

Problems and Solutions in the Construction of Roof Garden in the Old Buildings

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Keywords: Old buildings; Roof garden; Load; Waterproof; Arrangement of plants

Abstract. This paper studied the problems and solutions in the construction of roof garden in the old buildings. Many cities have adopted policies to ensure the green roofs of new buildings, but more widespread of old buildings were ignored. Although the market potential is very huge, it has been neglected. This paper discusses the solutions of the construction the roof garden in the old buildings from three aspects: the safety of structural load, the roof waterproof, drained and the arrangement of plants. It is intended to provide a reference for research and application of the technology in construction roof garden in old buildings.

Introduction

In recent years, the concept of ecological architecture has become more and more popular. As people living standard rise, people puts forward higher requirements on work and living environment. And increasing the urban greening area and improving the deteriorating living environment has become a problem that needs to be solved.

Roof garden can also bring a lot of ecological benefits, such as can improve local microclimate, adjust the temperature and humidity of the city, absorb CO₂ and SO₂, release O₂, adsorption contaminant, purify air, blocking dust, and so on. At the same time, the expansion of green space increased the biodiversity of urban areas and improved the quality of life of urban residents.

Roof garden also play a role of intercepting rainfall, generally about 80% of rainwater pass flat roof gutter and drain pipe into the sewer, compared to 30% of green roof rainwater discharged into the sewer, alleviate the pressure of urban drainage system. And reduced the investment of municipal facilities. In short, the vast economic and social benefits of rooftop gardens are not comparable to those of ordinary rooftops.

In addition to extending the life of the building itself, the roof garden can also provide a good living environment to relieve the urban heat island effect. Roof gardens can reduce natural radiation by about 80 percent by using soil moisture and growing plants. After the experiment, the temperature reached 30 °C in the summer, the ground temperature reached 40 to 50 °C, but at the bottom of the roof garden just 20 °C. In winter, a roof garden protects buildings like a warm cover, thereby reducing the cost of air conditioning. Practice shows that the amount of energy saving is related to the thickness of the substrate and the type of plant. According to the test, the soil on the roof garden at 30 cm, it can save 15% electric energy a year on average.

Nowadays, urban construction is developing rapidly, and the area of green space is being occupied without supplement. The city is lined with tall building and hard pavement instead of natural soil and vegetation. As the result is the imbalance of urban ecological. In order to expand the urban green space, many large and medium-sized cities have built large parks. But in general, the development of horizontal direction of green space has not met the need. Therefore, construction of roof garden in the new and old buildings is an effective way to increase the urban green space area, also is the important component of the human sustainable development strategy.

Current Situation and Problems

Current Situation. Serious environmental problems have become obstacles to the development of the city, how to expand the green area, reduce the pollution of the environment to improve the

urban ecological environment, promote the sustainable development of the city, has become a top priority in the construction of cities today.

At present, the domestic existing green roofs area is in a small proportion. As Shanghai for example, it has 203 million m² roof scape, but only 1.3 million m² has established the roof garden. And most of them was in the new buildings. Lots of old buildings roof were waste.

Problems. For many years, the construction of the roof garden has been without a standard model and a standard process, exposing many defects and shortcomings. For example: cannot prevent leakage, loss of soil and water, the serious pollution, the unreasonable arrangement of plants, the exceeds of load, the exceeds of the construction cost. Especially old building, because of the lacking consideration, the roof in the old building was not suitable for the construction of the roof garden. Due to the original design without considering the load and roof garden drainage, makes the structure safety reserve is insufficient, drainage pipe diameter is not enough, the design difficulty is greater. Once these problems are solved, the construction of roof garden in our country will be developed rapidly.

The key technical problem of building roof gardens on the roof of the old building: First, the structural bearing capacity of the original structure; Two, roof waterproof construction processing; Three Reasonable arrangement of plants.

Solutions

Load. In recent 40 years, the multi-floor unit buildings accounts for a considerable proportion in each big, middle city of industrial and civil construction. Most of them were steel reinforced concrete structures and used to flat roof. The flat roof is divided into people can go up to the roof and people cannot go up to the roof. And people cannot go to the slope roof too. Usually, the flat roof with people cannot go up and slope roof, can't build a roof garden, but it can be in the roof surface climbing greening value objects.

