IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

THE GREEN APPROACH- Efficient and Sustainable Design Alternatives through Vegetative Roofs in Indian Context

Associate Prof. Rasika Chodankar
M-arch, Construction Management, Aditya College of Architecture, Mumbai.

Abstract

Global climate change has had a direct impact on climatic weather patterns. A rise in the urban heat island effect, a decline in urban air quality, restrictions on storm water management, and improved water run-off quality have all been brought about by increased urbanisation and the encroachment on green belts. At the same time, biodiversity has suffered significantly as a result. The roof of a structure, which is immediately exposed to solar radiation, has been highlighted as the component that has the potential to contribute to significant energy savings and environmental benefits. This study compares the amount of electrical energy needed to maintain specified indoor air temperatures with the amount of cooling load a building would require if different thermal insulation techniques for roofs were used instead of a conventional flat roof.

Keywords: Comparative Analysis, Software Simulation, Vegetative Flat roofs, Solar Heat ingress, Heat gain

Vegetative flat roofs for commercial buildings in composite climatic zone.

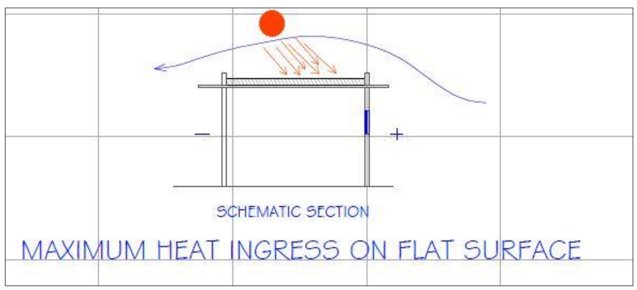
1.0 Introduction

Post the industrial revolution, urban development has undergone a rapid growth, leading to exponential expansion in the urban population of India. As is common practice, this expansion was simultaneously accompanied by a shrinkage in the urban green cover. Given the current trends, this problem is bound to grow even more severe.

Taking into account the rising levels of global climate change, the need to deploy sustainable concepts and practical solutions into every aspect of future development is of crucial importance.

Any building structure has its external walls and roof in direct exposure to the environment. The roof, in particular receives the maximum intensity of solar radiation. This increases the heat load on the building, especially during summer months.

Studies have shown that the walls and roofs contribute the maximum to heat load from solar radiation, with walls receiving 2/3 of the radiation, while roofs receiving it directly. In addition, the period of disposition for the roofs is much larger than that on the walls. This concentrated solar ingress raises the temperature inside the room due to absorption, and consequently is responsible for the increased energy consumption to cool the room.



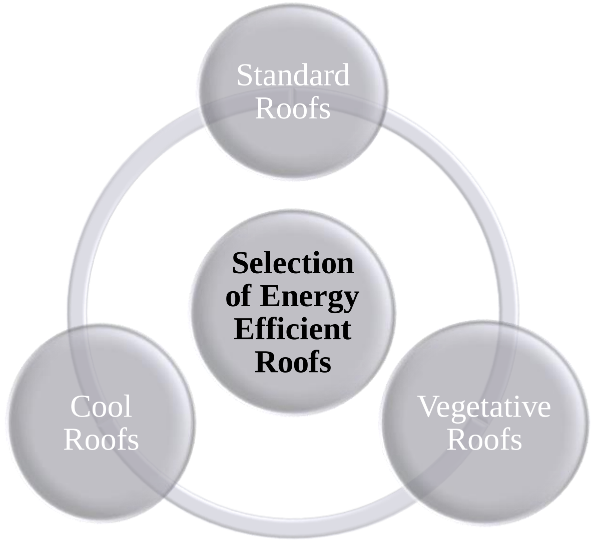
(Fig-1) Represents Schematic section showing maximum heat ingress on flat surfaces
Source: Author

Vegetative green roofs have been proven to be a sustainable solution to this problem by redirecting the solar radiation exposure towards the vegetation growth. In addition, they provide, insulation, reduce rainwater runoff, contribute to maintaining and improving the carbon-dioxide cycle and air quality—particularly in an urban landscape. A well-designed green roof also adds aesthetic and recreational value.

These environmental, social, and visual contributions that vegetative green roofs provide have been empirically observed and widely acknowledged worldwide; however, their adoption in India is severely limited as compared to the urban areas in Europe and North America.

