Utilization of Reflective Material in Passive Cooling of Built Environment

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Abstract : Cool materials have a high solar reflectance and a low thermal emittance, which allows them to stay cool in the sun. Several cool coatings have lately been developed. This research examines a low cost cool coating prototype made of lime that has a higher reflectivity than a normal cool coating. The effect of cool colored and white coatings on their ageing when exposed to external circumstances is also investigated. The study demonstrates that the spectrum reflectance of white coatings is reduced, whilst the cool colored decoatings exhibit nearly little degradation in the visual spectrum, preserving their original look.

*Keywords **:** passive cooling, reflective materials, energy efficient building, built environment , low cost cool materials*

1 INTRODUCTION

The heat island effect is a well-known occurrence that reflects a considerable shift in the metropolitan environment. Dawodu, A., & Cheshmehzangi, A. (2017). , Santamouris, M., Pavlou, K., Synnefa, A., Niachou, K., & Kolokotsa, D. (2007). and Chiatti, C., Fabiani, C., Cotana, F., & Pisello, A. L. (2021) reported that when compared to nearby suburban and rural regions, the positive thermal equilibrium in cities leads in a significant rise in urban temperatures.In Europe and internationally, research works on heat island abatement strategies has been conducted. Fabiani, C., & Pisello, A. L. (2021) and Khan, A., Carlosena, L., Feng, J., Khorat, S., Khatun, R., Doan, Q. V., & Santamouris, M. (2022) found that Utilization of green areas and cool sinks, the decrease of anthropogenic heating, and its use of highly reflecting materials were some of the most efficient techniques.[1,2,3,4,5]

Ashhar, M. Z. M., & Haw, L. C. (2022). and Gehlot, T., & Raina, A. (2021) reported in their study that high solar reflectance & infrared emittance levels describe cool materials.[6,7]

The current article discusses recent advancements in the disciplines described above. paper discusses research findings related to the creation and testing of a low-cost highly reflective white coating,

2 LOW COST REFLECTIVE MATERIALS

In order to improve the solar reflectance of the exterior surface of buildings, a new white coating comprising calcium hydroxide as the principal component was developed.. Lime-based coatings are low-cost, ecologically friendly, allow air to travel through, and have a good dirt-pick-up resistance. The acryl-based coatings that have been developed and tested can be applied to buildings and many other surfaces in the urban landscape. On white conventional concrete tile of 50 cm x 50 cm, the new coating as well as a normal white reflective coating were applied. Surface temperature of the samples was measured on a 24 hour basis in order to examine the optical characteristics & thermal efficiency of the coatings. Average temperature detectors (thermocouples type K) are coupled to a data recording system as the fundamental experimental equipment. Every 10 minutes, instantaneous readings were measured and recorded into a computer hard disc. The thermal sensors were installed in the middle of each tile's surface. The samples' infrared emittance was measured using the Products and Services emission metre type AE. In compared to normal lower and higher emittance materials, this emittance gadget determines the overall thermal emittance. A PTFE plate served as the measurement's reference standard reflectance material.

The samples were put on a specifically modified horizontal platform that was insulated from underneath to prevent heat transmission between the platform and the samples. Figure 1 depicts the results of the spectrophotometric measurements. Both of the cool white coatings have extremely high reflectance values in the visible and near infrared ranges of the electromagnetic spectrum. The reflectance curves of the prototypes cool white coating created using calcium hydroxide, on the other hand, is always higher than the cool white coating curve (Figure 1). The solar reflectance of each sample was calculated using spectral reflectance data. Weighted-averaging was used to do the computation, with a conventional solar spectrum serving as the weight matrix. The spectrum used was given by ASTM, and the solar reflectance values for every sample are listed in Table 1. Table 1 also includes the calculated data of infrared emittance. When comparing to the cool white coating, the coating incorporating calcium hydroxide (lime) exhibited a 15 percent higher solar reflectance value. Under hot summer circumstances, surface temperature measurements were made. Figure 2 shows a representative 24-hour temperature distribution between both the prototype cool white coating (containing calcium hydroxide) as well as the cool white coating.

