

To Investigate Thermal Effectiveness Of Green Roofs At Hyderabad.

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Abstract: Expeditious changes in environmental behavior is a significant task for the contemporary built environment. Green roofs are becoming a premier characteristics for its energy efficiency and sustainable evolution. Building energy-saving, production of urban wildlife domain and eco-friendly designs are its foremost concerns. Hyderabad is contemplating as the hot and dry climatic region of Sindh. The paramount percentage of electrical energy is being consumed by the building sector in Hyderabad because of its environmental performance and climatical changes, therefore, the abstraction of green roof not only furnishes energy efficiency for the built environment but also exertion for its sustainability, aesthetically and thermally comfortable for its users. For the implementation of the green roof, it is necessary to investigate the thermal effectiveness of green roofs at Hyderabad by case-studies. The green roof system is responsible for the thermal effectiveness of climate to provide the utmost cooling in summer and increases the heating effect in the winter season and also helps in the increment of outdoor temperature by about 42% and about 8% of indoor temperature throughout the daytime while about 17% of the temperature is maintained in the night. This concept has been demonstrated as an essential abstraction of green roof design.

Keywords: Green Roofs, Thermal effect, Energy-efficient.

I. INTRODUCTION

There is a major realization about the high warning to the major existence of human kind on earth is the suffering from the consequences of Climatic Change. Energy and environmental challenges have become a serious matter of concern on the globe. Global warming is increasing issue in respect to the growing demand of energy and depletion of natural resources ^[1]. The maximum percentages of energy is consumed by building sector and the concept of green roof technology in various buildings of different climatic regions provide a sustainable solution for built and natural environment. Extensive roof system are a part of green infrastructure which helps in the use of processes to manage water and development of healthier environment and provide thermal comfort inside the building.

Hyderabad city is considered as one of the hot and dry climatic region of Sindh province of Pakistan, have very hot days during summer while cool and breezy nights so in such a climatic regions green roofs helps to provide heating winter, cooling summer, energy saving, roof membrane longevity improvement and sustainability. Green roof has been proved as an effective energy efficient to provide comfort level in heating summers and cooling winters through its ecological benefits and landscape value in any community. It can attract extensive attention throughout the world.

The contribution of building sector is up to 30% and its consumption is about 40% of global annual greenhouse gas emission of all energies. In the next 20 years greenhouse gas emission will be more than double if nothing will be done to the increased growth in new building in economies in transition, and the deficiency of existing construction stock around the world. ^[2]

The increase of the heat emissions by various means that is vehicle emissions, combustion of fuels, less green spaces, water and increase in built environment are the main cause of global warming. Hyderabad city is facing many issues related to the climatic changes towards hot and dry climate due to the less green spaces. In such a climatic region green roofs can provide more consistent thermal protection for buildings and environment. Implementation of green roofs in sufficient scale can help in mitigating the uprising global warming effects.

Development of green roofs includes the construction of a vegetation layer on the top of man-made structure and introducing green spaces to an area that are unused ^[3]. The major benefits of green roofs are reducing air pollution, energy use, and greenhouse gas emission, enhancing water quality as well as reducing heat island effect by adjusting the temperature of roof and nearby areas and providing aesthetic value and habitat for many species.

The increase of heat emissions by various means that are vehicle emissions, combustion of fuels, less green spaces, water and increase in the built environment is the main cause of global warming. Hyderabad city is facing many issues related to the climatic changes towards a hot and dry climate due to the less green spaces. In such a climatic region green roofs can provide more consistent thermal protection for buildings and the environment. The proper installment of green roofs on a can help in mitigating the high global warming effects.

The aim of this research paper is to investigate the thermal effectiveness of green Roof at Hyderabad by different case studies, literature review and observing the investigation by indoor outdoor temperature thermometer. The objectives of this paper is to analyze the thermal behavior of buildings with and without green roof at Hyderabad. And To suggest the best solutions that green roofs can offer to improve energy efficiency suitable for buildings at Hyderabad.

II. MATERIALS & METHODS

A. Climate:

The climate of Hyderabad is hot and dry it usually varies from the extremely high temperature of 40°C. The nights of Hyderabad city are cool and breezy whereas days are extremely hot and dry. The winds of Hyderabad city usually bring dusty and hotness. The dust storms mostly occur in May and June whereas southeast monsoon starts from June till September.

