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GREEN FAÇADES

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Abstract

The Green Areas and Sustainable Architecture are very important to the ECO-System and the people live around them. However much of them has been degraded according to human behavior among the environment. There are many phases to reach sustainability; first to stop abuse and think green, second change the idea of construction buildings to green buildings, third reusing and recycling, finally monitoring and maintenance. The main aim of the paper develops is how to compensate the lake of green spaces by using green façades technology. Green Façade refers to how you can built with reduction of damaging environment, maximize the indoor air quality, saving energy and integrating natural vegetation with building construction. The importance of green façade is how to maximize indoor and outdoor quality and compensate the lake of green spaces. Methodology includes literature review and analytical examples. Research is expected to conclude some recommendations to use green façades technology and knowing the impact of using it.

Keywords

Sustainable Architecture, Vertical Gardens, Recycling and Reuse, Green Buildings and Socio-Economic Impact

1. Introduction

1.1 Green Walls

Green Walls with the another name Vertical Gardens is the term of used to refer to all form of vegetated wall surfaces *(fig 1/1),* (Green roof organization 2008) [ref. 1].

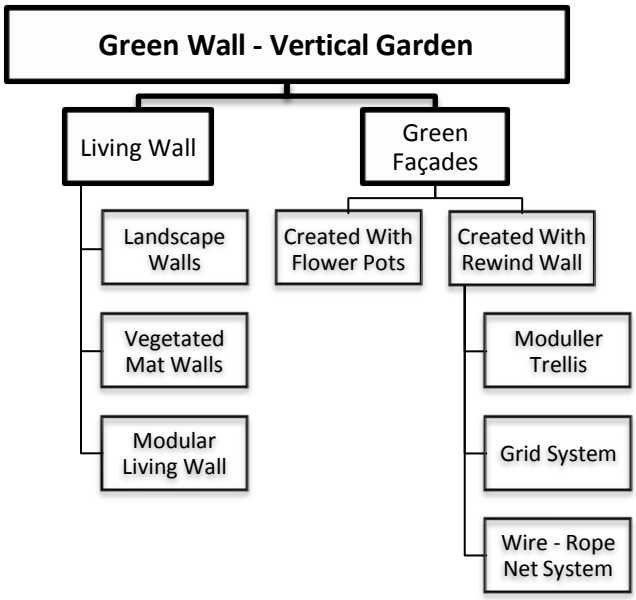

Figure 1.1: *Types of Green Walls (Green roof organization 2008, Yen 2012).*

2. Green Façades

"Green Façades are type of green wall, they are made up of climbing plants either growing directly on a wall or in specially designed supporting structures. The plants typically take 3-5 years before achieving full coverage (Green roof organization 2008) [ref. 1].

Green Façades are not only spectacularly beautiful, but also helpful in enlivening the ambiance. Green Façades can absorb heated gas in the air, lower both indoor and outdoor temperature, providing a healthier indoor air quality as well as a more beautiful space (Yeh 2012) [ref. 3]. Green Façades can be anchored to exiting walls or built as freestanding structures, such as fences or columns (Green roof organization 2008, Gonchar 2009, Yeh 2012) [ref. 1,2,3].

Three green façade systems that are frequently used are Modular Trellis, Grid and Wire – Rope Net System" (Green roof organization 2008, Yeh 2012) [ref. 1, 3].

2.1 Green Façades Systems

2.1.1 Modular trellis panel system

"The building block of this modular system is a rigid, light weight, three-dimensional panel made from a powder coated galvanized and welded steel wire that supports plants with both a face grid and a panel depth. This system is designed to hold a green facade off the wall surface so that plant materials do not attach to the building (fig 2/1), Panels can be stacked and joined to cover large areas, or formed to create shapes and curves, are made from recycled content steel and are recyclable. Because the panels are rigid, they can span between structures and can also be used for freestanding green walls" (fig 2/2) [ref. 1, 1.8].

