Marija STAMENKOVIĆ[1] UDK: 711.4;72

ANALYSIS OF THE BENEFITS OF GREENED FACADES IN URBAN AREA

Abstract: Increasing the greenery in densely built urban area is nowadays possible only through greening the building envelope, which allows obtaining a relevant improvement of its efficiency, ecological and environmental benefits. Although the green roofs are widely used, in regard to the greened facades, because of its easier installation and lower initial costs, greened facades show better performances related to energy saving by insulation. This occurs because the greatest heat losses in winter and heat gains in summer are through the facades, and additional insulation by greenery disables it. Topics of the paper are the benefits from environmental aspects of formation of greened facades. Comparative analysis of greened facades and bare walls was done through the studies conducted abroad. The complete analysis depends upon many factors, such as climate zone and location of the building, as well as the materials used for its construction. Integration of vegetation, in general, represents a sustainable approach for the envelope of new and existing buildings.

Key words: greened facades, environmental benefits, energy savings, comparative analysis, sustainability

ANALIZA PREDNOSTI OZELENJAVANJA FASADA U URBANIM ZONAMA

Rezime: Povećanje površina pod zelenilom, u gusto izgrađenim urbanim zonama, danas je moguće preko ozelenjavanja spoljašnjosti građevine što omogućava postizanje relevantnog poboljšanja njene efikasnosti i ekoloških pogodnosti.Iako su zeleni krovovi u širokoj upotrebi, u odnosu na ozelenjene fasade, zbog lakšeg postavljanja i manjih troškova ulaganja, ozelenjene fasade imaju bolje performanse kada je reč o uštedi energije izolacijom objekta. To se javlja iz razloga jer se u najvećoj meri odavanje toplote odvija preko fasada, a dodatna izolacija u vidu zelenila to onemogućava. Tema rada su pogodnosti koje se ostvaruju ozelenjenim fasadama sa ekološkog aspekta izgradnje. Na osnovu studija sprovedenih u inostranstvu, urađena je uporedna analiza između ozelenjenih fasada i klasičnih fasadnih zidova. Kompletna analiza zavisi od mnogo faktora, kao što su klimatska zona, lokacija objekta kao i materijali izgradnje. Upotreba zelenila, uopšteno predstavlja održiv pristup za oblaganje novih ali i postojećih objekata.

Ključne reči: ozelenjene fasade, ekološke prednosti, ušteda energije, uporedna analiza, održivost

[1] Assistant at the Faculty of Technical Sciences, University of Pristina, Kneza Milosa 7, 38220 Kosovska Mitrovica, Serbia; e-mail: marijastamenkovic81@gmail.com

1. INTRODICTION

It is widely known that extensive urban development does not have a favorable impact on the environment, which is primarily reflected in the degradation and reduction of green areas. Environmental changes, brought about by anthropogenic activities, have a dominant impact on the quality of life and health of residents. The degradation in the quality of the environment is especially emphasized in densely built urban areas, and is manifested as air pollution, occurrence of noise, changes of the microclimate of the cities, etc. One of the ways to improve living conditions in urban areas is greening the building envelope.

Greening the building envelope is not a new approach. It dates back to the traditional architecture, since 2000 years ago, but the benefits are rarely quantified. Nowadays, vegetation can be seen as an additive material to building construction in order to increase the multi functionality of facades of buildings [4].

Vertical green, commonly referred to as a "vertical garden", is a descriptive term which is used to refer to all forms of vegetated wall surfaces [4]. Vertical green is the result of greening vertical surfaces with plants which can be rooted into the ground, in the wall material itself or in modular panels attached to the façade in order to cover buildings with vegetation [3].

The integration of vegetation on buildings, beside the environmental benefits, allows obtaining a significant improvement of the building's efficiency. Greening the building envelope plays a great role in the regulation of internal temperature to make it stable and the systems act as passive air cooling systems during the summer and heat isolators during winter. This occurs because vegetation and substrate layer have thermo-insulation properties, which are confirmed on the examples of foreign studies by comparative analysis between bare facades and greened facades.

2. VERTICAL GREENING SYSTEMS

According to their growing method, vertical gardens are classified into:

- façade greening
- living wall systems (LWS) [3]

Greened facades based on the use of climbers attached themselves directly to the building surface, as in traditional architecture, are direct greening systems (Fig.1a). Also, they can be supported by cables or trellis and represent indirect greening systems (Fig. 1b). Climbing plants commonly can grow 5 – 6 m high, others around 10 m and some species at least 25 m, and they allow the creation of the systems [2].

