Innovative Device Technology of Green Roof Systems

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Abstract. This article analyses both traditional green roof structures and innovative modular green roof systems in the environmental development of green buildings. The purpose of the work is to analyse the technological processes associated with the installation of various types of landscaping systems on the roof, which minimize the complexity of the processes due to the manufacturability of the roofing device. In order to reduce the overall laboriousness when installing rooftop with green spaces it is possible to apply new technological solutions, including the option of installing green roofs by modules. Based on the study, technological indicators were determined for various types of roofing greening systems: simple green roof installation (option 1), modular green roof installation (option 2).

1. Introduction

Nowadays smart solutions of device technology of green roof systems are gaining popularity for their benefits of urban health. The work is determined by the fact that new technologies for building buildings with integrated landscaping systems are being formed to create a comfortable and healthy urban environment. In modern construction practice, organizational, structural and technological models of roof installation are used, including those with plant systems. The analysis of technological characteristics showed noticeable results of improving and improving the quality of modern construction production and the creation of new high-tech developments in the field of energy-saving measures in construction, environmentally friendly buildings, domestic and foreign experience of using its [1-7,15].

Interest in new technologies, which form the space of a qualitatively new urban environment with the installation of roof greening systems, is growing taking into account the development of global climatic changes and environmental problems around the world [8,9]. However, it should be noted that studies of the manufacturability of the roofing device with landscaping systems are not given either in domestic or in foreign research databases. The experimental data on green roofs obtained in studies in developed countries [10-14] showed that the passive cooling effect near energy-efficient roofs and walls with greening systems reduces the thermal energy of the green building by 40% (Figure 1).
The existing green roof and green wall technologies are improving noise quality and air quality environment [16-18].

2. Materials and methods
The green plants are implemented on the roofs, walls and open terraces of the green buildings. Development of green technologies in many countries is connected with climatic conditions and the national standards in the field of construction and building materials. In this article, methods of comparative scientific analysis and scheduling theory methods, assessment methodology, proposed by the authors are used to evaluate the technological processes of installing a roofing system with landscaping. The study presents 2 solutions of roof installation for evaluating technological solutions:
1) Simple green roof installation - option 1 (Figure 2);
2) Modular green roof installation - option 2 (Figure 3).
The manufacturability of design and technological solutions for the green roof installation is an important parameter. Despite the existing research and development of many scientists in the field of green construction and technologies for erecting roofing, substantiation of the manufacturability of roofing processes with landscaping systems is not given [19,20]. Manufacturability, as a combination of the complex characteristics of a technical device, expresses the convenience of its production, maintainability and performance. To assess the constructive and technological solutions used in the construction of buildings with integrated greening systems, the technological indicator, which introduced by the authors, \( K_{gr} \) is used - the technological factor of the roofing device with greening systems:

\[
K_{tgr} = \frac{Q_{gr} k}{Q_{ml} i + Q_{gr} k},
\]

The following criteria for evaluating the structural-technological solution (STS) of a roofing device with landscaping systems are applied: if this coefficient is \(<0.1\), then STS is rational; if \( K_{tgr} = 0.1 \ldots 0.2 \), then STS is acceptable; if \( K_{tgr} > 0.2 \), then, respectively, STS is irrational.

The technological coefficient for a roofing device with landscaping systems is supposed to be used to determine the rational STS from existing alternatives [21-23].

Let's evaluate the manufacturability of various options for roofing: simple green roof installation - option 1; modular green roof installation - option 2.

\[
K_{gr1} = \frac{Q_{gr} k}{Q_{gr} av} = 0.3 < 1,
\]

which means that the laboriousness of the device simple green roof is reduced.

3. Results and discussions (interpretation of the results)
The calculation of the technological coefficient of the device of simple green roof \( K_{gr1} \) showed that this STS is rational:

\[
K_{tgr1} = \frac{Q_{gr} k}{Q_{ml} i + Q_{gr} k} = 0.03 < 0.1.
\]

The calculation of the adaptability coefficient of the device of modular green roof \( K_{gr2} \) showed that this STS is valid:

\[
K_{tgr2} = \frac{Q_{gr} k}{Q_{ml} i + Q_{gr} k} = 0.13 = (0,1...0,2).
\]

4. Conclusions
Modular green roof constructive system and technology is regarded to the most effective solution of innovative approaches and techniques for green design and construction. Technological processes for the reconstruction of green roof systems are characterized by the best indicators of the complexity of the work. Installation of modules with soil and plant layer takes only 3.13 days in time and has little laboriousness. Thus, the manufacturability indicators are calculated for various options for the design of green roof systems. In order to reduce the overall laboriousness when installing rooftops with green spaces, the so-called green roofs, it is possible to apply new technological solutions, including the option of modular green roof installation. This result is achieved by reducing the complexity of the device multilayer roof structures. The calculation of technological factor of the roofing device with greening systems showed that solution of modular green roof installation is acceptable. It should be noted that there is a need to develop new technological indicators and supplement the provisions of the regulatory and technical base with a corresponding description of organizational, technological and structural and technical characteristics.

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