REVIEWING THE GREEN WALLS AND THEIR EFFECTS ON THE FORMATION OF SUSTAINABLE ARCHITECTURE

Iman AREFI¹, Elham KEIVANIZADEH²

¹MSc in Architecture, Bam branch, Islamic Azad University, Bam, Iran
²MSc in Geography, Rural programming

Received: 22.03.2015; Accepted: 29.05.2015

Abstract. Today, in the whole world, due to the existence of the basic problems such as global warming, air and water pollution, and ultimately the unsystematic consumption of energy and its high economic costs, it is highly necessary to use the sustainable architecture technologies, especially the creation of green buildings for reducing the energy consumption. Designing the green building is actually a process for increasing the building quality in which the buildings and their location consume the energy, water and materials in a way that causes the lowest negative effects on environment and human health. Therefore; using the approaches such as green walls and roofs, can be very helpful for reducing the energy consumption and destructive environmental effects. So, dealing with this issue, can be considered as one of the largest environmental developments in the cities. This research deals with the position of the green walls in the human environment for reducing the energy consumption and its effects on modern urban life. It also explains the role of green walls in improving the human life.

Keywords: Sustainable Architecture, Green Wall, Living Wall, Green Façade

INTRODUCTION

Due to the increasing urbanization in developed and developing countries, restoring those lost green spaces whose urban areas have been turned into residential, commercial, official or worst of all, industrial complexes, has become one of the main concerns of contemporary architecture and urbanization. Contemporary urban life and the growing number of cars, has caused problems such as increasing the environmental pollution, greenhouse gas emissions and creating heat islands. A different approach to buildings as the world’s largest consumers of energy (40% share of energy use) can also convert them to the best sources of energy savings. Building shell or in other words the façade of the building can be considered as one of the main factors in energy efficiency as well as in the parameters associated with the quality of the interior spaces, the comfort of the occupants of the building and the positive visual influences in urban environment. With the rapid consumption of energy resources and increasing environmental contamination in the cities, it is clear that the main purpose of designing building shells for contemporary buildings must be the maximum use of available technologies and strategies for creating the optimal space with the lowest consumption of non-renewable energy resources. One of these strategies that contemporary architecture has focused on, is the application of vertical green systems that causes retrieving the environmental integration of the urban spaces, biodiversity and sustainability of the environment. The application of various technologies of the living walls can cause the environmental benefits in new constructions and even in existing buildings. A look on megacities, especially in developing countries such as Iran, with loss of empty spaces in the cities and the movement of the buildings toward the sky, makes it clear that the application of vertical green systems is highly necessary with regard to the following items:

- Shortage of unoccupied spaces which have not been under urban construction for designing and performing vertical green walls

* Corresponding author. Iman AREFI

Special Issue: Technological Advances of Engineering Sciences

http://dergi.cumhuriyet.edu.tr/ojs/index.php/fenbilimleri ©2015 Faculty of Science, Cumhuriyet University
- Constructing tall buildings and increasing production of solid walls which will form the citizens’ views of the city and the vertical panels’ potential for being changed into vertical green panels in buildings and using their benefits in building and city layer.
- More practical benefits in using the green shells in the buildings rather than normal horizontal green surfaces in cities.
- Production of integrate green spaces by making each building green and connecting it visually to parks and public greenbelt in the city.

**Background of the study**

Combination of the architecture with nature and plants, is not a new idea. From early ages the natural and artificial sceneries were combined with urban constructions. Designed green spaces appeared right when humans showed concern for architecture. Slanted walls of NanaZiggurat which was built in 2100 BC were covered by trees and bushes. Hanging Gardens of Babylon, which included legendary magnificent roof gardens and stepped gardens have been the first known examples of green roofs and walls that were built between 700 to 900 BC(Figure 1) [3].

![Figure 1. Hanging Gardens of Babylon.](image)

The history of the green wall goes as far back as the 600 years BC and it belongs to Hanging Gardens of Babylon. The Romans also used to move vine and olive leaves on the networks located on the walls of building and thereby produce green walls easily. The design of green pavilions and climbing plants network in homes and gardens strongly expanded in 1920 in UK and North America. The green wall was invented by Stanley Hart at the University of Illinois Urbana-Champaign between 1931 to 1938. In 1988, the production of stainless steel cable caused a more advanced design for green views and in 1990 network cable and wire-rope net systems and modular network panel system were available in the North American market, which were used in the vertical green systems. The first standard examples of these networks were used in 1993 at Universal Parks in California (Figure 2) and in 1994 in Life Building in Toronto Canada (Figure 3) [3].
Reviewing The Green Walls And Their Effects On The Formation Of Sustainable Architecture

Figure 2. Universal Parks in California.