Figure 2.1: *Modular trellis panel system (http://greenwalls.com 2015).*

Figure 2.2: *Curved trellis (left), freestanding trellis fence (bottom), colu9mn trellis (right), (www.greenroof.com 2015), (http://st.hzcdn.com 2015), (www.pinterest.com 2015).*

2.1.2 Grid and wire – rope net system

"The grids and wire-rope net systems use either cables and/or a wire-net (fig 2/3, fig 2/4). Grids are employed on green facades that are designed to support faster growing climbing plants with denser foliage. Wire-nets are often used to support slower growing plants that need the

added support these systems provide at closer intervals. They are more flexible and provide a greater degree of design applications than grids. Both systems use high tensile steel cables, anchors and supplementary equipment". (Fig 2/5) (Green roof organization 2008, Yeh 2012) [ref. 1, 3, 1.4].

Figure 2.3: *Grid system, Ex Ducati Office, Italy (http://www.intechopen.com 2015).*

Figure 2.4: *Grid and Wire – Rope system, MFO Park, Switzerland (http://www.intechopen.com 2015).*

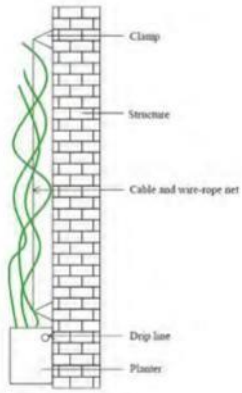

Figure 2.5: *Grid and Wire – Rope system (right) (http://www.intechopen.com 2015).*

3. Living Walls

"Living walls, also called bio-walls systems are composed of revegetated panels, vertical modules or planted blankets that are fixed vertically to a structural wall or frame (fig 3/1). These panels can be made of plastic, expanded polystyrene, synthetic fabric, clay, metal, and concrete, and support a great diversity and density of plant species. Due to the diversity and density of plant life, living walls require intensive maintenance" [ref. 1, 4, 1.8].

Figure 3.1: *Living Wall (http://www.greenovergrey.com 2015, http://inhabitat.com 2015).*

4. Green Façades Benefits

Green Façades provide economic and ecologic benefits as well as aesthetic value. The benefits change with options such as different buildings, green wall technologies, plant selections and plant coverage. In this part is examined important values of Green Façades [ref. 4].

4.1 Reduce Urban Heat Island Effect (UHI)

Replacing natural vegetation with buildings and another structures causes increasing in temperature. The result of replacing converts sunlight to heat. Vegetation cools building and surrounding area through shading and reducing reflected heat

Green Façades are the most popular way to cooling air and decrease The Urban Heat Island effect (fig 4/1, fig 4/2) [ref. 5, 6].

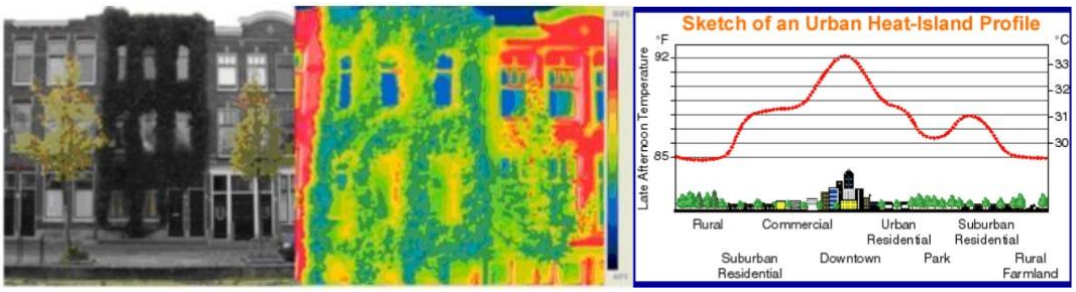

Figure 4.1 (left): *Urban Heat Island Effect, (Ottele, 2010),* **Figure 4.2 (right):** *Urban Heat Island Profile (http://www.ssbx.org 2013, http://www.lsgi.polyu.edu.hk 2013).*

4.2 Beauty abounds and adds visual drama (fig 4/3, fig 4/4)

Plants are one of the fastest, most cost effective agents for redeveloping the negative effect of buildings and reduction of green areas, enhancing a public profile of buildings and improving visual amenity. Green Façades increasing the amenity of buildings and transforming them to recognizable landmarks. (Doer ranch 2008, http://www.greenology.sg 2013) [ref. 7, 1.1, 1.10].

