Application of Green Roofing Technologies as Site Landscaping

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Abstract. Due to the problems of the urban environment, people began to develop the technologies for "green" roofings as site landscaping. The purpose of the study was to examine the design methods of "green" roofings and to identify their unique positive properties. The research objectives consisted of the analysis of the "green" roofing technology and the identification of their weak points. The study examined external and internal environmental factors characterizing the possibility of using the roof of the building. The following normative characteristics were considered as design methods for "green" roofings: load-bearing bases and slopes, load calculation, waterproofing, roots protecting barrier, protective layers, thermal insulation, vapor barriers, and building units. The results of the study are organizational and technological design solutions for a "green" roofing using regulatory documentation. The weak points of the "green" roofing can be solved by competent design and high-quality performance. "Green roofings" can be more widely developed especially in multi-storey constructions. Any one-time costs in the design and construction of any facility are economically justified if they provide low operating costs when using these facilities. The developers pay attention to the compositions and design concept of the layers of the cultural environment for growing plants, as well as methods of preserving the plant substrate. The design concepts related to operating roofs are of great interest: arrangement of sports grounds, pools, walking paths. The arrangement of a green roof is a multi-directional technological task and, if necessary, the purpose of the subsequent research. We can single out the implementation of forecasting the further development of green roofing technologies. In the future, a large number of green roofings can increase the ecological rating of the area.

1. Introduction

Today, the important problems of the urban environment are the lack of territory and poor ecology; therefore, "green" roofings technologies as the site landscaping started to develop actively.

The "green" roofing is a grassed and landscaped area within the boundaries of the operated roof of the building. The main task of this roofing system is to create an environmentally friendly greened site having both cleaning functions, and an aesthetic appearance. The segment of operated "green" roofings is a promising direction for both high-rise buildings in the urban environment and for suburban construction because of their functionality including the advantages of a full-fledged garden.

"Green" roofings can be used in different ways: as a recreation area (gardens), cultural and social areas (cafes, sun tanning parlors, parking lots), as conservatories and greenhouses.
The "green" roofing has a number of unique positive features:

- Reduced heat loss of the building due to the thick roofing pie in winter which cuts heating costs, as well as heat dissipation in summer due to natural thermal regulation in the trunk and leaves of plants.
- Ecology. "Green" roofings filter out dust particles and convert carbon dioxide into oxygen, and also purify storm water.
- The eco-roof protects the waterproofing layers from ultraviolet radiation, thereby extending their service life and the time between overhaul.
- Noise reduction in a wide range of frequencies.
- Fire safety. Fire cannot spread quickly over the roof due to green spaces and the earth layer.

But "green" roofings have their weak points. And the main one is, however, the cost, since such operated roofing requires completely different technical solutions, and this places great demands on both design engineers and installation workers.

The second weak point is the need to monitor the condition of the roof during operation. This is a particularly challenging task in the inter-season and in the winter.

The third weak point is the special qualifications of roofers during repair works on a green operated roofing.

However, routine maintenance of the "green" roofing is not so complicated, especially if it is designed properly for a particular building and has high-quality installation [1]. In fact, it comes down to the same measures that are required when caring for any garden, or lawn - basic watering and fertilizing plants.

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2. Materials and Methods

2.1. Let's consider environmental factors characterizing the possibility of using the roof of a building and structures as site landscaping [2].

Climate:
- Temperature changes: they affect the selection of material (their expansion coefficients and water-absorbing properties) and the choice of technical solutions (taking into account deformations as a result of temperature changes).
- Ultraviolet: it also affects the choice of roofing material which cannot be overheated since plants reflect a significant part of the sunlight without absorbing it.
- Wind: it is necessary to arrange parapets and substantial fastening of the top cover to prevent the formation of swelling and detachments of roof parts.
- Snow and rain: it is necessary to arrange a drainage layer.
- Chemically aggressive substances: when designing a "green" roofing at an altitude of less than 30-35 m, it is necessary to take into account the fact of the negative effect of industrial gases on plants [3].

Internal factors:
- High humidity: moisture condensation in the under-roofing space negatively affects the wooden and metal elements of the roof, therefore it is necessary to use technical solutions that allow the steam to go outside, for example, a film with low vapor permeability or partial laying of roofing materials.
- The remains of the life-sustaining activity of insects and microorganisms, birds: it is necessary to avoid the use of shiny objects (because of birds) and to protect wooden elements with special impregnations.
- Mechanical loads: it is necessary to take into account the uneven distribution of additional loads at the locations of green area and landscaping elements.