Figure 3. Life Building in Toronto Canada.

A structure consisting of 1300 climbing plant was made in 2002 in Zurich in the MFO Park. This structure was a new interpretation of the urban parks that represented the design of the open spaces and green architecture both vertically and spatially. (Figure 4 and 5) Many other examples around the world represent the increasing application of this technology and its positive influences in the city and the buildings. Recently the concept of the green wall with the growth and development of plants in mineral and nutritious water for strengthening the operational technology innovation, has been expanded. In 2012, the world's largest green wall covered 2700 m². It is located in the International Convention Center in Cabos Los. (Figure 6 and 7)
Figure 4. MFO Park.

Figure 5. MFO Park.
Reviewing The Green Walls And Their Effects On The Formation Of Sustainable Architecture

Figure 6. Cabos Los.

Figure 7 Cabos Los.

Varieties of green vertical systems
Different solutions are possible for producing the green shell of the building which are known with different names such as Bio-vegetated, Living Wall, Eco-wall, Vertical Wetlands, Green
Wall and Vertical garden Wall. It consists of two general categories: Green Facades and Living Wall.

**Green Facades**
These facades are designed in two ways including walls covered with the green vase, and walls with different Vegetation.

The second way can be designed and run in several modes.

**Modular Trellis Systems**
These systems are consisted of galvanized panels and welding steel lines. Solid structure is lightweight and three-dimensional and the vegetation grows on it. This structure is completely separate from the main frame-work of the building and its advantages are as follows: covering vast surfaces, formability and performability in different simple and curve shapes, being Made of recycled and recyclable steel, and the possibility of implementing the system as a self-standing structure.(figure 8 and 9 and 10) [4]
Reviewing The Green Walls And Their Effects On The Formation Of Sustainable Architecture

**Grid and Wire- Rope Net Systems**

This is a system which consists of a stainless steel cable traction, anchors and complementary equipment can be used for both vegetation with slow and rapid growth rate. Variation in the size and pattern is one of the advantages this system has. (Figure 11) [4]

**Living Wall System /LWS**

In this system, the aesthetic influences on buildings and urban environments are more into consideration than the environmental influences. Plants are grown on the panels of different genera and they are installed on the building's façade as green prefabricated parts. Choosing the type of vegetation is very important for the growth rate and the conditions of maintenance and its density. These plants must be watered using the special system with nourishing. Living walls can be either internal or external. Generally, its different forms include these three sectors: Structure or the metal frame, PVC layer and air layer. This system needs more maintenance than green facades. Its variety is as follows:
1- Green panels: They are brought to the workshop in a prefabricated construction form along with vegetation and are connected to the body of the building and its mechanical systems for irrigation and nourishment. (Figure 12) [4]

2- Felt system: plants are planted in the felt bags which have a humidity insulation in their exterior parts. This set is connected to the body of the building by a frame and the felt bags are kept constantly wet. (Figure 13) [4]

3- Steel containers system and network: The plants are planted within the steel Chamber and are grown on networks. The irrigation method is drip irrigation and it is done inside the chambers. (Figure 14) [4]
Benefits of using the green wall technology
Green walls have a wide range of environmental, social and economic benefits. Covering the façade of the building with Vegetation, in terms of the environmental aspects has a decisive role in reducing air pollution and contaminants, reducing greenhouse gases, a fall in the ambient temperature and adjusting the urban heat island effect, reducing noise pollution, decreasing energy consumption and generally improving the environmental quality. The green wall is ecologically important because it creates a Habitat for plant species and attracts animals and birds and helps biodiversity preservation.

In terms of economics, Green walls make the building more valuable by increasing the green spaces, maintenance of the frame-work and the authentic aspects. Green walls also helps saving the heating and cooling energy in summer and winter by creating thermal insulation. As a result, the energy costs will reduce. Using the drip irrigation system and turning the water in the system will provide it with the minimum consumption of water.