The average high temperature in summer 40°C in the month of June and the lowest temperature of approximately is 11.1°C in the month of January. The wettest month of Hyderabad city is August because of highest rainfall recorded 60.8mm and the driest month is January. ^[4]

B. Green Roof:

Green roofs can be installed in nearly the utmost climate with discrete effective emphases. Its evolution requires the formulation of a vegetated area consolidate structurally on top of a building. The word 'roof' in this factor is mentioned to any constant surface aimed for the defense of inhabitants from the components, whether open or closed on the sides. The vegetated medium may be above, at, or below grade, a 'sky garden' on an intermediate floor level, or at the very top level of the building, but in all cases, the plants are not planted in the ground. The development of green roofs involves the construction of a vegetation layer on the top of the man-made structure and introducing green spaces to an area that is unused. ^[4] The major advantage of green roofs are bringing down the air pollution, energy use, and greenhouse gas emission, enhancing water quality as well as bringing down heat island effect by maintaining the temperature of the roof and surrounding areas and providing aesthetic value and habitat for many species.

Green roofs are classified into two major categories according to its design maintenance and its installment as well as its occupancy. Following are the two types of green roofs system: ^[5]

- Extensive green roof
- Intensive green roof



Fig. 1 Extensive Green Roof



Fig. 2. Intensive Green Roof

Table. 1. Extensive Green Roof and Intensive Green Roof

Extensive Green Roof	Intensive Green Roof
Need Low maintenance	Need High maintenance
Require a depth of only 2 to 15cm	Require a depth of minimum 15cm
Low in weight i.e. 60 to 150 kg/m ²	Heavy in weight i.e. 200 to 500kg/m ²
Economical	Expensive
Eco roofs	Podium Gardens & Sky Gardens
vegetation is limited	Normally vegetation is not limited
Vegetation includes grasses, moss, and sedums	Large plants and trees are planted
no additional structural support	Needs additional structural support
Minimizes the structural demand for the roof	Maximizes the structural demand for the roof

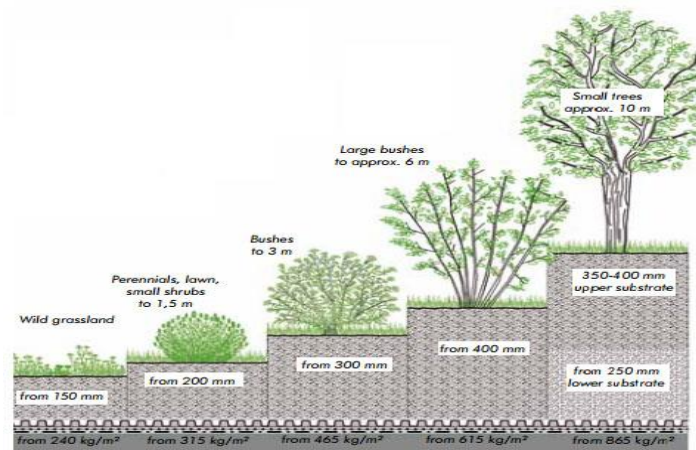


Fig. 3. Difference from Extensive To Intensive Green Roof System

C. Common Concerns to Green Roof:

Green roofs have several advantages that include the better aesthetic approach and reduce urban heat island effect with the insulation of buildings and improving the quality of air few are the common concerns related to the green roof through designs:

- *Vegetation Maintenance:*

Extreme weather circumstances can have a major effect on the survival of plants. The selection of suitable plants will help to make sure the survival of plants during the change of climatic conditions. Irrigation during the early years is important to establish vegetation and gradually its maintenance costs decrease after two years of an application once it gets established.

- *Climate:*

Green roofs have been proved feasible for both of the hot and dry climates. No climatic adaptations in operation are required.

- *Costs:*

To regulate cost-effectiveness for a structure it should include energy-saving, roofing lifespan, market value, tax, and aesthetic and storm water management. It has been estimated that the green roofs help to extend the life span of a roof as long as 20 years by minimizing the direct exposure of roofing material to the sun. [5] It also helps in the reduction of energy demand by approximately 75%. [6]

- *Water Damage to Roof:*

A leak detection system is used to install to minimize and prevent water damage. It has been noticed that any failure in waterproofing elements results in the risk of water drainage but similar to the traditional roof installation, damage can be repaired.