Figure 1: reflectance of the prototypes cool white coating versus the conventional cool white coating in terms of spectral reflectance.

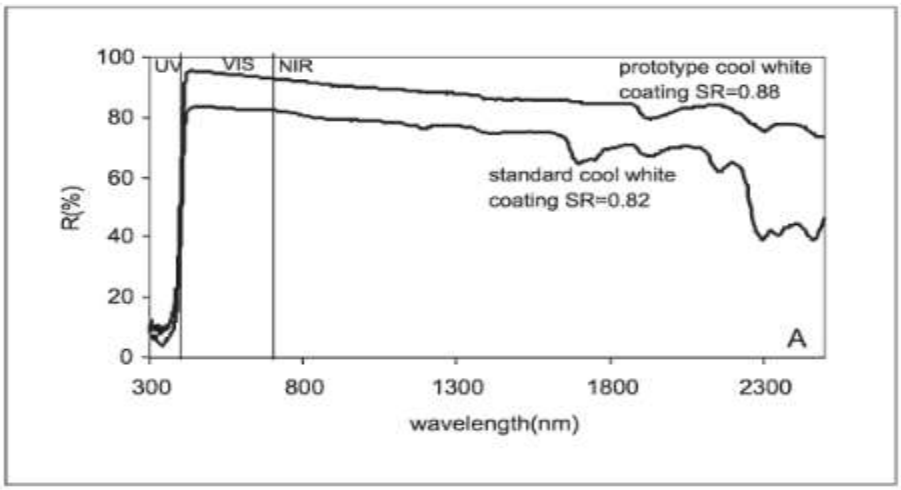


Table 1 : SR and IE of samples

Sample	SR	IE (error+or - 0.002)
CalciumHydroxide Prototypes Cool white coating	0.84	0.82
Standard white coating	0.73	0.87

Simulations were run for five cities named Jodhpur ,Mumbai ,Delhi, Kolkata and Jaiselmer. The simulations were carried out using TRNSYS thermal computer simulations .An hour time step was used in the computations. The weather data was obtained from the METEONORM database The simulations were conducted for area 150 m^2.. It's estimated to be 4 metres tall. Each wall has 5 m^2 of glass, a U-value of 5.5 W/m^2 K, and is well shadowed .The U-value of the walls was calculated to be 2.5 W/m^2 K, whereas the roof's U-value was calculated to be 0.80 W/m^2 K. The rate of infiltration was set at 0.9 each. 60% of the input was assumed to be convective heat and 40% was assumed to be radiative heat. This building style may not be indicative of a typical home in all of the places studied. However, the goal is to compare the cooling energy savings as well as potential wintertime consequences of modifying the roof's solar reflectance. The thermostat set points for cooling and heating were 29 and 25 degrees Celsius, respectively. Based on the testing findings for the cool materials mentioned above, three alternative values of roof solar reflectance were simulated. Solar reflectance was assumed to be 0.25 in the basic scenario. emittance of infrared light was calculated to be 0.93. It should be noted that the values indicated in this section of the research are dependent on the features of the structure and are thus merely suggestive. Increased roof reflectance reduces summer cooling demands, as predicted. A 0.45 improvement in roof solar reflectance reduces cooling demands by 16 to 28 kWh/m^2, whereas a 0.70 increase reduces cooling loads by 25 to 45 kWh/m^2. we may deduce that boosting a roof's solar reflectance is often more beneficial in warmer regions where its cooling load prevails for the majority of the year.

Figure 2: Surface temps of the cool white & regular white coatings throughout the course of 24 hours.

