Preliminary Report

Thermal performance evaluation of Insulla roofing tile of Japeva Engineering Pvt. Ltd, Chennai

Prepared for

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Introduction

Heat gain in buildings is maximum through roofs as they are directly exposed to the sun through out the day. This gain is about 30% of total heat gain (N K Bandal & J Mathur, 2006) in a building through envelope. In tropical climates like India, heat protection is important to reduce the heat gain; thus improve thermal comfort in naturally ventilated buildings and decrease the air conditioning load in air-conditioned buildings.

It is important to understand the influence of sol- air temperature, which takes into account of the solar radiation flux while determining heat gain in buildings. Seasonal and diurnal variation in temperatures results in transient heat transmission through building envelope. Heat transmission property differs quite significantly in phase change materials (PCM) depending on ambient conditions and moisture content in the material. PCM is one of the latent heat materials having low temperature range and high energy density of melting-solidification compared to sensible heat storage. As the phase change process is roughly isothermal, with a minimal temperature change, the heat absorbed or released can work to buffer the temperature of the PCM's immediate environment towards this phase change applications. This behaviour of PCM depends on change in its structure, configuration under varying ambient conditions.

Japeva Engineering Pvt. Ltd, is located in Chennai. They have developed a roofing tile using phase change material (PCM) that controls heat ingress in buildings located in tropical climates of India. The PCM in the form of encapsulated bio wax interacts with the ambient conditions both temperature as well as humidity and results in the cooling the surface below the tiles.

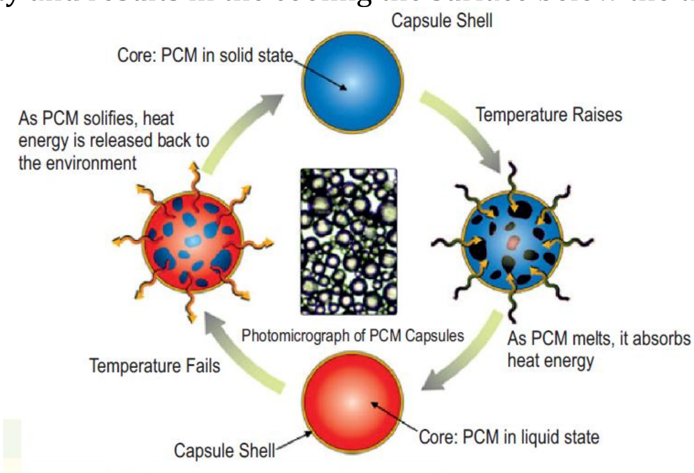

Figure 1 Thermal behavior of Phase change (Image Courtesy: Japeva Engg. Pvt Ltd)

In this context, the hypothesis established for the study is that varying heat transmission property of PCM roofing material would reduce the total heat flux, help to maintain more or less constant ceiling surface temperature in building and reduce the peak cooling load. The report presents on site experimental study to evaluate and validate the materials thermal performance. The material's influence on the overall energy consumption of an air conditioned building has been compared with the one with conventional roofing in Chennai.

Methodology

Field monitoring was carried out in two public buildings in Chennai namely Vivekananda cultural centre located on Marina Beach and Chennai corporation building, Annexure to Rippon Building located at Parrys. The city's climate is hot and humid with mean monthly maximum daily temperature above 35 especially during April to July and average relative humidity is about 70% most part of the year. The sky is sunny and clear for about 6 months (Oct-May) and the mean diurnal temperature is below 10deg C. The monitoring of Insulla tile on RCC roof along with Conventional RCC roof is carried out between 6th Aug 2014 and 7th Aug 2014. Details of the roof assemblies tested are shown in the Figure 2.