The indirect greening systems can be combined with planter boxes at different heights of the facades (Fig. 1c). In this case the system requires nutrients and irrigation, if the rooting space is not sufficient. In the case where nutrients and a watering system are needed, greened facades are defined as a living wall system (LWS) [6].

Living wall systems are constructed from modular panels, each of which contains its own soil or other artificial growing mediums (foam, felt, perlite and mineral wool, etc.) to provide the plant's food and water requirements [2]. The plant type for the systems is generally evergreen, as small shrubs, and not naturally growing in vertical. Considering principles of growing and conceptions, living wall systems can be based on planter boxes which are filled with potting soil (Fig. 1d), based on a foam substrate with steel baskets as support (Fig. 1e)

and the last system shown is based on several felt layers, working as substrate and water proofing , supported by a PVC sheet (Fig. 1f) [6].

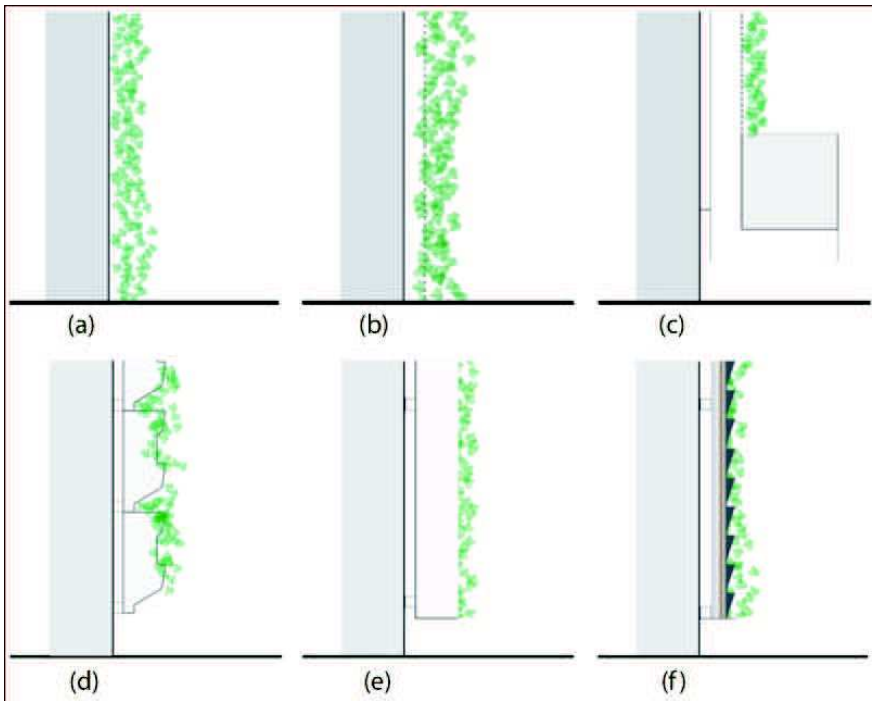

Figure 1 – Vertical greening systems: a – direct greening system, b – indirect greening system, c – indirect greening system combined with planter boxes, d – LWS based on planter boxes, e – LWS based on foam substrate, f – LWS based on felt layers [6]

The plant choice affects aesthetical and functional aspects of a greened façade. An evergreen plant protects the façade from wind flow, snow and rain, which can be relevant especially in the temperate climate or for northern exposed facades. A deciduous plant allows the building envelope to change visually and it is more suitable for the mild Mediterranean climate [6].

3. BENEFITS FROM ENVIRONMENTAL ASPECTS OF FORMATION OF GREENED FACADE

The environmental aspects of formation of greened facades in urban areas may be researched through their benefits compared to conventional bare facades. Reduction of the effect of urban heat island, air quality improvement and external noise reduction represent the advantages studied in this paper.

3.1. Mitigation of urban heat island

The temperature in urban areas rises with the increase of absorbing surfaces which retain the heat they accumulate during the day and emit it during the night into the surroundings, causing the effect of urban heat island. The difference in temperature between the city center and the suburbs during the summer months may be up to 10°C, which greatly impacts the health and quality of life of the residents. Greenery may absorb up to 80% excess heat energy through damp soil and vegetation [7].

The study conducted in Germany [6] on a plant covered wall and a bare wall shows a temperature reduction at the green façade in the range of 2-6°C compared to bare wall. Another recent study [8] on a free standing wall with vertical greening system in Singapore shows a maximum reduction of 11.6°C. This proves that a greened facade absorbed less heat than a non-greened facade and reveals itself in less heat radiation in the evening and night.

