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COMPARATIVE ANALYSIS ON GREEN ROOF ENERGY SAVINGS AND NORMAL CONVENTIONAL ROOF

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Abstract: **Green roofs are considered to be an effective solution to improve internal and external environment at the building and urban levels. In comparison to conventional roofs, green roofs present many benefits, such as reducing the temperature of the roof surface and surrounding air, reducing the air pollution, mitigating noise, improving the management of runoff water, increasing the urban biodiversity, and the reducing the energy consumption of buildings, especially for cooling purposes, Research has shown that green roof temperatures can be 30–40°F lower than those of conventional roofs and can reduce city-wide ambient temperatures by up to 5°F. In addition, green roofs can reduce building energy use by 0.7% compared to conventional roofs. This paper will use, a dynamic simulation of a building situated in the Campus University of Palermo, Italy, in the comparative analysis of green roof energy saving and normal conventional roof showing the importance of green roof over normal conventional roof. Two different situations were taking into consideration; in the first one, the building as it is, with a conventional covering, while in the second one the roof was equipped with a green roof. The results of the two simulations have been compared, recommending that application of green roof could contribute to the energy savings of the building.**

Keywords: **green roofs; energy building simulation; energy savings; green rooftop; black roof.**

1. INTRODUCTION

Green roof – sometimes referred to as living roof or vegetated roof, comprise of a waterproofing membrane, growing medium (soil) and vegetation (plants) overlying traditional roof. Green roofs are utilize to accomplish ecological advantages including decreasing storm water overflow, energy use, and the heat island effect. Urban areas are full with hardscapes, (Berardi et al 2014). These urban hardscapes, or intensely urbanized zones with regularly diminishing areas of available soil on which to plant vegetation, have lost the advantages that plants provide. Lack of advancement can prompt sewer floods and higher temperatures in urban communities and rural areas. Green rooftops are an innovation that can moderate a portion of the negative impacts of the urban hardscape by reintroducing a natural landscape into urban environment without making major changes to city infrastructure, Green space can give various social, natural and financial advantages to a region. Green rooftops include drainage and soil layers, installed on normal conventional roofing framework. There are two primary kinds of green roofs: extensive green roof, which are relatively inexpensive to install and also may not need irrigation, and intensive green roof permit a varieties of plants and are ordinarily nicer to look at, but are more expensive than intensive in terms of maintenance and installation (kumar et al 2005).

Green rooftops, which spread structures with a layer of living plants, can help relieve various issues of the urban hardscape by bringing the natural cooling and water-treatment abilities of undeveloped territories into the urban environments. Architects and planners can utilize green rooftops to help take care of ecological issues by taking nature back to the city in key manners. While they are progressively prominent as an environmental solution, green rooftops are not new thoughts. They can be traced back as far as the hanging gardens of Babylon in 600 BC. Scandinavians have used sod rooftops for centuries, taking advantage of their insulate properties, and sod roofs were also found in the sod homes built by Great Plains settlers in the United States, More recently, architects like Le Corbusier and Frank Lloyd Wright embraced green roofs for aesthetic purposes, and for their capacity to incorporate buildings more effectively into the surrounding landscape (Hall et all 2005).

Conventional, non-green roofs are often known as black roofs, since that is normally their shading. Their dim hues cause these rooftops to assimilate vitality from the sun to the point that they can arrive at temperatures as high as 150°F in summer. When it rains, runoff from black roofs flows immediately into sewer systems, adding to flooding during storms.

There is a third type of roof that is becoming more popular–the cool or white roof. These rooftops are made of light-shaded material and don't warmth up as much as dark rooftops in the sun. They share the spill over issues of dark rooftops, (Sorratino et al 2012).

2. LITERETURE REVIEW

As urban area develop, natural cover is replaced by man-made surfaces like asphalt and concrete, which keep water from being ingested into the ground. Rain that falls on these impenetrable surfaces prompt expanded wet climate streams, or flows due to rain or snow melt that can lead to flooding and decreased water quality through combined-sewer overflows and storm water discharges. Research has recognized green rooftops as perhaps the most ideal approaches to address wet climate streams in urban territories with high-thickness improvement (Florettie et al). They can lessen the pace of overflow by 65% and broaden the measure of time it takes for water to leave a site by over to 3 hours. Extensive green roofs intercept and retain the first ½ to ¾ inch of rainfall, preventing it from ever becoming runoff. Introducing a generally slender 3-inch-thick rooftop on a huge enough region could lessen the quantity of combine sewer overflow occasions throughout a midyear (Ascione et al 1999).