Socially, green walls by using a combination of nature, buildings and urban embellishment for citizens cause more merriment and help physical health and sanity. Optimization of urban scenery and improving the surrounding views of the building can be considered as other social benefits of this new technology. Providing job opportunities which are related to this modern technology, is also a positive point of green walls. Recently, urban agriculture and the cultivation of vegetables and summer crops on approachable parts of green wall have been common and it has so many economic and social benefits for citizens. (Figure 15)[5]

General Benefits of Using Vertical Green Walls in a City Associated with Society and Government
- Creating beautiful urban scenery and covering useless solid walls
- Decreasing the heat islands in the cities
- Effective reduction of noise pollution in urban environment (attracting the noise by vegetation)
- Decreasing the negative effects of modern life in the environment (decreasing in production of greenhouse gases and CO2)
- Increasing the quality of the urban spaces’ air (photosynthesis of plants and production of oxygen)
- Positive effect on increasing the water quality and adjustment of urban water resources
- Improving public health and comfort
- The possibility of making biodiversity
- Adaption of living environment with climate changes. [5]

Considerations in designing the vertical green systems: [6]

**Orientation**

In designing the vegetation, orientation and the region climate are very important factors of choosing the right vegetation for living walls system. Awareness of light attraction condition, airflow and humidity of these sublimates is really important in applicability and stability of the system. Factors such as scenery, prevailing wind, shadows of the surrounding buildings are effective in designing which is affected by the site of the building.

**Choosing the Vegetation**

One of the most effective factors for applicability and stability during the time in vertical green systems, is choosing the type of vegetation. The scales for choosing the vegetation are tested according to scenery, the maximum height (the maximum growth of plant), the type of demanded soil (local or not), maintenance and plant nourishment costs.

In a general view, without considering the climate as the most important factor in vegetation, plants with high strength in the atmospheric conditions (sun exposure and wind blowing), low soil humidity, thick covering and climbing plants which have a strong connection between the stem and the root are proper for being used in this system (In choosing the plant type, the pollination should be taken into consideration).

**Irrigation**

Watering the living walls because of their vertical and climbing motion and their high location, must be done very carefully.

Distributing water and nutrition to all vertical surfaces and controlling the humidity caused by it, and protection of buildings against this moisture, are some of the items that should be taken into consideration in designing the mechanical irrigation of these systems. Another important point which is notable in this section is water recycling and using sewage water of the building for watering these plants. The use of rainwater and excretory recycled water leads to the sustainability of these systems.

**Maintenance**

Proper design of these systems and using the living walls in the designing process and notifying the mentioned items can highly reduce the maintenance costs. Considering the maintenance condition and the forthcoming demands of these systems such as lopping, irrigation, nourishing the plants in the designing process and creating new methods for protecting with the minimum costs and energy consumption can result in sustainability of these systems.

**Intenal Designing**

Designing the vertical green systems should be coordinated with other components of the building in order to reduce the performance and maintenance costs of these systems. In designing these systems, accessibility to green layers for repairing and maintenance and the possibility of receiving appropriate sunlight in internal areas and the visual harmony for residents should be the essential points in designing. Generally considering the multiple aims for designing these system is the secret for their stability.
Costs
The statistics which are related to vertical green systems in cost section always represent the performance and maintenance costs. According to the potential for reducing the energy consumption costs of the building, those statistics should be compared with the costs after applying the vertical green systems which cause shading, thermal insulation and increasing the efficiency of the users. The more the systems’ efficiency grows, the less the costs will be.

CONCLUSION
Moving toward the architecture and urbanization which is adaptable with the environment, changing the design strategies and creation of new methods for restoring the balance of the nature and providing the modern life requirements at the same time have led to increasing use of vertical green systems around the world. As a result of this research, the necessity of designing the vertical green systems can be briefly represented as follows:

- When Living green walls are considered as one of the main components for designing the building shell, they can effectively enhance the thermal efficiency of the building. Hereon, the result would be the lower use of energy and a reduction in using fossil fuel and decreasing the greenhouse gas emissions and CO2.

- Using a proper approach for designing the vertical green systems and applying them to designing process can lead to a better design for façade, retaining constructions of the system, mechanical ventilation system of the building and their irrigation system and finally a noticeable reduction in performing costs.

- Planning for vertical green systems from the beginning of the deign process and awareness of the designing requirements and performing these systems can reduce the performing costs of the systems.

- Choosing the right vegetation for vertical green systems in building shell not only would improve the efficiency of the systems and reduction of maintenance costs but also would have an impressive effect on air pollution reduction. Finally, it would increase the air quality and would optimize using the spaces.

- What should be kept in mind while designing the vertical green systems is the difference between the designing condition and performing the systems in every country. This issue would be affected by two factors:
  - Specifications of the construction market including local constructions and their performance costs, convenient professionalism for construction, available technologies and industries and energy resources.
  - The climate of every region and the weather specifications which can enhance the irrigation and maintenance costs for vegetation of these systems.

At the end, it is good to know that the application of the vertical green systems as an environmental solution in developing countries is increasing, although it still demands many researches and innovations.
REFERENCES


