Rainwater Recycling in the Design and Construction of Urban Landscape Engineering

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Abstract: As the population of China continues to grow, the number of fresh water resources is steadily declining while human consumption continuously increases. Therefore per capita ownership of water resources in China is significantly lower than world average levels. It is an irrepressible selection to strengthen the effective use of water resources in accordance with scientific rules. This paper elaborates on several specific measures which can be adopted in the design and construction of urban landscape engineering to realize rainwater recycling for providing useful reference to the relevant personnel.

1. Introduction

With urbanization water scarcity has become one of the major problems. Rainwater has emerged as an essential renewable resource and the most important solution to combat urban water crisis. The effectiveness of rainwater recycling directly determines the level of sponge city construction in urban landscape engineering design and construction. Modern landscape engineering rationally utilizes water resources through construction facilities such as rain gardens and water storage tank technologies that offer stability in the supply of water necessary for gardens.

2. The Importance of Rainwater Recycling in the Design and Construction of Urban Landscape Engineering

Water recycling in the design and construction of urban landscape engineering is one of ways, water recycling, which can promote sustainable development of cities, reduce ecological environmental degradation. In particular, the significance in regard to the following:

2.1 Water Resource Utilization

However, when urbanization occurs, there is an increase in the demand of water while being decreased naturally as well [1]. Rainwater recycling is also used as a renewable resource, in order to be an effective supply alternative for the shortage of urban water resources. Urban water use includes a large proportion of landscape irrigation. Municipal water supplies should be curbed through the installation of rain gardens and other means to hold rainfall, which is then purified through scientific methods for vegetation watering. Data from surveys show that a mature rainwater recycling system can supply more than 50% of the irrigation water demand in gardens, which will greatly relieve the pressure on urban water supply.

2.2 Ecological and Environmental Protection

Rainwater in traditional drainage modes can lead to water pollution and serious urban flooding problems. Rainwater Recycling: Facilities including sunken green spaces and grass swales are made for the reduction of surface runoff and frequency of urban waterlogging [2]. On the other hand, while recycling rainwater, purification by plants and soil not only can alleviate the pollution problem in urban water,but also greatly enhance the urban ecological environment. One such technique, for instance rain gardens, can reduce more than 90% of suspended solids from the rainfall, and purify nutrients like nitrogen and phosphorus as well.

2.3 Economic and Social Value

The use of rainwater for recycling reduces the costs of urban landscape engineering operations and maintenance. Besides, it also improves urban residents' environmental awareness and extends the vision of sponge city construction.

2.4 Coping with Climate Change

Rainwater Recycling is a strategy that makes use of urban rainwater in an optimal way, taking into account ecological protection and water saving, and fundamentally improving the resilience of cities.

3. Pathways for Achieving Rainwater Recycling in Urban Landscape Engineering Design

3.1 Plant Configuration Design

Plant configuration is a core element in the rainwater recycling system of urban landscape engineering, serving as an important link between ecological functions and landscape effects. The reasonable configuration of plants in gardens can not only purify rainwater, but also improve the infiltration capacity of rainwater, and maintain the ecological stability of gardens [3]. In the process of plantation, principle of ecological adaptability should be followed, and native plants with good purification ability and waterlogging/drought resistance should be considered first. They are adapted to existing soil and climatic conditions so the investments that lead to lower long-term maintenance costs in rainwater recycling and other settings come with a level of performance stability. E.g.e.g. Aquatic plants (reeds) and their developed root systems can be chosen for core areas like grass swales, as they adsorb pollutants in rain water and intercept suspended solids. Under the condition of installing permeable pavements, we can also apply water-absorbing plants such as Zoysia japonica in the green space to absorb excess rainwater during rainy seasons and maintain ideal landscape effects during drought periods without losing a large amount of moisture causing plant death. For the multi-layered community structure, it is possible to utilize an orderly arrangement of plant combinations in order to create a three-dimensional rainwater treatment system. A plant combination mode of trees + shrubs + herbs can be applied vertically. Trees are frequent in the upper layer, which would slow the speed of rainWater falling and cut down Surface erosion [4], we can choose Deciduous trees like Sophora japonica. Middle layer: Moisture-resistant shrubs, such as Hibiscus syriacus, can be selected to intercept rainwater and filter excess impurities. (Lower Layer) Across the ground layer, fill in any surface holes with ground cover vegetation which helps improve soil permeability. Most importantly, horizontal gradient configuration shall be carried out according to the actual rainwater flow direction, and waterlogging-resistant plants should be planted in areas where rainwater gathers. In short, in the design of plant configuration, the plants should be scientifically selected and the structures reasonably combined so that the ecological functions are fully integrated into rainwater recycling system as much as possible, not only improving the treatment effect of rainwater but also improving plenty richness connotation of garden landscape.

