



“Stepping Stones” in Urban Greenways: Design Strategy of Roof Garden in Jiangbei New District, Nanjing, China

Wenhui Liu¹, Hong Zhang¹, Jiaxin Ni¹

¹School of Architecture, Southeast University, Nanjing 210096, China

Abstract

This paper focuses on the design strategy of roof gardens, analyzes the relationship between aerial greening from the overall shape of urban space, and discusses the greening spots effect of “stepping stones” in urban greenways. Taking the green corridor between the green space of the Yangtze River wetland and the green space of the Laoshan Mountain as a sample, the roof garden is analyzed as the impact of the stepping stones of the birds on the urban space shape control and height control. Afterwards, it researches the modular technology which can be adapted to building various types of roof gardens.

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Keywords

Roof greening; Urban greenways; Stepping stones; Ecological diversity; Modular design

1. Introduction

During the process of rural areas transforming into cities, the urban density is getting higher and higher, and the land resource has become the most precious resource in the city, which leads to the high-intensity and high-volume development of the city. In order to improve urban heat island effect, reduce carbon emissions and protect ecological diversity (especially birds), this paper starts from researching the overall form of green space in urban space, focusing on the greening spots in the air, known as roof gardens. By analyzing the relationship between these greening spaces, It explores the aerial greening corridor suitable for ecological sustainable development in urban space. In this way, the jump point of birds can be formed to achieve harmony between man and nature and achieve ecological balance.

Jiangbei New District, as a state-level new area in Nanjing which government has focused on in recent years, sustainable development of urban environment should be considered before its design and construction. The convenience and efficiency are particularly important in designing and constructing roof gardens of newly built buildings and existing buildings in the area. Therefore, this paper also discusses the integration technology of modular components for roof gardens and modular greening technology.

2. Background

2.1. Research on roof greening

Most of the world's population now lives in cities. So if we are to address the problems of environmental deterioration and peak oil adequately, the city has to be a major focus of attention (Richard, 2006). With the high-intensity and high-density development of land during the urbanization, green space is becoming smaller and smaller. "Roof greening" is an effective way to solve the lack of public green space in urban central areas and improve the effectiveness of ecological greening. The implementation of "roof greening" construction will be conducive to

improving the ecological level of the city, purifying urban environment and upgrading the quality of the inhabited environment. Accordingly, "roof greening" is not only an important part of city image, but also a significant manifestation of urban civilization, and a vital measure to build an ecological city.

A green roof or living roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems (Vandermeulen, Verspecht, Vermeire, Huylenbroeck & Gellynck, 2011).

Green roofs serve several purposes for a building, such as absorbing rainwater, providing insulation, creating a habitat for wildlife, increasing benevolence and decreasing stress of the people around the roof by providing a more aesthetically pleasing landscape, and helping to lower urban air temperatures and mitigate the heat island effect (Vandermeulen et al., 2011) and decreasing stress of the people around the roof by providing a more aesthetically pleasing landscape, and helping to lower urban air temperatures and mitigate the heat island effect.

Green roofs create natural habitat as part of an urban wilderness. Even in high-rise urban settings as tall as 19 stories, it has been found that green roofs can attract beneficial insects, birds, bees and butterflies. Rooftop greenery complements wild areas by providing stepping stones for songbirds, migratory birds and other wildlife facing shortages of natural habitat.

The area of urban roof occupies about one fifth of the urban area. If it is planned and utilized reasonably, the urban environment and greening will be improved significantly. Presently, the field of roof greening in China is still in the development stage, and the technology needs improvement. In the process of urban development, the sustainable development, design and utilization have not been valued. Therefore, the renovation plans of many roof gardens have been limited and influenced by the original roof structure. Nowadays, modularized integrated roof gardens are carried out to adapt to the demand of urban roof development.

Currently, there are few feasibility studies on urban roof gardens acting as springboards for flying animals. Research on the distribution of stepping stones can be used for designing urban greenways.

3. Study Object

3.1. Design concept of Jiangbei New District

Located in the north of the Yangtze River, Jiangbei New District (Fig 1) is a state-level new area in Nanjing. It consists of Pukou District, Liuhe District and Bagua Zhou street in Qixia District. Its total area is 2451 square kilometers, accounting for 37% of the area of Nanjing. Jiangbei New District is an important strategic fulcrum of East China. There are convenient highways, railways, waterways and aviation hubs. It is an important intersection between Yangtze Economic Zone and East Coastal Economic Zone, and it is an opening door of Yangtze River Delta radiating the Midwest of China.