Figure 4.3 (left): *Palace of Congresses Urbanarbolismo (http://inhabitat.com 2015),* **Figure 4/4 (right):** *Bridge in France before and after (http://twistedsifter.files.wordpress.com 2015, http://www.livingwallart.com 2015).*

4.3 Decrease voice level

Plants and soil which used in green façades have a voice absorption features. They perform to decrease voice which happened in both in building and its close area. Green Façades provide a noise buffer which reduce outside noise and vibration (up to 40 dB) (Dunnett and Kingsbury 2004, Erdogan and Aliasghari Khabbazi 2013, http://gsky.com 2013, Jacobs 2008, Wong et al 2010) [ref. 1.2, 8, 9].

4.4 Conserves water and watering takes less effort

How green façades manage waste water is one of the biggest benefits of green façades. For using a drip irrigation system or hydroponic system watering is very efficient. Waste water collected at the bottom of the garden. Alternatively, water can recycled and put back into the garden. Water ways are not effected by storm water and waste water (fig 4/5) (http://www.homeim provementpages.com 2013) [ref. 7, 1.9].

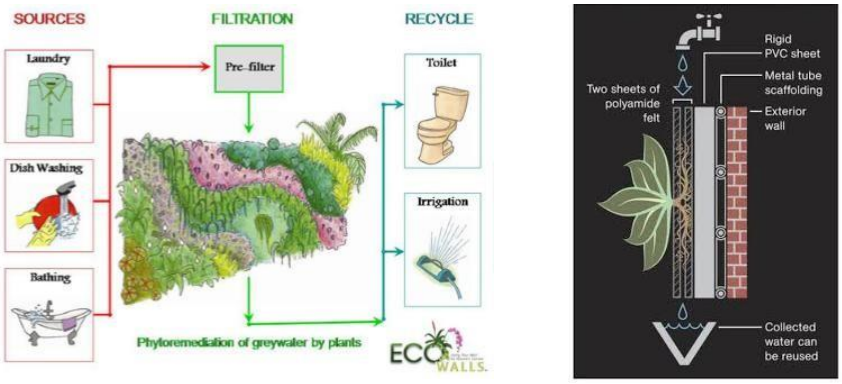

Figure 4.5: *Greywater Treatment (http://www.greenecowalls.com 2013).*

4.5 Reduces CO2 levels and increases oxygen and improved air quality

Green Façades reducing existing green house and other volatile organic compounds. Plants act as bio-purifiers and improving the quality of city air by removing air bone contaminants from both outside and inside building and filter pollutants from the air (fig 4/6).

Another benefit of green façades is taking carbon dioxide and produce oxygen rich air by photosynthesis (fig 4/7) (Erdogan and Aliasghari Khabbazi 2013, http://www.greenology.sg 2013, Truest 2003) [ref. 10, 1.1, 11].

