

Analysis of the Experience of Western Countries in the Use of Roofs of Low- And High-Rise Buildings

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Abstract: The article proposes the use of green roofs as a solution to the global socio-ecological problems caused by the increase in the level of urbanization, and the experience of Western countries is analyzed in order to implement this idea in the regions of Central Asia.

Keywords: building roof, green roof, usable roof, relative area of greenness, green tower, urbanization, environmental sustainability.

In many foreign countries of the world, the experience of designing and constructing buildings using green plants on the roofs of buildings has been for a long time, which serves to reduce the negative impact of these buildings on human health and the environment today and for decades to come. In a number of European countries, including Germany, France, the Netherlands, Norway, Italy, Hungary, Sweden, Greece, there are associations that actively promote the idea of "green roofs". For example, in the city of Linz, Austria, since 1983, the costs for greening the roofs of the building are covered by the local government. In Switzerland, the federal law on green roofs was adopted in 1990, and the construction of roofs of buildings is carried out on the basis of this document. In Canada, tax incentives are provided for residents of residences with green roofs. The trend of greening building roofs has developed mainly in countries where the costs are fully or partially covered [1].

Starting from the 1960s, the first scientific foundations of green roof technology were developed in European countries, namely Switzerland and Germany. German technologist Reinhard Bornkamm published his first scientific research on green roofs in 1961. In these scientific works, Bornkamm conducted research on limiting the deep growth of roots, waterproof membranes, drainage, and plants that grow easily in any environment. Based on his ideas, the roof of Geno Haus bank building in Stuttgart, Germany was greened in 1969, and this roof is still in use today (Fig. 1).



Figure 1. Geno House bank building in Germany

In the 1970s, a number of scientific researches were conducted on green roof technology. In particular, the famous German landscape architects Gerda Gollwitzer and Werner Wirsing have created liveable, vegetated, green roof projects, and in their scientific research, plants that grow well on the roof, limiting plant veins so as not to damage roof structures, water plants problem-solving questions about impermeable membranes, drainage, lightweight plants were given. As a result of such scientific solutions, in the 1980s, the market of green roofs in Germany developed further (an annual growth of 15-20%). By 1989, 1 million m² of green roofs were built in Germany. By 1996, this figure was 10 million m² [2]. This increase in numbers was due to state legislation and city government subsidies paid for each square meter of green roofs. Later, this experience was used by other European countries, as a result of the state's support, the green roof industry developed in countries such as France, Norway, and Sweden. A lot of scientific research on greening of roofs has been done in Europe based on the experiences accumulated for more than 30 years.

The main experiments were carried out in Germany, Scandinavia, Switzerland[3]. FLL (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau) "Society for Landscape Development and Construction Research" was established based on the experience gained in the research, which implements green architecture in Germany.

In this regard, the French state is distinguished by the fact that in its new Urban Development Code adopted in 2016, it has set important environmental goals for the territorial planning strategy [4]:

Including:

- preservation of existing natural landscapes, air, water, soil quality, natural resources, biodiversity, ecosystems, green areas;
- fight climate change and create architecture suitable for these changes, prevent greenhouse gas emissions, reduce energy demand.

In this document (French urban planning code), special emphasis is placed on the "used and green roof" as a source of overcoming the above problems. According to the new law, the roofs of the buildings under construction will be fined if they are not used. The French government has allocated 250 million euros for these activities. To date, as a result of such activities in the capital of France, Paris, the area of greenery per person in 2016-2022 has increased from 11.2 m² to 15.8 m². increased by m². Government representatives planned to increase this indicator to 19 m² by 2030.

In France, such campaigns began in the last years of the last century. In 1994, on the basis of the projects of landscape architects Francois Brun and Michel Pen, the Jardin Atlantique was established on the roof of the Montparnasse station in Paris, on an area of 3.5 hectares, 18 m above the ground, in the style of French regular gardens. In order not to damage the structure, the soil on the roof is covered with a thickness of 20 cm. Trees, bushes and flowers are selected in such a way that you can enjoy greenery in this place in any season of the year.



Fig. 2. The roof of Montparnasse station in Paris. Jardin Atlantique Park

The first modern green roofs in the USA were built in the first half of the last century, in the Rockefeller complex in New York. According to the project of landscape architect Ralph Hancock and architect Raymond Hood, it is planned to establish 11 gardens connected to each other by bridges on the roofs and terraces of the buildings of the complex. Architects such as Reinhardt, Hofmeister, Corbett, Harrison and Mac Murray participate in the creation of gardens with their projects. The first green roof in the complex was the roof of the 72-story General Electric Building built in 1933[5].



Figure 3. General Electric Building and roof garden, 1935 USA.

At the next stage, the largest garden (23,000 m²) was built by Ralph Hancock on the 11th floor of the main building of the complex. On April 15, 1935, the opening ceremony of the garden was held, and more than 1,200 guests paid \$ 1 came to see the garden that grows on the buildings.

2 types of methods were used in the establishment of gardens on the roofs of complex buildings:

1. Growing plants in small areas in 45 cm high containers (flat, similar to tubs);
2. In large areas, grow plants on soil beds up to 1 m thick and secure their edges with protective walls. This method was first used by Hancock [6].

And under the soil layer was the drainage part - ash, broken brick, crushed stone and drainage pipes with holes. According to Hancock, the key to making the entire green roof system work well is drainage. Several layers of bitumen mastic were used to protect the tiles from water. In

order to protect the gardens from the wind, decorative fences made of light construction were used [7].

