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Proceedings of the Second International Conference for Phd Students in Civil Engineering and Architecture

Editor Cosmin G. Chiorean

10-13 December 2014, Cluj-Napoca, Romania

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CE-PhD 2014

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Green Zone Buildings in Modern Architecture

Jelena N. Stevanović[*1], Milan G. Pavlović [2] , PhD Gordana Topličić Ćurčić [1]

[1] *University of Niš, Faculty of Civil Engineering and Architecture.*
Aleksandra Medvedeva 14, 18000, Niš, Serbia
[2] *University of Niš, Faculty of Mechanical Engineering.*
Aleksandra Medvedeva 14, 18000, Niš, Serbia

Abstract

Nowadays, when cities have rapid economic and spatial development, existing of green surfaces in strict urban city parts are less, but needs for them are more. Integrating of green surfaces, so-called green zones, in objects as their functional part, gaining in importance, so that presents a new idea in modern architecture. Green zones are parts of building which consist appropriate vegetation, and they can be derived on different ways, depending of construction and object needs. Use of green zones is multifunctional through improving of exterior and interior, purification of city air and other. Also, use of these zones has an effect on decreasing of energy consumption in objects through improving of its isolation. Some objects have systems for use of renewable energy, which increase its energy efficient and functionality. In this paper, types of direct use of green zones as a part of objects in city cores, are presented. Increasing number of these objects around the world justify the expansion of this idea in the future, emphasizing the principle of co-existence and respect of the nature in order to achieve multiple benefits.

Keywords: green zone, use, city, environment, energy consumption.

1. Introduction

We are aware of the fact that human population is constantly increasing, which causes significant growth and development of urban areas, especially cities. Expansion of cities leads to the situation that croplands, lawns, parks and forests, which have esthetic and functional role, are replaced with streets, driveways and many types of buildings. On the other hand, the presence of green areas in cities is very important and required for several reasons.
One way of compensation of green spaces lack in urban areas, is their use on (in) buildings. Organized use of green areas in the interior and/or exterior of the building, leads to forming so-called green zones, which are their functional and inseparable part. Green zones represent parts of the building that contain the appropriate green vegetation and they are integral part of the building in esthetic and functional terms. Depending on the design and building needs, they can be divided in many ways. One of the divisions is on: vertical gardens, green roofs and green zones in object. Each of these types has its own features and benefits, which justify their use.
Generally, green zones i.e. their use, are multifunctional through improvement of the interior and exterior of the building, especially in urban areas that is known as "gray of the city". Many authors have concluded that the existence of the green zone on objects contribute to purification of the air

[*] Corresponding author: Tel./ Fax.:+381638340096
E-mail address: stevanovicjelena@live.com

and air pollution control [1], what have direct effect to environment and thus the citizens of urban areas. Deficit of land in cities causes that many building had to be constructed very close to roadways, railways and other noise pollution sources. In recent years, some of cities found that green zones on buildings can be important element in reducing of the noise pollution. [2]
Also, they cannot be used as cooling device, but as insulation ones can, because reduce of incoming solar radiations through the roof. This leads to that the building with the green zones has reduced energy demand for space conditioning because of improved isolation, and can be used when retrofitting of existing buildings. [3, 4, 5, 6, 7] The use of new technologies and trends in modern architecture leads to that is each building sustainable so, in addition to the use of green zones, there are conceptual design of objects that are incorporate systems for use of renewable energy (solar panels, wind generators, etc.). This kind of solution combination affects on increasing of energy efficiency and functionality of the object. In this paper, application of green zone types on buildings is presented. All buildings are in central city cores, so the roles of green zones are analyzed.

2. Vertical gardens

Vertical gardens, also known as green walls or green facades, implies vegetation that grows directly onto a building's facade or to vegetation that is grown on a separate structural system that can be freestanding and adjacent or attached to the wall. Green wall systems can protect facades in a similar way as well as installing a green roof can protect roof construction. If we look back in history, we will see that vegetated facades are not new technology, but can offer multiple benefits as a component of urban design. Many researches agreed about positive effects of green walls such as evaporative cooling effects of plants, their contribution to insulating effects on facades, the ability of plants to mitigate dust, etc. [8]
Types of vertical gardens can be classified into three systems (Fig. 1.), depending on construction and placement on (in) object [9]:

- Panel System: pre-planted panels, which are installed during construction process and connected to the structural system of the building and a mechanical watering system.
- Felt System: there are felt pockets of growing medium. Felts pockets are connected to a waterproof back which is then connected to the structure behind. Water with necessary plants nutrients constantly comes to the felt and keeps it moist.
- Container and/or Trellis System: plants grown in this system climb onto trellises. Trellises framework is connected to structure of the building. Irrigation system drop by drop is usually used in those systems to control watering and feeding.