2.0 Selection of Energy Efficient Roofs

Increasing requirement of sustainable solutions have led to the development and adoption of many popular energy efficient roofing alternatives for habitable spaces, and more innovation are always on the horizon. Thus, it is of import that a proper and careful consideration of all available options be undertaken to meet the needs of the structure. In this study, we study the energy efficiency of vegetative roofs, cool roofs, and compare them against a standard roof through simulation techniques.

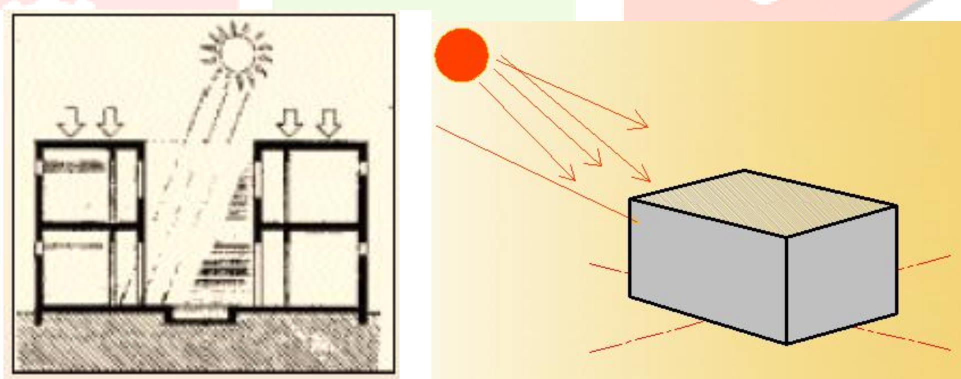


(Fig-2) Represents Schematic selection of different types of roofing techniques
Source: Author

3.0 Heat gain from roofs

The net heat gain from the building surface is the primary factor responsible for understanding the thermal loads in the structure. During summer there is heat ingress through the roof, walls, and openings, since the external temperature is higher than the internal temperature; this is the heat gain. During winter, there is heat egress thorough the walls, roof, and openings, since the external temperature is lower than the internal temperature; this is the heat loss.

For an Indian climate, solar heat gain is the primary concern, and this requires to be minimized by the selected roof structure configuration.



(Fig-3) Represents Schematic section showing maximum heat ingress on flat surfaces
Source: Author

3.1 Vegetation on Flat roofs

A vegetative roof (also referred to as a green roof) consists of thin layers of living, organic vegetation installed atop a conventional flat or sloping roof. This provides complete overlap of the roof surface which is exposed to solar radiation. These vegetative roofs can be further subdivided into two categories:

1. **Extensive vegetative roofs**: these are installations which are six inches or shallower, frequently designed to satisfy specific engineering and energy performance goals for the structure. They are an ecological alternative to conventional surface protection or ballast layers such as gravel and pavers. Being lightweight, they are easy to account for structurally.

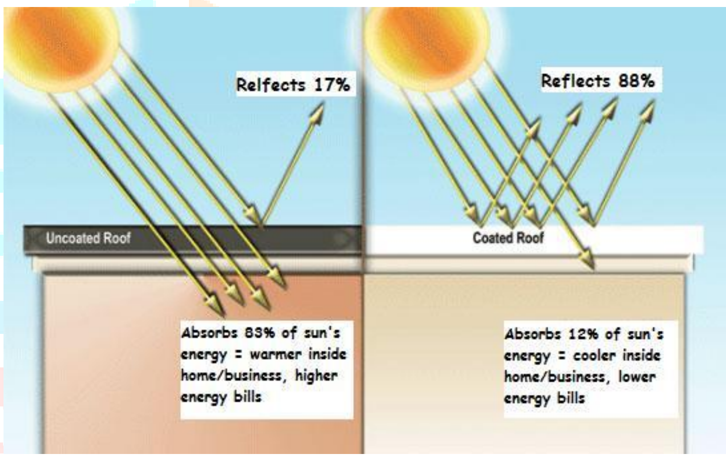
2. **Intensive vegetative roofs**: these are deeper installations, often merging into more familiar on-structure plaza landscapes with promenades, lawns, larger perennial vegetation and trees.

Such vegetative roofs provide multiple benefits including Controlling storm water runoff, improving water quality, mitigating urban heat-island effects, prolonging the service life of roofing materials, conserving energy, reducing sound reflection and transmission, improving the aesthetic environment, cost savings, etc.

