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Benefits of A Modular Green Roof Technology

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Abstract

This article aims to the various benefits of a modular green roof technology. Nowadays smart solutions of green roofs are popular for their ecological, technical, economic benefits and esthetic qualities. Green roofs are used in residential, commercial, government and public buildings. Innovative energy-efficient construction technologies will bring great benefit to the ecology and help to relief the heat island effect. The purpose of this research is to provide an effective apparatus and method for green roof system, the principal results of this research are focused on adjusting of optimal physical parameters of green roof modules. This friendly-environmental green roof technology is oriented on policy of sustainable development and protection of the urban ecology.

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Keywords: Sustainable development; modular green roof system; urban ecology; energy-efficient construction technologies; green building.

1. Introduction

Today more and more building owners and investors claim that they prefer to use energy-efficient construction technologies and adhere to the policy of sustainable development. Buildings consume 30% to 40% of all primary energy [1].

In a modern urbanized society, the role of nature is extremely important. Inventions that include technologies, which help people to save environment, are becoming more and more successful. Smart solutions of green roofs are popular for their ecological, technical, economic benefits and aesthetic qualities. Green roofs are used in residential, commercial, government and public buildings. In our time the most innovative solutions of greenery construction

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systems for buildings [2], which are green roofs and green façades. These innovative energy-efficient construction technologies will bring great benefit to the ecology and help to relief the heat island effect. A study in Japan [3] found reductions in heat flux on the order of 50% per year, and work in Ottawa [4] found a 95% reduction in annual heat gain. Research in Madrid [5] showed that green roofs reduced the cooling load on an eight-story residential building by 6% during the summer.

The present article is to be solved various problems of roof covering by little expenditure of labor and waste-free assembling green roofs. The unique roofing configuration with an unusual combination of architectural and aesthetic design solutions gives a beautiful appearance to the urban areas and also allows to use methods of landscaping on living roof. Also green roof technology includes the apparatus to integrate plurality of special roof covering elements with aspects of energy collecting and converting devices. Generally speaking, green roof systems fall into two principle categories: conventional and modular. Both categories of systems create an artificial planting covering over roof that is to be greened. The modules of green roof system have the advantages of being multiple in function, high in practicability and have a good application value. The implementation of modular eco-roofs allows an infinite variety of creations to designers and architects.

As a revived ancient system, green roofing systems were originally intended to restore environment and protect roof membranes, but as the green roofing technologies flourished scientific research began to find a number of versatility benefits, that include flexibility and simplicity in design, lightweight components of the system, effective storm water management. Modular green roof system is a modern way of sustainable development, that aimed to meeting the needs of present and able to solve needs of future generations in the shortest time.

2. Modular green roof technology

Modular green roof system is a modern energy-efficient construction technology. This innovation relates to the roof that to be greened by modules, which designed for simple installation, and allow for ease of access for roof maintenance and repair using method of clicking features of modules. With the evolution of green roof technologies in the last years more and more green roof systems have been developed and existing systems or green roof components have been improved.

In conditions of high-density urban areas quickly-installed modular green roof systems have a good potential in solving problems such as lack of urban space and form a living systems in green building rooftops. Modular green roof is technically advanced roof, including innovative solutions and additional options both for intensive and extensive green roof types.

Modular green roof technology is a method for roof covering system that comprises the following operations:

- the design of modular green roof system to be covered;
- mounting the waterproofing layer over the rooftop deck;
- installation of adjustable leveling devices on the waterproofing layer and placement the elements of grating on the adjustable leveling devices, if it necessary;
- installation of green roof modules side-by-side in an adjacent manner;
- filling of the green roof modules with growing medium and plants.

Aims of this study are to assess the benefits of green roof covering system. In order to compare the roll-out green roof and modular green roofs with different technical characteristics of modules were chosen.

A green roof module is provided for covering a roof surface with vegetation in a growing medium. Modular green roof is the system covering the roof with the vegetation including a series of modules: trays, boxes, containers, blocks and similar. These elements provide the structure support for growing medium and plants that is to be placed on a rooftop and may be arranged in a grid-like fashion. Green roof modules are a self-contained portable roof greening product that functions like roof pavers to ballast single ply roofing systems or rest on top of existing roofing.