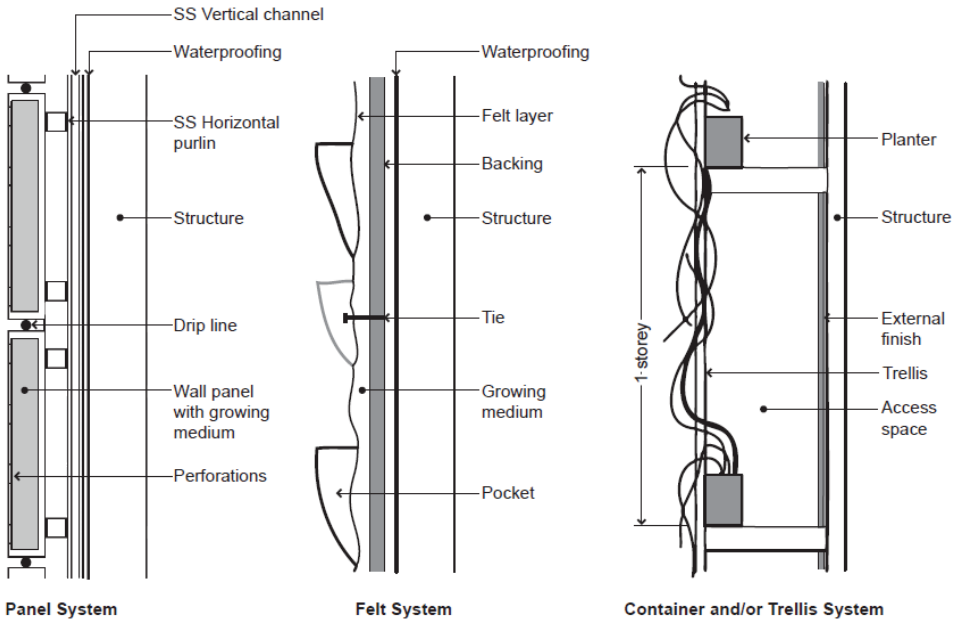

Figure 1. Types of vertical gardens.

Interior Living Walls can be built out of any of the above three systems. Some of living walls are integrated with the building's mechanical system. Air (recycled and fresh) can be supplied to the building's interior through the living wall. That air is cleaned and moisturized by the plants and the growing medium.

Bosco Verticale (Vertical Forest), as one of the representative of objects with vertical gardens, is a project of reforestation that contributes to the regeneration of the environment and urban biodiversity without expansion of its territory. This project, which consists of two skyscrapers in Milan, Italy, is an example of the vertical concentration of vegetation in the city, which allows afforestation even in the center of an urban environment. Buildings, showed on Fig. 2, are almost finished and, with heights of 76 meters and 110 meters, each building will contain about 900 trees, what can be planted in a hectare of forest. [10] The initial idea of Italian architect Stefano Boeri, was to create a way to combine high-density residential development with tree planting in city cores. Boeri Studio finds that "This is a kind of biological architecture that refuses to adopt a strictly technological and mechanical approach to environmental sustainability". [11]

Figure 2. Bosco Verticale: Idea and realization.

Vegetation will be planted in concrete boxes, on terraces, as part of the living space. The plant height will vary - some of the shrubs and flowers will be one story height, while trees will be two-story heights. (Fig. 3)
Because of the diversity of the plants, buildings will create a humid micro-climate where plants can absorb CO_2 and dust, produce oxygen, and, in summer, protect people and their apartments from the sun rays. On that way, air will be cleaner and vegetation will help in cooling and shading, what will have positive effects on lower energy consumption in buildings Also, vegetation is a good sound insulator, which is important, considering that the buildings are in the city center, where is many sources of noise (Fig. 4). Watering of plants will be conducted through filtration of water which was used in apartments.
"The creation of a number of vertical forests in the city will be able to create a network of environmental corridors which will give life to the main parks in the city, bringing the green space of avenues and gardens and connecting various spaces of spontaneous vegetation growth." said the studio. [11]