3.2 Cool Flat roofs

The term cool roof is used to refer to a roofing system that is designed to deliver a higher solar reflectance (reflecting the incident solar radiation, thereby reducing its absorption) as well as a higher thermal emittance (radiate out the internal heat of the building) than the standard design. Thus, there is a considerable amount of reduction in the net heat gain in structures with cool roofs installed as compared to a similar structure with standard roofs.

They are usually constructed with applying paints with high reflectance, a sheet covering, or highly reflective tiles/shingles. In practice, the temperature reduction observed is 10-16 degrees, reducing air-conditioning requirements.



(Fig-4) Represents Schematic representation showcasing heat reflects on coated/uncoated surfaces
Source: Cool-roof-Detail-Image

3.3 Base Case Used for Simulation

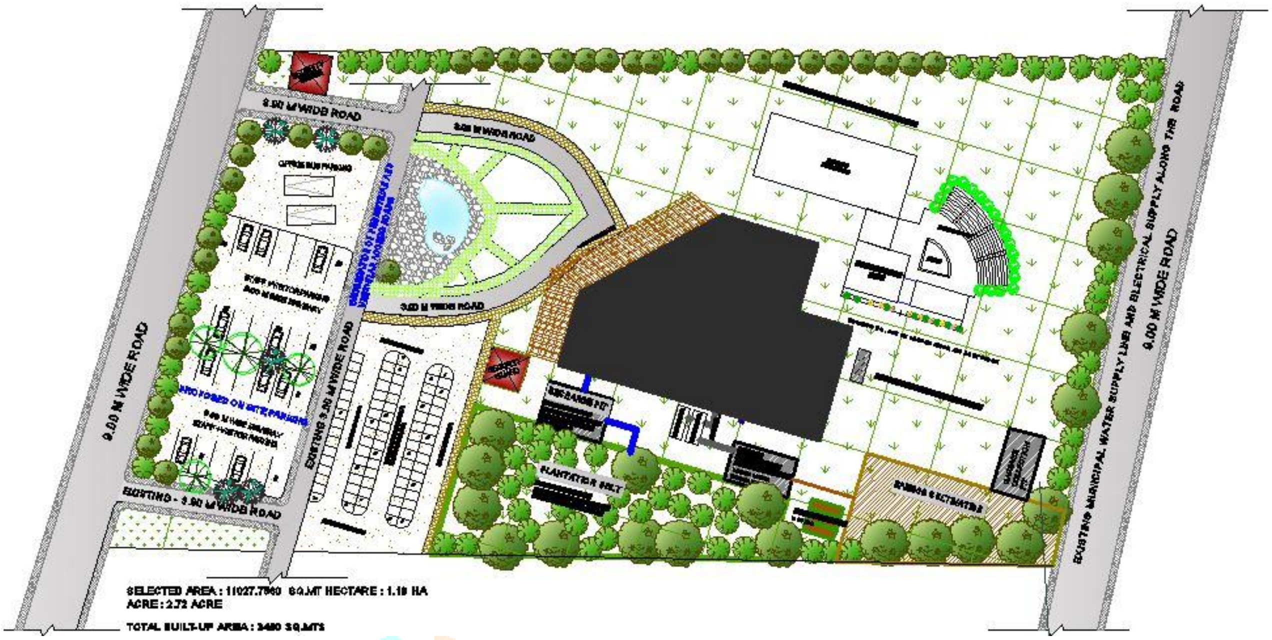
The simulation analysis was conducted on the selected application case based in Nagpur, Maharashtra, a region with composite climatic conditions.

Nagpur is situated at 21.15-degree North, which has hot and dry climate throughout the year. Generally, it experiences only 2 months of rainfall in the months of July-August, 2 months of chilly winters, and 8 months full of fierce sunlight for almost 8-9 hours/day i.e. from (10am -6pm).

The proposed site is located at Govt. Labour Institute, near SMS building IT park road, Parsodi, Nagpur, whereas the proposed IT building has a built-up area of about 3450sq.mts with G+4 structure.

