"Green architecture": technical problems of greening buildings

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Abstract. "Green building" today is a paradigm of the time, which requires a special approach to design. The building-base must meet the requirements of the strength of defect-free, which will provide a quality environment of human life from a construction point of view. This approach fully ensures the stability of the construction project. The formation of "green" architecture design (both architectural and engineering) is aimed at the formation of structures of buildings and structures that meet the following requirements: strength, stability, durability, as well as the needs of environmental characteristics of all users at the same time.

1. Introduction
"Green architecture" is a very common phenomenon in many Asian and European countries. This direction is becoming more and more widespread in Russia [1]. This is due to many aspects of the formation of the modern urban environment.

Evidence of this is the presentation of development companies, the main advantage of which is environmental friendliness [2,3]. And now we are not talking about the use of environmentally friendly materials, special methods of construction works that do not have a negative impact on the surrounding landscape and nearby buildings [4]. Complexes (residential, public or multi-functional) with the use of various forms of non-traditional landscaping are becoming increasingly attractive. Popularization of such projects is a tribute to time.

However, more and more often design solutions are not implemented. This may be due to various factors, one of which may be technical problems in the implementation of the proposed solutions. Especially if the role is about integrated landscaping.

There are several main areas of greening of buildings: greening of the internal space of the building, the outer surface, as well as greening of intermediate spaces. Creation of such type of gardening as "green" building assumes gardening of various designs, including: roofs, facades (balconies, loggias) and interiors [5]. Thus, there is a need to design a structure that is exposed to not only external environmental factors, mechanical human impact, but also the influence of growing plants.

However, the "green" objects have special requirements, both aesthetic and technical, different from the requirements for mass construction. As a rule, due to the specifics of the created object, traditional design principles, based mainly on standard design solutions, can not fully meet the modern needs of architecture.
2. Subject, tasks and methods
The object of this study is the specific design and structural elements of modern buildings, aimed at creating landscaping, integrated with the building.

Previously, two main types of landscaping of buildings are identified: horizontal gardening and vertical gardening.

It should be noted that today in the Russian construction practice the issues of landscaping are considered in many practical and scientific works, but as a rule they are aimed at studying the formation of aesthetics, design, landscape and garden organization of space and others. Environmental aspects are of greater importance [6], with the plant being considered as a mandatory component of the architectural environment of the "green" building [7]. It is regulated by GOST R 54964-2012 "Conformity Assessment. Environmental requirements for real estate", in order to improve the quality characteristics of the building to use non-traditional forms of landscaping. In a number of scientific works [8-10] non-traditional forms of gardening are considered as an innovative direction in construction.

In view of the fact that a typologically new building object – "green" building is considered, it becomes necessary to study the issues of its further operation, as well as the study of the formation of specific defects. In particular, the defects associated with the growth of vegetation. The formation of defects can lead to a violation of the performance and integrity of structures (bearing and enclosing), which can affect the quality of the internal environment, strength and stability of the building as a whole. This aspect was particularly highlighted in the work [11].

Many articles deal with the issues of architectural organization, including [12,13], but they only indirectly address the issues of constructive and technical organization of integrated landscaping.

3. Results and Discussion
Complex landscaping of architectural objects involves simultaneous gardening of the internal and external environment, which can be organized by means of various design solutions [5].

Vertical gardening in modern architecture as the most non-traditional form of gardening [14,15] can be organized by greening various building elements, including: vertical, negative slope, positive slope [16, 17]. Each form of vertical gardening involves taking into account specific factors, including: possible shift of soil, drainage of soil and sedimentary water, wind erosion; as well as a set of effects that affect the formation of the building as a whole. In addition, supporting structures can be used to provide aesthetic characteristics [18].

From a constructive point of view, the provision of vertical gardening objects depending on the slope can be provided in various ways:
- Low-lying gardens
  The soil substrate is retained by the root system of plants, additional structural elements are not required.
- Middle gardens
  Require the device of additional elements for fixing the soil, preventing it from slipping. It is possible to use a structural grid or half-dons.
- Steep gardens
  Require the use of special structural fasteners for landscaping. To maintain the ground part of the plants, additional structures are created, including grids, grids, tension cables, cantilever structures and others.
- Vertical gardens
  Require special design solutions of stationary nature, aimed at the formation and maintenance of ground and underground vegetation.
- Hanging gardens
  Formed by hanging baskets, containers, pots, pallets to the bearing elements of the building. In this case, it is required to provide for suspended structures.
The green roof is the main component of the horizontal greening of the structure of the "green architecture" objects. From the urban point of view, the "green" roof can be considered as an additional area, more often for recreational purposes [14].

Typologically, several types of green roofs can be distinguished depending on their spatial position:
- flat (horizontal with a slope of up to 70);
- low-slope (with a slope of 70-200);
- steep (with a slope of 200);
- spherical;
- curvilinear.

Today, there are many roofing systems for the device operated roofs of various functional purposes (pedestrian areas, roads, Parking, gardens on the roofs). Many scientific articles are devoted to the functional and technical features of the design of operated roofs. Depending on the functional features of the designed object, the composition of the roof cake differs.

Experience in the design and construction of such elements of buildings today is small. In the design of "green" buildings, specialists are faced with a number of technical problems that limit the possibility of using "green" roofs, and thus do not allow their mass distribution. When using the operated roofs of buildings and structures to create architectural and landscape objects on them, the following problems arose:
- increased load on the load-bearing structure of the building due to the weight of insulation materials and soil;
- increased chance of leaks with traditional roofing materials;
- destruction of building materials used to create roofing, plant roots;
- high initial capital investments, which did not pay off, as required regular repair of the roof due to the above reasons.

