Cool Roof Technology

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Abstract— The motive of undertaking this project "cool roofs technology" discusses the various technical and design considerations as applicable for a composite climate. The primary intent of "cool roof technology" is to reduce the amount of energy (heat) absorbed by a roof surface and maintain the temperature of upper floors in building in summer season. The manual addresses architects, engineers, and other building professionals are responsible for the performance and construction of buildings. The direct and indirect benefits and energy savings potential of cool roofs, its helps to reduce the urban heat island, global warming, local air temperature and creates a more comfortable and healthier environment.
Key words: Solar Reflectance, Cool Roof Technology

I. Introduction

Cool roofs can help many building owners to save money while protecting the environment. Anyone who has lived on the uppermost floor of a building in hottest city, or a similar composite climate, may have experienced the discomfort of significantly high temperatures during the summer as compared to other floors in the same building. Many modern buildings in India are constructed of concrete or cinder blocks and are topped with flat, tar covered roofing. Such surfaces absorb the incident sunlight, transferring it to the interiors of the building. The hot ceiling continues to heat up the space during the day and well into the night making the spaces unbearably hot throughout the summer season. Cool roofs have the ability to reflect and reject heat because the roofs are prepared with such materials or paints, which have properties of both high solar reflectance and emittance. Besides reducing cooling load requirements (freezer & AC) in a building, cool roofs also help in improving occupant comfort level and mitigate the urban heat island effects associated with warm buildings heating up the air around them.

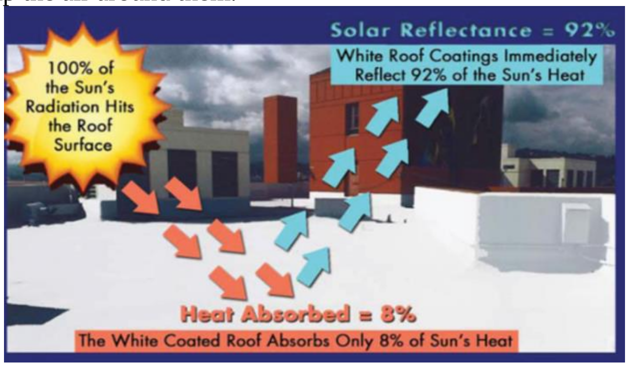

Fig. 1: Solar reflections

II. A Cool Roof

It is a technology to reduce the temperature indoor and outdoor of our environment, through a white wash or white painting of top portion of roof. Present time architects have many choices. They can either use cool roofing material during construction or retrofit the existing roofs with cool roof technologies. One can also option for green roof with vegetation cover, which do not reflect sunlight but have cooling benefits.

A. *White v/s Green Roofs*

- Green roofs are costlier than white roofs. Green roofs have high installation and maintenance cost, while white roofs need periodic refurbishing
- Green roofs have a longer life but due to its installation floor load is highly increases while white roof does not change the floor load.
- Green roofs improve storm water run-off management whereas white roofs optimize rain water harvesting
- White roofs are three times more effective than green roofs in cooling down the neighborhood

III. Properties of Cool Roof

Cool roofs have the ability to reflect and reject heat because the roofs are prepared with materials which have properties of both high solar reflectance and emittance.

A. *Solar Reflectance*

Solar reflectance, or *albedo*, is the fraction of the incident solar energy that is reflected by the surface material. Solar energy consists of a spectrum of wavelengths, including ultraviolet, visible, and infrared light.

