Sulaymaniyah

ARCHITECTURAL ENGINEERING

Green Façade and Sustainable Architecture

2023

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Introduction:

For various reasons, sustainability today is producing an important and interesting approach between architecture and the environment. This is taking place in forms and with different degrees of intensity. Within the challenges of energy crisis and climatic changes architects started to develop new approaches to address the quest of energy demands in buildings. One of these approaches is façade greening which started to take an important place in the last 10 however it has not been approved as an energy saving method for the built environment. Vertical greening can provide a cooling potential on the building surface, which is very important during summer periods in hot climates. The cooling effect of green facades has also an impact on the inner climate in the building by preventing warming up the façade. Within this quest, this paper is focused on the analysis of the effect of green facades systems on the building temperature and addressing different types of green facades systems and their thermal effect.

Green Facades and its environmental Impact on Buildings:

In recent years, has been enumerated by various authors and a number of advantages disadvantages associated with the vegetation of the buildings. These aspects have been studied, tested and described in greater or lesser extent depending on authors, the countries of the possibility of obtaining objective data; the time needed experimentation, etc. Lately also considering using the strategy of building plants urban and in relation to the environment. It is considered that the building to support vegetation has a decisive role in the strategy of urban vegetation as part of its essential relationship with the environment must have in the city. The consideration of roofs and facades of the skin of the building to support different models of urban vegetation, must be properly studied and included in the planning and ordinance related [1]. Vegetation can play an important role in the topo-climate of towns and the microclimate of buildings. With buildings, some vegetative climatic effects could be made by combining green cover on walls, roofs and open spaces in the vicinity of buildings [2].Many researches proved that vegetation on building façade can be effective on the level of building environmental performance, Lambertini [3] presented a pictorial collection of the most important architectural projects that embraced the emerging trend of designing and cultivating once inconceivable greenery on a vertical plane while Dunnett [1] cited the associated benefits and reasons for integrating green techniques of organic architecture into our built environment as well as provided a massive collection of appropriate plant information and extensive plant directories for both rooftop gardens and vertical greenery systems. Lastly, Van Bohemen [4] showed within an ecological engineering context the impact of the greening of outdoor walls and questioned the hesitation to implement vertical greenery systems as outer layer of buildings with special emphasis on the relationship between particulate matter and aerosol deposition with vegetation.

Methods for installing green facades:

Green façades are defined according to the application of climbers (deciduous or evergreen), as attaching themselves directly to the building elevation (in traditional architecture), or indirectly supported by steel cables, mesh or trellis. Fig. 1 illustrates different kinds of green facades. Climbers planted at the base of the buildings, in the ground, or in the intermediate planter boxes or even on the rooftops, provide a relatively inexpensive façade greening. The plants normally take 3-5 years before reaching full coverage. When planning a green façade with this method, it is important to consider that the climbers can raise to a maximum of 25 meters height, but it may take a number of years [1].

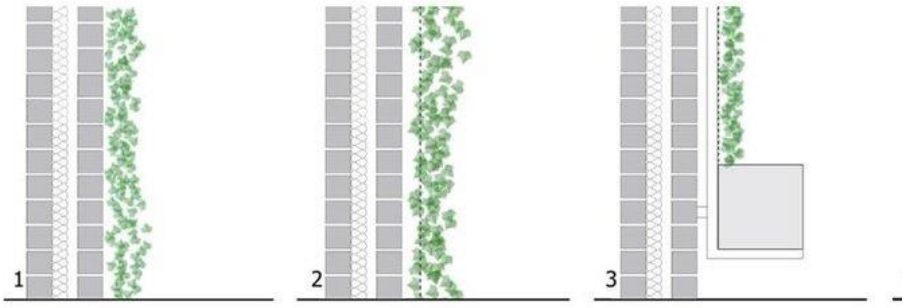

Fig (1): a-Direct System b-indirect system c-indirect system that id combined with planter box

Direct system of green façade:

In the first case, climbers planted in the ground at the base of the building as in traditional architecture, allow to obtain a cheap façade greening work. Self-clinging plants, which have been used frequently, have sucker root structure allowing them to attach directly to a wall and covers the entire elevation. But they cannot be applied for all building facades. These aggressive climbers can decay inappropriate walls and cause some problems for maintenance or when the time comes for plant removal [4].