3.2 Technology Integration Design

Technology integration design can lead to traditional modes transformation in urban landscape engineering rainwater recycling and thus facilitate system intelligence. Through in-depth integration of modern information technology, automation control technology and renewable energy technology, accurate rainwater recycling can be achieved, actively allocating rainwater while improving the function and ecology of garden landscape. The accurate management of the rainwater system is grounded on intelligent monitoring technology. It is designed to scientifically deploy water quality monitoring sensors and rainfall sensors in various solving process branches to construct a real-time data collection network. Rainfall sensors can also be installed on the high points of the garden to dynamically collect data on rainfall, precipitation intensity parameters, and reference for rainwater collection strategy optimization and dynamic adjustment processes. With the use of Liquid level sensors, we are able to place these in rainwater storage tanks that will monitor real-time (level) changes of water in order not to have empty or overflowing tanks. Sensors which can measure water quality in terms of suspended solids, these can be installed at the inlet and outlet of water purification facilities to monitor if the recycled rainwater satisfies irrigation requirements. The use of automation technology is conducive to improve the efficiency of rainwater recycling [5]. In the design, you can build an Intelligent Monitoring System which associates sensor information and with executive equipment. When the level of precipitation reaches a specified range, the system automatically opens diversion valves to discharge rainwater into purification factories. Research can be conducted on weather-based predictive control as well. One possible use is to reduce the amount of water contained in storage tanks (when needed) by benchmarking water forecasts up to 24 hours into the future so as to create enough space for anticipated precipitation and thus avoid flooding. Moreover, the suitable implementation of renewable energy technology back up rainwater system [6]. In particular, garden landscapes can be decorated with the installation of lighting frames; solar photovoltaic panels are incorporated to convert solar energy into electrical energy, which can provide enough power for control systems, sensors and other equipment and reduce reliance on municipal power sources. It is important to note that the design of technology integration does not simply overlay technologies, but should be consistent with the layout of garden landscapes. Like intelligent control cabinets can be hidden in the rockery, so that sensor appearance design into a stone shape, to prevent technical equipment from terrorist development garden overall aesthetics.

4. Pathways for Achieving Rainwater Recycling in Urban Landscape Engineering Const ruction

4.1 Construction Preparation Work

Pre-construction preparation is an important guarantee of the implementation of rainwater recycling system in urban landscape engineering, which ensures that system functions do not fail because of inadequate preparations during scale-up.

4.1.1 Technical Preparation Stage

Technical preparation basics is about confirming feasibility of the design. The technical teams should be organized to carry out constructioning drawing review work, including analyse and verification of the details of crucial rainwater recycling facilities, which are clear about the essential techical points of each construction unit of it and more understanding connection logic between different constructioning techniques. Thus, pre-defined standards for the base compaction degree of permeable pavements should be defined in advance. Design may include and targeted solutions developed for on-site adaptation issues. Preparation of a detailed construction plan aimed at deepening the quality control of the rainwater recycling is necessary, which needs to clarify each construction procedure (such as the laying steps of rainwater purification modules/steps and sequence of laying permeable materials). The technical disclosures are also similarly carried out, ensuring that construction personnel become proficient in applying rainwater recycling facilities.

4.1.2 On-Site Preparation Stage

On-site preparation aims to achieve precise adaptation to the construction environment. First, a detailed survey of the construction site should be conducted, focusing on recording soil permeability, the distribution of underground pipelines, and the operational status of drainage systems. Soil sampling and testing should be carried out to clarify permeability parameters. If the soil permeability is poor, a replacement and improvement plan should be formulated in advance. The specific locations of underground pipelines should be clearly marked to prevent construction damage from hindering the effective connection of rainwater pipelines. Subsequently, site cleaning should be carried out to thoroughly remove obstacles within the construction range. Micro-topography should be appropriately adjusted according to the actual flow direction of rainwater to create favorable conditions for the construction of permeable pavements and other facilities [7].

4.1.3 Material and Equipment Preparation Stage

Strict quality control should be implemented for materials. The quality of rainwater recycling-specific materials should be carefully checked, and key indicators such as anti-seepage performance and compressive strength should be sampled and tested to ensure compliance with design standards. Rainwater pumps and other intelligent equipment should be debugged in advance to test the stability of their data, and sufficient spare parts for equipment should be reserved.

