Effectiveness of Green Roofs in Urban Buildings

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Abstract. Accelerated urbanization has made cities face many environmental problems such as rainwater runoff and the heat island effect, and green roofs can absorb and store rainwater, reduce heat radiation, etc., which can effectively alleviate these problems. The purpose of this paper is to explore the importance of green roofs in improving the urban ecological environment by analyzing relevant cases and to clarify the factors affecting their utilization to provide a reference for the improvement of the urban environment as well as the sustainable development of cities. By analyzing relevant cases, this paper further discusses the importance of green roofs in improving the urban ecological environment. This paper starts from the principle of green roof design and understands its multiple functions through specific structures and vegetation configurations. The influence of building structure and economic cost on the utilization rate of green roofs is clarified. Practical examples demonstrate how green roofs can be utilized in different scenarios and grasp the economic costs of construction and maintenance. This paper not only provides a new way to alleviate the pressure on water resources but also improves the urban environment. In the future, methods to reduce cost, optimize design, and enhance promotion can be further explored to contribute to sustainable urban development.

Keywords: Green roofs, utilization, environment.

1. Introduction

In today's era of accelerating urbanization, green roofs play an important role in urban buildings. Rapid urban development has led to an increasing strain on land resources, and the traditional construction model has brought about many environmental problems. Currently, impermeable materials such as cement, reinforced concrete, and metal are commonly used in urban buildings, and urban floors are mostly paved with asphalt. All of these materials are impermeable, and they prevent rainwater from infiltrating, causing it to collect quickly on the surface to form runoff. During rainfall, large areas of asphalt pavement can lead to a drastic increase in the amount of rainwater runoff in a short period of time, increasing the burden on the city's drainage system, which can lead to urban flooding in severe cases. On the other hand, with the development of the city, there are many industrial zones have been established, which leads to the urban heat island effect becoming more and more obvious, the temperature of the city center is obviously higher than the surrounding areas, affecting the ecological balance of the city. At the same time, people have higher and higher demands on the quality of the urban environment and desire to live in a beautiful and pollution-free environment. Based on these problems, it is necessary to explore effective methods to alleviate urban pollution.

Green roofs can effectively alleviate this series of problems. First, plants and soil on green roofs can absorb and store rainwater, reduce rainwater runoff, lower the pressure on the urban drainage system, and reduce the occurrence of waterlogging. Secondly, green roofs help to reduce solar heat radiation, thus alleviating the urban heat island effect [1]. Plants absorb heat through transpiration, thereby reducing the temperature of the surrounding environment and bringing a cooler climate to the city. In addition, green roofs can increase the green area of the city and improve the ecological environment of the city. In China, green roofs are developing well, popularized in more cities, and encouraged by policy support. Shi Xiangyun et al. analyzed the advantages of green roofs in reducing drainage pressure by taking Spain as an example [2]. Ye Chuanzhi et al. analyzed the advantages of green roofs in mitigating the urban heat island effect in many cities in the United States as an example [3]. However, green roofs still face challenges such as funding, technical standards, and maintenance management.

This paper will focus on the application of green roofs in urban buildings, exploring their environmental benefits, economic feasibility and promotion challenges. By listing some practical application examples in detail, comprehensively analyzing their impacts on the environment or buildings, and conducting economic cost analysis, it aims to provide a basis and reference for the promotion and optimization of green roofs in urban buildings.

2. Rainwater utilization and water resource challenges

As the global population grows and the economy develops, the demand for water resources is increasing. As a result, water resources are facing great challenges. On the one hand, many regions are faced with the dilemma of water shortage, especially in arid and semi-arid regions, where the lack of water resources seriously affects people's quality of life and the speed of economic development. On the other hand, the problem of water pollution is also very serious, industrial wastewater, domestic sewage, and agricultural surface pollution have led to a sharp decline in the quality of water resources, further aggravating the situation of water resources tension. In addition, the uneven distribution of water resources globally is also an important challenge. Rainwater utilization can effectively alleviate the problem of water shortage, reduce the pressure on urban drainage systems, and reduce water pollution. Rainwater can recharge groundwater through green space, and at the same time can play a role in rainwater purification [4].

First, collecting and utilizing rainwater, can supplement water resources in cities and rural areas and reduce dependence on groundwater resources. It can alleviate the problem of water shortage to a certain extent. For example, in some water-scarce areas, collected rainwater can be used to irrigate farmland. Secondly, rainwater utilization can alleviate flooding. A well-developed rainwater collection system can discharge or store rainwater in time, reducing the risk of urban flooding. Finally, rainwater utilization can also improve the ecological environment. Increased groundwater recharge and suitable soil moisture can promote the growth of vegetation, providing strong support for the stability and development of the ecosystem. There are many forms of rainwater utilization, which can be divided into three: infiltration into the ground, collection and reuse and regulated discharge [5]. Green roofs can then better collect and utilize rainwater.

3. Effectiveness and utilization of green roofs in urban buildings

3.1. Principle of green roof design

The core principle of green roof design is to utilize the roof space and plant vegetation to form a natural environment with appropriate cold, temperature and humidity [6]. Green roofs usually include three layers: a waterproof layer, a drainage layer, and a vegetation layer. The waterproof layer provides a stable foundation and waterproof guarantee for green roofs, preventing rainwater from leaking into the interior of the building. The drainage layer removes excess water and prevents stagnant water from causing plant root rot. The vegetation layer enhances the ecological function of the roof and positively affects the urban environment through greening and the natural regulating effect of plants.

