„GREEN ROOF" TYPE ARRANGEMENT – NOVELTY FOR MODERN URBAN LANDSCAPE DESIGN

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Vegetal roofs imply growing plants on the upper part of the buildings, thus replacing the surface taken away from nature by building that construction. Depending on the thickness of the substratum and the irrigation possibilities, there can be arranged extensive or intensive type plantations. The advantages of installing a green roof system are multiple, with a technical impact on the resistance and comfort a roof assures: ultraviolet rays protection, thermal shocks, thermal and sonic isolation, landscape impact, impact on health (improves the air quality), increases social and economical value etc.

The experiments show that an extensive type vegetal roof of 15 cm height reduces the overheating of the building with 95% and the heat lost with 26% comparing to a conventional type roof. A green roof acts like a humongous sponge, diminishing the pressure from the water collecting points, thus, during the summer, depending on the plants and the thickness of the growing substratum, vegetal roofs retain 70-90% from the rainfall, and during winter, 25-40%. It is proven fact that green roof type landscape arrangements increase a construction's value, residential or commercial, with 15-20%.

***Key words**: green roof, plants, waterproof membrane, substratum.*

The green-roof type arrangement system is a roof extension, made of multiple layers, including a water - proof and sun - proof membrane, a protection layer and one for the drainage system, a net-filter floor, a soil and vegetation layer, the last one being chosen considering the region's climate, soil and roof slope, from succulent plants like *Sedum sp.*, grass, plants with flowers, to tree species.

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MATERIAL AND METHOD

The green – roof type arrangement system implies using some synthetic sealing membranes (elastic polymers, PVC), mono or double layered. If bituminous membranes are used (multilayered asphaltic membranes), which can be penetrated by roots, association with a root pressure resisting folio is recommended. Checking and repairing the membranes after the vegetal roof arrangement is difficult, so the folios must be of a good quality, water-proof, highly durable, sustainable, resistant to extension and plant root penetration.(*fig. 1*). For the extensive type roofs membranes with approximately 20 years warranty will be used, while the intensive type roof is realized only with 50 years warranty type folios.

Another element, indispensable for an efficient installation of a vegetal roof is an isolator meant to protect the water-proof membrane against the mechanical shocks that can occur during the arrangement and maintenance.

The next component is represented by the separation layer that offers an open cavity under the soil layer, in order to assure the water drainage; it consists of a goffered polyethylene drainage membrane that must be very well separated from the growing layer. The perforated surface of this material assures the soil's aeration and the small cavities retain the water for the plants. The perlite layer, another element from the green – roof system's structure, also has a drainage and aeration function, and prevents the covering of the drainage and filtering layer with soil. The filter that covers the perlite layer is a geo fabric tissue that diminishes the infiltration of the small soil particles.

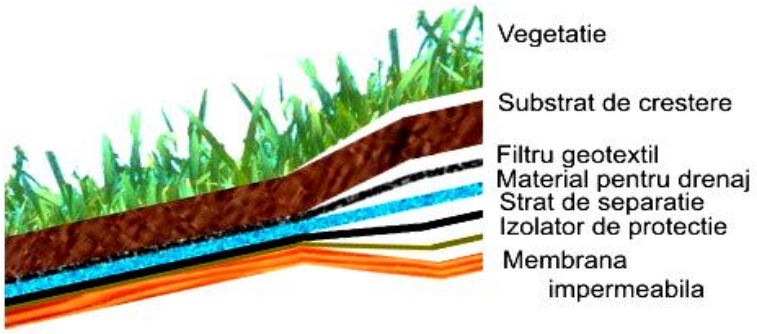

Figure 1 **The structure of the green – roof's components**

The growing layer for the plants must be light, stable, to have a balanced nutrients content, a pH value from 5 to 7, capacity of cationic change between 20 and 45, temperature conductibility factor of 0,42 and suitable to be installed on roofs with a slope up to 30-35°. It is not recommended a soil rich in organic matter because it will decompose, leading to crust formation and nitrogen and phosphorus depletion, the same problem appearing when fertilizers are applied. The substratum contains soil mixed with leaves, dried bark pieces and light, absorbent gravel of 3-12 millimeters in diameter. The volcanic stone, expanded clay or even brick crumbles are recommended.

The proper arrangement consists of assembling the layers presented above in accordance to the desired system (extensive or intensive). Thus, over the building's roof the protective membrane against root development is spread, and over it, the isolating material and the separation layer. The next step consists of assembling the perlite or another material in order to assure the drainage, followed by the geo fabric tissue. The last added layer is the soil. Along the parapets and at the roof's exit doors special pipes will be used to allow the drainage of the water from the alleys.

Figure 2 **Urban green – roof model**

In order to arrange a green – roof system there is another efficient variant which consists in using water – proof concrete in the building's construction, thus eliminating the necessity of water – proof membrane; the process is simplified and the economical viability is increased. The humidity input required for the plants development is essential, but the more inclined the roof is, the dryer the environment is, because the water drains quicker and the roof retains a smaller quantity of water for each square meter of surface, while the water can form puddles on a flat roof.(*fig. 2*). The roof's length, from top to eaves, influences the soil's humidity, too. There must be considered the fact that a roof segment, in accordance to its exposure, to north or to south, benefits from different light and heat conditions. In these conditions, irrigation becomes a neccessity.