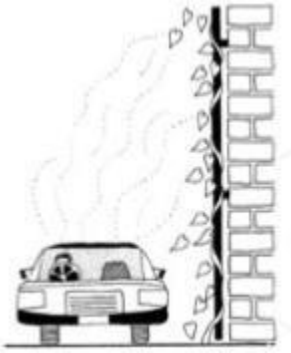

Figure 4.6: *Drawing about prevent dust with plants (Johnston and Newton 2004)*

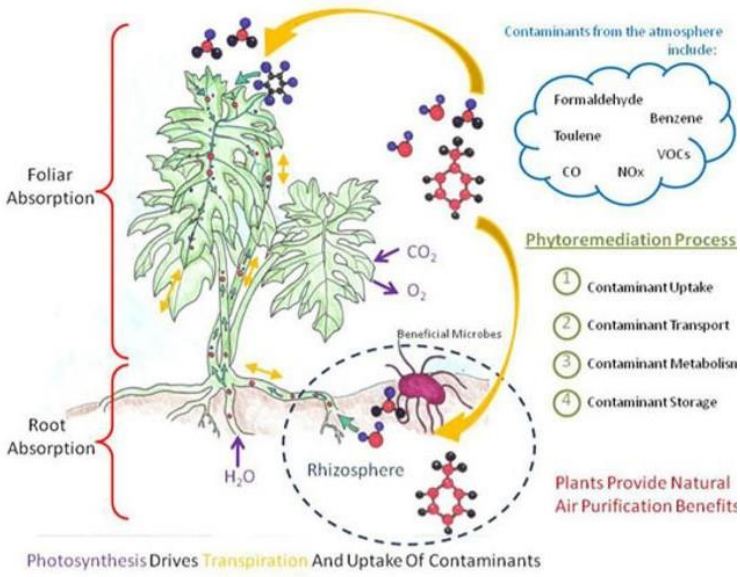

Figure 4.7: *Indoor Air Quality (http://www.greenecowalls.com 2013).*

4.6 **Acts as natural insulation for hot and cold air and a save energy for your building**.

Indirectly, green façades reduce air-conditioning requirements and energy consumption by cooling buildings in summer and insulation them in winter

Façades which covered with plants reduce the wall temperature and building cooling load. (fig 4/8). (Baumann 1986, Doernach 1979, http://www.marthastewart.com 2013, Johnston and Newton 2004) [ref. 12, 7, 13].

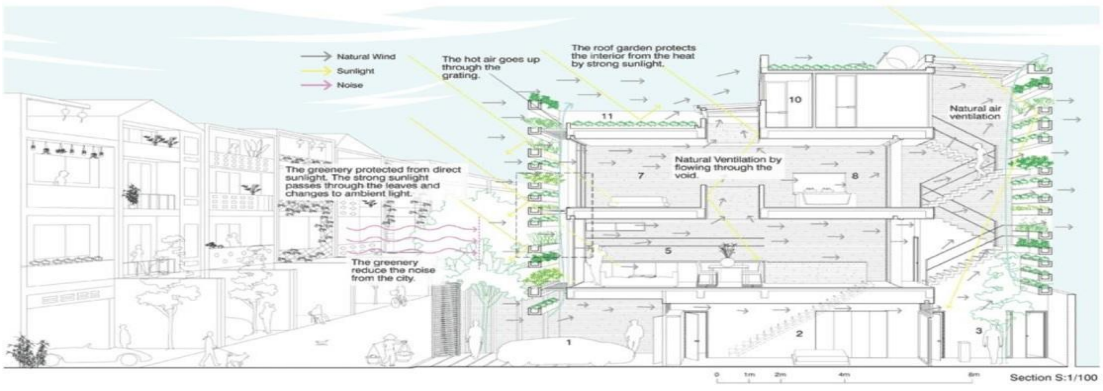

Figure 4.8: *Stacking green (http://www.dezeen.com 2013).*

5. Maintenance

All green façades require maintenance because they are a living system. The amount of maintenance that client provides is an important for design factors, which impact the selection of the type of the system and plants. Green façades generally use vines that may grow from soil or containers. Site location and containers require non- dependent vines species be given additional irrigation and nutrients. Some will be deciduous or provide fruits which may require additional maintenance. Cable and wire-rope system require periodic checking of cable tension.

Maintenance issues should be discussed with client in the early stage of design to define the design criteria [ref. 14].

5.1 Maintenance Task [ref. 15]

Maintenance falls into a number of categories:

1. Establishment maintenance occurs during the first one to two years after installation. For vegetation, this includes tasks such as pruning, weed control, and irrigation to ensure healthy and vigorous plant growth.

2. Routine or recurrent maintenance for facades include standard of appearance, functionality and safety. For vegetation, includes tasks such as weeding, pruning, removal of leaf litter and, in some cases, mowing.

3. Cyclic maintenance includes maintenance of the underlying building structure and of specific components of the green roof, wall or facade system. This may include infrequent pruning or other formative management of woody vegetation, such as coppicing, or annual treatment of decking.

4. Reactive and preventative maintenance is undertaken when some component of the system fails suddenly, or shows signs of imminent failure. Failure may be happened due to a long-term problem (such as blocked drains by tree roots), or sudden damage resulting from an extreme weather event (such as storm water incursion).

5. Renovation maintenance includes works that change the design intent. This may arise after a change of ownership of a building.

