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The Concept of Optimizing the Environment and Moving Towards Sustainable Development Goals with Green Infrastructure

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Abstract. At this stage, the United Nations has established the Sustainable Development Goals (SDGs) to guide global sustainability goals. In order to improve the environment and achieve the goal of sustainable development. This study mainly uses green roofs, the most common among green infrastructures, as the object of study. Green roofs are an auxiliary facility commonly developed on general buildings. They can reduce flood flow and increase water storage capacity through infiltration. This study mainly uses indoor experiments, using green roofs as experimental facilities to simulate the effect of increasing infiltration. The experiment uses an indoor rainfall machine, sets situational simulation conditions as the inflow flow, and uses common grass species as planting. The final experimental results show that this experiment mainly uses a horizontal slope of 0% as the condition for a flat roof. The infiltration rate is as high as more than 50%, and the flood peak can be reduced by more than 30%. Therefore, in the initial design of the building structure, green roof facilities can be considered to achieve the water retention effect through the infiltration rate and reduce the peak flood. It can later be used as a reference for water retention in the building base.

Introduction

In the process of urbanization, economic development has reduced the usable space on the original land, and at the same time changed the land use pattern, and will also change the original hydrological environment and ecology of the land. As the surface impermeability gradually increases in the region, the hydrological cycle function of the original land is reduced, rainfall infiltration into the soil is reduced, flood peak flow is increased, and groundwater replenishment is also limited. Green infrastructure can mitigate the negative impacts of urbanization. Managing rainwater at the source in a decentralized manner not only increases the soil infiltration rate, reduces peak flow, and slows down the trend of hydrological changes after development, but also increases the area of green space, reduces the pressure on the ecological environment, and restores the help of plants to the environment. The water stored in the facility can also moderately alleviate the urban heat island effect through evaporation. This study mainly takes green roofs in green infrastructure as the re-search object. It uses indoor artificial rainfall machines to simulate general rainfall patterns, and uses scenario conditions as simulation conditions to explore the impact of green roof facilities on general buildings on flood peaks. The research results can be used as a basis for the construction of new building water storage systems in the future and the improvement of the environment in flooded areas around the building. Indoor experimental results show that the peak flow reduction benefits are greater than 30%.

Literature Review and Discussion

Cities often develop rapidly due to commercial, economic or people's livelihood needs. Large-scale construction consumes the original green space in the city, causing the original green space to become fragmented and shrink. Therefore, the ecological and social impact of urban development can be reduced through the development of green infrastructure. The impact caused by green spaces and open spaces is solved, and the problem of landscape fragmentation such as green spaces and open spaces is solved. Generally, basic public facilities systems need to be constructed to maintain urban development, which can be collectively referred to as gray infrastructure [1]. Green infrastructure

(G.I.) is a relative concept. Through the interconnected green The spatial network is composed of various open spaces and natural areas, surrounding and connecting gray infrastructure and other components to form an interconnected and organically unified network system. [2]

Low Impact Development (LID) facilities, or Green Infrastructure (GI), are mainly used to mitigate problems caused by urbanization [3] and improve the environment by coexisting with water. In addition to reducing the impervious area in urban areas, it can also increase the infiltration and evaporation functions of soil and vegetation, reduce surface runoff and reduce peak flow, and manage rainwater at the source in a decentralized form. However, current research rarely discusses the development of non-urban areas. Flooding caused by behavior, and the benefits of low-impact development facilities. The green roof is mainly constructed to improve the urban eco-logical environment. It is a multi-functional roof structural component option; it can provide green shade through plants and condensation and evaporation (water is gradually released into the surrounding air through the pores of the plants). To reduce the urban heat island effect, filter, absorb or retain rainwater, and help reduce the impact of urbanization on water quality [4]; it is a lightweight growing medium structure, beautifies urban roofs, reduces the impact of the greenhouse effect, and achieves The function of energy saving and carbon reduction. The structure of green roofs in Europe can be simply divided into: the basic components of roof greening are a vegetation layer, a substrate layer and a drainage layer [5]. The prerequisite for setting up a green roof is to ensure the safety of the building's roof structure. The components of a green roof must at least include: waterproofing, drainage, growing media, plants and other structural facilities. Each structural layer must have many types of materials to choose from.