The development orientation of Jiangbei New District (Fig 2) is a state-level demonstration area for industrial transformation and upgrading, new-type urbanization and open cooperation. It is also an important development

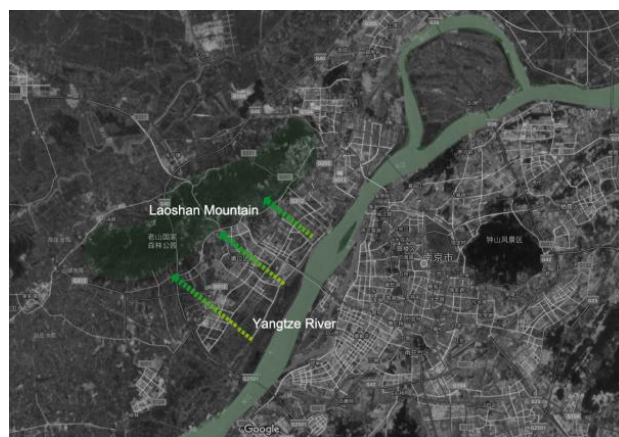


Figure 3 Green axis of Jiangbei New District



Figure 4 Three-dimensional traffic in Jiangbei New District

fulcrum of Yangtze Economic Zone and Yangtze River Delta, as well as an important base for scientific and technological innovation and advanced industry in China. The Northern Service Center and comprehensive transportation hub of Nanjing Metropolitan Area; and the ecology of Nanjing City. A suitable and relatively independent urban sub center. Jiangbei New District is the northern service center and comprehensive transportation hub of Nanjing, and a livable and relatively independent sub-center.

The planning of the central area of Jiangbei New District will integrate comprehensive services such as commercial business, cultural leisure, and tourism education. At present, according to the needs of urban development, many urban parks have been planned and designed between Laoshan and the Yangtze River, forming greenways between the two places.

Bird ecosphere in Jiangbei New District

Facing the Yangtze River and against Laoshan National Forest Park, Jiangbei new district has an excellent geographical location, and it is an undeveloped ecological community with high greening rate. There are settlements of various birds in this area. Along the Yangtze River, there are many migratory birds in the wetlands. Laoshan National Forest Park, as the largest forest park in Nanjing, has a large number of wild birds.

To study the jump point effect of the roof garden, it is first necessary to research the species, flight distance and habitat of the birds in the area. According to the surveys, the main habitats of birds in Jiangbei New District are areas as follows: The Yangtze River Wetland and Lvshuiwan Bay: Snipes, lapwings and eophona migratoria harterts; Laoshan: Shiziling Forest Farm: Minivets and brain-fever birds; Egret Garden: Egrets, cattle egrets, chinese pond herons and herons; Laoshan National Forest Park: Cyanopica cyanuses, grey treepies, Chinese bulbuls and masked laughingthrushes; Railway Forest Farm: Brain-fever birds, black-eared kites and tomtits; Tangshan Hot Spring: Yongning Egrets; Nanjing University of Technology: Mynas, barn swallows and cyanopica cyanuses; Qilihe River: Ceryle rudis, greater pied woodpeckers, daurian redstarts and tringa erythropuses; Pukou Campus of Southeast University: Thrushes, greater pied woodpeckers, magpie robins and tringa ochropuses;

Table 1. Flight height and distance of birds.

Species	Flight height(m)	Flight distance(km)
Blackbird, brown headed Brucea, black tailed waxbeak, great tit, grey magpie, grey tree magpie, Bulbul, black faced noisy babbler	<100	2.5~3
Barn swallow	>100	2.5~3

Table 1 continued

Egret, cattle egret, pond egret, Heron	>100	>3
Black-eared kite	>1000	>3

It can be seen from the table that the flying height of most birds in Pukou District does not exceed 100m. Even if the flying height of birds like barn swallows exceeds 100m, the living range is also within 2.5 to 3km. As for large predatory birds, generally they have strong flight ability and have little demand for roof gardens.

Therefore, based on these information, a limited range of height for urban planning can be drawn to design roof gardens that allow birds to jump in the air.