4.2 Construction of Permeable Pavement Systems

The construction quality of permeable pavement systems in garden landscape engineering directly affects the efficiency of rainwater infiltration. In this construction link, strict control should be exercised over base treatment, surface layer paving, and joint treatment to enhance the stable permeability of the pavement while meeting bearing requirements. In base construction, a solid foundation for permeability should be laid. The roadbed should be rolled and treated using heavy rollers for layered compaction, ensuring a compaction degree of approximately 94% to prevent later settlement from damaging the permeable structure. Subsequently, a crushed stone base should be laid, with a particle size of about 30 mm and a thickness of about 17 cm. During specific laying, leveling should be carried out layer by layer, with a compaction degree of each layer greater than or equal to 90%. If the soil permeability is insufficient, a permeable geotextile should be added between the base and the roadbed to prevent soil particles from blocking the gaps in the crushed stones and ensure the smooth infiltration of rainwater into the ground. However, the surface layer paving should be based on both permeability as well as durability. Otherwise, a 4 cm thick dry hard cement mortar with a ratio of 1:3 The layer should be laid as the surface before laying on such permeable brick. When doing permeable bricks, they must be installed exactly according to the design pattern with no wider than a 4 mm space between them. Soak treatment, Special permeable joint fillers must be use filled, So rainwater free falling through the gap bring mud and sand away. When building the permeability concrete surface layer, the rationality of aggregate gradation and cement dosage must be guaranteed, and the amount of cement shall not exceed 300 kg/m^3. Light vibration and compaction may work with the help of a plate vibrator while pouring. The quality control for the actual construction also has to be made easier. Sampling and testing of permeation coefficient was carried out to verify the seepage coefficient of permeable brick pavement system, so far after the base and surface layer construction is completed.

4.3 Construction of Sunken Green Spaces and Grass Swales

Sunken green spaces and grass swales are also essential to the rainwater recycling system in gardens. With highways, they construct using interception techniques to hold rainwater and optimize resource context. In the construction phase, you should focus on planting plants and soil improvement in order to coordinate ecological functions and landscape effects. For the construction of sunken green space, it is necessary to control the terrain height difference within an appropriate range. Excavation of the site should be performed to natural design elevation, and the base treated and compacted to ensure an in-situ compaction degree of 88 % or more of material for purposes of functionality, without compromising water collection due to later settlement. In the renovations to land, proper river sand and rotten leaves should be added to reduce clay content of soil and improve soil permeability coefficient. Low permeability zones may require the laying of a specific thickness of crushed stone blind ditches filled with crushed stones, which should be wrapped in permeable geotextiles to increase rainwater infiltration capacity so that no water ponds occur in the green spaces. Grass swales for which cross-section of the trench is designed, should be constructed in accordance with their functional characteristics. Typically, a trapezoidal cross-section is used with an width at the top of 1-2 m and at the bottom 0.5-1 m. A 10 cm thick layer of planting soil should be laid at the bottom of the trench, and an appropriate amount of perlite should be mixed in to enhance its air permeability. To achieve ideal purification effects, a crushed stone filtration zone can be set up at the bottom of the trench, filled with crushed stone mixtures, etc., to effectively adsorb nitrogen and phosphorus pollutants in rainwater.

4.4 Construction of Rainwater Storage and Purification Facilities

Rainwater storage and purification facilities play important roles in the rainwater recycling system, undertaking functions such as pollutant removal and rainwater storage. During actual construction, the anti-seepage performance of storage facilities and the functionality of purification facilities need to be controlled module by module to ensure the reasonable utilization of rainwater. In the construction of rainwater storage facilities, the focus should be on ensuring anti-seepage and capacity. For example, in the construction of underground reinforced concrete water storage tanks, the foundation pit should be excavated first, and slope protection with steel sheet piles should be carried out when the depth exceeds 3 m. An appropriate thickness of cushion should be laid at the bottom of the foundation pit. When the strength meets relevant standards, steel bars should be bound, and the spacing and protective layer thickness of the steel bars should be set strictly according to design requirements to avoid excessive steel bar spacing affecting the overall structural bearing capacity. Formwork installation requires the use of steel forms, and sealing adhesive strips should be glued to each joint to prevent grout leakage caused by concrete pouring Featured Design the layered purification effect in constructing rainwater purification facilities. Take the construction of artificial wetland purification as an example, first to lay the anti seepage membrane (the distance between the membranes should be greater than or equal to 10 cm). Double-weld technology is adopted, and water-tightness test adopting pneumatic testing method should be conducted after welding to verify the anti-seepage performance is within with the prescribed range of values. Then layers of gravel, substrate and planting layers should be laid. Lastly, aquatic plants like Acorus calamus should be chosen, too, but choose those with the root systems able to reach into deep substrate layer.

5. Conclusion

To sum up, the design and mechanism of rainwater reuse, forced by ecological sayings and carried out through engineering practices, is intertwined in urban landscape engineering. This systematic project invigorates garden landscape ecology, recollecting lost green urban hydrological cycles, and enhancing sponge city construction. Therefore, explore the balance between technology and cost to be repeated work in the future Rainwater recycling is a representative feature of urban gardens.

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