Ecological architecture: the green roofs

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Abstract. Ecological architecture is not just a new-fashioned tradition and an attempt to keep up with the times. If you think globally, then ecological architecture is a new way of life and thinking, the opposite of what is generally accepted. For several centuries, man has been using nature as he pleases. The peak of this trend, perhaps, happened in Russia, when the Soviet authorities changed the river beds for their convenience, planted the fields with crops unacceptable for the climate and soil. In the twenty-first century, the world community understood the value of nature and took up preserving it sensibly. The problem of environmental pollution is very relevant at present. Many technologies are being created to protect our planet, and architecture is one of their main components. In this article, we looked at the new ecological type of roofing - the “green roof”, examined its pros and cons and summed it up at the end.

1. Introduction
The question of environmental protection often arises in modern society. People strive for a good, comfortable life through the development of technology [1-5], but it is also very important that it does not harm the environment [6-10]. In this case, architecture plays a key role, because the construction material is directly related to natural resources. Today we consider roofings as one of the construction parts. There are many types of roofs, such as metal, galvanized steel, slate, etc., but has anyone heard a term like "green roofs"?

"Green roofs" means "planting greenery on the roofs" in English. This phrase means partial or full filling of a roof with live plants. Plants are planted directly into the ground, and a waterproof membrane layer is installed between it and the roof. This technique appeared relatively recently, but the "green roofs" already have a history of their own, as they appeared several centuries ago. This design has excellent thermal insulation qualities. In the cold countries of Scandinavia or Iceland, “green roofs” helped to keep the houses warm, and in hot countries, such as Tanzania, for example, they kept the room cool [11-16]. Modern planting technologies appeared in the 1960s in Germany due to the deteriorating environmental situation in the city. In the following decades, this application of planting of greenery spread throughout the world.

Today this kind of technique is mostly popular in megalopolises: on the roofs of shopping centers, office buildings, residential high-rises. Just recently "green roofs" began to be made for country houses and household buildings. But one can agree that it has long been thought out how to heat houses in the modern world, and an air conditioning system was created to make rooms cool. But then why is the demand for this technology increasing every day? Let us find it out.

The traditional arrangement of the green "turf" roof.
Not every resident of a large city has the opportunity to relax in the forest or breathe the fresh air in mountain meadows. Most often, it is not enough time to take a nature hike. Multi-meter buildings, stuffy streets and scorching asphalt under their feet are depressing every day. Therefore, many happy owners of private homes seek to achieve their desire to communicate with nature in the construction of housing from natural environmentally friendly materials.

Russian experts have learned many technical solutions for the installation, weatherization, decoration and reconstruction of houses from the experience of the Scandinavian countries. Finnish, Norwegian and Swedish engineers have long been using a number of technologies in the construction that are becoming popular in our country just now.

Among them is the very “turf roof”, which is being actively built on residential buildings not only in Scandinavian countries, but also in some European ones.

The general principle of building a green roof in the old Norwegian version was as follows: a clay bedding material was placed under the sod layer. Its thickness was about 10 cm. Clay served simultaneously as a heat and water proof. Using that kind of system, it was necessary to create very strong supporting structures. Not only did the dirt cake weigh a lot, in the winter a mass of snow was added to this load. If the supporting pillars were not weighty enough, the inhabitants would wake up one morning with a pile of earth and snow on their heads. Perhaps in the summer the building looked very picturesque, but the arrangement of that kind of roof was not cheap. For some time, they completely stopped doing a turf roofing.

Perhaps an interesting constructive solution would have remained a relic of the past, were it not for the new manufacturers who recalled the well-forgotten old Scandinavian customs.

Modern installation of green roofs.

The challenge for modern specialists was to reduce the overall weight of the roof structure. With this technology, it was necessary to preserve its decorative appearance. The main problem was to create a durable layer of waterproofing. It was supposed to be dense enough so as not to let in moisture and plant roots, and light, so as not to give a serious load on the roof structures [17-20].

A supporting flooring is laid as the first layer. The material in this case is unimportant. It can be boards or sheets made of pressed chips. Linings are is also suitable, but then the cost of building materials increases slightly.

The next layer is insulation. This part of the roof structure should protect the roofing rooms from rain and melt water penetration. In addition, it is the insulation that prevents the germination of plant roots. The building stores offer a lot of rubber or bitumen-based roll waterproofing. There are plenty of choices.

Figure 1. "Green roofs".
2. Methods and materials
The work is carried out using a set of modern methods of theoretical and experimental research: modeling of the formation of layers; design of the experimental batch; laboratory experiments on the selection of the optimal composition and thickness of soil layers; the use of methods of mathematical statistics and computational software package Microsoft Office.