Biodiversity, the expression “biodiversity” refers to the variety of plants and animals in an area. A locale is considered to have high biodiversity if it contains a wide range of animal types, and enough people of every specie to keep up a reasonable populace size throughout the years. Expanded biodiversity helps environment to keep on capacity in any event, when they are upset by advancement or in different manners (Barrio 1993).

Green rooftops can give new environment to plants and creatures in urban territories, expanding nearby biodiversity. Vegetation type, growing medium depth and variation in plant tallness and spacing are the three most significant factors in empowering biodiversity on a green roof. Studies suggest that the depth, topography, plant composition and age of a green roof, as well as the local landscape, can affect a roof’s ability to enhance biodiversity (Spala 2008). Likewise, design components that advance biodiversity may also help a roof improve performance on other criteria like reducing storm water runoff and bringing down summer surface temperatures. Decreases in summer surface temperatures have also been identified in comparisons between ranges of different vegetation types.

Urban Heat Islands, (UHI) refers to the effect whereby near-surface air temperatures are higher in urban communities than in nearby suburban or rural areas. This effect is common in cities where natural landscapes, which absorb a significant portion of solar radiation to create water vapour, have been replaced with non-reflective surfaces that absorb most of the solar radiation and re-radiate back into the environment as heat. Heat islands cause increased energy consumption, heat-related illness and death, and increased air pollution. Heat islands can also cause mortality, particularly during heat waves, which amplify the heat island effect. Prolonged exposure to high temperatures can cause heat cramps, heat exhaustion, heat stroke, heat syncope, and death. Heat exposure may also exacerbate cardiovascular illness, diabetes, and respiratory disease. Health impacts of the heat island effect are expected to worsen with climate change. Green rooftops can diminish the urban warmth island impact by decreasing temperatures and cooling buildings through the characteristic elements of plants (Lazzarin et al 2005).

Energy prices and greenhouse gas emissions are increasing as petroleum derivative vitality sources, for example, coal, oil and gaseous petrol decay. Official order 13423 issued in January 2007, requires federal buildings to decrease their energy use by 3% per year, bringing about 30% decrease in energy use by 2015. An energy preservation measure like green roofs may help federal government facilities meet this objective, and help other commercial buildings lessen their energy use. Green roofs can reduce the amount of energy a building uses for cooling in the summer and heating in the winter. Green roofs can lessen the amount of heating from solar radiation a building experiences in the summer, and can protect buildings, providing heat retention in the winter. The exact amount of energy saved depends on the climate, the type of roof and building, the height of the building and its neighbours, the measure of dampness on a rooftop, the fluctuation of temperature changes for the duration of the day, and occasional varieties in temperature (Kotsiris 2012).

Aesthetic and quality of life, green roofs make an appealing space for inhabitants and tenants of neighbouring buildings. At the point when open to occupants, they can likewise provide a place of refuge and relaxation, thus reducing stress and improving worker productivity. Green roofs can also offer recreational space with a heightened sense of security.

2.1 IDENTIFYING AND CONTRASTING IDEAS

Green Roof vs. Conventional/Traditional Roofs,

The vegetative roofs are increasing in popularity due to their many advantages compared to traditional roofs, as they absorb solar radiation and, as a result, the waterproofing membrane is warmed by the sun during the day and cooled down at night. (El Bachawati et al.) Insisted on characterizing and evaluating the temperature profile of the conventional roof mock-up and two large green roof mock-ups with different substrate depths and composition during the winter season. Green roof mock-ups were each built using the following layers: roof assembly, thermal insulation layer, waterproof membrane, root resistant barrier, drainage layer, filter plate, growing medium and vegetation.