Indirect system of green façade:

In this case, vegetation is supported by cables or meshes while keeping them away from the walls and other surfaces of the building. Different materials such as aluminum, plastic, wood, steel (stainless steel, coated steel, galvanized steel) can be used as supporter for climbing plants. Each of the materials causes changes on the functional and aesthetical properties due to cost, profile thickness, different weight and durability [6]. The indirect greening system can be integrated with planter boxes at different levels of the façade. In this case, the system requires nutrients and a watering system if the rooting space is not adequate and can be defined as a kind of living wall system [3],[4] but two indirect green facade systems which are commonly applied are “modular trellis panel” and “cable and wire-rope net” systems [12].

Modular Trellis Panel System:

This modular system consists of a three-dimensional, rigid, lightweight, panel and designed to hold a green facade off the building membrane because plant materials do not attach directly to the buildings' façade. Panels are normally made from a powder coated, galvanized and welded steel wire and prepare a captive rising environment for the climbing plants with numerous supports for the climbers. Panels are usually made from steel and rigid enough to both span between structures and be applied as freestanding green facades. They can be fixed and combined to cover large parts and designed to form different shapes [12] (Fig. 2).

Fig. (2): Modular trellis panel system

Cable or Wire-Rope Net System:

Cable or Wire-Rope Net System applies high-tensile steel cables, anchors and also complementary equipment. Numerous pattern and sizes can be accommodated as flexible vertical and horizontal wire-ropes are joined through cross clamps. Wire-nets which are more flexible than cables and provide a greater degree of design utilization, are often used for slower growing plants, but for green facades that are designed to support the faster growing climber with denser foliage, cables are employed [4] (Fig3)

Fig. (3): Cable and wire-rope net systems

Indirect greening system combined with planter boxes:

If planter boxes at different heights are combined with indirect greening systems, greenery can cover a vaster area of façade. In this case, if the rooting space is not satisfactory, the system requires a watering and nutrients system therefore can be defined as a living wall system [12], (Fig. 4).

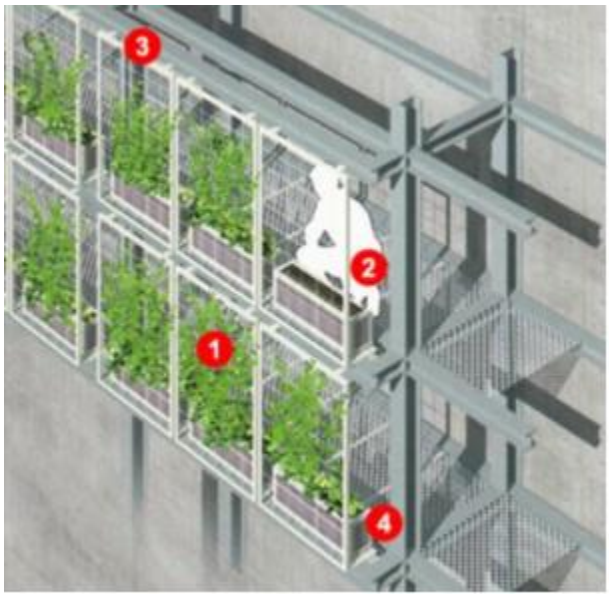

Fig. (4): Indirect greening system combined with planter boxes, 1. Containers 2. Insulated container 3. Maintenance remote monitored irrigation / fertilization system 4. Wall mounting system

Thermal Impacts:

A-Thermal Impacts: Temperature Reduction:

Research showed that the humid climates can achieve substantial benefits of a maximum temperature decrease of 8.4 _C with vertical greenery systems [5]. This is significant as the distribution of ambient air in a canyon influences the energy consumption of buildings as higher temperatures in canyon increase heat convection to a building and correspondingly increases the cooling load [6]. It was also noted that vegetation can alleviate UHI directly by shading heat-absorbing surfaces and through evapotranspiration cooling [7]. Vegetation can dramatically reduce the maximum temperatures of a building by shading walls from the sun, with daily temperature fluctuation being reduced by as much as 50%. Through evapotranspiration, large amounts of solar radiation can be converted into latent heat which does not cause temperature to rise. In addition, a façade fully covered by greenery is protected from intense solar radiation in summer and can reflect or absorb in its leaf cover between 40% and 80% of the received radiation, depending on the amount and type of greenery [8]. In terms of vegetated facades, the presence of a barrier blocking the transmission of plant radiation to the interior but also outwards, becoming a potential tool of isolation. Other interesting effects in terms of temperature regulation in buildings are the ability to reduce wind speed falling to the facades of the building, and modifying the climate of the intermediate space Plant remains from the screen and the facade of the building.

B-Thermal Impacts: shading and insulation:

The use of vegetation in vegetated facades as a blocker of solar radiation is clearly, with the advantage that the traditional elements Meta-Plastic or metal that are going and this heat will radiate back into the surrounding the building, while the vegetation does not. The magnitude of this effect depends crucially on the density of the foliage. The temperatures of the different layers of a double-skin facade are generally lower if Plants used against slat space inside. For the same solar radiation, increasing the temperature is two times lower than in the case of plants with respect to the slats [1]. The physiological process that occurs in plants implies that a small portion of solar radiation incident to be done for photosynthesis, and the rest is used in the evaporation of water, which makes the plant go a mechanism of temperature regulation. This leads to the vegetation gets effective blocking of solar radiation without increasing its temperature.

C-Evaporative Cooling:

In tropical climate, the cooling effect of plants was confirmed by measuring the temperature atmosphere at different altitudes. Regarding the performance of vegetated facades, these require maintenance, but offer similar shadow effects that other systems a plus evaporative cooling and beauty, The evaporative cooling to the blades and the soil depends on plant type and exposure, Thus, the evaporation of water is the most inexpensive and effective to cool a building. a meter cubic consumes 680 kWh of water evaporated. Vegetating facades of a building provides result in significant additional evapo-transpiration, which represents a high potential for reducing temperatures of the surfaces of buildings and improving the environment inside and around the building [3].

D-Variation of the effect of wind on the building:

The degree of wind protection offered by a green barrier depends primarily on the speed and wind direction, the dimensions of the barrier (height, width and length), density and penetrability of the material that is finally on its way. In considering the use of vegetation as a modifier of the effect of wind on buildings, space must be careful not to obstruct the ventilation in summer, and not encourage drafts in the winter. One of the ways in which green facades can increase the energy efficiency of a building by the wind. In winter, the cold wind plays a crucial role in reducing the temperature inside buildings. Even in airtight buildings, the wind reduces the effectiveness of regular insulation. Protecting the building of wind cold, the heating demand can be reduced by 25% [4]. However, it should be taken into account the ability to reduce the wind speed that affect the facades of the building and the climate change that occurs in the space between the screen and vegetable the facade of the building. This effect can offset the negative effect of the screens vegetated in winter because of the shadow effect. It is observed that is becoming more emphasis on the positive aspects of plant buildings than the negative, although the latter may become more conditions while making a decision project. Available data reflect cases widely scattered, both in terms of building systems and plant species used, such as geographic location, with different climate, which hinders the comparison and interpretation [2].

Benefits and threats:

1- Aesthetic enhancement and sound reduction are the common benefits of green facades. They can also serve as an “extra insulation” of the building envelope [8].

2-In winter, evergreen vegetation layer decreases the wind flow around the building façade. In addition, heat radiation of the external walls is insulated by the dense plant foliage and thus help prevent building to be cooled down [9].

