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Green Retrofitting Of Existing Buildings Using Cool Roof Technology

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Abstract
Particularly in the urban areas, the roof and walls are major contributor in the absorption of solar radiations and also retarder to the outflow of the absorbed radiation from the building, thereby increasing the heat island effect leads to global warming. The impact of using cool roof technologies on the thermal comfort of the buildings reduces electricity consumption for maintaining the thermal comfort of buildings, without relying completely on cooling equipment. The cool roofs, however, can mitigate summer urban heat islands by improving indoor air quality and comfort. By thermal analysis of different materials analyzed the impact of the rate of heat transfer on the building envelope and the results obtained shows that different cool roof techniques are beneficial in maintaining the comfort level of the building of course depends on the ambient temperature conditions.
Keywords: - *Cool roof technology, Retrofitting, Power consumption.*

1- INTRODUCTION

Buildings use about 50% of all the energy produced in our planet during operation for heating, cooling, and lighting and also during building construction (ERG et al.1999). Today India have about 27.87 billion sq ft of existing building stock, and is the fourth largest carbon emitter. The Building construction sector is one of the highest contributors to the country's carbon emissions, accounts for 22 per cent of India's total carbon emissions. At present, India's construction industry is booming and with the development of more new buildings, it is seems to increase India's CO_2 footprints significantly. Market estimates shows addition of 11.5 million homes every year in India. Thus, India is making the world's third largest construction market by 2020. Major part of this energy consumption is directly related to buildings operational life & Approx. 80% of GHG emissions take place during the Operational Phase of Buildings, when energy is used for HVAC, lighting, appliances and other applications.

The main challenge is to converting existing buildings into energy-efficient green buildings. only solution to these existing problems is making our existing building green. "By doing that, we can save 20-30% in energy, 30-40 per cent in water and at the same time, enhance great occupant, health and comfort. There should is a need of strategy to make the existing buildings more sustainable and efficient.

2- NEED OF RETROFITTING EXISTING BUILDINGS

Buildings which were constructed about 10-50 years before and that have a remaining service life of minimum 60-10 years and presents a good retrofitting potential for energy saving in buildings through active & passive strategies.

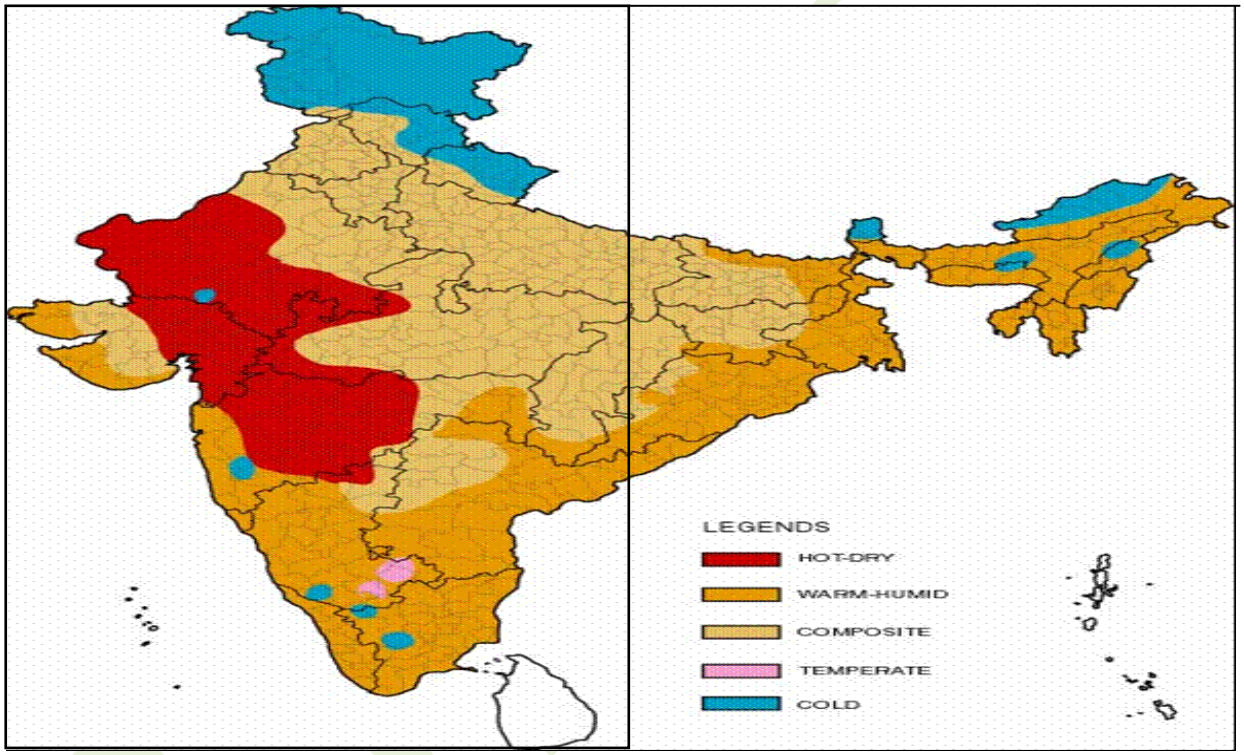
Retrofitting - the replacement & up gradation of old systems and addition of new technologies for the purpose of improved efficiency to address technological