The high cost of operating the roof gardens (\$45,000 per year) and Hancock's move to England weakens the attention of the local authorities to the roof gardens. In 1938, public access to the gardens on the top of the complex is prohibited. Currently, the Rockefeller complex has only 3,000 m² of gardens, which add additional green space to the city, and at the same time serve to reduce the heat effect of the area.



Figure 4. Today, it is a garden on the roof of the Rockefeller complex.

Another green roof established in the USA is located at City Hall, the mayor's building in Chicago. The roof garden was established in 2001 on an area of 3,600 m², and the green roofs have a heat island effect in urban areas, the amount of precipitation that flows, the roof garden for the climate of Chicago. It served as a test project for the selection of plants with a chance to grow.



Figure 5. The roof of City Hall, the mayor's building in Chicago.

The green roof is closed to the public, but you can't beat the garden, fresh air, humid environment, beautiful view, and the rooftop is visible from 33 other taller buildings in the area. Designed by the design team at Chicago's Conservation Design Forum and famed "green architect" William McDonough, the roof features more than 20,000 plants of more than 150 species, including shrubs, vines, and two trees. Because of the abundance of plants that bloom year-round, beekeepers harvest about 200 pounds (91 kg) of honey from rooftop beehives per year. Rooftop tours are organized by special arrangement only. In 2002, the City of Chicago received an award from the American Society of Landscape Architecture (ASLA) for this green roof.

According to 2010 data, the total area of green roofs in the USA and Canada is 900,000 m². Another green roof was erected above the Gary Comer Youth Center designed by Hoerr Schaudt Landscape Architects in Chicago, Illinois, USA.



Figure 6. Gary Comer Youth Center, Chicago.

The project was put into operation in 2006 by landscape architect Peter Lindsey and employees of Kierkegaard Landscape Organization. The green roof above the gymnasium and cafe in the center is covered with a 60 cm floor. In addition to various plants and flowers, you can also find vegetables and fruits in this place. This green layer serves as a good insulation for the buildings below, saving the costs of heating and cooling the building. According to the observations of the technical staff of the building, during the rainy season, the roof covered with vegetation absorbs more than 50% of the rainwater, helping to reduce the pressure in the drainage systems [8].

Activities promoting green roofs are included in the US strategic document OneNYC 2050 approved by the mayor of New York in 2019, which includes 8 goals and 30 initiatives that prepare the metropolis for the future. In particular, the 6th goal is called "Creation of favorable climatic conditions for the population" and it is aimed to build residences in the metropolis based on the principles of green architecture [9].

Regarding the use of roofs, the roof of the Selfridges shopping center in the capital of England deserves special attention. In the 1920s and 1930s, this roof was used as an entertainment venue for fashion shows and golf games.



Figure 7. The roof of Selfridges Center in 1930.

The author of the project was American urban planning architect Daniel Hudson. In 2011, the building and its roof were reconstructed by the Italian architect Renzo Piano.

Since 2011, the roof has been used as an entertainment area. On this roof in the center of London, not only a garden, but also a system of artificial water bodies was designed, where boats can be freely walked.



Figure 8. Selfridges center roof 2001.

Warsaw, the capital of Poland, was named the best European city for travel in 2023 by the European Best Destinations project. Indeed, this city is favored by many travelers with its modern architecture and rich history. One of such examples of architecture is the roof of the University of Barshawa, which is one of the largest rooftop botanical gardens in Europe, attracting not only students, but also visitors to the country. Here, visitors can walk around the large and small ponds and find everything from Polish native plants to exotic plants.



Figure 9. The roof of Barshawa University.

The roof project was completed by landscape architect Irena Bajerska and commissioned on June 12, 2002. The garden consists of two parts: the upper garden (2000 m²) and the lower part (15000 m²). The lower garden contains ornamental flowering shrubs (including *Stephanandra incisa* 'Crispa'), as well as alpine plants. Trees, shrubs and perennials are mostly found in blue and pinkish-white colors. The territory of the upper garden consists of four parts, in which plants planted in a layer of soil 30 cm thick live.

The influence of the large urban agglomeration in and around Warsaw is very large (urban heat island effect). This is reflected in above-average temperatures and higher precipitation in the city center; the warming of the air leads to strong convection of clouds, from which more precipitation and storms fall. The temperature difference between the city center and its outskirts can be 7-8 °C, even up to 10 °C [10]. Due to the height of the buildings in the city center, the wind speed is also reduced. Due to high air pollution and aerolization, cloudiness increases and air transparency decreases, which leads to a decrease in sunlight and an increase in diffuse radiation. Warsaw has 1,600 hours of sunshine per year, but in the city center this indicator is 10% lower than outside the city.

N.P. According to Titova, the roof of modern buildings heats up to +800C on hot days, this process occurs not only due to the heat of the air, but also due to toxic waste in the air. This has a negative impact on the city's climate. In big cities, the above processes cannot be avoided, and we can reduce its negative consequences only by greening the roof surfaces [11].

The research of German scientists shows that with the help of green roofs, the temperature of the building roof can be lowered to 25°C in summer. The daily average temperature on the green roof with traditional roll roofing differs not only in winter, but also in summer. As a result, the costs of cooling the building in summer and heating in winter are saved. In addition, plants on the roof prevent dusting of the air. On hot days, dusty air masses settle on the surface of bushes and trees, as well as on the rough surface of leaves. It is because of these reasons that Western countries attach special importance to greening of buildings.

Western Malakal is located in the region of the earth with moderate climatic conditions, there are few very hot, hot and dry summer days. Even so, global climate problems have disturbed the existing climate conditions, even if they are small. The higher organizations of the Western countries have been searching for adequate solutions to such problems and bringing them to the political level, achieving good results. However, the above problems are still waiting to be solved for the countries of Central Asia, which are strongly continental, mostly arid and hot.

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