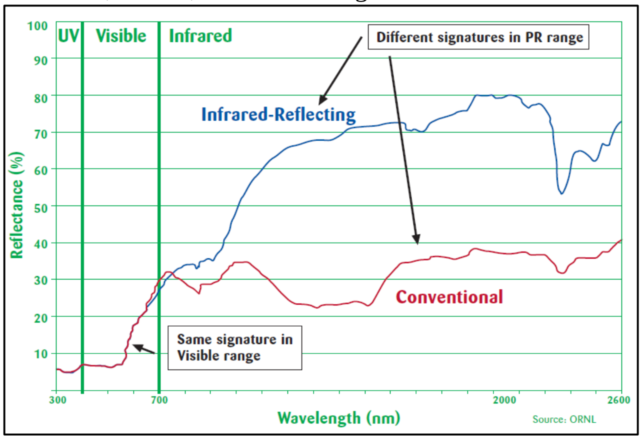

Fig. 2: Solar Reflectance Effect of a Cool Colored Coating

The solar energy distribution as a function of wavelength is shown in Figure-2. Surface materials that reflect solar energy and all over wavelengths (i.e., that have a higher solar reflectance of surface material), will have better performance in reducing roof solar heat gain. Color is a good indicator of solar reflectance only in the visible light range, with reflectance typically increasing from a dark-colored to a light-colored surface. For example, traditional dark-colored roofing materials have a solar reflectance of about 0.04 to 0.18, whereas light-colored roof surfaces have a reflectivity of 0.70 or higher "Cool color" technologies can increase the solar reflectance of roofing materials in the infrared range through the application of a special coating. In this application, the roof has the same visual appearance, but is much cooler. In this example, the solar reflectance in the visible portion of the spectrum is the same for both products; however, the product employing "cool color" technology remains cooler by having much higher reflectance in the IR range.

B. Thermal Emittance

No roof is a perfect reflector, as all surfaces absorb some solar energy as heat. Part of the retained heat will be emitted back to the environment in the form of infrared radiation. Thermal emittance is a ratio between what a warm or hot surface emits and what a perfect blackbody emitter would emit at the same temperature. It has a value between 0 and 1, with a low emittance roof becoming relatively hotter than a high emittance roof since it is not as effective at getting rid of the retained heat.

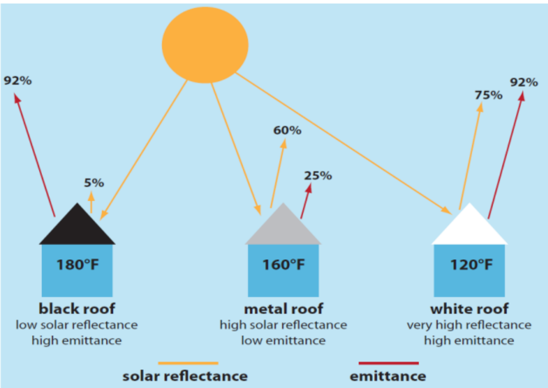

Fig. 3: Example of Combined Effects of Solar Reflectance and Thermal Emittance on Roof Surface Temperature

The thermal emittance of most common roofing materials is approximately 0.80. Metallic surfaces are the exception, since bare metals become extremely hot in the sun. For example, in one outdoor experiment, a bare clean sheet of galvanized steel with a solar reflectance of about 0.38 reached temperatures nearly as high as a black surface. Thermal emittances of metallic surfaces vary widely between 0.20 and 0.60, depending on surface conditions.

The reflectance and emittance of bare metals are very sensitive to the smoothness of the surface and the presence of surface oxides, oil, film, etc. Metal roofing is available with pigmented polymeric coatings, similar to paint. These coatings are used to protect the metal panels, and sometimes also to provide a more appealing appearance; they can also keep the roof cooler.

For example, metal roofing with cool white coatings (MBCI Siliconized Polyester White and Atlanta Metal Products Kynar Snow White) have emittances as high as 0.85.

C. Roof Heat Transfer Mechanism

Several phenomena occur to the incident solar radiation upon striking a roof's surface, as shown in Figure-4. Much of the solar radiation is reflected back toward the sky, but some is absorbed by the roof as heat. A portion of the retained heat will be emitted back to the sky in the form of infrared (IR) radiation. Some heat is also carried away from the roof surface through convection. The remaining heat flows through the roof. The amount of heat that reaches the conditioned space below the roof will be determined by the insulative property of the roof material, and on the difference in temperatures on either side of the roof.

A cool roof has a higher solar reflectance and higher thermal emittance than a non cool roof. High solar reflectance and high thermal emittance of a cool roof combine to keep the roof surface much cooler than a traditional roof, with peak temperature reductions of 30°F - 60°F. Achieving this type of drop in roof surface temperature will reduce the overall heat gain through the roof and reduce a building's annual cooling needs. Studies show cool roofs can typically reduce summer air-conditioning energy use by 10%-20% .