In figure 2 it is shown a photo taken with an infrared camera in Netherlands during the summer period. The surfaces uncovered by greenery are red and they are warmer than the area covered by greenery which are blue and green [6]. The vertical greening system is facade greening with vegetation rooted in the soil at the basis of the building.

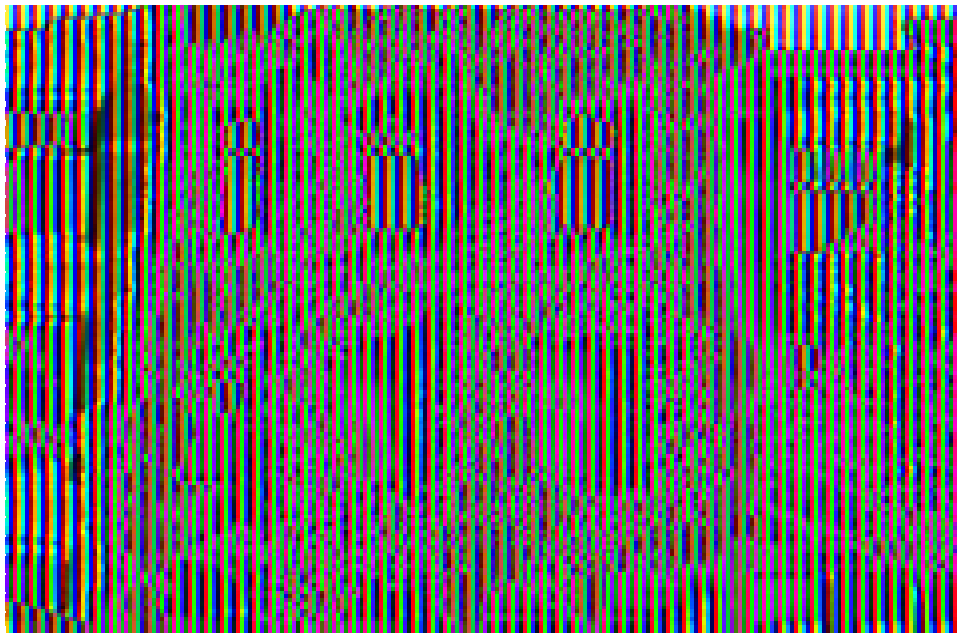

Figure 2 – Greened façade and bare façade photographed with infrared camera [6]

In the events of densely built areas, greened facades and green roofs may be a suitable solution for increased surfaces under vegetation. By cooling and humidifying dry and warm air, there is an improvement of the microclimate, which leads to a more suitable and healthier living environment.

3.2. Air quality improvement

It is a well-known fact that vegetation in urban areas has a favorable impact on the reduction of air pollution, which is saturated with carbon monoxide, volatile organic compounds, particles and other products of burning fossil fuels and industries that are harmful to human health [7].

The air quality improvement due to vegetation is mainly related to the absorption of fine dust particles and the uptake of gaseous pollutants. For example, carbon dioxide is used by plants for the photosynthesis process creating oxygen and biomass, and nitrogen and sulfur dioxide are converted into nitrates and sulfates in the plant tissue. The fine dust particles, especially the smaller size fractions (less than 10 μm), are mainly adhered to the outside of the vegetation parts [5]; therefore vegetation is a perfect sink for airborne particles. Figure 3 shows the upper side of a leaf with particulate matter covers it.

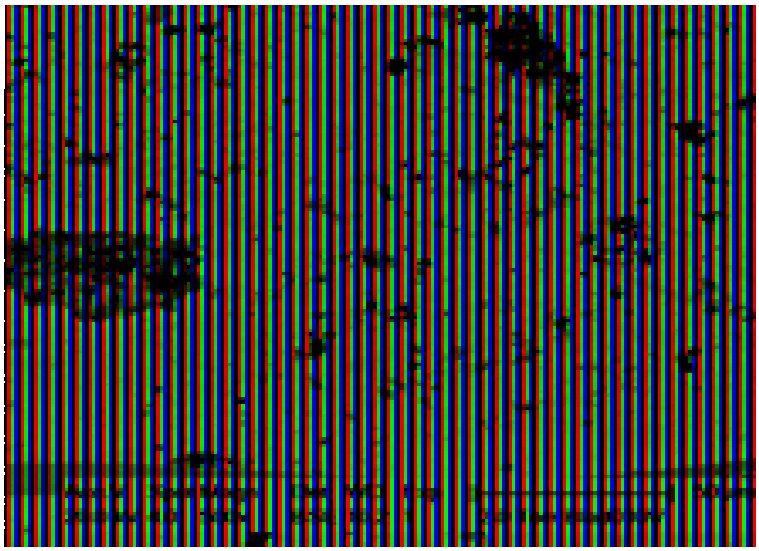

Figure 3 – Electron microphotograph of particulate matter on the upper side of a leaf [6]

Trees planted along pedestrian roads improve the quality of air. Greening the building envelope would have a significant role in a more efficient purification of air, increasing the green area in densely built city centers.

