plant covering the surface ditch,
and the rainwater is infiltrated by gravity. When the rainwater flows through the shallow ditch, the effect of removing pollutants in the runoff is achieved by the combined action of sedimentation, filtration, infiltration, absorption and biodegradation [6].

4.5.2. Rainwater storage measures. The rainwater storage measures are mainly through a series of ecological pools with different functions, which have undergone two key steps of filtration and purification. It will achieve the ultimate runoff storage in order to achieve the goal of improving water quality. According to the terrain elevation, a concave green space is set at the low ground of the green space, which collects, infiltrates and initially filters the rainwater on the impervious ground such as roads and squares. By planting moisture-tolerant plants in low-lying areas of the green space, it can also be combined with rain gardens, rainwater retention ponds, etc. for artistic design. This will enhance its enjoyment and practicality. Rainwater gardens are used to collect rainwater runoff from nearby hard pavements and building houses, mimicking natural infiltration systems to retain rainwater. Under the combined action of gravel, plants and water microorganisms, the solid suspended matter in rainwater is effectively removed [7]. At the same time add aeration technology. It can effectively filter a small amount of organic pollutants such as metal ions, and can form a fountain with a landscape. And people can also participate in it and visually see the process of rainwater treatment. The role of popular science education is reflected here. Figure 2 shows the Application profile of rain garden. The rainwater retention pond uses the sinking space to connect the urban river. It has a large footprint in the site and becomes a permanent landscape water body for treating the site's rain. The ecological revetment is used as a rainwater buffer zone to connect aquatic and wet plants around the rainwater detention pond. It can exert the biological adsorption of plants and naturally increase oxygen. At the same time combined with the surrounding green space. It forms a waterfront landscape when there is no rainfall, and it plays its landscape leisure function.

5. Summary
Urban green space is an important carrier for rainwater resources utilization and has great management potential. However, in view of the current situation of urban development in China, green space cannot completely replace the rainwater management function of urban drainage system. It is the auxiliary role. Therefore, the rainwater management objectives of green space need to consider the practical feasibility. At the same time, it needs to be set according to the water resources of different regions and sites. There are many types of urban green space. Although this study has a certain
personality, the design principles and basic strategies for rainwater are common. Urban green space should understand "use water and benefit water." Designers should consider the layout and structure. The aim is to minimize interference and maximize resource utilization, to protect and restore the natural landscape characteristics of the site, and to promote hydrological regeneration. First of all, for the square and open space, under the premise of the function of collecting and distributing, we consider how to deal with the surface runoff while adding more attractive scenery, such as the use of aeration technology to form a fountain. Secondly, we make good use of the ecological benefits of green space, wetlands and ponds. These natural resources give full play to their positive role in regulating and purifying rainwater runoff, so as to better guide the development direction of urban green space and make urban rainwater play its natural rainwater management function as much as possible. Finally, micro-topography such as low open space is used to combine various non-structural engineering methods. Joining the trails to create a woodland effect makes it easier to combine with the landscape to make "city = park". Starting from the most fundamental aspect of nature, the ecological design method is used as a medium to create a living environment where people and nature coexist. Due to the universality of urban green space and the urgency of rainwater resources utilization, the study applies landscape applications of rainwater resources in the urban green space to create a water and green ecological environment is of great significance for improving urban water environment and green space resources.

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