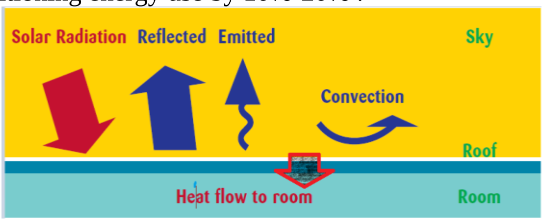

Fig. 4: Solar radiation

IV. PERFORMANCE & DURABILITY OF COOL ROOF COATINGS

Cool roof coatings are commonly used in re-roofing projects. They apply mostly bright white paint-like materials to traditional roofs or metallic surfaces. The coating extends the life of the underlying roof materials and greatly increases the solar reflectance. Cementitious coatings use cement or ceramic particles to enhance solar reflectance. They can be sprayed, rolled, or brushed on the rooftop properly and installed, they perform well; however, they can be brittle and crack, flake, or peel from surfaces over time.

Fig. 5: Performance & Durability of Cool Roof Coatings

There are two main types of cool roof coatings: cementations and elastomeric. Cementations coatings contain cement particles. Elastomeric coatings include polymers to reduce brittleness and improve adhesion. Some coatings contain both cement particles and polymers. Both types have a solar reflectance of 65 percent or higher when new and have a thermal emittance of 80 to 90 percent or more. The important distinction is that elastomeric coatings provide a waterproofing membrane, while cementitious coatings are pervious and rely on the underlying roofing material for waterproofing. In a present time many types cool (coating) materials and paint are available in the market.

1) *Coating Adhesion*
- Surface preparation
- Primer selection
- Primer & top coat application
- Correct weather conditions during & immediately after application

2) *Coating Durability*
- The durability of a roof coating is determined primarily by the type, quality and quantity of the binder and pigments in the coating.
- Durability is also determined by the application process, the weather conditions during and after application, the suitability and quality of the primer and the total applied coating thickness.
- Gloss coatings are more durable and have higher solar reflectance than semi-gloss, low sheen or flat coatings due to dirt moisture and surface light refraction.

3) *Coating Functionality*
- Anti corrosion metal sheet coatings
- Water proofing membranes for flat roofs
- Anti condensation for metal sheet
- Anti fungus for high humidity areas
- Anti bacteria for contaminated & high humidity areas
- Sealer binder primer for loose fibrous asbestos cement surface or powdery oxidized loose surface.

V. BENEFITS OF COOL ROOF

- Reduces interior temperature of building.
- Reduces roof surface temperature by 20 to 60 degrees.
- Increases effective 'R' value.
- Reduce a local air temperature, which improves air quality and slows smog formation.
- Reduce peak electric power demand, which can help prevent power outages.
- Reduce power plant emissions, including carbon dioxide, sulfur dioxide, nitrous oxides, and mercury, by reducing cooling energy use in buildings.
- Reduce heat trapped in the atmosphere by reflecting more sunlight back into space, which can slow climate change.
- Applies toward LEED (Leadership in Energy and Environmental Design) credit.
- Extends life of air-conditioning systems.
- Creates a more comfortable and healthier interior environment.
- It helps to reduce urban heat islands
- Can be applied over almost any type of roof surface
- Extends life of roofing systems.
- Easier installation when compared to other alternatives
- Reduces the carbon footprint of the building and the city
- Reduced Air Pollution and Greenhouse Gas Emissions.
- In night time (moon light) roof is clearly visible and improve aesthetics.

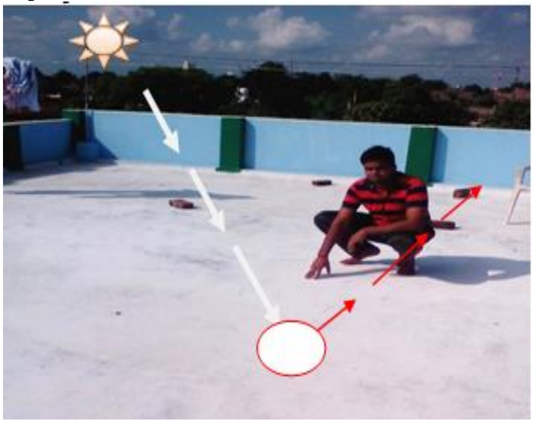

Fig. 6: Cool Roof

VI. ENVIRONMENTAL IMPACTS

Installing cool roofs also has positive environmental impacts. At a community scale, increasing the solar reflectance of roofs can effectively and inexpensively mitigate an urban heat island.