3.3. Acoustical effect of greened facades

Noise pollution is a daily occurrence in urban areas which has an impact on the health of people and the development of natural surroundings. In recent years, sustainable cities have found that greenery is a key element in addressing noise pollution, giving rise to the popularity of vertical greening systems.

Research on the acoustic performance of vertical greening systems is limited and almost non-existent, but the noise reduction properties of vegetation on the ground are extensively researched [9]. In some of the studies it was found that trees reduced sound level beyond 10 dB. Another research found that a combination of earthen berm with a variety of plants can reduce noise by 6-15 dB and increasing the width of the plant belt can lower the noise level [9].

The experimental study conducted in Singapore [9] includes comparative analysis of different types of building materials and vertical greenery systems in order to measure the average sound absorption coefficients. The results are presented in Figure 4.

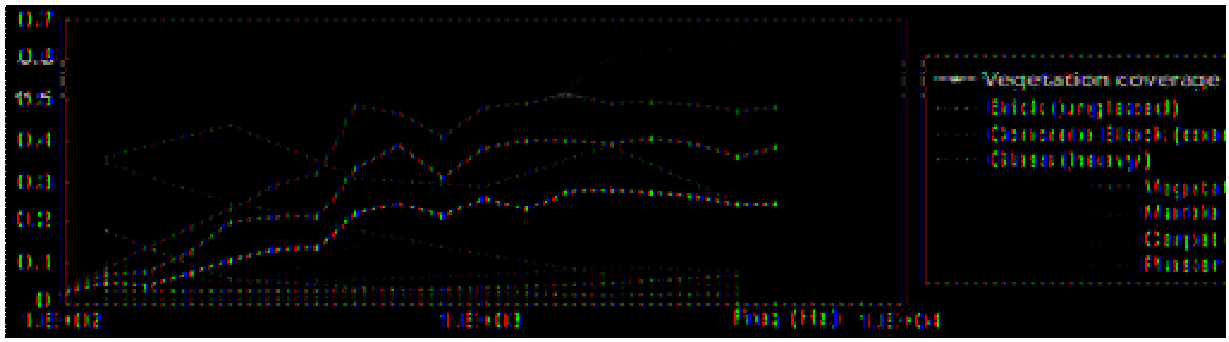

Figure 4 - Sound absorption coefficients of vertical greenery system and other building materials [9]

Most of the materials such as brick, concrete and glass display low sound absorption coefficients, which remain constant or decrease with increasing frequencies. Coarse concrete block is comparable with vertical greenery system at 71% greenery coverage and outperforms all vertical greenery systems at low frequencies in terms of greenery coverage. The coefficient of carpet on concrete is comparable at high frequencies but performed poorly at low frequencies. Based on the results, it is clearly shown that vertical greenery systems have a great potential to be sound absorbers.

4. ENERGY SAVINGS DUE TO FACADE GREENING

Exposure to the sun is significant for greenery maintenance. At the same time, the utilization of solar energy improves the efficient energy use of buildings. Greened facades, as well as green roofs, play a great role in the regulation of internal temperature to make it stable, and act as passive cooling systems during the summer and heat isolators during the winter.

Empirical data on the thermal performance of greened façade are scarce, though emerging. Some of the studies reported temperature reduction by 5-8 °C at greened wall surface and the other, even better cooling effect of up to 10.8 °C [1].

As the thermal and energy data in the studies were obtained by computer simulation, it is hard to determine the real state because it depends on many factors such as climate zone, weather conditions, wind speed, orientation of the greened wall, type of greenery used, etc. However, the conduced studies can help to predict the results for the locations with similar conditions.