6. Factors for successful Green Façades

"Green façade projects require that the designers, installers, manufacturers and maintenance staff take the following into careful consideration:

- Attachment to building envelope – how the system will be secured.
- Calculation of structural loads for larger systems, resulting from loads.
- Plant selection for wind and light exposure, hardiness zones, and amenity context.
- Realistic expectations related to plant aesthetics and growth – some systems require 3 to 5 years to become fully established.
- Plant maintenance or long term maintenance plan to secure the health of these living systems.
- Check with manufacturers who may have registered or specially trained installers that will be able to complete the project successfully.
- Appropriate plant selection for the geographic region, correct plant spacing for desired coverage, and release from the temporary support structure used by the nursery" [ref. 17, 1.4].

7. Examples for Green Façades

The following case studies give some indication of the range of costs you are likely to find for different types of applications; descriptions of the design goals; and an overview of the project solutions.

7.1 RMIT University Building 21 (fig 7/1) [ref. 16, 1.5]

Location: RMIT University city campus 124 La Trobe Street, Melbourne, Victoria

Completion Date: 2011

Cost: $230,000

Area: 122m² on existing building

Description: The green façade was constructed on the north and west-facing external walls of Building 21.

Structural support information:

- A Ronstan X-TEND mesh trellis system in a diamond-shaped pattern. This system is secured in place by steel framing at the top, bottom and sides of the wall, there is 40 cm gap between the trellis system and the brick facade of the building so no root barrier or waterproofing layers were needed.
- Planter boxes, which are mounted to the existing brick facade using a galvanized steel frame which encases the entire planter box. Zinc sheet vertical cladding covers to hide the drainage system below.

Maintenance:

Regular maintenance tasks include:

- Monthly inspection of irrigation system function.
- Twice yearly (spring and autumn) pruning and retraining climbers around windows.
- Twice yearly (spring and autumn) fertilization, plus additional if required.
- Monthly comprehensive visual inspection.
- Weekly general inspections (including removal of rubbish) [ref. 18].

Figure 7.1: *RMIT University, Victoria (http://www.growinggreenguide.org 2015).*

7.2 Pritzker Family Children's Zoo at Lincoln Park Zoo (Cable System) (fig 7/2) [ref. 1.3, 1.6, 1.10]

Location: Chicago, IL

Completion Date: 2004

Cost: $7800

Area: 4,000 sq.ft

Design objectives / criteria:

Create a natural, imaginative, multi-sensory experience of the North American woods

Green Wall System:

Plants used: Vitis Riparia; Riverbank Grape (Special Hybrid)

Structural support information:

4mm stainless steel vertical wire ropes and 4mmø horizontal wire rods connected in a rectangular grid using UV-Resistant cross clamps. Hand-installed terminal end fittings allowed field trimming of ropes and rods for simplified installation.

Figure 7.2: *Pritzker Family Children's Zoo at Lincoln Park (http://depts.washington.edu/ 2015).*

7. Conclusion

The reduction of green spaces and increasing of urban heat island effect (UHI) considered as a main problems in recent times, therefore Architects turn to use the green façades technology to compensate the reduction of green spaces and decrease the effect of urban heat island. Green Façades are a key component of living architecture and they will become increasingly important fixtures in our cities in the year to come. Green Façades can also restore ecological balance at the lowest cost, planting 1.5 m² enough for one person to breathe for a year.

Green Façades is not only spectacularly beautiful but also, maximizing indoor and outdoor air quality, saving energy, reducing thermal load and increasing the amenity of buildings. Choosing kind of plants taking into account climatic condition increasing the efficiency of green façades. Green façades benefits not also for vegetation and environmental treatment but also, for food producing by using productive plants.

Green Façade technologies provide a wide range of options for designers who are interested in using green architecture technology and provide a new freestanding design features on the interior and exterior building.

Determine the type of green façades systems (modular, grid and wire-rope system) which used according to the condition of the building increases the efficiency of green façades.

Maintenance should be periodically to be sure of the efficiency of the system and protecting building from any leakage of water, maintenance issues should be discussed with owner before making design strategy, the amount of maintenance that client provides effects in choosing type of the systems and plants. Maintenance planning should also incorporate risk management, with the aim of reducing or eliminating the likelihood of failure that could result in property damage or personal injury.

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