Each module includes a pair of sidewalls, and a lower end wall and an upper end wall extending between and interconnecting the ends of the sidewalls such that the walls define a perimeter of the module. The vegetative fillings of modular system help absorb pollutants, including greenhouse gases such as carbon dioxide. The plants are selected according to the specific geographic zone and climate characteristics and green roof types: extensive, semi-intensive

and intensive roofs. Also it is important in selecting, that plants effect on the roof's performance and its tolerance to drought, wind, light, shade and pollutants.

Modular green roofs provide a great opportunity to reduce and attenuate storm runoff. The green roof systems consist of modules pierced with calibrated holes, so water flows drain away freely through the holes on a surface under modules. In this way, C. Lameraa, G. Becciua [6] in their study suggest that green roofs can reduce storm water runoff in comparison to conventional roofs with volume retention scores in the order of 40–80% of the total rainfall.

The modules of green roof system differ because of the depth and type, which distinguish from an intensive, semi-intensive and extensive roofs.

A semi-intensive and intensive green roof systems are characterized by using a wide range of herbaceous plants, shrubs and small trees, the systems are able to retain more stormwater than an extensive system. The growing medium depth for a semi-intensive and intensive green roofs is typically 15÷30 cm. These types of roofing can be used in the coatings system of residential buildings, sports grounds, patio, terraces and other coatings. There are very popular such systems in the commercial and office centers as a recreation landscaping area at the rooftop for building occupants.

Extensive green roofs are lightweight systems designed with small herbaceous plants and grasses and it is characterized a lower maintenance, nutrient, and irrigation requirements. A typical growing medium depth for an extensive green roof is 3÷15cm. The objective of the research of Bau-Show Lin [7] shows that different seasons can affect the performance of the thermal effectiveness of the extensive green roof.

According to the standard classification of the central regions of Russia, as well also most of the suburbs belong to the zone № 4, where the minimum temperature is in the range of -34,4°C to -28.9°C. Coastal areas of Western Europe, Sochi belong to the zone № 7B, where the minimum temperature is in the range of up to -14,9°C -12,3°C.

A. Sfakianaki analyzed the energy-saving effectiveness of a green roof in Athens, Greece. The results showed that a green roof system in the Mediterranean climatic conditions [8] improved heat comfort for the green buildings, with a maximum expected temperature drop of approximately 0.6 C between the roof surface and interior.

For this study in case of a cold climate scenario, a zone № 4, where the minimum temperature is in the range of -34,4°C to -28.9°C, is considered. 11 A climate is one of the most important criteria for the selection of plant species. The low-growing plants of extensive green roofs may include a plant species such as Erica carnea "Foxhollow", Erica carnea "Springwood White", Festuca valesiaca "Silbersee", Polygala calcarea "Lillet", collectively referred to as "Shortgrass Meadow Plantings". As another example, for Coastal areas of Western Europe, Sochi, belonging to the zone № 7B, the vegetation could include another mixture of vegetation such as Sedum acre "Aureum", Sedum album "Coral Carpet", Sedum spatulifolium "Purpureum", Sedum spurium "Green Mantle", collectively referred to as "Desert Succulent Plantings". The high-growing plants of semi-intensive and intensive green roofs may include a wider range of plant species such as Cryptomeria japonica "Elegans", Cryptomeria japonica "Nana", Cryptomeria japonica "Vilmonaria", Cupressus arizonica "Blue Ice", Juniperus squamata "Blue Carpet", Picea pungens "Glauca Prostrata" and others. Also green-roof plant can be selected for full sun exposure [9], using species that originate in permanently open (nonforested) habitats such as rock outcrops (e.g., most sedum), cliffs, dunes, and heathland.

3. Analysis of the laboriousness of a green roof install process

The method of research comprises the analysis of the laboriousness of a green roof install process. This is the most appropriate method that enables to receive principal results of this work, that focused on adjusting of optimal physical parameters of green roof modules. Figure 1 shows the process of installing a modular green roof. The method of research and the data collection are described below.