The device of a flat roof requires a high culture of conducting construction works, the use of high-quality building materials, ensuring the reliability and durability of building structures. Modern roof consists of a sufficiently large number of components: roofing material, insulation, vapor barrier, drain funnels, connecting and fixing elements and others. Moreover, all components play an important role in ensuring the quality of the roof (figure 2).

Design of structures for horizontal gardening requires a systematic approach that ensures the quality of the structure as a whole. The system approach to design involves the selection of building materials, as well as their joint work in the roof pie, taking into account the projected landscaping.
Related materials, such as heat, steam, waterproofing and other, must meet these standards and specifications, and be used in accordance with the recommendations.

Green roofs, as well as traditional, depending on the planned functional purpose, can be made in the traditional or inversion version. The main technical difference of inversion roofs is the location of the insulation above the waterproofing and thus, the entire structure above the roof carpet during the rain will be located in the wet area. At the same time, it provides additional structural protection of the waterproofing layer, avoiding leaks. For insulation of inversion roofs it is recommended to use a solid insulation-extruded polystyrene foam with closed pores in view of the preservation of thermal protection properties in a humid environment (humidity not more than 0.2%), has sufficient compressive strength. Mineral wool insulation is not recommended in connection with the need to provide ventilation of the material.

To exclude the connection between the water-insulating carpet and the protective layer, as well as between the plate insulation and the leveling screed from the cement-sand solution, it is necessary to provide a separating layer that allows these elements with different coefficients of linear expansion to deform independently of each other.

Water drainage should be provided both from the surface and from the level of the drainage layer and the waterproofing carpet, in view of which, in modern construction practice, it is recommended to use two-level drain funnels.

When designing a structure intended for further gardening, it is necessary to provide protective layers. In view of the continuous development of the root system, as well as the presence of a substrate with an increased degree of aggressiveness in relation to the structures of the building, in the roofing systems, an additional profiled layer made of a material with increased strength characteristics is provided.

The water storage layer consists of a material capable of accumulating and retaining moisture for a long time. This material can swell when moistened from 5 to 20 mm. Special plastic membrane-drainage-storage element-is the main element that supports the life of plants in hot and dry periods of summer. The system filter acts as a separating layer - separates the soil and plant layer from the plastic membrane. A plastic membrane with a thickness of 4 to 8 cm with cellular structure, holds water, layer in half of the cell. In the upper protrusion of the membrane there is an opening with a diameter of about 1 mm. Water from half-filled cells rises along the outer walls of the membrane, due to the forces of capillary adhesion and the diffusion method, and through the system filter enters the soil layer. In addition, from the water-accumulating layer, moisture rises through the opening in the system filter along the inner walls of the membrane and also enters the soil layer.

![Figure 2. The composition of the "green" roof](image)

1. the coating plate or ceiling of a building; 2. waterproofing membrane with anti-root additives included; 3. hard thermal insulation (if necessary); 4. special drainage layer, sometimes with built-in water tanks; 5. landscape or filter cloth; 6. designed plant environment (substrate), which generally may not contain soil; 7. plants.
Irrigation of the soil layer with green spaces can be surface or intra-soil. Surface irrigation is provided from a hose or by mechanical sprinklers. Intra-soil irrigation is carried out by means of perforated pipes located in gravel-lined trenches.

Design of structures for horizontal gardening should meet the requirements for the strength of the structure, with particular importance is their integrity and lack of defect. The occurrence of defects in structures can be due to the neglect of the peculiarities of the vegetation of the plant, its influence on the elements and design in general [19].

4. Conclusions
Surface greening, operation and improvement of the special environment radically changes the functional and construction nature of the building object, the formal and constructive nature of the building elements, putting them in the position of specific architectural, landscape and urban facilities that require full design development.

Structurally, plant surface integrates:
- Landscape biosystem;
- Coating design of the building;
- Functional and protective elements of the structural structure of the coating.

In the practice of operation of such objects there are damages, leading to the failure of the building-base, as well as surface damage, to varying degrees, reducing the quality of the structures themselves, the quality of the internal environment of the lower premises and external parts of the building [20].

Depending on the position of the considered landscaping design, it should be presented with the appropriate technical requirements in accordance with its main function in the structure of the building. Depending on the spatial position of the landscaping surface in the structure of the building have significant differences in temperature and humidity characteristics of the environment, as well as increased loads. The classification is based on the signs of spatial location of integrated landscaping in the structure of the building, isolation of space from the external and internal environment of the building, as well as the nature of the relationship with the main volume of the building. As a result of the analysis the following types of spaces suitable for horizontal landscaping, taking place in the architecture, are identified:

- Artificial territory
  Covering located above underground or semi-underground space

- Platform
  Coating, located above ground non-heated space

- Passage
  The length of the space is much greater than its width, located along the facade of the building, which has a canopy

- Terrace
  Space limited on one or several sides by walls depending on the location in the structure of the building-basis, without a canopy

- Air floor
  The space has a canopy, located along the perimeter of the entire building

- Atrium
  The space closed between the four walls, open from above.

The formation of complex landscaping of buildings, representing a set of elements of horizontal and vertical gardening, requires a special approach to design and construction, caused by the integration of different needs in a single building structure.

Formal solutions of the "green" object should meet the challenges of modern architecture and take into account the features of engineering solutions. The tasks facing the engineer, in this case, are limited not only by the requirements for the strength and stability of the object, but also its environmental features, the issues of faultless operation of the object.
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