- *On Private Property:*

The property owner needs to be understood and educated about the green roof routine maintenances, its operation and understand its long term maintenance plan. The property owners and managers are encouraged to maintain existing practices. [7]

D. Green Roof Role as Sustainable Development:

The actual prosperity of any state is its inhabitants and the aim of its evolution is to make the environment reliable, healthy and lively. The strong but simple reality is often forgotten in the activity of economic wealth and material. The temperature of Hyderabad city of Pakistan with the extremely hot climate of summer is recorded as 49.5°C approximately in the month of June whereas the lowest temperature recorded in winter is about 3.3°C on 21 January with different relative humidity difference. [3]

The capability of green roofs has become the use of green roofs as a strategy to reduce the negative environmental impact of buildings on its surroundings. The green roof is an economic, social and environmental use of the building rooftop. It can be fixed at any height with proper for its maintenance. The vegetated spaces can be used to provide human comfort and environmental enhancement or energy conservation for the users.

The roof with growing plants on its top partially occupied with vegetation can provide numerous benefits that can help in minimizing the indoor as well as outdoor negative environmental aspects. This can help in energy conservation, mitigation of urban heat island effect and improve the water storm management by minimizing water runoff and helps to improve water quality.

The hardtop of urban areas styles to consider acoustics issues rather than absorb it. It helps in absorbing sound with substrates as well as plants making a contribution, it helps to block sound with lower frequencies and the latter the higher ones. Some

excessive requests are made about the ability of green roofs to reduce noise. For example, it has been stated that a green roof with a 4.8-inch substrate layer can minimize sound by 40 decibels whereas an 8-inch layer can minimize by 46-50 decibels. ^[8]

E. Green Roof Components:

Green roofs generally consist of both horticultural elements as well as traditional roofing components. The green roof contains three layers shown in figure 1 from its bottom that provide structural unification and a growing medium with a plant canopy.

- Roof Deck, Insulation, waterproofing
- Protection Layer – root barrier
- Drainage Layer
- Root permeable filter layer
- Growing Media
- Vegetation, Plant



Fig. 4. Green roof components.

F. Benefits of Green Roof:

Green roof when constructed provides a number of benefits that helps to minimize the negative environmental effect especially in the urban environment. It becomes a cause to conserve energy, reduce noise pollution, mitigate urban heat island effect and provide aesthetical appearance to the environment. One of the major benefit of green roof is that it reduces the flood risk, overloading of duct, and water recycling. Many of the studies have cleared that green roofs can maintain rainfall but the quality of maintenance depends upon many other factors that is substrate depth, duration and intensity of precipitation and the types of vegetation. This variation helps to increase the green roof efficiency. ^[9]

Green roof provides natural environment and home for insects, birds and isolate carbon dioxide and other dangerous pollutants from the environment in order to purify the air. Intensive and extensive green roofs are used in an areas which are densely populated for the recreation and open space to create positive environmental impact.

The presence of green roof allows hydration in an environment that humidify the cool air and minimize the urban heat island effect. This temperature increases the temperature at night. ^[10]

Following are the few benefits of green roofs: ^[11]

- Storm water management
- Aesthetic and practical benefits
- Mitigation of urban heat island effect
- Reduce noise pollution
- Thermal reduction

G. Green Roof and Energy Efficiency:

A green roof has a number of advantages for the environment, structure, and humans. ^[12] The effectiveness and intensity of green roofs still required to be properly assessed and qualified. The assessment of the environmental benefits of green roofs explains energy-saving and cooling effectiveness and cost-benefit analysis. The effectiveness of the green roof helps in energy saving by reducing the use of air conditioning in the extreme hotness of the summer season and the use of a heater in the winter season. One of the energy-saving efficiency of the green roof is cooling the interior temperature by the natural effect of vegetation and plants. ^[13]

The consumption of energy is minimized to a maximum extent in case of a structure installed with a green roof. the percentage cooling load can be minimized for the complete structure varying from 15% to 39% while for the floor just below the roof, the effect was highly important showing a reduction up to 58% during summer. The decrease in heating load differs from 2% to 8% for the whole building and from 5% to 17% for the floor just below the roof. ^[14]

Green roofs are energy-efficient planted vegetated roofs. They are if once installed can last longer than conventional roofs. The well-known advantage of commercial green roofs is its energy efficiency and residential green roofs help to improve residential energy efficiency and regulate the internal temperature of buildings and minimizing building heating and cooling costs. A structure having a 2-3 story could experience approximately 15-25 percent saving energy costs during summer. ^[15]