Fig. 1. Modular green roof install process.

The method is characterized in that laboriousness of a roof install process are compared for green roof systems assessment and selection of the optimal technical characteristics of the modules.

Legislative practice shows that construction of green roofs requires in many urban centers. Legal underpinnings of green building [10, 11] have a major effect on the widespread implementation and success of green-roof technologies throughout Germany. Green-roof coverage in Germany alone now increases by approximately 13.5 million square meters per year. Approximately 14% of all new flat roofs in Germany will be green roofs. Green roofs cover a building with vegetation and growing medium, a filter layer, drainage layer, root barrier, insulation, waterproofing membrane, and finally roof desk. There is much variation in the usage and composition of these layers (Table 1).

Tab. 1. Green roof systems for assessment.

Green roof type	Roll-out green roof	Intensive modular green roof A	Intensive modular green roof B	Extensive modular green roof C	Semi-intensive modular green roof D
Layer 1	Grass	Sedum, perennials, shrubs	Sedum, perennials, shrubs	Grass	Sedum, herbs
Layer 2	Growing medium	Module A with fillings	Module B with fillings	Module C with fillings	Module D with fillings
Layer 3	Filter layer				
Layer 4	Drainage layer				
Layer 5	Root barrier				
Layer 6	Insulation	Insulation	Insulation	Insulation	Insulation
Layer 7	Waterproofing membrane	Waterproofing membrane	Waterproofing membrane	Waterproofing membrane	Waterproofing membrane
Layer 8	Roof desk	Roof desk	Roof desk	Roof desk	Roof desk

According to the analysis of modular green roof systems the assessment has been carried out per modules and, specifically:

- Module A - square tray,500 x 500 x 100mm;
- Module B - square tray, 500 x 500 x 150mm;
- Module C- square tray, 400 x 400 x 100mm;
- Module D - tray with rounded edges, 400 x 500 x 100mm.

For this purpose, there are considered different types of green roof modules, that shown in the Tab. 2.

Tab. 2. Different types of green roof modules.

Green roof module	Module A	Module B	Module C	Module D
Saturated weight	80 kg/m2	90 kg/m2	60 kg/m2	60 kg/m2
Material of module	injection moulded recycled polypropylene	recycled high-density polyethylene (HDPE)	recycled high-density polyethylene (HDPE)	recycled high-density polyethylene (HDPE)
Typical size	500 x 500 x 100mm	500 x 500 x 150mm	400 x 400 x 100mm	400 x 500 x 100mm
	(A x B x H)	(A x B x H)	(A x B x H)	(D1x D2 x H)
Vegetation	Sedum, perennials, shrubs	Sedum, perennials, shrubs	Grass	Sedum, herbs

The main advantages of modular green roof systems over roll-out green roofs surround convenience, speed, future-proofing and instant results. For areas which are very difficult to access, such as single storey extensions, domestic projects and other completed structures, roll-out roof is simply not possible. Green roof modules can be hand-balled into even the most awkward areas, even carried through a window, if it necessary. They are the perfect retro-fit product.

As a result, for finding out which roof is the most efficient, in figure 2 compare the results of laboriousness of different types of green roof modules.

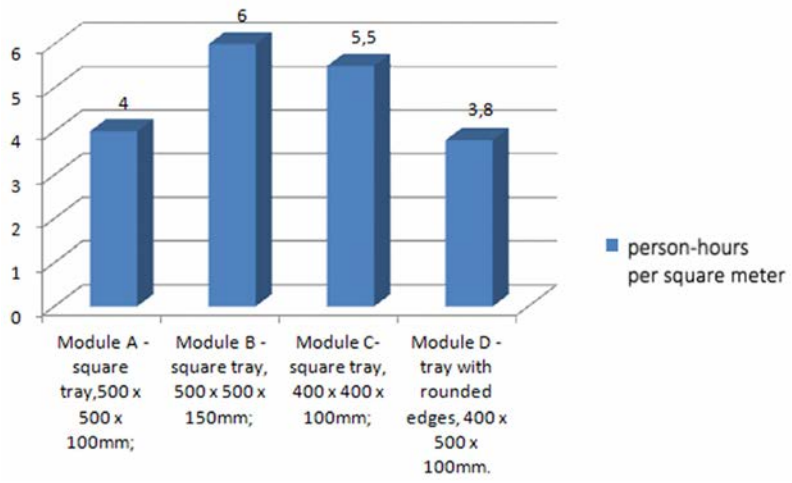

Fig. 2. Laboriousness of different types of green roof modules.