3. Draining systems for green roofs. Drainage options
Once the way into the house for the water is blocked, it means that it must find a way out in another place. For this, roof drainage is provided. Without this layer, water will accumulate on the waterproofing surface and cause acidification of the soil. This, in turn, will cause rotting of the roots and stems of the green covering, which will spoil the whole idea of creating a green roof. A thin layer of sand or rubble can be poured as a drainage. If possible, one can buy lighter coatings such as geotextiles [17, 21-23].

Ready-made solutions are often used as drainage systems for green roofs.

1. Drainage Plates

![Drainage Plates](image1)

**Figure 2.** Drainage plates.

Drainage plates are profiled plastic panels that are interconnected and laid over the entire roof area. Water is kept in reservoirs of the plates, and its excess amount flows to the bottom plates. Thus, the water is drained away to the lower part of the roof and further to the outer drainage system.

2. Drainage pads

![Drainage pads](image2)

**Figure 3.** Drainage pads.

Drainage pads work on the same principle as the drainage plates. They are fairly quick and easy to install. Plus, they function as a waterproofing material. However, water disposal in this way is limited by the roof slope. This method will not work for too shallow or flat structures.

3. Drainage boxes

Not only properly selected material, but also the slope of the roof affects good drainage. If there is no slope, another problem arises. It is necessary to take measures to forcibly remove water from the roof or use drainage boxes. Water enters the funnel, and then flows down the sewer or drainpipe.

4. The cost of installing the "green roof"
As stated by the company "Green Roofs for Healthy Cities", installing a square meter of green roof costs about 120-180 US dollars. This price does not include a waterproof coating. The installation cost is directly dependent on the type of landscaping, the material of the coatings and the complexity of the installation of supporting structures [16-17].

It is also worth remembering that it will be necessary to spend money on annual weeding of the vegetation, and fertilization of the soil.

In some German municipalities, the installation of a green roof has already been made mandatory under penalty of fine for all owners of flat roofs. Authorities say that, as a result, there is less dirt, it becomes cooler in summer, and the air is cleared. In the vicinity of Stuttgart, even huge warehouses are covered with grass, otherwise the buildings simply will not be put into operation.

The owners of green roofs point out how interesting it is to watch how the roof's appearance changes depending on the time of year.

Green roofs in Russia only start appearing in the largest cities such as Moscow, St. Petersburg, Yekaterinburg, Kaliningrad, Tver, Voronezh, and some others. A prominent example is the green roof of Crowne Plaza Business Center in Pulkovo airport in St. Petersburg. In the project, implemented in 2011, a roof was created with extensive landscaping, covering an area of more than 2000 sq. m.

Green roofs are also used in the construction of international-level facilities for the 2014 Olympics in Sochi and the 2018 World Football Cup. There is an increase in the needs of real estate market to design eco-roofs in residential buildings, since the economic effect of their presence in the implementation of development projects has the prospect to exceed the costs of construction by more than a third.
Meanwhile, there are some factors that slow down the development of this idea in our country, and they cannot go unnoticed. These factors are associated not only with economic conditions, but also with established stereotypes.

So, here are the advantages of "green roofs":

1. Improving the environment, because green plantings purify the air, retaining about 20% of harmful impurities.
2. As we have said, it is the increase of the insulation level. Plants help regulate the heat transfer between the building and the environment.
3. The increase of noise reduction. This roof is perfect for buildings that are located near railway tracks, airports, and highways.
4. Long service life. This method involves protecting the roof from negative influences, such as moisture, snow and sunlight.
5. These roofs are undoubtedly a stunning additional recreation space.
6. And of course, green roofs are the aesthetic components of modern urban planning. They are original and always memorable.

It should also be noted that, except the positive sides, there are a number of disadvantages.

1. First of all, this is a high initial cost.
2. It is very difficult to establish that kind of structure in earthquake-prone areas.
3. The problem of the permanent preservation of roof humidity is relevant for many plant species.

5. Conclusion
In addition to the obvious strengths (decorative, environmental and fire safety), the green roof has another advantage. The roofing pie is considered heavy enough to provide high-quality and uniform shrinkage of the house log. In summer, the eco-roof protects the building from sun rays inside the attic and creates a comfortable, cool indoor temperature.

Summing up, we can conclude that this type of roof has great prospects. People just need to think seriously that everyone switched to this technology, because this is our health and our clean air. It is clear that to implement this kind of project is not an easy task. But if you correctly calculate everything, the investments will be exactly justified. It will not take many years to repair that kind of roof, and over the years the appearance of the structure will be still pleasing the eye with its elegance and accuracy.

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Figure 6. “A green roof in Moscow in Bolshoy Gnezdnikovsky lane”.

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