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# Multifunctional New Green Roof Based on Sponge City Construction

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**Abstract:** The so-called sponge city is a new era of urban stormwater management concept, refers to the city can be like a sponge, in adapting to environmental changes and respond to natural disasters brought about by rainwater has good elasticity, can also be called "water elastic city". The international common term is "low impact development rainwater system construction", which absorbs, stores, infiltrates and purifies water when it rains, and releases and uses the stored water when needed to realize the free migration of rainwater in the city. In this paper, based on the new concept, we improve the comprehensive utilization of precipitation and improve the recovery of precipitation, so as to add water saving functions such as water storage, interception and purification, and social functions such as greening and production capacity to the traditional green roof, forming a new green roof with multi-functional functions, and proposing an immature solution to alleviate urban flooding in the rainy season.

**Keywords:** Sponge city, New green roof, Model analysis.

## 1. Research Background

Due to the influence of climate change and human activities, cities are facing many water ecological and environmental problems such as flooding, water shortage, and black odor of water bodies. In recent years, under the combined influence of extreme climate and rapid urban development, many large and medium-sized cities in China have been repeatedly affected by heavy rainfall and flooding disasters, such as the "5-7" rainstorm in Guangzhou in 2010, the "7-18" rainstorm in Nanjing in 2011, the "7-21" rainstorm in Beijing in 2012, and the "7-21" flood in Henan in 2021. The "7-21" rainstorm in Beijing in 2012, and the flooding in Henan in 2021. The phenomenon of "seeing the sea" in cities has seriously affected the normal production and living order and brought huge economic losses to people, and urban flooding has become one of the urgent problems in urban development. In recent years, sponge city construction has become a hot research issue in the field of urban planning and construction and water resources and water environment in China, and the concept of sponge city was first proposed at the Central Urbanization Work Conference in December 2013. In October 2014, the Ministry of Housing and Urban-Rural Development officially released the "Technical Guide for Sponge City Construction". -The concept of sponge city is clearly defined in the "Low Impact Development of Rainwater System Construction": it means that a city can be like a sponge, with good "elasticity" in adapting to environmental changes and responding to natural disasters, absorbing, storing, seeping and purifying water when it rains, and "releasing" and using the stored water when needed. "release" and use. Sponge City requires "priority use of natural drainage systems, construction of ecological drainage facilities, give full play to urban green space, roads, water systems and other rainwater absorption, storage and infiltration and slow release role, so that the hydrological characteristics of the city after development and construction close to the development before, with natural storage, natural infiltration, natural purification function. As one of the main hardened parts of the city, roofs have a large rain-collecting surface and fast flow production and sink characteristics, which have an important impact on the generation of urban flooding. According to the construction concept of sponge city, green roof is one of the main elements of low impact development rainwater system construction, compared with the traditional hardened roof, has the hydrological characteristics of urban development and construction close to the characteristics before development, has the function of natural accumulation, infiltration and purification of rainwater, is an important way to abate urban storm water runoff (especially abate peak runoff), control non-point source pollution and beautify the city Green roofs can also be used as a pre-treatment measure for the continued use of rainwater, and can regulate building temperatures, reduce the urban heat island effect and beautify the urban environment

## 2. Research Content

This research review is based on the previous research related to the traditional roof, green roof runoff, interception rate, rainwater content of nitrogen, phosphorus and other elements in different periods derived from a multifunctional new green roof, mainly for urban flooding to solve the problem combined with its social value and economic benefits, through the acrylic panels to establish a laboratory homogeneous scale reduction model to prove the feasibility and viability of the idea.

### 2.1. Model making

#### 2.1.1. Preparation Materials

Acrylic board, common filter layer of different particle size, glass light stone (placed in the uppermost layer, light, porous, high water storage rate, water and fertilizer retention, high strength inorganic new material, using this substance can ensure the water requirement of the upper layer of vegetation), drainage board, water transmission network, full circle nozzle, small water pump, electric wire, circuit board, soil moisture sensor, valve, water level alarm, solar panel, vegetation, etc.

### 2.1.2. Production steps

The acrylic board will be cut according to the planned size to ensure that there is no tilt or bend at the edges and corners so as to avoid the inability to combine due to the size problem. The model is Mainly divided into three major structures, the upper structure, the lower structure and the circulation structure. The structure of the system from top to bottom is vegetation layer, cultivated soil substrate layer, geomembrane, drainage board, and acrylic sheet bearing layer.( Details can be found in Figure 1)