This paper compares the roofs of two different rooms with different climatic regions shown in figure 5 and 6. In order to investigate the thermal effectiveness of the green roof at Hyderabad, a small test has been done and observed the efficiency of the green roof. The test is done over the roof of a small room measuring a dimension of 8.8 sq. yds. Two rooms having the same dimensions and location were observed roof of one of the rooms was covered with plants and vegetation whereas the other was left as it was. The indoor and outdoor temperatures were carefully observed for 3 months with different climatic conditions. Both of the rooms having a window of the same dimension that is 3'-0" x 3'-0" and the orientation was almost the same but the room where the plants were fixed was already shaded by a tree which was beneficial for the purpose of green roof concept. The temperature was clearly observed by a device used to measure indoor and outdoor temperatures.

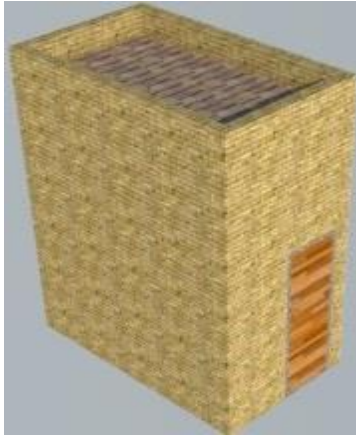


Fig. 5. Room without Green Roof

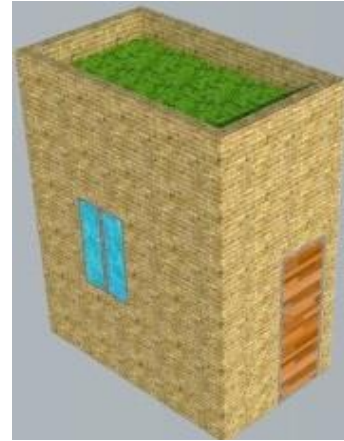


Fig. 6. Room Having Green Roof

H. Observations:

Following are the observations have been taken by a device as shown in figure 7 while detecting the temperatures of both rooms i.e. a traditional roof and a room having green roof room A and room B respectively at the same time with different climatic conditions:



Fig. 7. Device used to measure indoor and outdoor temperature

Thermal Effectiveness of Green Roof in Outdoor Temperatures:

Table. 2

Sno.	Months	Temperature of room A:	Temperature Of room B:	Temperature Difference
a.	11 th July 2019	45°C	43.1°C	1.9°C
b.	18 th July 2019	40°C	38.3°C	1.7°C
c.	25 th July 2019	46°C	44.8°C	1.2°C
d.	7 th August 2019	39°C	37.2°C	1.8°C
e.	14 th August 2019	33°C	29.5°C	3.5°C
f.	25 th August 2019	42°C	39.8°C	2.8°C
g.	9 th September 2019	42°C	39.7°C	2.3°C
h.	14 th September 2019	38°C	36.3°C	1.7°C
i.	28 th September 2019	38°C	37.4°C	0.6°C

Average out door temperature of room A: 40.3°C

Average outdoor temperature of room B: 38.4°C

Average temperature difference: (average outdoor temperature of room B) – (Average outdoor temperature of room A)

Average out door temperature difference: 38.4°C - 40.3°C

Average outdoor temperature difference: -1.95°C

Thermal Effectiveness of Green Roof in indoor Temperatures:

Table. 3

Sno.	Months	Temperature of room A:	Temperature Of room B:	Temperature Difference
a.	11 th July 2019	44.5°C	39.7°C	4.8°C
b.	18 th July 2019	39.2°C	35.3°C	3.9°C
c.	25 th July 2019	45.1°C	40.3°C	4.8°C
d.	7 th August 2019	38.2°C	34.4°C	3.8°C
e.	14 th August 2019	32.8°C	29.9°C	2.9°C
f.	25 th August 2019	41.5°C	38°C	3.5°C
g.	9 th September 2019	41.3°C	36.5°C	4.8°C
h.	14 th September 2019	36°C	31.7°C	4.3°C
i.	28 th September 2019	36.5°C	32.7°C	3.8°C

Average indoor temperature of room A: 39.4°C

Average indoor temperature of room B: 35.3°C

Average temperature difference: (average indoor temperature of room B) – (Average indoor temperature of room A)

Average indoor temperature difference: 35.3°C – 39.4°C

Average indoor temperature difference: -4.06°C

III. RESULTS

If we compare the outdoor and indoor temperatures of both the rooms it can be clearly observed that beside the aesthetic appearances and other benefits of green roofs which also plays a vital role in the thermal effectiveness of temperatures in maintaining the indoor and outdoor temperatures of a structure having green roof. Green roofs not only reduce indoor temperatures of any structure in a hot season but it also helps to manage outdoor environment. These results are based on the data collected by three months from the summer days to July to the moderate temperature of September.