3- Of all sun light that falls on the leaves, merely 5–30% of energy is passed through the leaf. The others may be reflected, transformed into heat, used for photosynthesis or evapotranspiration. This blocking of the direct sunlight disposal ensures a cooling effect in warmer climates and help the reduction of heat island effect especially in urban areas (fig.5), [13], [14].

4-Due to the evapotranspiration, green façades cool the heated air through evaporation of water [15].

5-A research in Australia quantified energy saving and indicated that the green façade can save 9.5-18% of the cooling energy consumption in commercial buildings [1], [1].

6- Relevantly improves the buildings’ energy efficiency and produces ecological benefits for a more sustainable urban environment, [10], [3].

7-The green envelope also reduces the quantity of UV light and cause a positive effect on building durability [15].

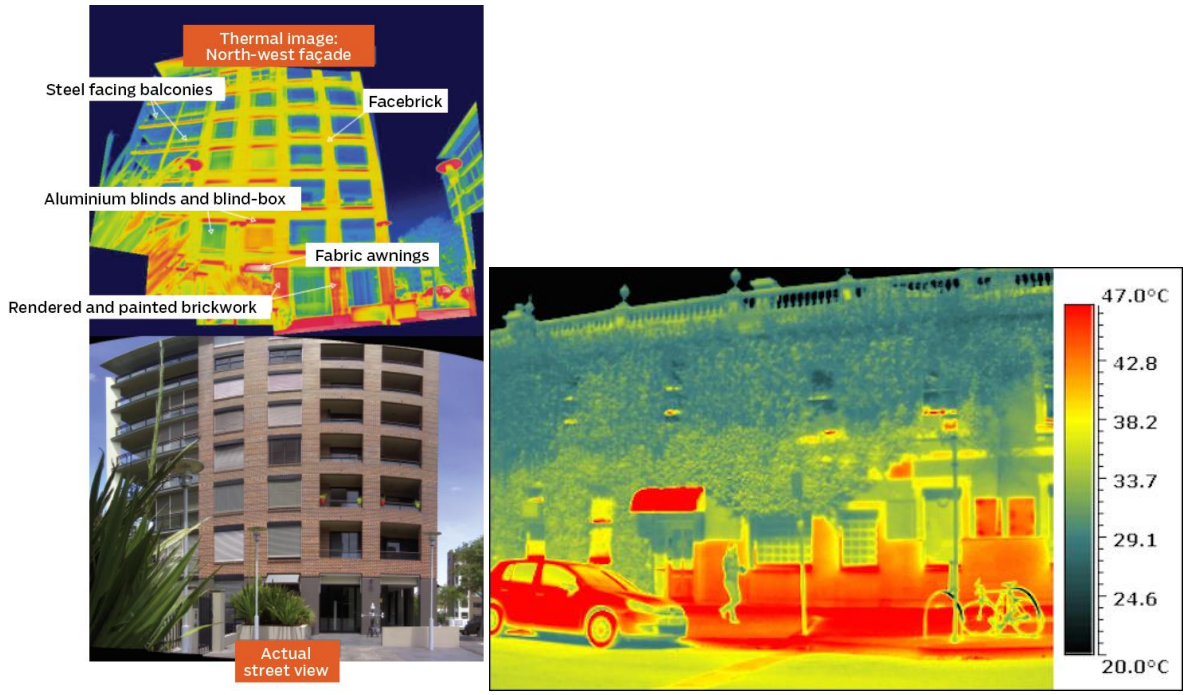

Fig. (5) Urban Heat Island Effect

On the other hand, the installation costs of direct green façade as well for indirect greening are climbing plants, and a dig at the base of the façade and the supporting system and steel mesh cost should be added to indirect green façade. For the indirect green façades combined with planter boxes the costs are higher because besides these systems they require an irrigation system. Maintenance cost depends on the type of the green façade. For the direct and indirect green façades, which is planted at the base of the façade, maintenance covers only pruning every year. These costs are different for the first four years and for the other remaining years of service life. For the indirect greening system combined with planter boxes, maintenance needs include also the plant species substitution and water pipes substitution [10].