Plan of IT building
Total floor Area: 754.65sq.mts

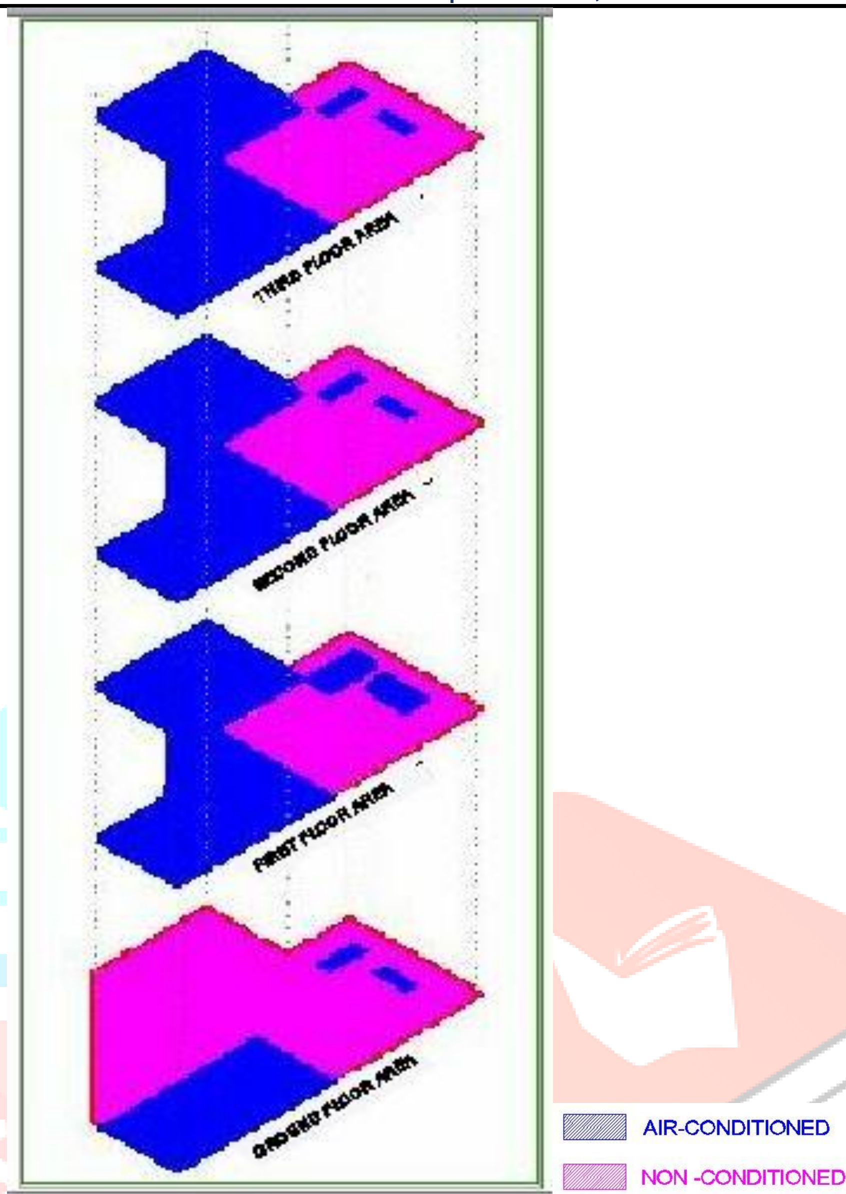
Heat Transmitted crack develops due to temperature variation (Heat and rain)



(Fig-5) Base case for simulation
Source: Author

The base case used in (Fig 5) for accessing comparative analysis with the help of simulation software in order to examine the heat gain due to direct ingress of solar radiation from roofs on energy parameters was analysed on the basis of heating/cooling loads which largely depends upon the operating hours, energy efficiency measures, sample size, climatic zone etc. on Design Builder. The floor plates at each floor showcases conditioned and nonconditioned areas, kitchen building services and active core is not conditioned. The active core consists of sustainable passive cooling strategies, thus reducing the energy load on the structure. As the building is operative on 24 hrs basis, the workstations on each floor are fully conditioned, thereby increasing the pressure on mechanical cooling systems.

Thus, this study focuses on comparison between electrical energy consumed to achieve stipulated indoor air temperatures and reduce the overall cooling load demands of a building by adopting alternative thermal insulation methods for roofs, rather than having a standard conventional flat roof.