RESULTS AND DISCUSSIONS

An extensive roof with a surface smaller than 300 square meters can be manually watered in the dry periods, but if the surface is bigger, a dripping irrigation system is necessary. The intensive systems can't be designed without an automatic irrigation system, because the plants need to be watered 3-7 times a week in summer and up to 3 times a week during the other seasons. An automatic irrigation system costs approximately 4-5% from the capital invested into the green – roof arrangement. Knowing that the vegetal roofs lose their efficiency if the soil is not kept moist, we recommend the installation of an automatic irrigation system, considering also the implied economical advantages.

From a technical point of view, all plants can grow on roofs, but some of them need constant care to protect them from the permanent sun exposure, frost

and strong winds. In most of the cases, the vegetation will only be herbaceous or shrub type and it will be chosen considering a multitude of factors, from which we mention: the region's climate, the type and the thickness of the substratum, the roof's bearing capacity, the roof's weight and slope, the maintenance disponibility and the presence or absence of an irrigation system.

In choosing the plants used for the arrangement of a green – roof type system there are preferred indigene and robust species, highly resistant to extreme temperatures and which develop quickly. We can resort to mulching the substratum, so the weed development to be stopped, needing less maintenance. For an extensive type roof, the essential objective is that the plants tolerate drought, requirement fulfilled by the succulent plants, which are able to deposit water in their tissues for a long period of time.

In combination with mosses, the succulent plants are the most popular plants used for an extensive type roof. The arrangement of an intensive type roof allows the use of a larger number of species, from flower plants, ornamental herbs and grass, even vegetables, to shrubs and trees.(*fig. 3*).

Figure 3 **Isle – type green roof model**

The initial cost of such an arrangement can be with 30% bigger than of an ordinary one, but in time, the maintenance and the energy savings compensate this cost with an increase up to 50% of the benefits.

The systems of vegetal roof type arrangements are guaranteed more than 15 years (up to 30 years in Germany).

The isle urban heat represents an atmospheric phenomenon caused by the concentrated heat produced inside the cities by the intense traffic, air - conditioners and massive quantities of asphalt and concrete that absorb heat. The green roofs reduce this effect using heat in the process of plant. (*fig. 4*).

A dry green – roof absorbs the summer showers, which could otherwise flood the tunnels and the underground structures. In the same way in which the

water flow is delayed when a plant grown in a pot is sprinkled, a green – roof acts like a huge sponge, diminishing the pressure from the water collecting points.

In summer, considering the plants and the growing layer's thickness, the vegetal roofs retain 70-90% from the rainfall, and 25-40% in the winter.

Figure 4 **Urban green - roof**

It's proven fact that the landscape arrangements on the top of the residential or commercial buildings increase their value with 15-20%. It is considered a perfect place for relaxation, a place to take a break from work or where customers can relax during shopping, reading a book or sight-seeing, watching sunset.

If the maintenance is proper, a surface of 10 square meters of extensive type green – roof consumes in one year approximately the same quantity of CO_2 as a tree of 4 m height, but also important quantities of nitrogen oxides (42.8 g/year) and sulfur dioxide (1.8 g/year).

Vegetal roofs have a buffer function, significantly reducing the noise and vibrations from outside the building. The plants, the soil and the air between layers isolate the construction, so the noise produce by heavy engines, traffic or airplanes is absorbed, rejected or refracted. The substratum tends to block the low frequency sounds, and the plants the high frequency ones. A green roof with a 12 cm substratum can reduce noise with 40 Db, and one with a 20 cm substratum, 46-50 Db.

The disadvantages presented by green – roof systems include the necessity of structural support consolidation of the roofs that must be modernized in order to sustain a vegetal roof and the fact that often, the vegetation does not tolerate to be stepped on.

CONCLUSIONS

1. Considering the continuous urban development and the more and more substantial "greenhouse effect", we propose that the green – roof arrangements to become a main option for the contractors and investors as well as for the landlords.

The integration of a green – roof into the building is more successful when the possibility of creating a green – roof is took into discussion right from the beginning, when blueprints are designed.

2. Related to the substratum layer and the irrigation possibilities, we can assemble extensive or intensive type plantations.

3. The advantages of installing a green-roof system are multiple, having a technical impact on the durability and comfort a roof offers – protection against UV rays and thermal shocks, thermal and sonic isolation, landscape impact, restoration of the cities' esthetic value, impact on health, improving the air quality, the social and economical value.

4. The initial cost of such an arrangement can be with 30% bigger than of an ordinary one, but in time, the maintenance and the energy savings compensate this cost with an increase up to 50% of the benefits.

5. When proper built, the vegetal roofs restore the cities, especially the industrial ones, with an indisputable esthetic value and enrich the habitat, offering a good solution for the building integration in the environment.

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