or environmental obsolescence. [Richard Hyde, 2013]

3- CLIMATE ANALYSIS

India having five different climatic conditions (see Map) varying from very hot and dry to cold and humid. The characteristics of each climate differs the comfort requirements from one climatic zone to another. Based on the building use, comfort requirements and design adopted, the energy requirement of buildings change. The five climatic zones based on the hourly temperature, various climatic parameters and solar radiation are:

- Composite
- Hot-dry
- Moderate
- Warm-humid
- Cold



Ambient temperature of important cities in different climatic zones and seasons shown below

Table-1

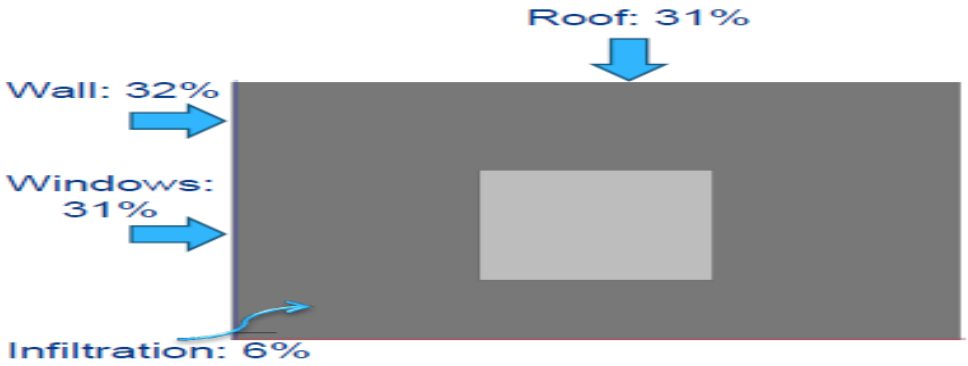
Zone	Location & Cities	Ambient temperatures summer		ambient temperatures winter	
		Day	Night	Day	Night
Hot and Dry	western and the central part of India; Jaisalmer, Jodhpur and Sholapur	40 to 45ºC	20 to 30ºC	5 to 25ºC	0 to10ºC
Warm and Humid	coastal parts of the country; Mumbai, Chennai and Kolkata	30 to 35ºC	25 to 30ºC	25 to 30ºC	20 to 25ºC
Moderate	hilly or high-plateau regions Pune and Bangalore	30 to 34 ºC	17 to 24ºC	27 to 33 ºC	16 to 18ºC

Composite	central part of India New Delhi, Kanpur and Allahabad	32 to 43 ºC	27 to 32ºC	10 to 25ºC	4 to 10 ºC
Cold and Cloudy	situated at high altitudes. Ootacamund, Shimla, Shillong, Srinagar and Mahabaleshwar	20 to 30 ºC	17 to 27ºC	4 to 8 ºC	-3 to 4ºC
Cold and Sunny	Leh (Ladakh)	17 to 24 ºC	4 to 11 ºC	-7 to 8 ºC	-14 to 0ºC

4- NEED OF COOL ROOF BUILDINGS

Heat flow trend in percentages in composite climate and warm-humid climatic condition shows below, heat flow through the roof are 31% and 25% respectively.

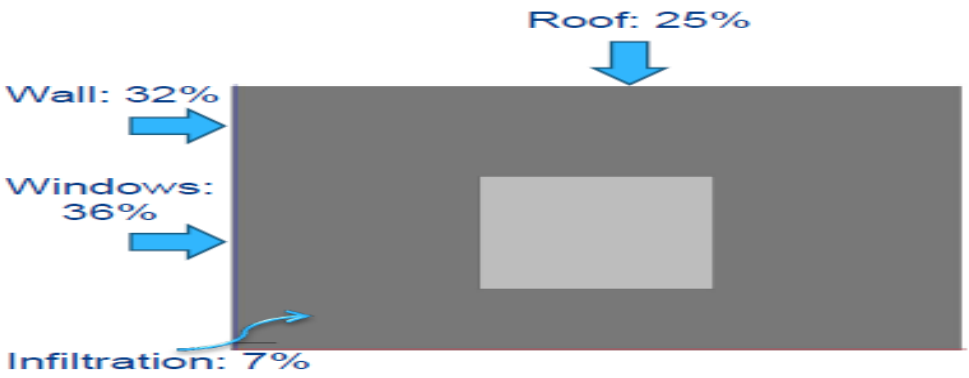
i- Composite Climate (New Delhi)