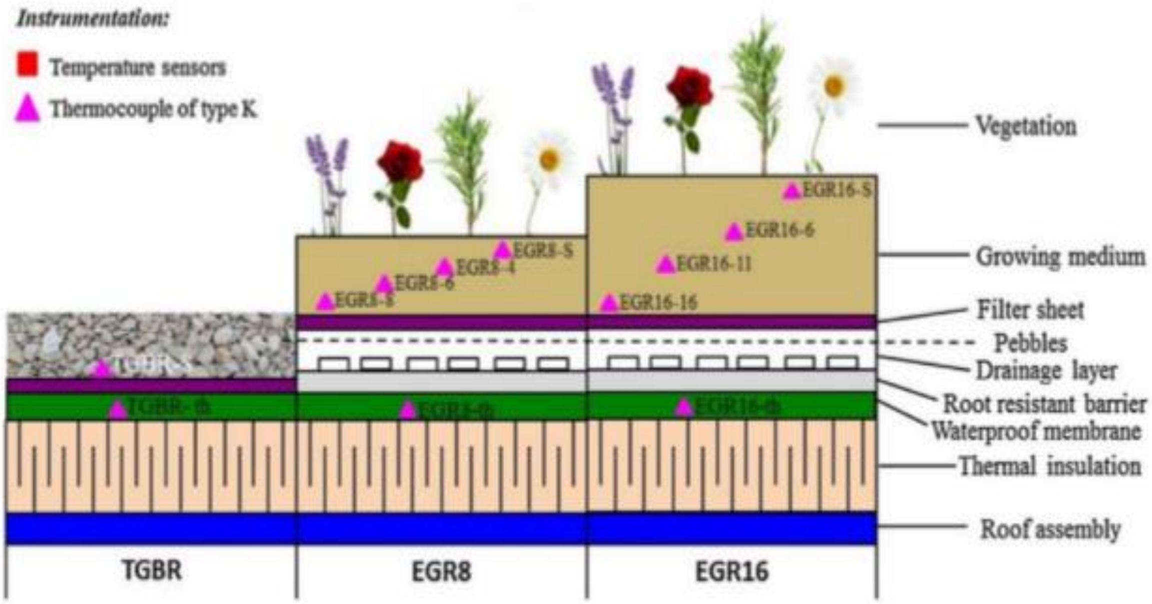

Figure 1: Comparison between traditional and green roof. (a)Traditional roof; (b)Extensive green roof (substrate thickness 8 cm); (c) Extensive green roof (substrate thickness 16 cm) (El Bachawati et al.)

Results showed that the temperature of the substratum was below that of the traditional roof surface during warmer days. During the colder winter days, the average daily temperature of the substratum was similar to that of the traditional roof surface, mainly due to partial plant coverage. This demonstrated that the highest temperature values of air and the conventional surface of the roof are higher than those of the substrates.

In addition, (Dos Santosetal 2019) claimed that the use of greenroofs resulted in lower day-to-day temperature variations, decreased internal temperatures, and decreased thermal amplitude compared to a traditional (with tiles) roof. The decrease was respectively 0.8 Percent C, 1.7 Percent and 1.6. (Theodosioueta l) showed that a green roof in Mediterranean countries can make a substantial contribution to the energy conservation of the building during the warm period of the year, while its influence is negligible during the cold period. Because roof finishing materials from non-vegetated roofs are most commonly rigid, there is a great potential for attenuating sound waves which diffract over the building's outer skin and enhancing quiet façades, e.g. in road traffic. (VanRenterghem and Botteldooren) have shown that green roofs result in clear and important sound reduction attributions where only sound waves arrive relative to common, non-vegetated roofs are diffracted.

In terms of cost, (Sproul et al) used a 50-year life-cycle cost analysis (LCCA) ND data collected from 22 flat roof projects in the U.S. to present an economic perspective on roof colour selection. The authors found that green roof shad negative net savings of $71/m2 ($6.60/ft2) relative to black roofs because they could not compensate for the cost premium of installation. However, green roofs should be chosen by owners concerned with local environmental benefits.

3. METHODOLOGY

This research is carried out based on a case study methodology. A particular building is used and fully analysed based on its green roof system. The case study was carried out in Italy, the analysed building is situated in Palermo (Lat. 38° 06' N, Long. 12° 56' E, elevation 60 m). It is located inside the Campus of the University and identified as "Building 9", namely the Department of Energy, Information Engineering and Mathematical Models (DEIM).

3.1. FINDINGS AND DISCUSSIONS

The building has four stories and a basement floor. The basement is composed of laboratories and technical rooms with ceiling height equal to 3.5 m. The first floor comprises of the main entrance of the building and laboratories. In this floor, the ceiling height is equal to 4.2m. While the second and third floors consist of office spaces with ceiling height of 4.20 m. at last, the fourth floor houses a solar laboratory and a terrace on which the vegetated roof is introduced. The building has a framed structure with infill walls made of bricks and a decking consisting of concrete and bricks and windows are two folds glasses with air (4-12-4) and aluminium frame. The main thermo-physical properties are for outer walls thickness 36 cm and transmittance 2.635 (W m-2 K-1); b) glass type 4-12-4 and transmittance 2.725 (W m-2 K-1); c) roof thickness 32.5 cm and transmittance 1.756 (W m-2 K-1); d) vegetated roof thickness 53 cm and transmittance 0.363 (W m-2 K-1). In two parts of the roof (see Fig. 2).