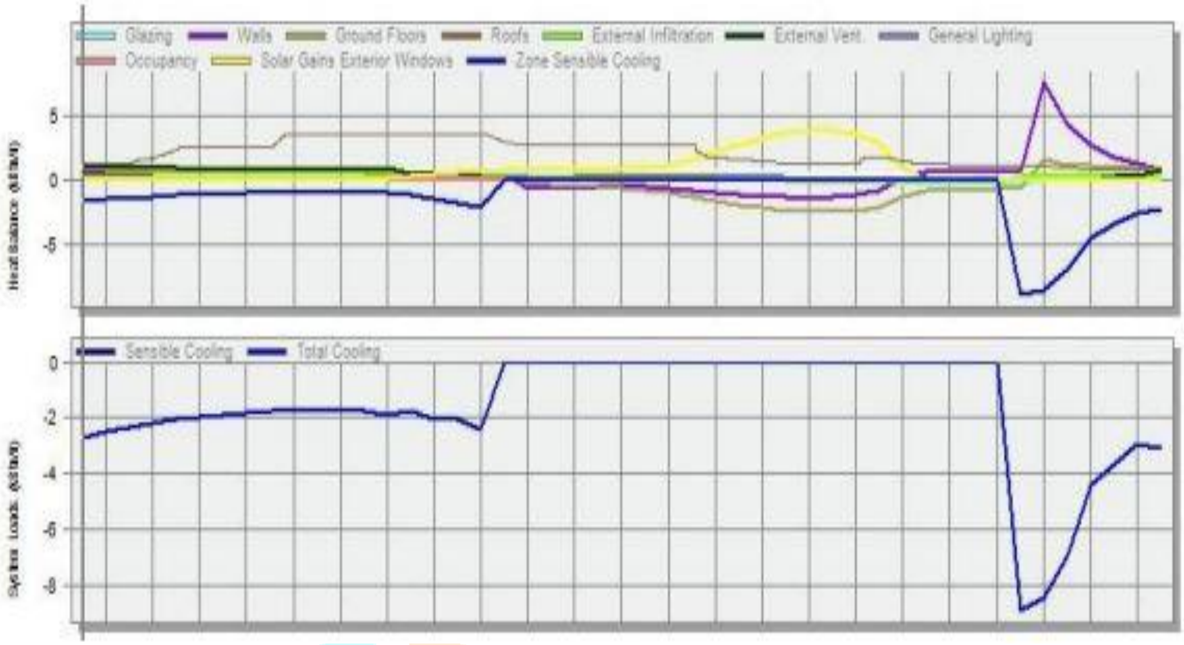


FLOOR PLATES SHOWING CONDITIONED AND
NON-CONDITIONED AREA ON EACH FLOOR
(Fig-6) Base case for simulation
Source: Author

3.4 Results of Base Case after Simulation

A. Standard Roof

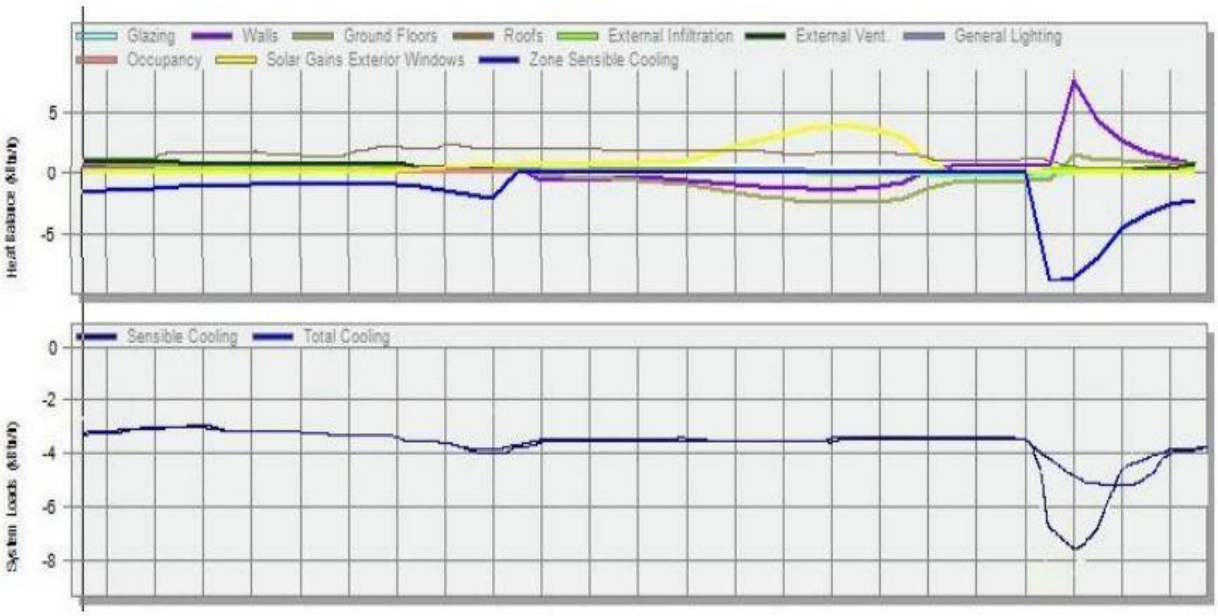
First, we see the results of the simulation on a standard flat roof. The below charts graphically represent the findings. The light brown band illustrates the heat gain in the standard case, while the blue band below illustrates the cooling load required to offset the heat gain in the IT building.