2.2. Let's classify the types of "green" roofings [4].
Depending on the approach to the arrangement, three main types of “green” operated roofings can be distinguished.

Extensive: it seems to be the easiest option of all. It includes the creation of an almost autonomous ecosystem with a relatively thin layer of turf, as well as the simplest plants which, after planting, exist independently without any care. Such a "green" roofing does not need a constant presence of people on its surface - and if this is required, then special narrow paths that support the weight of a person are organized for passage. This type of "green" roof will require minimal financial costs both during arrangement and maintenance. More over, the final load on the building will be quite small. The average weight of such a roof is usually from 20 to 35 kg/m², and the thickness of the soil is 5-15 cm. However, a designer will not have much to do around here - such roofs turn out to be quite typical and ordinary.

Intensive: this is a much more expensive and complex option. It involves the organization of entire gardens with the possibility of a constant presence of people on the roof. It is necessary to strengthen significantly the base - the minimum layer of soil base for an intensive "green" roofing is 1 m and the weight can reach 700 kg/m². As a result, even small trees are planted on such operated roofs, not to mention shrubs and other small plant species. As a result, the unique appearance compensates for any efforts spent on additional design, building strengthening, development and installation of plant irrigation systems.

The structural difference between an intensive roof and an extensive one lies in the mutual arrangement of the insulation and waterproofing. The insulation of the intensive roof is located on top of the waterproofing, and for an extensive roof - on the contrary.

The operated roofings with intensive simple landscaping: an option that is intermediate between the extensive and intensive green roofing. Such roofings are still adapted for the constant presence of people there, however, the main layer of the soil is significantly reduced to less than 1 m. This still allows to garden many plants and shrubs that are viable in these conditions, but the trees are excluded from the landscape design [5].

3. Discussion

During the study, the general issues of designing green roofings were analyzed [6]:

3.1. Bearing bases and slopes.

The base of the "green" roofing are the supporting structures of the building itself. Usually, concrete slabs in case of a flat roofing or a solid wooden crate in case of a pitched roof. In accordance with SP 17.13330.2016 [7], the slopes of the base should be 1.5-3.0%. They are created either with the help of supporting structures, or with the help of a sand cement screed. There are two options for the location of the waterproofing carpet: on a heat-insulating layer (traditional option) or under a heat-insulating layer (inversion option).

3.2. Calculation of loads.

Calculation of loads is performed according to SP 20.13330.2016 “Loads and effects” [8]. Additional loads to the calculation are as follows:

The weight of the soil layer in the wet state, the weight of the moist soil in containers (excluding the weight of the container which depends on the material used) with the size of the container, the weight of the grass cover, shrubs and trees.

Details and structures that give significant loads (large containers, hills) should be located above columns and supporting walls. Concrete decorative walls need to be oriented across the floor slabs distributing the load from them to several slabs.

3.3. Waterproofing.

The materials used are polyethylene films, polymer membranes, liquid rubber, as well as roll materials. Installation is to be made in two layers.

3.4. Roots protection barrier.
The materials used is landscape fabric which protects the remaining layers of the “roofing” pie from damage caused by the roots of plants.

3.5. Protective layers.

As a layer separating a waterproofing carpet and a cement-sand screed, rolled material Pergamyn (GOST 2697-83 [9]) or a plastic film is used.

The filtration layer (landscape fabric) is located between the roof and gravel backfill, which acts as drainage, or between the insulation and gravel drainage, as well as between the soil and drainage layers. Drainage is provided from washed gravel with a grain size of 5 - 10 mm, expanded clay gravel and perlite.

3.6. Thermal insulation.

The thickness of insulation is determined according to SP 50.13330.2012 [10]. The material used is a plate material, for example polystyrene foam boards (they are lightweight and have high heat-shielding properties), according to spesification 2244-001-47547616-00 [11], spesification 5767-002-46261013-99 [12].

3.7. Vapor barrier.

The vapor barrier shall comply with the requirements of SP 50.13330.2012.

The material can be modern bituminous materials, for example, surfaced roll materials without coarse graining with a reinforcing durable base of glass materials or synthetic fibers, as the most effective according to the laying technology [13].

3.8. Building units.

The places where pipes and anchors pass through the roof shall be sealed. In the joints between the roofing and the parapet, the layers shall be fixed with dowels, and the upper part of the parapet is to be finished with roofing steel fixed with crutches or covered with parapet tiles with sealing joints between them [14].