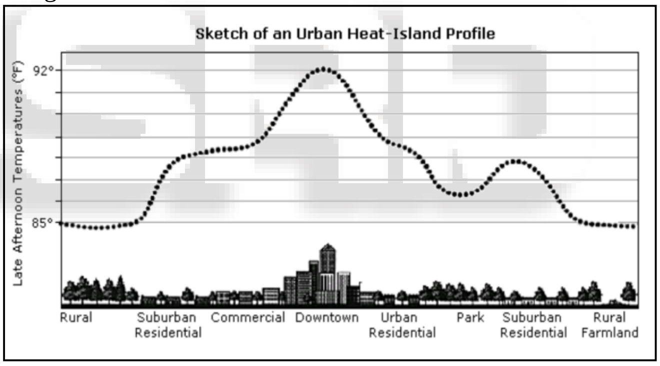

Fig. 7: Positive environmental Impacts

An urbanized area can be about 2-9°F hotter than the surrounding rural area. Increasing the solar reflectance of roofs, transfers less heat to the ambient environment than to non-cool roofs. The resulting lower outdoor air temperatures can slow down the urban smog formation. Simulations predict a reduction in ozone of 10-20%, resulting from a 3-4°F cooling in ambient temperature. Urban air temperature elevation also aggregates air-conditioning use by adding 5-10% of peak electric demand, at a direct cost of several billion dollars annually .Widespread use of cool roofs could be a significant contributor to a reduction in urban ambient temperature. A 10-20% reduction in ozone would be comparable to that obtained by replacing all gasoline on-road motor vehicles with electric cars. Electricity savings and peak demand reductions yielded by cool roofs can reduce power-plant emissions of NOx, carbon dioxide and undesirable particulate matter, especially when peak demand reduction decreases the use of inefficient peak-power plants.

A. Potential Adverse Impacts

Cool roofs can have a winter time heating penalty because they reflect solar heat that would help warm the building. The amount of useful energy reflected by a cool roof in the winter tends to be less than the unwanted energy reflected in the summer. This difference occurs primarily because winter days are shorter, and the sun is lower in the sky. The sunlight strikes the Earth at a lower angle, spreading the energy out over a larger area and making it less intense. In mid-Atlantic and northern states with higher heating requirements, there also are more cloudy days during winter, which reduces the amount of sun reflected by a cool roof. Snow cover on roofs in these climates can also reduce the difference in solar reflectivity between cool and non-cool roofs.

VII. PECAUCTION & CONSIDERATION

Although cool roofs have been used successfully for many years, their use is growing and cool roofs are now being installed in a wider range of climates. There are some important questions about the durability of cool roof systems in certain applications. Designing a roof that can withstand and control moisture is essential since uncontrolled moisture could cause damage to the roof or the building. The following considerations illustrate how cool roofs handle moisture differently than dark roofs. Ponding occurs when water, typically from rain, accumulates in pools on the roof. This happens when a roof has insufficient slope (caused by poor design or damage) or drain blockage. It takes longer for ponded water to evaporate from a cool roof due to its lower temperature. If your cool roof cannot tolerate ponding, it may be necessary to inspect the roof more frequently to prevent damage or leaks.

Moisture from the indoor air can also condense within roof materials. If allowed to accumulate over months or years, moisture could damage those materials. Ordinarily, heat from the sun dries out building materials during the daytime and throughout the summer. In consistently hot climates, there is little risk for this kind of moisture build-up in colder climates; there is less heat available to dry out the roof and more opportunities for condensation to occur. Without proper design, both dark and cool roofs can accumulate moisture in colder climates.

Cool roofs maintain lower temperatures than dark roofs, and so they may provide less heat to dry out moisture. Potentially, this could make a cool roof more susceptible to moisture accumulation when used in colder climates. While this issue has been observed in both cool and dark roofs in cold climates. The potential for persistent moisture levels to arise in different roof designs and climates is the considered in the context of your surroundings.

It is relatively easy to specify a cool roof and predict energy savings, but some thinking ahead can prevent other headaches.