For the roof in the old building that people can go up, the construction of the roof garden must to check the structure of the original building to bear the safety. In the structural design of the roof garden, how to determine the load is the first problem that structural design needs to solve.

The central problem of building roofs garden is the roof load which is directly related to the safety of people's lives and property, according to the items: CDB51/510016 -1998, CGB50345 -2004 and CGD50207 2002. Making the roof garden to get rapid development need to solve the issues of roof load.

The roof load of the roof garden is mainly of live load and static load. Live load of the roof garden on the old building Should not be more than 150 kg/m². And should not be conducted on the assembly or performance. Roof garden of the static load is relatively complex, which includes the area load, potted flower, and lotus pond, water load, rockery and sculpture, the ornament and landscape architecture. The larger load can be applied to the structure of the beam, column, or on the main wall that were the main consideration area load.

The load of the growing area, including plant, soil, filtration, and drainage layer, is the key to determining the load of the plant and the load of the soil.

The load of plants. At present, there is no complete information about the load of cover plants, flowers and shrubs. According to the foreign information, the load of plant in table 1.

Table 1 The Plant Load

Plant Species	Load (kg/m ²)
Cover plant, Lawn	5
Short low shrubs	10
Grown shrubs	20

Planting soil and its load. Different plant growth and reproduction of the soil layer Minimum thickness were different. Meantime due to the wind load that plants on the roof need a certain depth of soil. Above all, the soil thickness and load value of roof garden growing area were shown in table 2.

Table 2 The Thickness of Soil and Load

Category	Cover Plant	Small Shrubs	Large Shrubs	Shallow-Rooted Trees	Deep-Rooted Trees
Thickness of Plant growth	15 cm	30 cm	45 cm	60 cm	90-120 cm
Thickness of Plant reproduction	30 cm	45 cm	60 cm	90 cm	120-150 cm
Thickness of Drainage Layer	-	10 cm	15 cm	20 cm	30 cm
The average load	150 kg/m ²	300 kg/m ²	450 kg/m ²	600 kg/m ²	600-1200 kg/m ²

Drainage layer load. The thickness is usually 100 to 200mm pebble, gravel and coarse sand can be weighed 2000 to 2500 kg/m², the ceramic grain is 600 kg/m², and the weight is lighter when using plastic hollow ware.

In addition, the planting soil, drainage layer, and the filter layer, waterproof layer and leveling layer, when calculating the roof garden of load, can be unified into the weight of the planting soil, to reduce the calculation workload.

Water Proofing and Drainage Treatment. The construction of roof garden in the old buildings also need to solve another very important technical problem: water proofing and drainage treatment. Because of the old roof leakage rate was more than 30%, and the original building asphalt out of use in 10 years later or will be natural aging, appear rupture extremely easily. Therefore, before the construction of the roof garden, a completely overhauled and renovate the waterproof layer. Abandoned the traditional way in roof water proof, switch to the new overall waterproof layer, such as JG series waterproof layer or APP modified asphalt waterproof coiled material. This way of roof waterproof has been widely used in the roof garden of waterproof project in Italy, France, the United States, Canada and other countries. This asphalt has developed successfully and put into production in 2003 in our country.

The water outlet of the planting pond should be combined with the water outlet in the roof surface. And be careful not to dig holes in the roof and bury the pillars and iron parts in it. Before the construction of the garden, the test of water proof on the whole roof should be carried out, and the roof will be full of 100mm deep water. After 24h, check the floor boards and brick walls of the roof for leakage and find the exact cause and location of the leak. The construction of the roof garden projects in the old building will be fully inspected until the roof is perfect. If the check was not carry out carefully, it would be leak one day. As the result of leaking, the roof garden will be remove the roof garden projects from the roof and repair the roof and it will cost a lot.