3.2. Factors affecting the utilization of green roofs and their influence

Green roofs have a great role in urban ecology, energy saving and safety, but their utilization still faces the influence of many factors. First of all, there is a greater pressure on the economic cost. At the initial stage of green roof construction, money needs to be invested in the installation of a high-quality water storage layer, drainage layer and substrate. The substrate materials usually selected contain porous vermiculite and perlite, peat and recycled bricks [7]. It is also necessary to procure vegetation and high-quality substrate materials such as terra cotta, pumice, perlite, vermiculite, cinder blocks, crushed bricks, etc. that are suitable for the local growing environment. In addition to this, the roof structure has to be reinforced and the total weight of the green plants and equipment laid on

the roof structure has to be within the range of the weight that the building can bear, if it is exceeded, the building will be in a precarious state [8]. Moreover, maintenance is also required at a later stage, when there are costs involved, such as vegetation pruning, irrigation, and pest control, etc., and these cost factors have caused some building developers to be hesitant about choosing construction.

Although the construction cost of green roofs is high, their technical difficulty and spatial constraints are also factors that need to be considered. With the continuous development of the construction industry, buildings have a variety of shapes, and there are many problems in design and construction. If the design is not reasonable, it will lead to problems such as water accumulation and leakage on the roof, which will affect the safety of building use and the life span of the green roof, for example, insufficient drainage slopes or improper waterproofing treatment may lead to serious consequences. Not only does it fail to alleviate flooding, but it may also aggravate it. At the same time, plant selection and planting techniques are also crucial, and plant species that are adapted to the special environment of the roof need to be selected, such as some vegetation that can resist high winds, large temperature differences and rapid water evaporation. Not only that, the planting method is equally important, which will directly affect the plant growth and ecological function of the green roof. In addition, spatial factors also limit the utilization of green roofs. Some building roof space is occupied by air-conditioning units, solar panels and other equipment, making it impossible to build green roofs. Some older buildings or light structures have limited roof capacity and cannot bear the weight of green roofs, leading to a decrease in the utilization rate of green roofs.

3.3. Examples of green roof applications

Nowadays, green roofs have many successful application cases. For example, the Singapore Interwoven Building, which has a unique design concept, uses a horizontal stacking structure, and the excess space stacked constitutes several permeable courtyards, whose interwoven spaces form a system. The building intertwines public space with plants to increase the green area and create a green and natural environment for people. The building is a departure from Singapore's traditional architectural typology. It is planted with a large number of tropical plants that can be adapted to the local environment. These plants not only beautify the appearance of the building, but also play an active role in improving the microclimate of the city, helping to reduce the urban heat island effect, regulating the local temperature and humidity, and creating more pleasant living conditions for residents. This successful application demonstrates that green roofs not only beautify the urban environment but also effectively improve the urban microclimate and reduce energy consumption, thus playing an important role in energy conservation and environmental protection.

3.4. Economic cost analysis of green roofs

Green roofs in terms of economic costs mainly include two aspects: construction costs and maintenance costs.

In terms of construction, green roofs require higher costs. As mentioned above, it is necessary to install high-quality water storage and drainage layers to ensure that there are no leakage problems during long-term plant growth and rainwater management. The procurement of high-quality substrate materials and the selection and planting of a wide range of suitable vegetation will also require significant capital investment. Structural reinforcement is also required to carry the additional weight of the green roof.

In terms of maintenance, vegetation needs to be cleaned regularly and plants all require management measures such as watering, fertilizing, pruning, weeding and pest control. Drainage facilities are serviced and cleaned periodically to avoid siltation of debris, which can block drainage outlets and drainage channels, thus eroding the roof surface, leading to roof leakage and affecting the service life of the building as well as the green roof [9]. All of these require significant investment.

However, in the long run, a green roof can also bring economic benefits. In terms of energy saving, it can provide thermal insulation and reduce the use of some electrical appliances such as air-conditioning in buildings, which can save some money. In terms of stormwater management, it can

reduce stormwater runoff and ease the pressure on urban drainage systems, thereby reducing the cost of maintenance and repair of drainage facilities. In conclusion, although green roofs are more costly in terms of construction and maintenance, they can bring some economic benefits when considered over a long period of time.

4. Challenges

Green roofs face multiple challenges in their promotion. Cost is a particular issue, as the special materials and technologies required to build green roofs significantly increase the construction cost, and maintenance work later on also raises the cost. In terms of technology, the design and construction of green roofs require specialized skills and knowledge, and architects and builders face challenges in selecting appropriate vegetation and building roof structures. Insufficient public awareness of green roofs is also a major problem, and the lack of public awareness of green roofs makes it difficult to promote them [10]. In addition, fewer related policies and a lack of government support affect the widespread promotion of green roofs. However, the promotion of green roofs can be promoted by raising people's awareness of environmental protection and their knowledge of sustainable development, as well as technological innovation, such as the development of intelligent maintenance systems. As a greening method in line with modern sustainable development, green roofs will be widely used in the future and have a broad development prospect.

5. Conclusion

This paper explores various aspects of green roofs and analyzes their role in rainwater utilization and meeting water resource challenges, as well as their application effects and utilization rates in urban buildings. Through examples, it is found that the rainwater utilization of green roofs can effectively alleviate water scarcity, reduce the pressure on the urban drainage system, and reduce water pollution, and the application effects in different scenarios are seen through actual cases. Green roofs can alleviate urban environmental problems such as stormwater runoff and heat island effects. They can also provide new ways to relieve water stress and improve the urban environment. However, the utilization of green roofs is affected by a number of factors. For example, building structures that are not suitable for the installation of green roofs can limit their utilization. Also, the economic cost can affect the utilization rate, including the construction cost and maintenance cost. In the future, further research can be conducted on ways to reduce costs and increase the feasibility of promotion, optimize the design for the characteristics of different regions to improve adaptability and utilization, and strengthen publicity and policy support to overcome the challenges of promotion, so as to better utilize the important role of green roofs in alleviating water pressure and improving the urban environment.

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