Ask this question before installing a cool roof:

A. Where will the reflected sunlight go?

A bright, reflective roof could reflect light and heat into the higher windows of taller neighboring buildings. In sunny conditions, this could cause uncomfortable glare and unwanted heat for you or your neighbors. Excess heat caused by reflections increases air conditioning energy use, negating some of the energy saving benefits of the cool roof. Highly Energy Efficient Buildings and Rooftop Solar Equipment Cool roofs may add only marginal energy savings to buildings that are already highly energy efficient. Highly efficient buildings are often well insulated to minimize the flow of heat through the walls and roof. This helps the occupied space stay cool in summer and warm in winter, regardless of the roof's surface temperature. However, dark roofs on well- insulated buildings can become very hot, so cool roofs help achieve the environmental benefits associated with lower roof temperatures. Keeping a roof cool may also extend its lifetime. Solar energy systems, such as photovoltaic (PV) panels and solar thermal collectors, absorb solar energy and can become hot in the sun. Solar equipment mounted flush with the roof's surface can act like a dark roof, transmitting heat to the building and increasing air conditioning demand. Physical gaps between the solar equipment and roof can reduce this effect, since airflow through the gap can remove some of the heat that would otherwise flow into the roof. On permanently shaded portions of the roof, the roof's solar reflectance does not affect air conditioning demand. This includes regions of the roof that are completely shaded by solar panels.

Some newer thin-film PV modules can be integrated directly with roofing materials. They may meet current cool roof requirements for steep sloped roofs but do not satisfy the more stringent standards for low sloped roofs.

VIII. CONCLUSIONS

The conclusion of the project "cool roof technology" is very simple and economical to reduce the cooling load on the building's HVAC (heating, ventilation and air conditioning). It significantly increases the expected life of the building's roof and they can decrease the urban heat island effect by reflecting some of the incident solar energy back into space as opposed to absorbing the heat and releasing it to the surroundings.

REFERENCES

[1] US Green Building Council, LEED-NC for New
[2] Construction, Reference Guide, Version 2.2, First Edition, October 2005, 95.
[3] Akbari, Hashem, Surabi Menon, and Arthur Rosenfeld. "Global Cooling: Increasing World-wide Urban Albedos to Offset CO2." Climatic Change 95 (2008)
[4] Tijen, Michelle Van, and Rebecca Cohen. "Features and Benefits of Cool Roofs." Cool Roof Rating Council Program 3 (2008)
[5] "Cool Roof Bill Poised to Heat Up the Economy." Polyiso, the Top Performer. N.p., 3 Oct. 2011.
[6] "Cool Roofs for Cooler Summers." Briefings. Environmental and Energy Study Institute, 21 July 2011.
[7] Energy Efficiency and Renewable Energy: Cool Roofs. Washington DC: US Department of Energy.
[8] Cool Surfaces and Shade Trees to Reduce Energy Use and Improve Air Quality in Urban Areas, Akbari, H., M. Pomerantz, and H. Taha. Solar Energy 70(3): 295-310, 2001.

[9] Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements, LBNL Report 50451, Ronnen Levinson, Hashem Akbari, Steve Konopacki, and Sarah Bretz, Heat Island Group, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, December, 2002.
[10] Mitigation of Urban Heat Islands: Material, Utility Programs, Updates. Rosenfeld, A., H. Akbari, S. Bretz, B. Fishman, D. Kurn, D. Sailor, and H. Taha. Energy and Buildings 22: 255-265, 1995.
[11] High Aledo (Cool) Roofs, Codes and Standards Enhancement (CASE) Study, Pacific Gas and Electric Company, November 17, 2000.
[12] Cool Roofs and Title 24
[13] Cool Roof Workshop, Lisa Garland, Pacific Energy Center, San Francisco, September 27, 2005.
[14] http://www.energy.ca.gov/electricity/consumption_by_sector.html
[15] Chen, Allan. Cool Colors, Cool Roofs, part 2. Science Beat Berkeley Lab. 27 August 2004. Retrieved 14 April 2008 from <http://www.lbl.gov/ScienceArticles/Archive/sb/Aug-2004/3_coolroofs-2.html>.
[16] Cool Roof Rating Council
[17] Cool Roofs Design Manual Bureau of Energy Efficiency Delhi