For drainage, the key is to set up an unimpeded drainage system in the growing area. Due to the stagnant water effect of soil layer and the vegetation root leaves, silt and so on, it is easy to clog the pipe, so it is necessary to increase the drain and increase the diameter of the pipe. In addition, the original drainage system and the position of the outfall should be taken seriously consideration. New set of cultivation pool, water, and garden buildings, etc., should leave a distance with the original port. Garden road and the direction of the slope should also consider the location of the drain, make garden road drainage channel unblocked.

The building pottery is the ideal material. First it is lighter, with a weight of 600 kg/m², which is only a third of the gravel. Moreover, because it is made of drilling soil, the grain size is uniform, which makes the pore space between the clay grains, which is good for the air and water.

The ecological box is laid on the waterproof layer, the direction of the box should be uniform, the clasp should be tightened, and the laying of a straight line. In the place of the intersection of the pebble, the water board should be added. When the eco-box is laid, the light perlite is added to the box, which is covered with a non-woven cloth. The joints of non-woven fabrics and other nodes must be bonded securely with adhesives.

The special complex soil is packaged in bags, which should be spread in batches. According to the measuring standard point or fixed building and structure of the site before planting, set the line to be accurate. Light qualitative roofing garden plant can be stonecrop plants or low drought-tolerant plants. The thickness of the matrix should be uniform, and plant planting should be moderate. After completion of construction, check the roof drainage system and the flow of the drainage system, liquidation may be clogged drainage of construction waste, prevent the drain plug.

Arrangement of Plants. Due to the roof garden on the top of the building, the natural environment of the plant is different from the ground, such as sunshine, temperature, air composition, wind, etc. In different areas, the collection of plant will be different, local plants should be the first choice as plant materials. The roof compared with the ground, it has higher sun radiation, bigger light intensity, longer light time, it is favorable to the plants growth. Roof in a higher position, the temperature should be lower than the ground, but the roof sunshine radiation is strong, such as reinforced concrete roof material by the solar radiation heating up fast, strong reflection. During the summer, the roof is 3-5 °C higher than the ground. And the temperature is 2-3 °C cooler than the ground at night because of the large wind in the roof. The large temperature difference is good for the growth of plants. The temperature in the winter of the roof garden is at least 5 °C above compared with the ground. Because the roof is high, the sun is abundant, the temperature is high, the wind is high, so relative humidity is 10-15% lower than the ground. Especially in the summer, transpiration is strong, and the building materials are hot, the water evaporates fast, and the plant's demand for water is more important. In general, a height of 10m building the wind will be 1-2 times higher than the ground. In the windy buildings, the wind of the roof is larger. Because of the larger wind in the roof garden, arrangement the big tree is not a smart choice.

In view of the above the actual ecological factors on the roof, choose the dry climate, shallow root resistance, robust, low wind resistance, cold resistant and drought tolerant, transplantation, varieties of plant of slow growth will be good.

Use fewer trees, try to choose sun plant, drought-tolerant, hardy, the shallow root flower shrubs, climbing plants, cover plants and flowers, but also must be low, the variety of wind resistance, resistant to transplant to create landscape. Large flowered shrubs, small trees put them in the pot. Depending on the plant, the collocation between the different shape, color, design and color, the organic combination of flowering plants, form a micro-ecological communities, effectively change the microclimate, creating a beautiful and comfortable garden space. Choose to be adaptable to manage the coarse native plants, which will not only show the local characteristics, but also facilitate the maintenance management in the future.

Roof area uses the artificial planting soil, not only can greatly reduce the load on the roof but also suitable for nutrient-rich planting soil. At present, the more commonly used light materials of the roof garden were peat, perlite, wood chips and vermiculite etc. These materials weight in were well below the weight of ordinary earth 8t/m³.

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Conclusion

The construction of roof garden in the old building has lots of difficulties and cost lots of money. But in a long run, architecture with the roof garden compared with the ordinary building will more cost-effective. Because they can protect the structure of the structure layer and waterproof layer, make it more durable, and reduce the maintenance costs.

At present, the roof garden in the old building is still not enough popular. Scientific design, construction and management methods, still need to constantly explore in practice and summary.

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