*Direct heat gain from windows not accounted

Source : BEEP

ii- Warm-Humid Climate (Chennai)



*Direct heat gain from windows not accounted

Source-BEEP

5- COOL ROOF TECHNOLOGY

A roof can bring lot of heat into buildings during summers especially when there is high amount of solar radiation. A roof that decreases heat ingress into the buildings by reflecting and emitting the sun‘s heat back into the sky is said to be a cool roof.

From an experimental demonstration project conducted in an office building located in a city(Hyderabad) with composite climate, it has been observed that cool roof with solar reflectivity of 0.7 has a potential of saving 19% of cooling energy consumption for the top floor of the building as compared to a

conventional concrete grey roof.(Surekha Tetali)

Further, an experimental observation showed that, out of various cool roof materials such as: different kinds of coatings, ceramic tiles, and reinforced aluminium foil, ceramic tiles might provide a better payback due to their extended life period compared to other materials.

6- ADVANTAGES OF COOL ROOF

A cool roof can benefit a building and its occupants by:

- Reducing energy bills by decreasing winter heating needs and in summer cooling needs
- Improving indoor comfort for non-air conditioned buildings.
- Decreasing roof temperature, which may extend roof service life up to 15 years.

Apart from the building itself, cool roofs can also benefit the environment, especially when many buildings in localities densely situated. Cool roofs can:

- Reduce local air temperatures (referred as the urban heat island effect)
- Lower peak electricity demand, which can help prevent power outages
- Reduce power plant emissions, including carbon dioxide, sulphur dioxide, nitrous oxides, and mercury, by reducing cooling energy use in buildings.

7- COOL ROOF STANDARDS IN INDIA

Energy Conservation Building Code: The Energy Conservation Building Code, 2007 requires

Commercial building roofs with a minimum solar reflectance of 0.7, either through the prescriptive path or whole building simulation path to prove a minimum expected reflectance of 0.7. While the ECBC does not specify cool roof requirements for different climate regions, it does state: "Roofs with slopes less than 20 degrees shall have an initial solar reflectance of no less than 0.7 and an initial emittance no less than 0.75. Where solar reflectance shall be determined in accordance with ASTM E903-96 and emittance shall be determined in accordance with ASTM E408-71 (RA1996)." Rating systems in India, including the Indian Green Building Council (IGBC), Leadership in Energy and Environmental Design (LEED) and the Green Rating for Integrated Habitat Assessment (GRIHA) require mandatory ECBC norms compliance as a prerequisite for buildings applying for rating.

	Standards
ECBC	ASTM E 903-96, ASTM E408-71 (RA 1996)
LEED India	ASTM Standard E1980-01, ASTM E 408-71 (1996) e1, ASTM E 903-96, ASTME1918-97, ASTM C1371-04, ASTM C1549-04
GRIHA	The GRIHA rating system takes into account the provisions of the National Building Code 2005; the Energy Conservation Building Code 2007 announced by BEE (Bureau of Energy Efficiency) and other IS codes.

8- WORKING OF COOL ROOFS

Cool roofs function primarily by reflecting heat incident on a building back to the atmosphere to a greater extent than a regular roof surface. To understand the mechanism of this process, the two primary thermal properties of a roof – solar reflectance and emittance – need to be understood. Every time solar radiation falls on a roof, the roof performs four actions:

 Reflection - a part of the incident heat back into the atmosphere

 Conduction - a part of the heat through itself into the ground and to other buildings
 Convection - a part of the heat to the ambient air (external and internal)
 Emission - a part of the absorbed heat to internal surfaces and back to the sky

The extent to which the surface can perform these actions determines its effectiveness as a cool roof, with the two most important factors being its ability to *reflect* solar energy and *emit* absorbed energy.

9- COOL ROOF

9.1 ROOF INSULATION (OVER-DECK) –– A HOLISTIC APPROACH

This type of insulation has to take a composite approach to provide –

 Thermal insulation
 Waterproofing and
 Slope built-up.

The traditional and conventional systems of waterproofing and thermal insulation was suited to the Indian construction and economics earlier . However, these systems have a short life span and require frequent maintenance. Now a days these systems not suited to the present complicated site dynamics and do not offer insulation as per compliance to ECBC norms.