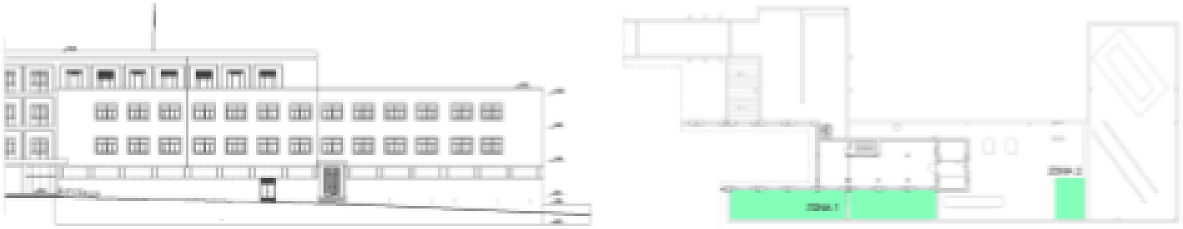

Figure 2: The front view (left) of Building 9 and the two zones (right) on the terrace selected for the installation of a green covering.

In the following, the different layers constituting the green roof, from the outer to the inner one, are reported:

- Vegetation layer, i.e. Phyla nodiflora in zone 1 and Gazania nivea in zone 2;
- Growing medium layer Agriterram TVS, particularly indicated for extensive green coverings, a mix of inorganic inert components and organic (like clays and fertilizers) ones, characterized by slow releasing;
- Filter layer Drenalit® F130, a non-woven geotextile in calandered polypropylene;
- Water storage layer, consists of a 5 cm pillow made of a particular calandered not woven polyester geotextile, filled with inert soil of expanded perlite (Igroperlite® Agrilit T2) characterized by a granulometry of 1÷3 mm;
- Drainage layer Ecodren SD5®, a geo-composite that consists of a geo-net heat bonded to a non-woven geotextile 4.5 mm thick;
- Anti-root barrier 5 mm thick;
- Structural support consisting of a 10 cm light concrete layer, a 20 cm concrete slab and a 2 cm plaster layer.

As input for the simulation in Design Builder, the TRY of Palermo developed by means of the (Hall et al). method, has been used. The other inputs refer to the dimension and materials of the elements and the scheduling of equipment and plants. The building is occupied during working days (Monday to Friday) from 8 a.m. to 6 p.m. Openings are double glass with air (4-12-4) with aluminium frame and inner blinds. Blinds are open from April to September on working days and closed otherwise. Lighting is provided with fluorescence lamps of various power, scheduled on from October to November (from 2 p.m. to 6 p.m.) and December to March (from 7 a.m. to 6 p.m.), while from April to September natural lighting is high enough to maintain comfort. The heating system is a mix of radiators and fan coils and is scheduled on from 7 a.m. to 12 a.m. and from 3 p.m. to 6 p.m. during the heating season. A heating (20 °C) and cooling (25 °C) set points are fixed. Finally, we considered a natural ventilation of nearly 0.4 ac/h for zone 2 and a mechanical ventilation for zone 2 with mean values of 1.4 ac/h in heating season and 2.8 ac/h in cooling season.

Two different simulations have been carried out on the considered building, i.e. as it is and with a green covering, as described in the previous section, installed on top of it in the above-mentioned two zones. Simulation results are reported in Figures 3 and 4. We report, for both zone 1 and zone 2, the comparison in terms of energy lost from roof and the total energy lost between the two described configurations.