Based on the depth of the base material layer, green roof types are also divided in-to two main types in Europe [6] as follows: "extensive green roofs" (extensive green roofs), the maximum depth of the base layer is about 150 mm [7]. Species often form an important part of the vegetation. This type can also be installed on sloping surfaces, with slopes up to 45 degrees, and "intensive green roofs" have a base layer depth of more than 150 mm [8].

Referring to the concept of relevant green infrastructure operation cases in the United States and the United Kingdom, it is known that the most important thing when implementing a green infrastructure plan is to conduct an inventory of green resources to identify appropriate protection, consolidation, coordination, and reconstruction development targets in the future [9]. The uniqueness of green infrastructure planning is that it combines a systematic planning approach with conservation concepts, incorporates natural asset management into the overall land use planning process based on local land use planning, and develops green infrastructure based on local conditions and site characteristics. By defining the resource types and projects included in the green infrastructure, the resource classification types include the cur-rent land use status and the existing land use status [10].

Research Methods

The design size of the green roof test (2) is 120 cm (length) * 60 cm (width). Based on the recommended area ratio of the LID facility, this LID facility is scheduled to be used to process rainfall in a catchment area of 120 cm * 240 cm. Runoff and rainfall conditions are designed for 60-minute heavy rainfall. Refer to the rainfall pattern used in Alfredo et al., 2010, and use the instrument conditions of the wind and rain laboratory to design three scenario rainfall calendars as shown in Figure 1 and Figure 2. As shown in Figure 3.

The green roof receives the rainfall from the artificial rainfall machine, and flows into the rain barrel from the seepage port through the pipeline. The green roof and rain barrel of the LID are integrated. This study used 1 slope (horizontal 0%), combined with the three inflow conditions shown in Figures 1 to 3, to reduce the design storm inflow for the three scenarios, in a wooden box of 60cm (length) * 120cm (width) * 30cm The test is carried out in a (high) container. The conditions of each group are as shown in Table 1. Each group of conditions is numbered to facilitate identification. The numbers of the green roof + rain barrel are GR1-GR3. The configuration and elevation of the test unit is shown in Figure 4. In this facility unit, the layers from bottom to top are: waterproof layer, root blocking layer, drainage and water retention layer, geotextile, growth medium layer (intensive type), and covering layer (planting). This study uses Amphora as the test grass species, and studies the green roof + rain barrel with a horizontal slope of 0%. The growing medium is fresh sea red soil.

Table 1. Vegetated Swales facility test conditions

Experiment number	Slope	Inflow conditions
GR1		situational rainfall(1)
GR2	0%	situational rainfall(2)
GR3		situational rainfall(3)

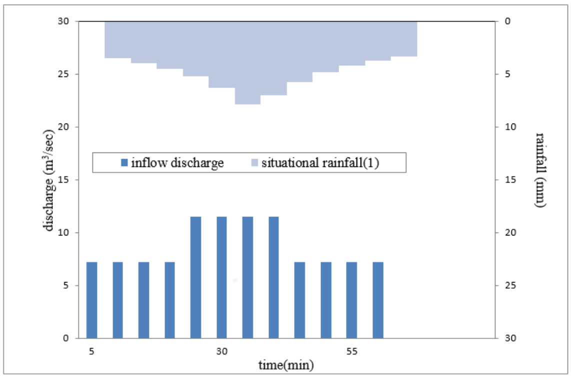

Fig. 1 Situational Rain-1.

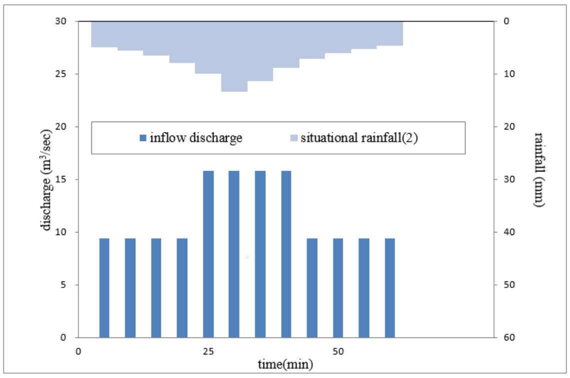

Fig. 2 Situational Rain-2.