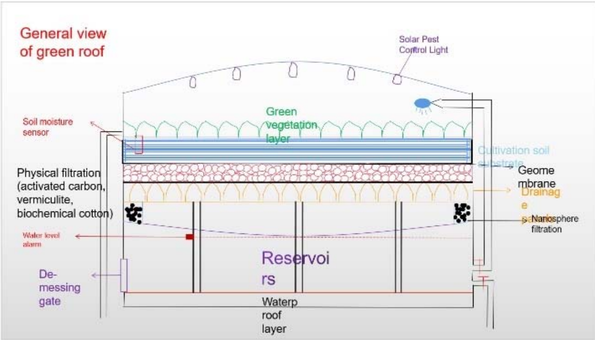


**Figure 1.** General view of green roof

The upper structure is the planting area, and the vegetation layer is planted with cabbage, lettuce, spinach, rape, baby lettuce, leek, strawberry and other economic vegetables and fruits, which need to be planted in separate beds to facilitate subsequent comparison experiments; the cultivation soil substrate layer is determined according to the length of the vegetation root system, in which the ratio of cultivation substrate to common loam is 1:2, at which time the field water holding rate is the highest; the particle size of the filtration layer decreases from top to bottom in order to The particle size of the filtering layer decreases from top to bottom to filter the water quality; the drainage board adopts the water-proof type, so that the middle is high and the surrounding is low, and the water enters the substructure reservoir from all around.( Details can be found in Figure 2 and Figure 3)

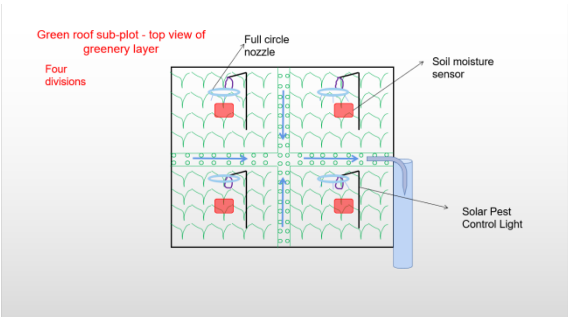


**Figure 2.** Green roof sub-piiot-top view of greenery layer

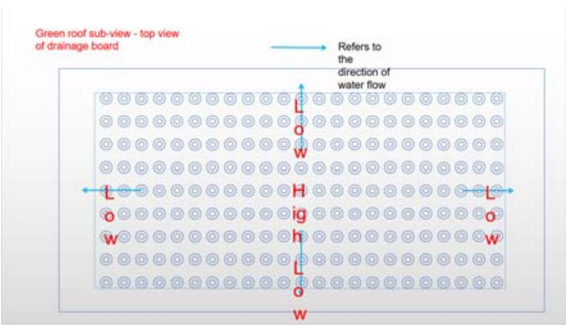


**Figure 3.** Green roof sub-view-top view of drainage board

The lower structure is a cistern, and under laboratory conditions, the bottom of the cistern is replaced with a 10mm post-acrylic plate because it is only a simulated situation. Water continues to flow down after passing through the drainage board, passing through the nano-filter ball compartment, through which the harmful elements and organic pollutants are filtered and enter the cistern after passing through the baffle, which is to prevent the filter ball from entering the cistern; the cistern is the bottom surface of this work, which is installed with a water level controller, when the water in the cistern reaches the set height, the solenoid valve will be opened automatically for drainage, but the water storage will always be carried out. As the discharged water has gone through the filtration process, if it is an individual user, it can also be used for daily household use or yard use. If the water quality requirement is not high, a sand and gravel filtration layer can be set under the cultivated soil layer of the green roof system. (Details can be found in Fig 1)

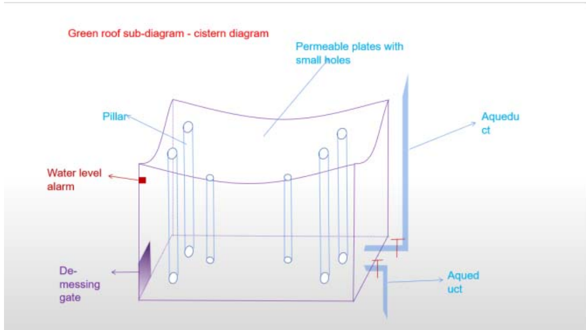


**Figure 4.** Green roof sub-cistem diagram

Circulation structure that connects the upper and lower parts, the vegetation layer placed soil moisture sensor, when the upper layer of soil moisture is reduced to the specified entropy value, through signal transmission, the lower part of the collected rainwater will be pumped to the upper layer of vegetation to ensure that the green vegetation can grow normally, and stop watering when the control humidity is reached or when the water level in the reservoir is low.

## 2.2. Research ideas

Test whether the system can achieve the purpose of water storage. Under laboratory conditions, different intensity levels of rainfall are simulated by using artificial rainfall. When the intensity of precipitation is low, it just wets the vegetation layer, while at higher intensity, there will be different levels of water flowing down from the perimeter of the drainage board and entering the reservoir through the filter ball compartment.

Test whether the water quality in the impoundment can meet the irrigation demand of the vegetation layer. The content of ammonia nitrogen and COD in five cases, i.e. when the reservoir is just filled with water, 1/4, 1/2, 3/4, and full, can be obtained in the first case when the water content is high, and with the storage of water in the reservoir, its concentration is diluted and can finally meet the requirements.