(Fig-7) Graph represents cooling load required when the roof type is **Standard flat roof**
Source: Design Builder Interface

B. Cool Roof

Next, we see the results of the simulation on a cool flat roof. The below charts graphically represent the findings. The light brown band illustrates the heat gain, while the blue band below illustrates the cooling load required to offset the heat gain in the IT building.



(Fig-8) Graph represents cooling load required when the roof type is **<u>cool roofs</u>**
Source: Design Builder Interface

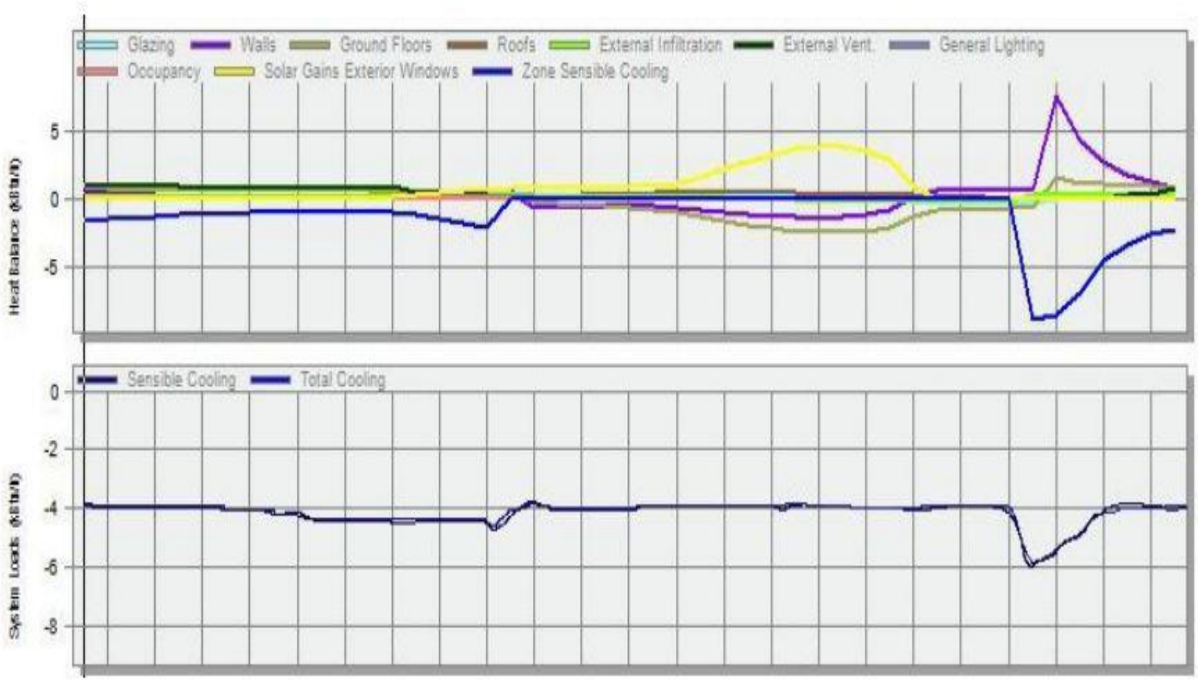
The heat gain is reduced by approx 20-30% across

Subsequently, the cooling load required is also reduced from the base case

The energy savings for a cool roof are thus 20-30% as compared to a standard roof

C. Vegetative Roof

Finally, we see the results of the simulation on a vegetative flat roof. The above charts graphically represent the findings. The light brown band illustrates the heat gain in the vegetative roof case, while the blue band below illustrates the cooling load required to offset the heat gain in the IT building.