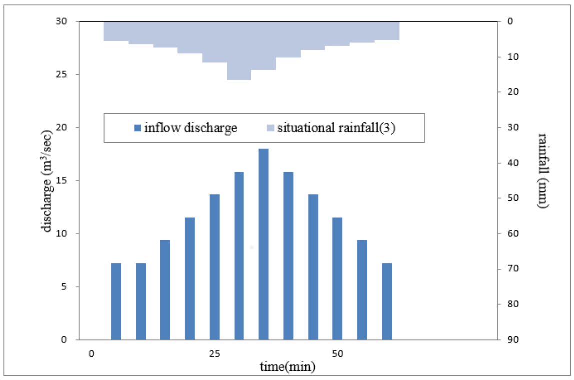

Fig. 3 Situational Rain-3.

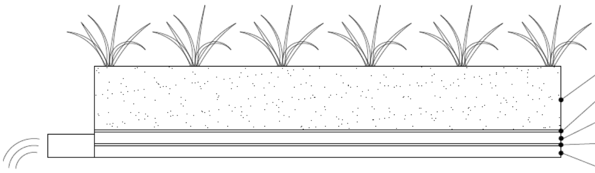

Fig. 4 Green roof test configuration.

The green roof receives the rainfall from the artificial rainfall machine, and flows into the rain barrel from the seepage port through the pipeline. The green roof and rain barrel of the LID are integrated. In this study, three different slopes (0% slope, combined with the three inflow conditions in Table 1, were used to reduce the design storm inflow for three scenarios. In this study, wooden boxes were made of 60cm (length) * 120cm (width) * The test is carried out in a 30cm (height) container. Each set of conditions is numbered for easy identification. The green roof + rain barrel number is GR1-GR3. The configuration and elevation of the test unit is shown in Figure 4. In this facility unit, the layers from bottom to top are: waterproof layer, root blocking layer, drainage and water-retaining layer, geotextile, growth medium layer (intensive culture type), and covering layer (planting). In this study, Amphora was used as the test grass species. The green roof + rain barrel slope (horizontal 0%) was used as a research and discussion. The growing medium was fresh sea red soil.

Green roof grass seeds are laid with amphora. The layout of the test chamber is shown in Figure 5. The bottom of the test chamber is supported by a stainless steel iron frame. The iron frame device can adjust the slope to meet the slope required by the test (Figure 6). Place the facility flat in the center of the artificial rain machine, and measure the outflow of the green roof test box using the rainfall of the rain ma-chine as the inflow condition.

Open a 1-inch PVC water pipe in the test box to facilitate drainage, connect the rain barrel with a plastic pipe, and place the rain barrel on an electronic scale. Measure the weight of the water discharged from the green roof test box and enter the rain barrel, and convert it into a volume (equivalent to 1 kilogram) 1 liter), the test device is shown in Figure 7. The actual rainfall situation is shown in Figure 8.

Fig. 5 Test box layout diagram.

Fig. 6 Adjustable stand.

Fig. 7 Experimental configuration.

Fig. 8 Actual experimental situation.

Experimental Results and Discussion

Using a 60cm (length) * 120cm (width) * 30cm (height) test chamber, with three inflow flows (scenario 1, scenario 2, scenario 3), and a configuration with a slope of 0%, the test results are as follows: The test results of slope 0 degrees (GR1~GR3) are shown in Figure 9- Figure 11. The water retention capacity of the green roof + rain barrel is summarized in Table 2. In this facility, the impact of rainfall conditions and test slope on the water retention capacity is discussed. Among the three rainfall scenarios, the rain pattern designs of Scenario 1 and Scenario 2 are similar, while Scenario 3 cooperates with the wind and rain laboratory to design rain patterns that increase over time. The overall total rainfall is: Scenario 1 < Scenario 2. In terms of water retention capacity GR1-GR3, the infiltration capacity of low rainfall frequency is better than that of high frequency rainfall. In terms of flood peak, Scenario 2 is better than Scenario 1. With the indoor rainfall machine controlling the intensity of rainfall, the green roof and rain barrel test result is a horizontally placed (flat-top) green roof. In terms of the water retention capacity of green roof facilities, with a slope of 0%, the horizontal water retention capacity of 0 degrees is the best. This study mainly uses green roof facilities, whose purpose is to slow down the rise in building temperatures and help reduce carbon emissions, thereby achieving the United Nations' sustainable development goals.