4. Conclusions

Today, due to the wide variety of composite materials designed for heavy loads over a long period, as well as the constant development of construction technologies, a “green” operated roof as a roofing solution is an excellent choice due to a huge number of unique positive properties and extensive functionality. The weak points of the "green" roofing can be solved by competent design and high-quality performance. Eco-roof is one of the best solutions to the problem of territories deficit in the urban environment and has a positive impact on the environment and ecology.

In 2012, the total area of green roofs and green walls grew by 24 percent in the United States according to a study conducted by Green Roofs for Healthy Cities (GRHC). In 2011, the growth was even greater: 115 percent. The leader is the capital of Washington with approximately 130 thousand square meters of green roofs. Chicago takes the second place with 60 thousand square meters, and New York is the number three: 36 thousand square meters.

An example of a successful project to improve the roof of a building in Moscow is the comprehensive improvement of the square of an administrative building (with a green roofing) located at a transport interchange (Sheremetyevskaya St., Vetkina St., Ogorodny passage, railway lines of the Leningrad direction) was carried out according to the project of the company “Ilya Mochalov and Partners”.

The purpose of this implemented project is the environmental rehabilitation of a degraded urban environment (transport interchange and new construction) using modern means of landscaping creating a vivid “small” space - a new urban square. When creating and implementing the project, BREEAM sections were taken into account.

In the design and construction process, several landscape techniques were used, which both changed the appearance of the previously deserted area around the building and the building itself, and also allowed to create a natural oasis that (despite being squeezed between city highways) is now a
favorite vacation spot for citizens as well as the habitat of many plants, birds and insects, thereby increasing urban biodiversity.

The main plantings of woody-shrubbery plants were carried out in the form of multilayer green wings, which created a reliable protective screen around the perimeter of the square and formed a cozy isolated space for relaxation. In addition to the undeniable visual effect, the plants created favorable conditions for the fauna. Numerous species abundantly blooming, resistant to urban conditions are as follows: decorative apple trees, hawthorn, serviceberry, spiraea, etc. both attract numerous insects during the magnificent spring-summer flowering, and also are tasty food for birds in the winter when bushes strewn with small apples and berries.

Landscaping completely excludes trimmed grass lawns and flower beds of annual flowers which are so traditional for modern Moscow. Instead, decorative gramineous plants (moon grass, phalaris, silk grass) were used, which are mowed only once during a season, and perennial flowers and wild plants (chamomile, burnet, tufted vetch, aliums, etc.) which can create a stable, self-renewing biotope.

Using vertical gardening of facades allowed to reduce the effect of overheating of the building facades in the hot season and at the same time created an additional “living screen” effect - barriers for suspended particles of dust and exhaust gases.

All hard surfaces of the square (parking paving, retaining walls, pedestrian walkways) are made of various natural materials: natural stone, wood, granite chips. Street furniture at the site (benches, litterbins, trash cans) is made of sustainable larch wood. Moreover, the canopy box for household waste containers has doors and green roofing therefore completely isolating it visually.

A special pride the authors of the project feel for the green roofing which creates a special mode of maintenance and operation of the building, as it extends the life of the waterproofing of the roof covering to 40-50 years, it saves heat loss in the winter and essentially eliminates overheating of the roofing in the hot period, it cleans and reduces 50% rainwater runoff from the roofing to the city’s storm sewer system returning it to the natural cycle. In addition, the "green" roofing compensates in some way for the loss of green territory at the site.

"Green roofings" can be more widely developed especially in multi-storey constructions. In this case, one more fact shall be taken into account: any one-time costs in the design and construction of any facility are economically justified if they provide low operating costs when using these facilities. The first lines of the metro is the most striking example in this regard. Being insanely expensive during construction, they have not needed major repairs for more than 50 years, and due to this fact, they justified long ago and by far the costs that had been incurred during their construction.

The developers of "green" roofing approach the solution of the issue multilaterally from the point of view of constructive solutions of the roof itself, including its hydro and thermal insulation, the composition of materials for these purposes, and from the point of view of developing soil layers and their placement on the roof of the building.

The developers pay attention to the compositions and design concept of the layers of the cultural environment for growing plants, as well as methods of preserving the plant substrate. Moreover, the design concepts related to operating roofs are of great interest: arrangement of sports grounds, pools, walking paths.

The arrangement of a green roof is a multi-directional technological task and, if necessary, the purpose of the subsequent research. We can single out the implementation of forecasting the further development of green roofing technologies. In the future, a large number of green roofings can increase the ecological rating of the area.

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