Test when the reservoir storage to the specified water level can be maintained. As the water storage continues, reaching the water level controller level, although not control the infiltration of water, but a solenoid valve below the cistern will open, control the water level in the cistern remains unchanged.

Test whether the circulation system can perform automatic irrigation. Since the planting layer is carried out in separate bays, soil moisture sensors of the same specifications are placed in different bays, and the pump irrigates them through the soil moisture of the bays. 2.3 and 2.4 The electricity used in the process is provided by the solar panel, and no more power circuit connection is made, which can constitute an independent system.

# 3. Analysis of Results

Through the actual modeling, the following elements are proved: when the rainfall reaches a certain level, the water volume infiltrates, and a certain amount of rainwater with better water quality can be collected in the reservoir to slow down urban flooding and shorten the retention time of rainfall on the urban surface; when the water volume of the upper planting body is lower than the soil entropy value, the whole life cycle of the structural system can be implemented without artificial automatic irrigation, and the collected rainwater meets the irrigation of the upper planting body The collected rainwater meets the water quality requirements for irrigation of the upper layer of the plantation; it can absorb greenhouse gases such as carbon dioxide and create a certain economic value.

# 4. Defects Exist

Although the multi-functional new green roof can operate normally under the laboratory conditions and solve many problems, there are still more problems that cannot be ignored in the actual promotion and application, such as the load-bearing problem of the roofs of many buildings that have been built, the depth of water penetration in the planting soil during the rainfall process with different precipitation intensities and different rainfall times, the time of penetration into the reservoir and the amount of water, the amount of runoff that cannot be stored in the reservoir and discharged to the ground, and the obvious extent of the discharged runoff on urban drainage. The problem of how much runoff will be discharged to the ground without storing water in the pond and how much runoff will be discharged to alleviate urban flooding are not suitable solutions. The following is an analysis of each of them.

## 4.1. Load-bearing analysis of existing buildings

Even though the construction industry has developed rapidly in recent years and various new building materials have contributed to the rapid development of the field, many high-rise buildings can only meet the requirements of housing or office, etc., and the load-bearing problem of the top floor is not considered in the architectural design. If multi-functional new green roofs are applied on such buildings, the perimeter of the cistern should be set on the load-bearing wall (or beam) of the building under the premise of satisfying the force conditions, and the bottom surface is separated from the top surface of the building, presenting a similar force effect as the floor slab. If this practice is applied, then numerous existing houses and other buildings can use the new green roof, which will have a significant impact on environmental improvement. However, the total weight of the structure is supported by the perimeter of the cistern and transferred to the ground, and the ground and the corresponding impermeable equipment need to be built separately, significantly increasing the cost, where the economic costs should be evaluated in relation to the benefits.

## 4.2. Soil infiltration time and water storage during the rainy season

Due to the colder winters in northern China, the building height affects the growth of the implants, thus only the collection of rainfall is considered, without considering other precipitation methods such as snow and hail. Different rainfall intensities, duration of a rainfall event, and different soil textures of different planters affect the rate of rainwater during rainfall when it is filtered in the upper layer, the time it takes to infiltrate into the cistern, and the amount of water required. The authors suggest correlating the depth of infiltration, the time when it first infiltrates into the pond, and the time when the cistern is full for different rainfall intensities at different times in subsequent studies.

## 4.3. Surface runoff

The question is based on the situation where the above two problems are solved, considering that when the cistern is full, the excess water will be discharged to the ground as runoff. Here, it is necessary to explore the extent to which the application of multifunctional new green roofs throughout the process will alleviate the urban drainage network system during the rainy season, the magnitude of damage to social property due to the reduction of surface runoff, and whether the normal operation of the surrounding water system will be affected due to the storage of rainwater inside the city for evaluation and analysis.

The above three problems are wider in scope and require a lot of rainfall information, area floor area division, and drainage system for statistical analysis, etc. For the time being, we have not addressed these problems, but only provided research ideas.

# 5. Development Prospects

## 5.1. Impact on urban flooding mitigation

Implementing the concept of sponge city, collecting rainwater directly by filtration on the roof of the building, effectively relieving the pressure of the urban pipe network in the rainy season, reducing urban flooding, and ending "urban sea-surfing", which is the most important goal of this structural system; at the same time, the water-storage green roof can significantly reduce the temperature of the building surface through the action of water, reducing the This is the most important goal of this structure system.

## 5.2. Impact on global warming

As the country attaches importance to the double carbon target, green vegetation can be added to the structure to increase the amount of carbon absorption and strive for early carbon peaking carbon neutrality to do our part in reducing global climate temperature.

## 5.3. Impact on economic benefits

The reuse of rainwater saves water and improves the efficiency of water utilization, and the planting of organic vegetables or flowers, etc., can improve economic benefits; at the same time, the power supply to the system's circuit through solar panels increases the efficiency of the use of solar energy and saves energy.

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