Figure 3 Height of plants

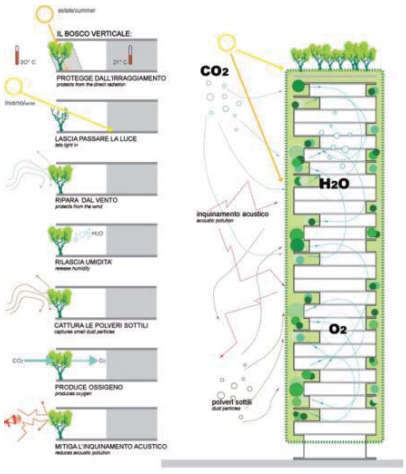

Figure 4 Effects of plants in buildings

3. Green roofs

Green roofs give a new look to modern architecture and add new value to the role of buildings in urban planning. They are designed not only to bring a natural element in the urban environment, but also to provide solutions to important environmental problems. Whether they are with a vegetated surface or with substrate, green roofs have many advantages: better regulation of building temperatures, improving of stormwater management, increasing of sound insulation, providing of ecosystem in urban areas, etc. [12]
Because of their wide usage and adaptive nature, green roofs can be used for many types of public objects, as business and trade centers, hotels and other, but lately, they begin to acquire their function in private houses and schools. Based on the depth of the substrate layer there are two main types of green roofs used in Europe [13]:

- Extensive green roofs - this type of green roof involves plant overgrowth of 5-20 cm in height, where the depth of the substrate layer does not exceed about 15 cm. Plants that are used in this type of roofs are more resistant to sun, drought and extreme weather conditions. It is not necessary maintenance of the roof, but verification of the state of the plants once in a season, is sufficient. Fertilization and weed removal work is required, depending on the

climatic conditions and soil types. Also, extensive green roof may be installed on sloped surfaces with slope angle as high as 45°.

- Intensive green roofs – this type of roof is almost identical to the natural habitat of plants in the nature. Vegetation can be up to 4 m in height, depth of substrate layer is more than 15 cm. Intensive green roofs are, usually, installed on a slope roofs where is slope angle less than 10°. These roofs, besides energy efficiency, also have other uses as gardens with benches, boardwalk, etc...

The School of Art, Design and Media at Nanyang Technological University in Singapore (designed by CPG Consultants, completed in 2006, officially opened in 2009) is unusual example of extensive green roof, formed by two sloping, tapering arcs that interlock with a third, smaller arc (Fig. 5). Because of this and lush green surroundings, it looks like a structure that grew from the ground. The initial idea was to create a "non-building", that looks more like a small mountain than a school. Regarding to this, Dr Timothy Seow, from design studio, said: "The idea was to make the architecture part of the landscape. We wanted a building that flirts with the landscape, not opposing it.". [14] Unusual curved green roof (Fig. 6), landscaped garden and a sleek curtain wall, give transparency and extraordinary appeal to the building, adding richness and depth to the architectural form. This building is characterized by non-existence of exact border between building and landscape, so the curving green roofs distinguish the building from among the other structures on campus. The roofs create open space and gathering place for students.

Figure 5 Situation plan

Figure 6 Curved green roof

The construction of the roof, which is approximately 10,000 m^2, was most difficult for building. In the most cases, green roof requires soil as a growing medium but, depending of the roof size, a large amount of soil can damage structure and foundations of the building. Because of that problem, the architects developed new greening system. Instead of layer of soil, plants grow on a 150mm layer of lightweight volcanic stones and sand. The entire composite section incorporates a water absorption mat that constantly provides moisture to the roots, thus reducing the need to frequently watering the grass. This mat absorbs water during the rainy season, and releases it during a dry season. Planted grass is mixed with native greenery and creates unique bond between object and environment. Used type of grass is specific because of fact that it can withstand heavy downpour, so this type of grass is ideal for tropical weather. Also, designers used additional bracings to prevent the shearing of the steep roof.

Using of green roofs on this building is eco-friendly, because they insulate it, cool the surrounding air and harvest rainwater for its irrigation. This building has a Green Mark Platinum certification because of its energy-saving features. According to the named certification, estimated annual energy savings of the building is 119,134 kWh as well as estimated water savings of 1,171 m^3 per year.

Because of all described, it can be concluded that this building has a potential to offer a new

experience at every level as well as to promotes idea of creative living in accordance with nature.

4. Green zone in objects

In latest architectural projects there are increasingly frequent incorporating green zones in building structure, so it can be analyzed as a new idea in modern architecture. Vegetation is present on entire floors or partially, and can be on two or three story heights. These zones are most commonly used in public or mixed use objects, in central city cores. Main function of this zone is to create green public space inside of building, in a lack of space in urban environment, but they have many other advantages like temperature moderation, air purification, etc. [15] Systems for use of renewable energy (solar panels, wind generators, etc.) are in some objects, and they, in addition, increase its energy efficient and functionality.
One of the projects of this type, which is under construction, is this mixed use object Beach Road in Singapore. Foster + Partners won the international competition for Singapore's new eco-complex, which will contain hotel, shops, cafes, restaurants, a new public space and a "green" link to an Mass Rapid Transit (MRT) station.
Project implies combination of new construction and restoration of old buildings, in order to achieve sustainable urban quarter, and consists two towers with gently curving form and undulating canopy below them (Fig. 7). The entrance to the canopy rises up to form an arc, which catches the wind, and directs it through the space, creating the natural ventilation. The ground level is designed as pedestrian zone, large canopy mitigates the harsh tropical climate, keeping out rain and direct sunlight while allowing wind to flow through the site.
Hotels and apartments are located in the south tower, while offices are in the north tower. Facades of these towers are angled to capture dominant winds and direct this air to cool the ground level, and contain solar cells. Green gardens are incorporate in two towers, greening the whole structure, producing ambient temperature moderation and creating the natural and relaxing space for its users. [16]

