Optimization of green roof processes

Elena Korol1, Natalia Shushunova1, Valentin Gorbachevskii1
1National Research Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia
nshushun@gmail.com

Abstract. This research is devoted to the optimization processes of installation of the green roof systems in combination with the Building Information Model (BIM) technologies used in the engineering design of such systems. There is a decision of such models which contained the most optimal parameters for the cost and time of the construction processes. The aim of our study is to explore the potential of a patented green roof technology for the residential and office buildings. The modular green roof system is the upper roof structure, technically advanced design solution of roofing, with innovative technological multifunctional advantages and the ability to integrate devices that convert solar and wind energy - solar panels and wind turbines. This technique has proved to be highly effective in reducing the nutrient load in a runoff, controlling watering over a period of time.

1. Introduction
At this research, the green roof systems with smart-energy devices are considered. At present, the problems associated with the study of technological parameters in the design of non-traditional energy-saving engineering systems for optimization of green roof processes.

In many European countries, there are special Codes, rules and recommendations, which include different types of green roofs, basic requirements for its and other details of green roofing processes:

- Planning, Implementation and Maintenance of Green Space on the Roof (FLL), developed by the Research Society for Landscape Gardening and Landscape Development in Bonn (Germany). The actual German guidelines have been widely adopted for green roof design and regulation worldwide, because of proven building and landscaping tradition [1].
- UNI 11235: 2007 Design, Device Monitoring and Green Roof Maintenance, standard in Italy.

To the purpose of the sustainable development, green buildings are improving the competitiveness of the buildings by their higher environmental and economic performance at all stages of the life cycle of the building [2, 3]. The NBS National BIM Library in the UK sets an industry standard for quality, efficient generic and manufacturers’ objects, including green roof systems [4]. The standard BIM Object Standard (BOS) establishes every object with a core property set that adopts a consistent approach to classification and standardizes approaches to the level of detail and object presentation.

For example, to create the BIM object of extensive green roof system SPRA there is need to use the complex programs such as AECOsim, ARCHICAD, IFC, Revit and Vectorworks. The system device of vegetation, planting medium, drainage layer - loose laid, single ply membrane - loose laid, insulation - loose laid, vapour control layer - loose laid.

Analysis and visualization of the global green building research with the sustainability assessment of green building industry are presented in studies [5, 6].
Consider the green roof technology Zinco, one of the most successful green roof companies, which was founded in Germany in 1957. The increase in weight of the structure, with the use of modern technology (extensive roof) does not occur. The substrate is a material that weighs 600 kg/m³ and contains all the nutrients necessary for the plants. With the use of this material, the weight of the structure does not increase significantly. The green roof processes of Zinco technology are the following:

1. Plant layer device;
2. Substrate device;
3. Device of SF system filter is made of thermally hardened polypropylene;
4. Device of membrane Floradrain FD 25;
5. Device of moisture accumulating and protective mat SSM-45;
6. Device of anti-root film WSF 40;
7. Waterproofing device, according to the project.

The waterproofing is designed individually since it must be resistant to temperature and waterproof. The best version of energy-efficient construction and technology of green roof has been identified. For modern buildings, with the use of progressive building technologies, compliance with the criteria of high constructive quality, manufacturability, and the durability of building materials is considered (Figure 1).

These green roof systems presented as passive cooling technology in various climatic conditions. Also, there is one of the elements in the field of energy-efficient construction production [7].

2. Materials and methods
The modern methodology of organizational and technological modelling of the building construction with green roofs is the main tool in the study of technological and technical parameters considered in this work in the installation of non-traditional energy-saving engineering roofing systems, least labour intensive in processes of the installation engineering system.

Integration of the patented technology in the architectural design of the building shell contributes to changing the spectrum of parameters having dependency at all levels of interaction (Figure 2).
The determining key parameters of green roof systems are based on the labour resources and time-organisational parameters for optimization processes of installation of green roof systems.

### 2.1 Case study: green roof and transport industry

Interestingly, the first taxis in New York were electric cars. And in general, at the beginning of the last century, most of the machines worked on electricity. Integrated green roof systems and energy-saving transport are those elements of the urban environment that complete each other.

The largest transport highway is passing through Denmark, Austria and Germany [8-10], which is called «Green roof».

Smart-energy transport systems to complete the integrated green roof systems are forming the innovative urban views – the urban space of tomorrow. These complex systems bring large energy-savings to the megalopolises. Analysis of the green roof thermal properties and investigation of its energy performance, based on the mass transfer model, were measured and modelling on a green roof in many research projects [11-16]. The performances of a planted roof as a passive cooling technique were discussed, suited to extensive green roof conditions in a maritime climate [17-20].

### 3. Results and discussion

In this research we had determined the parameters for assessing changes in the building envelope during integration green roof technology: system viability, the optimum layout of engineering networks, urban in the landscape, rationalization of resource consumption, acceleration of information delivery to all levels, network adaptive control.

Trends of growth in the use of green technologies in construction, a special role is assigned to the state in the implementation of environmental projects related to the development of the normative-technical base of the organizational and technological design. In recent decades, the transition of most developed countries to a policy of restoring damaged ecosystems in urban space has been planned. The aim of the research is to analyse the technological processes of the device of the operated roofing coatings with landscaping systems and the search for optimal structural and technological solutions. The study used a method of comparative analysis of various options for the device of roofing with landscaping systems.