According to the data from figure 2, green roof installation process for different types of green roof modules vary in labour from 3,8 to 6 person-hours per square meter of roof. Human energy for modular roof installation is required for following processes:

- installation of green roof modules side-by-side in an adjacent manner;
- filling of the green roof modules with growing medium and plants.

The installation of intensive green roof with vegetation such as sedum, perennials and shrubs, using modules B - square trays, 500 x 500 x 150mm is the most laborious process of the modular green roof covering process. Roof covering by the modules A - square trays,500 x 500 x 100mm for intensive green roof and modules D - trays with rounded edges, 400 x 500 x 100mm for semi-intensive green roof are the best cases for installation in purpose of

saving more human energy. As a second option, it seems that two other types of roofs are similar for this situation. The rounded shape of module is a significant advantage, so it is easy to handle and lift them and furthermore it is provided access of cables, piping via a technical space in maintenance. Modules are made from recycled high-density polyethylene (HDPE) and their saturated weight is 60 kg/m2, so lightweight is prefabricated and pre-assembled before on-site setting up the modules.

4. Results

The results indicated that significant advantages of modular green roof systems over roll-out green roofs, environment effects provide a future-proofing and energy-efficient technology for green buildings.

Laboriousness analysis shows that optimal physical parameters of green roof modules to provide the least-time laborious installation. The system for covering roof by rounded shape modules is a the most appropriate method, that provide a green roof system, installing in a relatively short period of time, which characterized by the lowest laboriousness. Green roof installation by modules with rounded edges, 400 x 500 x 100mm requirements shown is 3,8 person-hours per 1,000 square feet. Thereby, the research observations showed, that optimal physical parameters of green roof modules to provide the least-time laborious installation are following:

Saturated weight - 60 kg/m2;

Material of module - recycled high-density polyethylene (HDPE);

Typical size - 400 x 500 x 100mm (D1x D2 x H);

Vegetation - sedum, herbs.

5. Conclusion

This article discusses the modern effective apparatus and method for green roof system. The aim of this article is to analyze green roof structures, researching of modular green roof systems and adjusting of optimal physical parameters of green roof modules. Modular green roof technology is an attractive and energy-saving alternative to a conventional green roof structures.

Modular green roof systems have a multiplicity advantages over roll-out roofs:

1.Lightweight structural elements, is prefabricated and pre-assembled before on-site setting up;

2.Integration of energy collecting and converting devices and accessories such as solar panels, lights, automatic watering and decorative elements.

3.Accessibility, as each module can be carried by one operative, that allows maintenance green roof without complete dismantling of the system;

4. Ecological and recyclable materials trays in combination with natural components of vegetative system as a greater protection of the environment;

5.Easy access of cables, piping via a technical space for the entire year;

6.Prevention of soil creep (horizontal ruled out for rain water);

7.Effective storm water management, that allows to collect the optimum amount of rainwater, which is due to a specially designed shape of the modules;

8. Flexibility and simplicity in design;

9. Aesthetic appeal of the green roof space and unique design, that allows architect to create a great variety of roof configurations and wide array of customization.

The analysis was able to obtain that the optimal sizes and optimal physical parameters of green roof modules to provide the least-time laborious installation. Modular green roofs provide environmental, technical and well-being benefits and, as they relate to sustainable practices, help accomplish a variety of sustainable goals The economic benefit [12] brought about by participation in agriculture roofing comes in a variety of forms, including the job creation, supplementation of family income and saving money by not purchasing food. Eco-roof systems can provide amenity benefits, creating a habitat for wildlife and helping to urban ecology by mitigating the heat island effect. Modular green roof system is advanced green building technology of the near future.

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