Figure 7 Two towers

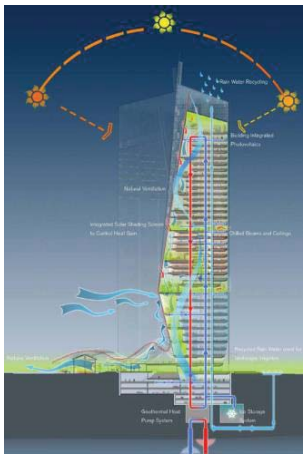

Figure 8 Green building principles

Recycled rain water is used for watering of plants. Heating of the object is provided by geothermal heat pump system, and cooling through chilled beams and ceilings, and an ice storage system (Fig. 8). This design of Foster + Partners works in synchronization with the surrounding climate, combining advantage of simple green building principles like passive solar, natural ventilation and natural cooling.

5. Conclusions

Today, when cities are rapidly expanding and green spaces are less, vertical forests, and green surfaces in general, are increasingly gaining in importance as part of the modern architecture. Using of this zones provide a wide range of options for architects who are interested in using vegetation to accomplish multiple objectives and to provide new design features on the interior and exterior of buildings. This zones are not only significant for the purification of air, they create a green oasis in the cities where is the lack of vegetation. Also, utilization of renewable energy sources in combination with green zones, progressively defines new direction in architecture of sustainable buildings. It can be concluded that green zones with other elements of co-existence with nature become a key component of living architecture and, as the number of this type of objects is constantly rising, they will be an essential part in our cities in the years to come.

6. References

[1] Yang J, Yu Q, Gong P. Quantifying air pollution removal by green roofs in Chicago. *Atmospheric Environment*, **Vol. 42**, pp. 7266-7273, 2008.

[2] Wong NH, Tan AYK, Tan PY, Chiang K, Wong NC. Acoustics evaluation of vertical greenery systems for building walls. *Building and Environment*, **Vol. 45**, pp. 411-420, 2010.

[3] Del Bario EP. Analysis of the green roofs cooling potential in buildings. *Energy and Buildings*, **Vol. 27**, pp. 179-193, 1998.

[4] Liu K, Baskaran B. Thermal performance of green roofs through field evaluation. *Proceedings for the First North American Green Roof Infrastructure Conference, Awards and Trade Show*, pp. 1-10, 2003.

[5] Castleton HF, Stovin V, Beck SBM, Davison JB. Green roofs; building energy savings and the potential for retrofit. *Energy and Buildings*, **Vol. 42**, pp. 1582-1591, 2010.

[6] Perini K, Ottelé M, Fraaij ALA, Hass EM, Raiteri R. Vertical greening systems and the effect on air flow and temperature on the building envelope. *Building and Environment*, **Vol. 46**, pp. 2287-2294, 2011.

[7] Sheweka SM, Mohamed NM. Green Facades as a New Sustainable Approach Towards Climate Change. *Energy Procedia*, **Vol. 18**, pp. 507-520, 2012.

[8] Köhler M. Green facades—a view back and some visions. *Urban Ecosyst*, **Vol. 11**, pp. 423-436, 2008.

[9] Loh S. Living walls – a way to green the built environment. In: Environment design guide, Institute for BEDP, 2008.

[10] www.stefanoboeriarchitetti.net

[11] www.dezeen.com

[12] Oberndorfer E, Lundholm J, Bass B, Coffman RR, Doshi H, Dunnett N, Gaffin S, Köhler M, Liu KKY, Rowe B. Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. *BioScience*, **Vol. 57**, pp. 823-833, 2007.

[13] Mentens J, Raes D, Hermy M. Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century?. *Landscape and Urban Planning*, **Vol. 77**, pp. 217-226, 2006.

[14] Case Study NTU School of Art, Design and Media, Nanyang Technological University (NTU) Singapore

[15] Wolverton BC, Wolverton JD. Interior Plants: Their Influence on Airborne Microbes inside Energy-efficient Buildings. *Journal of the Mississippi Academy of Sciences*, **Vol. 41**, pp. 99-105, 1996.

[16] www.fosterandpartners.com