Table 2. Water retention capacity of Vegetated Swales planting trench test conditions

Slope	0%		
Experiment number	GR1	GR2	GR3
Flood conditions	situational rainfall(1)	situational rainfall(2)	situational rainfall(3)
Infiltration (%)	59.23	56.66	57.12
Peak reduction (%)	32.99	35.26	38.86

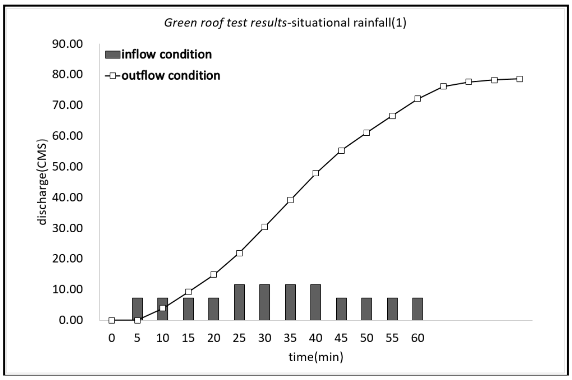

Fig. 9 Green Roof Test Results – Scenario Rainfall 1.

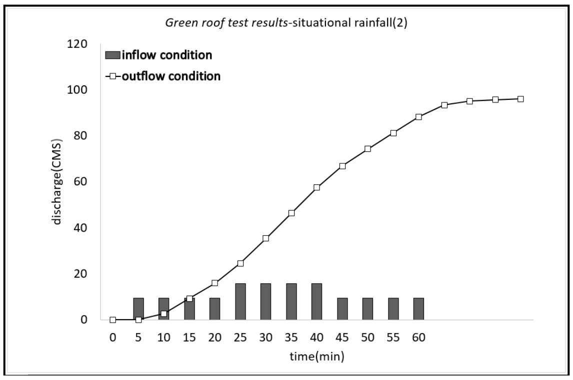

Fig. 10 Green Roof Test Results – Scenario Rainfall 2.

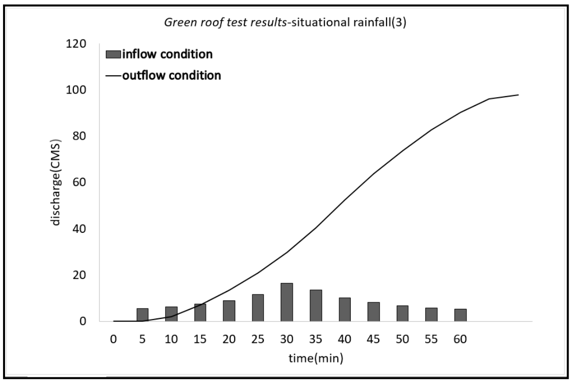

Fig. 11 Green Roof Test Results – Scenario Rainfall 3.

References

[1] Benedict, Mark A., and Edward T. McMahon. "Green infrastructure: smart conservation for the 21st century." Renewable resources journal 20.3 (2002): 12-17.

[2] Chenoweth, Jonathan, et al. "The interrelationship of green infrastructure and natural capi-tal." Land use policy 75 (2018): 137-144.

[3] Ahiablame, Laurent M., Bernard A. Engel, and Indrajeet Chaubey. "Effectiveness of low impact development practices: literature review and suggestions for future research." Water, Air, & Soil Pollution 223 (2012): 4253-4273.

[4] Park, Jinsil, et al. "Efficient plant types and coverage rates for optimal green roof to reduce urban heat island effect." Sustainability 14.4 (2022): 2146.

[5] Mentens, Jeroen, Dirk Raes, and Martin Hermy. "Greenroofs as a part of urban water management." Progress in Water Resources 8 (2003): 35-43.

[6] Krupka, Bernd. "Dachbegrünung: Pflanzen-und Vegetationsanwendung an Bau-werken." (1992).

[7] Nash, C., Ciupala, A., Gedge, D., Lindsay, R., & Connop, S. (2019). An ecomimicry design approach for extensive green roofs. Journal of Living Architecture, 6(1), 62-81.

[8] Teotónio, Inês, Cristina Matos Silva, and Carlos Oliveira Cruz. "Economics of green roofs and green walls: A literature review." Sustainable Cities and Society 69 (2021): 102781.

[9] Leal Filho, Walter, et al. "Addressing the urban heat islands effect: A cross-country assess-ment of the role of green infrastructure." Sustainability 13.2 (2021): 753.

[10] Zhang, Xindi, et al. "Development of a cross-scale landscape infrastructure network guided by the new Jiangnan watertown urbanism: A case study of the ecological green integration demonstration zone in the Yangtze River Delta, China." Ecological Indicators 143 (2022): 109317.