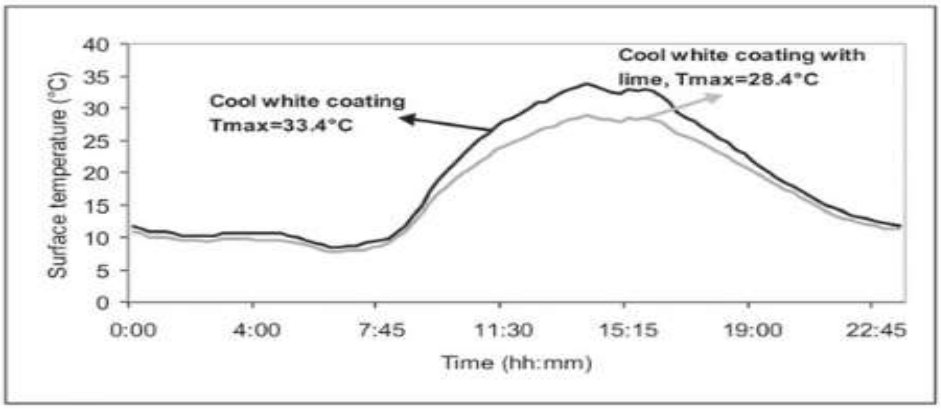
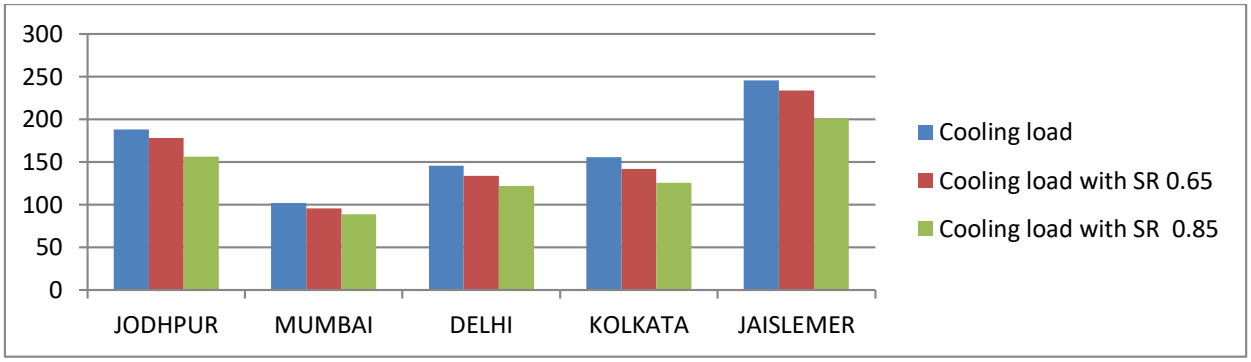


Table 2: The calculated cooling loads

Area	Cooling load	Cooling load with SR 0.65	Cooling load with SR 0.85
Jodhpur	188.34	178.32	155.89
Mumbai	101.45	95.32	88.44
Delhi	145.32	133.34	121.78
Kolkata	155.78	141.56	125.67
Jaiselmer	245.64	233.67	200.67

Figure 3:Cooling and heating load changes



3 CONCLUSIONS

The findings of this study show that producing a white fluorescent coating is a significant success. Calcium hydroxide was utilized to improve the solar reflectance of a white coating. The prototype white coating, which uses lime (calcium hydroxide), has a better thermal performance than the regular cool coating, which ranges between 1–5 degree Celsius . This is due to the fact that, while both coatings have extremely high spectrum reflectance, the prototype's reflectance is always greater. Through modeling, the influence of cool coatings on the temperature control loads of urban structures is examined. Due to the climatic circumstances and the features of the structures, the cooling load is lowered in all circumstances. The savings range from 15 to 45 kWh/m^2/year. The increase in heating demand due to cool coatings is small, and it is always offset by a decrease in cooling load.

Declaration of Conflict of Interest : Authors Proclaim that they have no any Conflict of Interest

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