Average outdoor temperature difference: -1.95°C

Average indoor temperature difference: -4.06°C

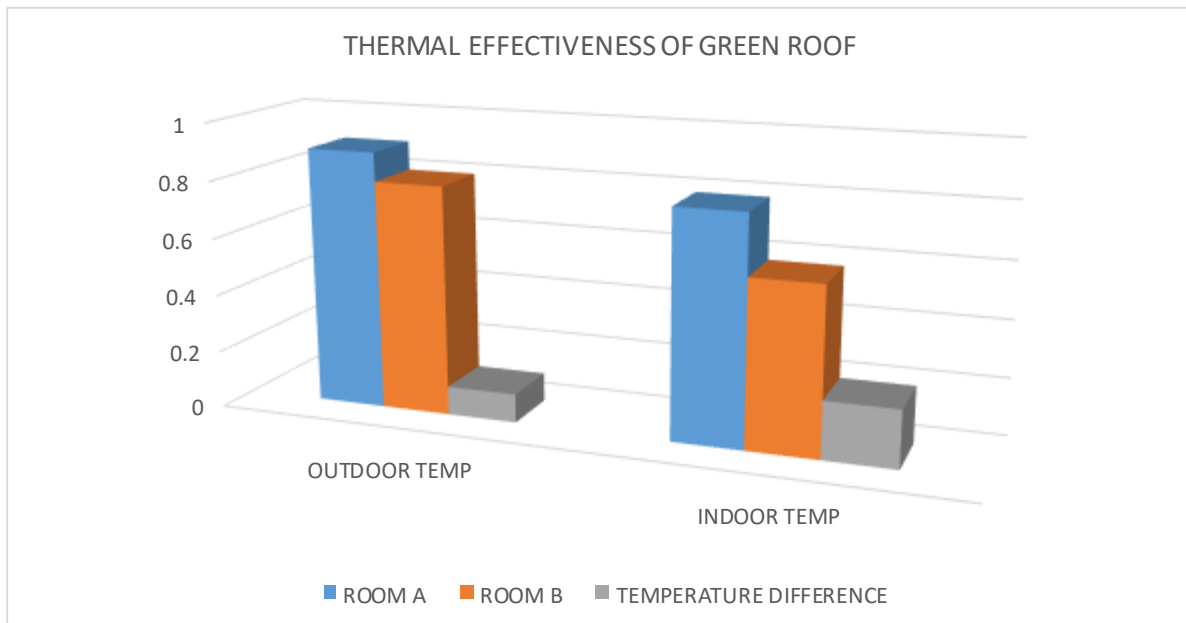


Fig. 8. Comparison of Green Roof and Traditional Roof

IV. CONCLUSIONS

The main reason of this research paper was to investigate how a green roof in a hot and dry climate like Hyderabad would perform compared to the traditional roof with same orientation and dimensions in a varying climatic condition from 11th July of

2019 to 28th September 2019 the role of green roof in a heat transfer interface can be related to passive temperature regulator. Throughout the day time, the green roof helps to reduce outdoor temperature (decreases hotness) and increase the indoor temperature (increases indoor cooling effect). The indoor cooling effect is high in the afternoon because of the implantation of green roofs that resists the direct impact of sunlight on a roofing slab. It is observed that during the rainy days green roof helps to change the indoor temperature at night time with the influence of water level and roofing slab by maintaining the temperature inside and outside the structure.

V. RECOMMENDATIONS

It is highly recommended to install green roof, it is not only for the purpose of thermal effectiveness and energy efficiency but it also provides positive environmental impact to natural habitats and helps in the mitigation of urban heat island effect. In modern architecture green roofs plays a remarkable role in aesthetic appearance of any structure. In hot and dry climatic region green roof helps to reduce indoor temperature approximately 4.06°C and once green roof is installed it is necessary to provide proper maintenance to it, first two years are important for the maintenance of green roof. For the installment of green roof it is necessary to select proper material and details should be handled carefully.

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