4. Analysis on urban spatial form based on roof gardens

Pukou new area is a belt space between Laoshan and the Yangtze River. Jiangbei New District is an approximately square urban space between Laoshan and Pukou wharf. Presently, in the urban design made by SOM, a green corridor (Fig 3.) has been reserved between Laoshan and the Yangtze River. This green corridor is composed of several S-shaped strip green spaces (Fig 4.), and it interlaces with Qilihe River, and other water systems, forming a good ecological circle. The core area has a central avenue from Laoshan to



Figure 3 Green corridor of Pukou new area



Figure 4 S-shaped strip green spaces of Pukou new area

the Yangtze River, which will become the main axis space in the future. In order to reduce the use of private cars and carbon emissions, transit-oriented development is adopted and 5-minute walking range of metro stations has been taken into consideration for deciding the development sites. From the previous urban space design made by SOM in 2015, it is difficult to form an aerial greenway because there are many landmark buildings on the central avenue with high height and high density.

However, along the S-shaped green corridor on both sides, there are many multi-storey, low-rise buildings, and high-rise buildings no more than 100 meters. These buildings are suitable for the design of the roof gardens acting as jump points in the air. Therefore, the green corridor is not only feasible on the ground, but also can be extended to the three-dimensional space through the roof gardens.

It can be concluded that the control of buildings on both sides of the green axis within 100 m is more suitable for the movement and migration of birds in the aerial garden. Through bird activities in Pukou District, the whole green area will be more ecological, and species diversity can be preserved in this strip space. Similar green jumping points can be found between strip green corridors and rivers. The aerial green corridors composed of these corridors are not a single linear space, but a network space. And it is a space showing a multidimensional network.

5. Modular technology of Roof Gardens

The main disadvantage of green roofs is that the initial cost of installing a green roof can be double that of a normal roof (Getter & Rowe, 2006). Traditional roof gardens, which require a reasonable depth of soil to grow large plants or conventional lawns, are considered intensive because they are labour-intensive, requiring irrigation, feeding, and other maintenance. Intensive roofs are more park-like with easy access and may include anything from kitchen herbs to shrubs and small trees (“Seattle Department of Planning and Development”, 2008).

Under the demand of rapid construction, a modular design idea is needed. Modular design is a combination of different forms of modules to create a variety of styles of space, just like building blocks. The modular roof garden has several features such as versatility, economical practicability, quick operability, safety and aesthetics. Therefore, it has strong adaptability in the construction of the new buildings and the renovation of existing buildings in the new district.

The following modular design methods are available:

First point: Plant landscape module: Generally, the planting layer of roof gardens consists of these layers: Vegetation layer, soil layer, blanket, drainage layer, water barrier, etc. In the process of arranging the roof garden module landscape plants, the lightweight root zone is explored, and the vegetation layer, the blanket and the drainage layer are combined in a modular way to form a system for water permeation, filtration, collection and conveying. As for plant selection, due to different geographical locations and climatic conditions, the selection criteria of roof garden plants should be adapted to local conditions. Generally speaking, evergreen, slow-growing, shallow roots and moisture-tolerant plants are usually chosen for later management and maintenance.

Second point: Artificial landscape module: The artificial landscape of roof gardens includes roads, squares, etc. When designing the roads of roof garden, lightweight, durable, ecological, environmentally-friendly and anti-skidding paving materials are usually taken into account combining with modular characteristics to coordinate with surrounding environment, and pursue an artistic effect of concise. Meanwhile, there should be a good connection between artificial landscape and plant landscape.

Third Point: Facility module: When designing roof garden landscape, rainwater filtration and gathering system, solar drip irrigation system and solar lighting system are considered and applied in the facility module. The connection and transition between each module should be handled well.

Fourth Point: The modular planting method of roof gardens directly separates the relationship between the planting soil and the ground, which significantly reduces water-holding capacity of the soil. Because of the lack of water storage, it is difficult for roof gardens to achieve water balance in a certain range of time. Therefore, proper watering methods and advanced watering techniques are important guarantees for the greening effect of the roof garden.

And so on, a number of light structures can be used in roof gardens to form a semi-enclosed roof space, which can provide birds with the possibility of nesting.

4. Conclusion

The arranging of roof gardens is very important for urban planning and design. An eco-city is not an existent form in which green spaces and buildings are in opposition to each other, but an urban design concept that aims at ecological

balance and is oriented by a three-dimensional ecological circle. The sustainable development of cities needs balanced natural environment and appropriate policy guidance.

Jiangbei New District, as an important demonstration area in Nanjing, has a certain demonstration effect on the urban design of the whole country and even the world. Based on this demand and the city's own development characteristics, the design of the roof garden and its impact on urban design make more sense. Through the data analysis and experiments of urban environment and ecosphere, as well as the concrete practice in urban design, establish an ecological “stepping stone” suitable for bird activities.

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