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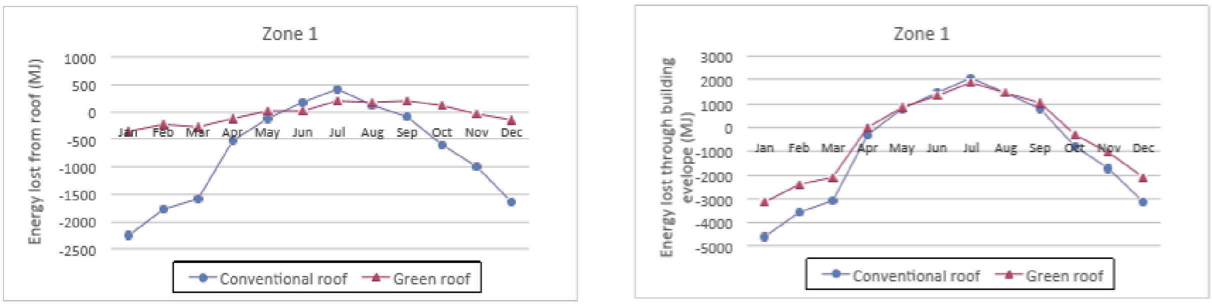

Fig. 3. Energy lost from roof (left) and through building envelope (right) for zone 1.

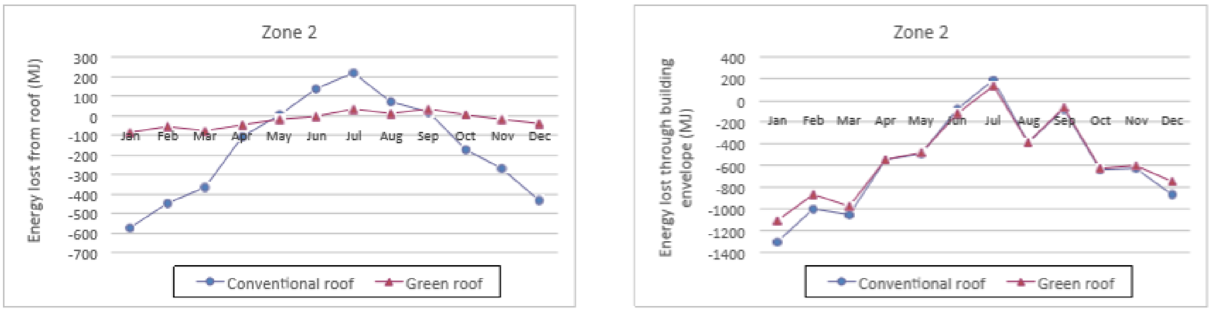

Fig. 4. Energy lost from roof (left) and through building envelope (right) for zone 2.

(D.J. Sailor, A green roof model for building energy simulation programs, Energy and Buildings 40 (2008) 1466)

In Table 1, the obtainable energy savings by means of the installation of a green roof with respect to a conventional one both for heating (from December to March) and cooling (from June to August) season is reported.

Table 1. Obtainable energy savings by means of a green roof

Zone	Season	Energy savings from roof (%)	Energy savings through building envelope* (%)
Zone 1	Heating season	86.5	32.9
	Cooling season	44.7	6.0
Zone 2	Heating season	86.2	35.4
	Cooling season	89.5	29.4

*Considering only heat losses from glazing, outer walls and roof.

The simulation results refer only to the rooms under the two analysed zones. The graphs in Figures 3 and 4 outline a greater energy savings during the heating season than in cooling season. This is also due to the limits of the used model that totally disregard the influence of moisture on the thermal properties of the green roof.

The heat flux through the roof falls into the range reported by (Chen et al). 60-90% , except for zone 1 in the cooling season. This is probably due to the big value of the ventilation rate, as reports in the previous section. The energy saving in the rooms under the two zones inside is less than the values reported by (Spala et al,). (58-73%). Moreover, zone 1 shows an energy saving percentage very low. This is probably due to the same reason above mentioned.

4. CONCLUSION

Green roofs or vegetative roof offer great potential savings and advantages. Despite the fact that the additional upkeep expenses of a green roof as compared with a conventional roof are significant these added costs are more than made up for over the roof's lifetime by its increased longevity. This analysis puts the average life expectancy at 40 years, versus 17 for a conventional roof. Various green roofs have outlasted that time period, including green roofs on government buildings in Washington DC, in place since the 1930s. In conclusion, we analysed the energy saving contribution of a green roof compared with a conventional one in the city of Palermo Italy. Truth be told, the commitment of the green rooftop relies upon the atmosphere of the establishment site, The results obtained by the simulations point out a good rate of energy saving; therefore, the green roof falls in the set of possible interventions to improve the energy performance of buildings. By the way, such energy saving greatly decreases when the ventilation rate is high.

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