9.1.1 Mud Phuska

In this system of providing thermal insulation, a 10 cm layer of grass straw mixed puddled clay is applied in slope on waterproofing layer of a sand-bitumen. This consolidated layer is plastered with 13 mm of cow-dung mortar. Flat tile bricks are laid on plastered surface with help of cement mortar.

The Thermal and surface properties of mud phuska are as below;

Density = 1622 kg/m3

Thermal conductivity = 0.750 W/mK

Specific heat capacity = 0.88 kJ/kg-K

[Reference: SP 41, Handbook on functional requirements of building (Other than industrial buildings), Part 1-4, Bureau of Indian Standard (1988)]

9.1.2 Brick bat coba

The most popular method for roof in the Indian construction industry is the use of brick bat coba. In this system slope is provided by putting brickbat on flat roofs and then grouting them with cement mortar with some water proofing compounds. This is mostly finished with IPS topping with a tile pattern cut into the top to form crack inducer joints to prevent cracks from appearing; alternatively China mosaic is done as the top wearing course. There is a myth that brick bat coba offers waterproofing and also insulation against heat. In fact the heat absorbed by brick bat coba it is the same as that absorbed by concrete, and absorb water also.

Advantages

 Provides Slope: This system provides an excellent slope for the water to drain away. As water does not accumulate and as it has a certain capacity to absorb water, there is no leakage.

Disadvantages

 Impose Dead Load: This system puts unnecessary dead load on the structure.
 Cracks Up: Brick bat coba cracks up due to temperature variation and movements due to thermal stresses. Once cracks appear, water travels below the coba and leakage starts. It is very difficult to trace the inlet point and repair it.
 Difficult to Dismantle: Some parts of the coba stick so well to the concrete that an attempt to dismantle the system may damage the slab.

9.1.3 Tar felt / APP membrane

This system uses layers of tar interspersed with various forms of reinforcements to hold the layer together and prevent cracking to provide impermeable layer between the water and the surface to be protected.

Advantages

 Cheap
 Suitable for AC sheet roofing

Disadvantages

 Not UV Resistant: Tar/Bitumen - the binder in the system disintegrates on contact with 'UV' radiation leading to biodegradation of reinforcement leading to collapse of the system.
 De-bonding: Vapour trapped inside exerts vapour pressure resulting in de-bonding of the membrane.

9.1.4 In North Western India, in states such as Gujurat and Rajasthan, it's a common practice to coat the roofs white, using lime and chalk. China mosaic also is another popular practice in which women arrange the broken tiles (mostly white) in a spider web pattern. Based on the local climate of the place, and availability of the material, the roof finishes use to vary. The white coating always helped to keep the terrace surface cool, and emit less radiation during the cooler parts of the day.

9.2 TOTAL INSULATION CONCEPT – THE MODERN APPROACH

To provide over-deck roof insulation that complies to ECBC requirements, a composite builtup is required which consists of a thermal insulation material with high "R-value", coupled with a suitable waterproofing and complete with a light weight material for the slope built-up or water run-off.

Cool roofs can be broadly divided into four categories [Anil Bakshi]

 Coated cool roofs: In these roofs, the coating of a material or paint applied on top of an existing roof material to increase the roof surface's SRI. These are liquid-applied coatings made of an acrylic polymer technology and are usually white in color but not necessarily.

 Membrane cool roofs: In these roofs, the application of a pre-fabricated membrane such as tiles, shingles, or sheeting over an existing roof to increase the roof surface's SRI. These types of roofs can be polyvinyl chloride (PVC) or bitumen-based.

 Tiled cool roofs: these roofs made by the application of high albedo tiles on top of an existing roof or to a new roof.

 Green roofs: green roofs make, by planting vegetation on the roof so that it absorb less solar energy by providing a thermal mass layer and it is reduce flow of heat into a building. Vegetation is especially useful in reflecting infrared radiation.

10- CONCLUSIONS

According to the Ministry of Power's Bureau of Energy Efficiency, low-rise buildings can absorb up to one-fifth of a building's heat through the roof. Therefore roofs contribute significant impact on internal temperatures and provide thermal comfort indoors, in both air conditioned and non-air-conditioned buildings. There is a need for Cost benefit analysis of cool roof materials, market availability, technical standardizations, to be disseminated to all stack holders and public through a series of workshops and seminars to promote cool roof technologies. These awareness campaigns need to be promoted such a ways to reach to broader audiences including businesses. Efforts also be made to identify cost-effective cool roof solutions for low-income housing.

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