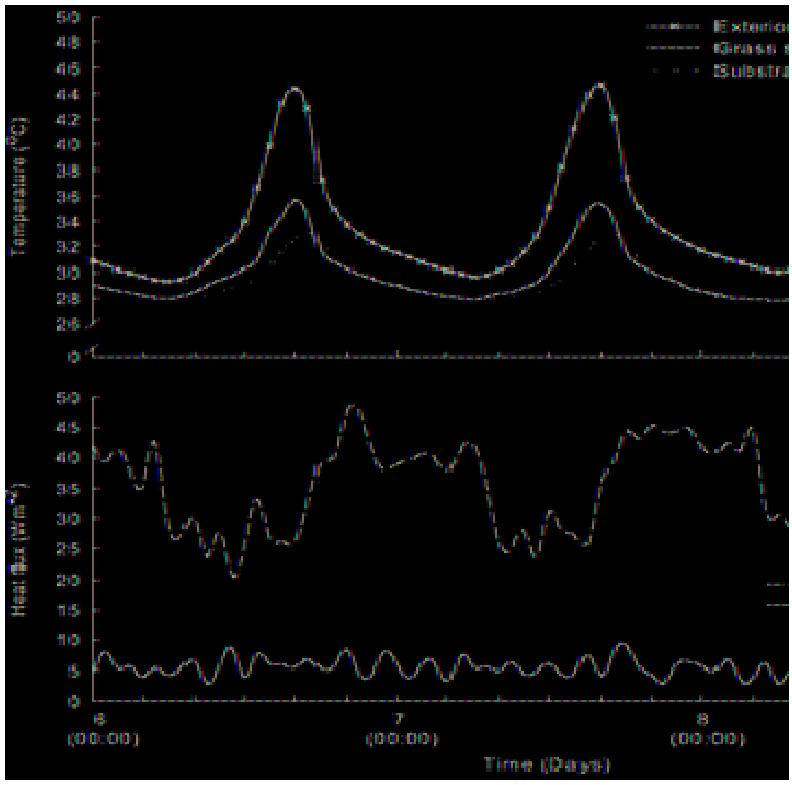

Figure 5 – temperature of the wall and green panel recorded on days 6-9 and the heat flux data at the corresponding time [1]

The presented study refers to the thermal effects of the vertical greening system on the indoor environment [1]. The vertical greening system is a living wall system, with the layer of substrate beside the vegetation layer. The temperature and the heat flux were measured in the summer months, and the results are shown in Figure 5. It is confirmed that vertical greening system has a cooling effect and makes the indoor temperature pleasant and stable despite daily temperature fluctuations. The use of energy for cooling the building interior is less with the vertical greening system compared to the buildings with bare walls.

5. DISADVANTAGES OF FORMATON OF GREENED FACADES

There are many benefits of using the greened façade, and some of them are presented in the paper. However, some disadvantages may occur in the planning stage, construction stage and during the maintenance of the greened façade.

Most of the living wall systems demand complex design which must consider a major number of variables, including several layers of the system, supporting materials, control of water and nutrients, etc., on the top of which they are often very expensive and difficult to maintain. For example, direct greening system with climbing plants costs 30 – 40 €/m², indirect greening system with climbing plants and supporting material costs 40 – 75 €/m², living wall system based on planter boxes costs 400 – 600 €/m², living wall system based on foam substrate costs 750 – 1200€/m² and living wall system based on felt layers costs 350 – 750€/m² €/m² [6]. Inside the range given, the costs depend on the facade surface and height, location, connections, etc. It is clear that the living wall systems are much more expensive than the direct and indirect greening systems and this is due to the maintenance needed, the materials involved, the design complexity.

The durability of the systems also has to be taken into account. For example a panel of a living wall system based on felt layers has an average life expectancy 10 years, but the living wall system based on planter boxes is more durable – more than 50 years [6]. The added vertical greening system on the facade requires the calculation of larger building construction which increases its load and the building cost. During the maintenance stage, some damages may occur due to the lack of maintenance and design mistake.

These disadvantages can be minimized by proper design and construction. Considering this, some of the layers of bare facades can be replaced, in the design stage, with a vertical greening system. Proper maintenance influences the extended life of the construction. And the starting investments in vertical greening systems are justified by the realized quality of the environment in the short run and by the durability of the structure in the long run.

6. CONCLUSION

The violation of the natural surroundings and the degradation of the quality of the environment in urban centers may be reduced by greening the building envelope. By increasing the green surface, many benefits are gained, some of which have been described in the paper.

The popularity of vertical greening systems is growing in the context of urban landscaping because of its smaller footprint, aesthetic value and the benefits from environmental aspects of construction. Vertical greening is certainly an alternative to roof greenery in a city composed

of tower blocks which have high wall to roof ratio, and consequently large potential surface area for greening.

A brief overview of the benefits of greened facades, with considerations to the advantages of the vertical greening systems compared to bare façade walls, may lead to their application in our region. Although every researched case is special, they may form the basis for anticipating results by making simulations of climatic conditions of a certain region. This paper represents a sort of promotion of greened facades.

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