(Fig-9) Graph represents cooling load required when the roof is **<u>Vegetative Flat roof</u>s**
Source: Design Builder Interface

The light brown band is superlative and the amount of heat gain is reduced

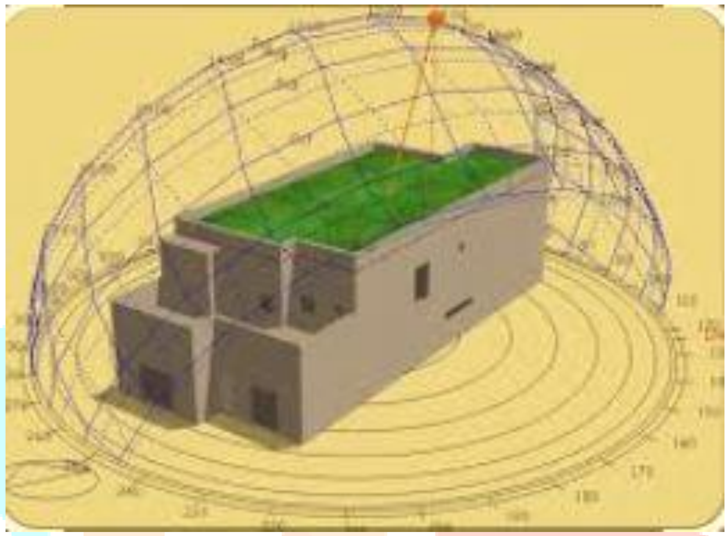
hence, the cooling road is also reduced by 40-50%

Thus the Vegetative Flat roof is saving upto 40-50% of energy consumption

4.0 Conclusion

The current worsening state of the global climate change requires that sustainable solutions be integrated as much as possible. Environmentally responsible and sustainable roofing practices provide positive results, and vegetative roofs are by far the most promising.

This study was primarily concerned with analysing the heat gain patterns on a typical conventional flat roof, and the effects that augmenting such a roof with sustainable solutions has.



(Fig-10) Schematic Representation of the Sunpath on a typical green roof
Source: Google Images

Undertaking a comparative analysis of simulated scenarios on the selected base case, we observed significant reductions in the heat gains on using sustainable solutions, with Vegetative Flat roofs surpassing all others by providing up to 50% energy savings.

This has tremendous potential for adoption in the increasingly warming Indian urban landscape, and the adoption of such a passive and promising energy saving installation will have a significant impact.

Further study should be focused on checking the cost benefit analysis and understanding what other social barriers might pose an obstacle to widespread adoption of Vegetative Green Roofs in India.

5.0 References

1. Baxevanou, C, Fidaros. D, Bartzanas. T, Kittas. C., 29 September -1 October 2010. Estimation of the reduced cooling needs from a typical green roof. Palenc 2010. Retrieved May 13, 2014, from http://ireteth.certh.gr/agrotechnology/files/2010/07/C01-2010.pdf
2. BerndtssonJC.Green roof performance towards management of runoff water quantity and quality: are view .Ecol Eng2010;36:351–60.
3. [2]Oberndorfer E,LundholmJ, BassB ,CoffmanRR, DoshiH, DunnettN,Gaffin S, Köhler M,LiuKKY,RoweB. Green roofs as urban ecosystems: ecological structures, functions,andservices.Bioscience2007;57:823–33.
4. [3]BerardiU,GhaffarianhoseiniA,GhaffarianhoseiniA.State-of-the-artanalysis of the environmental benefits ofgreenroofs.ApplEnergy2014;115:411–28.
5. [4]VijayaraghavanK,JoshiUM.Applicationofseaweedassubstrateadditivein green roofs: enhancement of water retention and absorption capacity. Land sc UrbanPlan2015;143:25–32.
6. [5]GetterKL,RoweDB,RobertsonGP,CreggBM,AndresenJA.Carbonseques-tration potentialofextensitegreenroofs.EnvironSciTechnol2009;43:7564– 70.
7. https://www.grihaindia.org/files/shashwat/2019/integrated-sustainability/files/basic-html/page140.html
8. Köhler;M.Long-term vegetation researchontwo extensive green roofs in berlin. *Urban Habitats [Online]* **2006**, *4* (1).