Examples:

Bronx High School of Science As part of a proposal to make this high school carbon neutral and energy positive, it has been proposed adding a large facade farm and enclosing the outdoor entry plaza into an all-season student lounge area (figure 6).

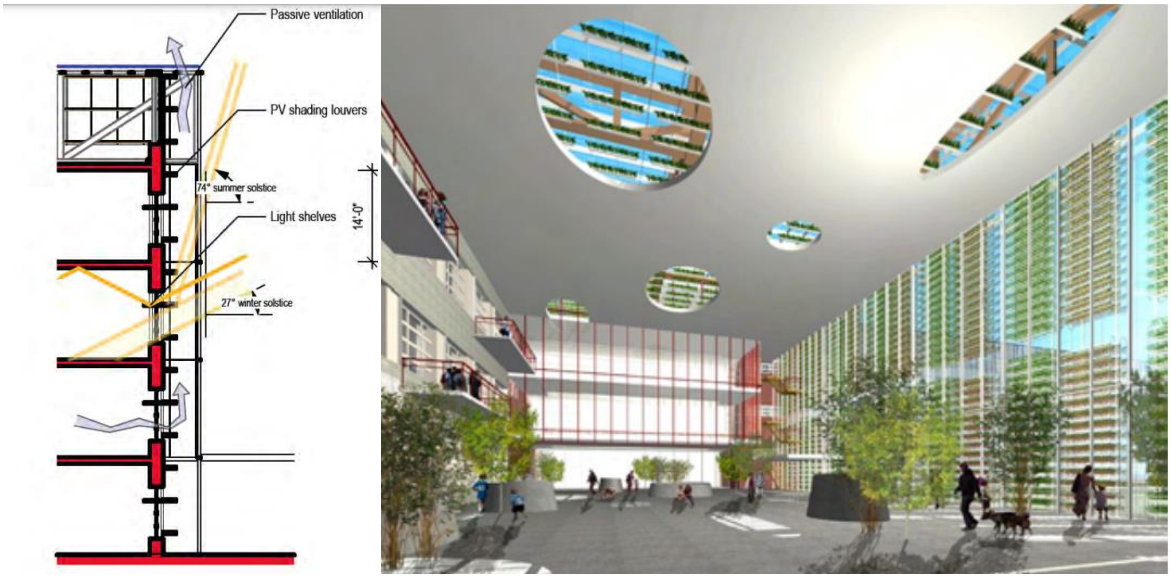

Fig. (6): New enclosed entry with facade farm to right and openings to horizontal rooftop greenhouse above

2-Jakop Factory, Chi Minh City, Vietnam.

Fig. (7,8): jakop factory, Ho Chi Minh City, Vietnam

Conclusion:

1-Greening systems should be chosen wisely according to the climate, budget and design criteria. Vegetation and plants should be selected carefully according to their natural supporting mechanism and their adaptability environment. For receiving full sunlight at the highest possible time, façades should be oriented accordingly. In addition, plants grow on the vertical plane constantly, so they need frequent maintenance: regular pruning, sufficient watering and so on. Regards to all these aspects vertical greening will be a significant component of sustainable architecture in future.

2-The integration of vegetation architecture in recent years has evolved conceptually from a primarily aesthetic design, gardening, or of artistic expression by the designer or the manifestation of economic power by the promoter, no a "vegetated architecture" in which the vegetation is another element of the building, with specific functions to develop the building as well as its relationship with the environment (energy aspects, acoustic protection material, support of biodiversity, etc.).

3-Facade greening can be just as a great contribution to urban air, making this fact is already known, but not yet quantifiable. The collaborating parties endeavored to keep the vertical greening system simple and robust which could provide the basis for benchmarking so as to encourage research and development of the vertical planting technology.

4-In general, the use of vegetation, so well designed and managed, can be a useful tool for passive thermal control of buildings with the consequent energy saving. This can occur in four ways, often related, thermal insulation, and the interaction with solar radiation, i.e., shade, evaporative cooling, and the variation of the wind on the building.

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THANKS ……..

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16- October -2023