The study of integrated building production management systems based on an economic model makes it possible to assess many risks in the construction.
4. Conclusions
The development of modern construction industry and the construction industry as a whole is associated with the increasing rates of growth of energy-efficient and environmentally friendly construction technologies, including the technologies using exploited roofing with landscaping systems aimed at creating a favourable urban environment for the future generations. Modular landscaping systems have specific structural and technological features that must be considered when developing documents for organizational and technological design. The introduction of the green building technologies requires an integrated approach and an assessment of such innovative projects. At present, there is a need to develop new standards in the field of green building technologies and complement the provisions of the regulatory and technical framework, containing guidelines that cover the design and construction processes with a detailed description of organizational, technological and structural characteristics. The constructed spatial-technological and functional models of the technological processes of the device of the operated roofing coatings with the landscaping systems make it possible to identify reserves and eliminate technological non-production interruptions in the production process. The determining organizational and technological parameters of such models are the labour resources and the time parameters. At the same time, it is possible to use the proposed approach in building a spatial-technological structural and functional model for various organizational and technological processes to assess and make the right technological decisions in the construction industry.

References
[1] C. Catalano, V. A. Laudicina, L. Badalucco and R. Guarino, Some European green roof norms and guidelines through the lens of biodiversity: Do ecoregions and plant traits also matter? Ecological Engineering, Volume 115, pp. 15-26, 2018.
[2] V. G. Borkovskaya, Environmental and Economic Model Life Cycle of Buildings Based on the Concept of "Green Building", Materials Science and Mechanical Engineering, pp. 287-290, 2013.
[3] R. Roe, W. Bardenwerper and V. Borkovskaya, Using a Case Study Interactively to teach Sustainability Risk Management, MATEC Web of Conferences, Vol. 251, 2018.
[4] NBS National BIM Library in the UK, 2019 [Online], Available at: <https://www.nationalbimlibrary.com/en/single-ply-roofing-association/green-roof-system/>.
[5] A. Darko, A. P. C. Chan and X. Huo, D. Owusu-Manu, A scientometric analysis and visualization of global green building research, Building and Environment, Vol. 149, February, pp. 501-511, 2019.
[6] S. Ulubeyli and O. Kazanci, Holistic sustainability assessment of green building industry in Turkey, Journal of Cleaner Production, Vol. 202, 20 November, pp. 197-212, 2018.
[7] O. A. Korol, Issledovaniya i naukoyemkiye razrabotki v oblasti energoeffektivnogo stroitel'nogo proizvodstva, Research and knowledge-intensive developments in the field of energy-efficient construction production. Stroitel'nye materialy [Construction Materials]. 2015. № 6. 13-15 p. (In Russian).
[8] Underground space as an indicator of urban development: quantitative assessment of the use of underground space [Online], Available at: <http://www.undergroundexpert.info/stati-i-doklady/item/1696-podzemnoe-prostranstvo-kak-indikator-gorodskogo-razvitya.ru/.
[9] HochtiefAktiengesellschaft [Online], Available at: <https://www.hochtief.com/hochtief_en/0.jhtml>.
[10] V. Kasyanov and C. Oksana, Use of Underground Space in Large Cities, IOP Conference Series Materials Science and Engineering, 2019.
[11] N. J. Paull, P. J. Irga and F. R. Torpy, Active green wall plant health tolerance to diesel smoke exposure, Environmental Pollution, Vol. 240, Pp. 448-456, 2018.
[12] B. Chak-Man Leung, Greening existing buildings [GEB] strategies, Energy Reports, Vol. 4, November, pp. 159-206, 2018.
[13] R. M. Lazzarin, F. Castellotti, and F. Busato, Experimental measurements and numerical modelling of a green roof, Energy and Buildings, vol.37, issue.12, pp.1260-1267, 2005.
[14] K. Lui and J. Minor, Performance evaluation of an extensive green roof, Greening Rooftops for Sustainable Communities, 2005.
[15] A. Niaouchou, K. Papakonstantinou, M. Santamouris, A. Tsangrassoulis, and G. Mihalakakou, Analysis of the green roof thermal properties and investigation of its energy performance, Energy and Buildings, vol.33, issue.7, pp.719-729, 2001.
[16] S. E. Ould-boukhitine, R. Belarbi, I. Jaffal, and A. Trabelsi, Assessment of green roof thermal behavior: a coupled heat and mass transfer model. Building and Environment, 2011.
[17] E. Palomo, Roof components models simplification via statistical linearisation and model reduction.
techniques, Energy and Buildings, vol.29, issue.3, pp.259-281, 1999.

[18] L. Pérez-lombard, J. Ortiz, and C. Pout, *A review on buildings energy consumption information*, Energy and Buildings, vol.40, issue.3, 2007.

[19] J. S. Macivor and J. Lundholm, *Performance evaluation of native plants suited to extensive green roof conditions in a maritime climate*, Ecological Engineering, vol.37, issue.3, pp. 407-417, 2011.

[20] T. G. Theodosiou, *Summer period analysis of the performance of a planted roof as a passive cooling technique*, Energy and Buildings, vol.35, issue.9, pp.909-917, 2003.