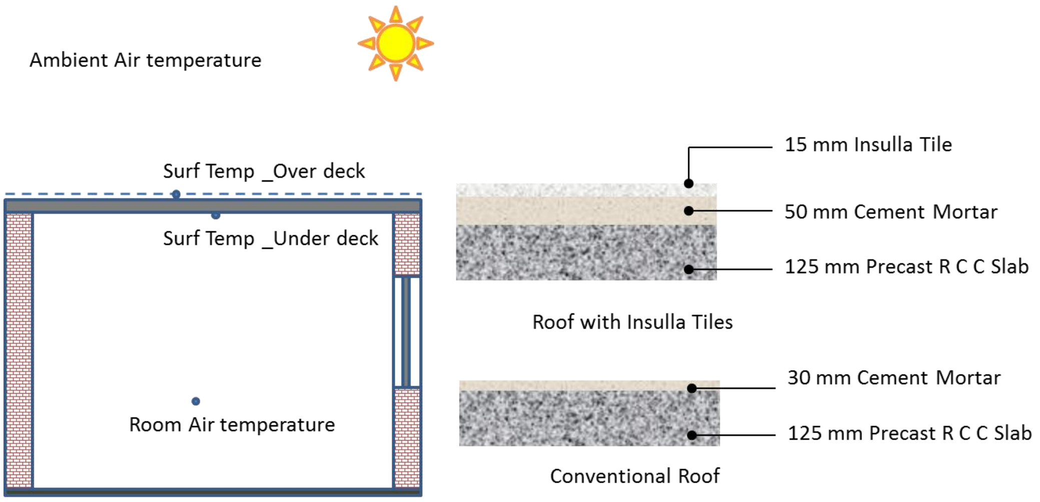

Figure 2. Details of sensors instated on site and the roof sections monitored

Air temperature and relative humidity were monitored inside the three assemblies as well as outside using thermohygro data loggers. Surface temperatures both over the deck and under the deck were monitored at half an hour interval for all the three assemblies. K- Type thermo couples in surface probes were fixed with insulated tapes over these roof sections. Details of the instruments used for the monitoring are mentioned in Figure 2 & Table 1. These parameters were further analysed to calculate various indicators and compare the performance of the roof sections.

Table 1: Details of Instrument used for the experimental monitoring			
	Instrument	Parameters monitored	Accuracy
1	  Leaf type surface temperature probes (K- Type) connected to 4 channel data logging thermometer (Extech make)	Surface Temperature	±1°C
2	 Laser Gun (Raytek make)	Surface temperature	±1°C
3	 Thermohygro Datalogger (Dickson make)	Air temperature & Relative Humidity	±0.5°C

Experimental Results

The parameters logged during the monitored were analysed in detail. Heat flux was calculated using the surface temperatures and the overall heat transfer coefficient of the tested roofs. Thermal performance of the roofs was evaluated using different indices developed by the Indian Standards. Figure 3 shows the images of the buildings and the instruments fixed at Vivekananda Cultural Centre. Surface temperature of the envelope becomes an important indicator while studying indoor conditions in the context of thermal comfort and energy conservation. Thermal comfort is a key criterion while designing low energy buildings in tropical climates. It is good to evaluate building envelope with respect to the comfort conditions possible with the same.

Figure 3 a) Overdeck of Insulla tiled roof; b) Overdeck of conventional roof; c) Underdeck of Insulla tiled roof; d) Datalogger connected to temperature sensors

Figure 4 depicts the surface temperature profile observed during the monitoring.

Although it was little cloudy, the overdeck surface temperature of the conventional roof reached almost 40°C. The peak ceiling temperature of the insula tiled roof was 33°C. A difference upto 3 degC between inner surface temperature and indoor comfort temperature is usually accepted to tackle the discomfort (Gulten Manioglu and Zerrin Yilmaz, 2008). The adaptive comfort range derived as per ASHRAE 55 2010 for the month of August in Chennai is 24 to 31°C when relative humidity is controlled up to 60%. Thus it is also understood that the indoor comfort could be maintained in naturally ventilated buildings with Insulla tiles covered on the roofs.

The maximum difference observed for under deck temperature between both the roofs is about 4.6 deg C while the maximum difference in overdeck surface temperature is 2.9 degC; However, the maximum difference in overdeck surface temperature observed in earlier studies by Japeva is upto 15degC. The total heat heat flux though roof with Insulla tile is almost 50% lower than the heat heat flux through conventional roof.

It is very essential to keep the temperature changes of interior spaces at a low level to minimise the total heat load and improve the thermal comfort conditions inside the building. The fluctuations in the under deck surface temperature during the day with conventional roof is as high as 10 degC whereas it is only 3 to 4 degC with Insulla tiled roof.

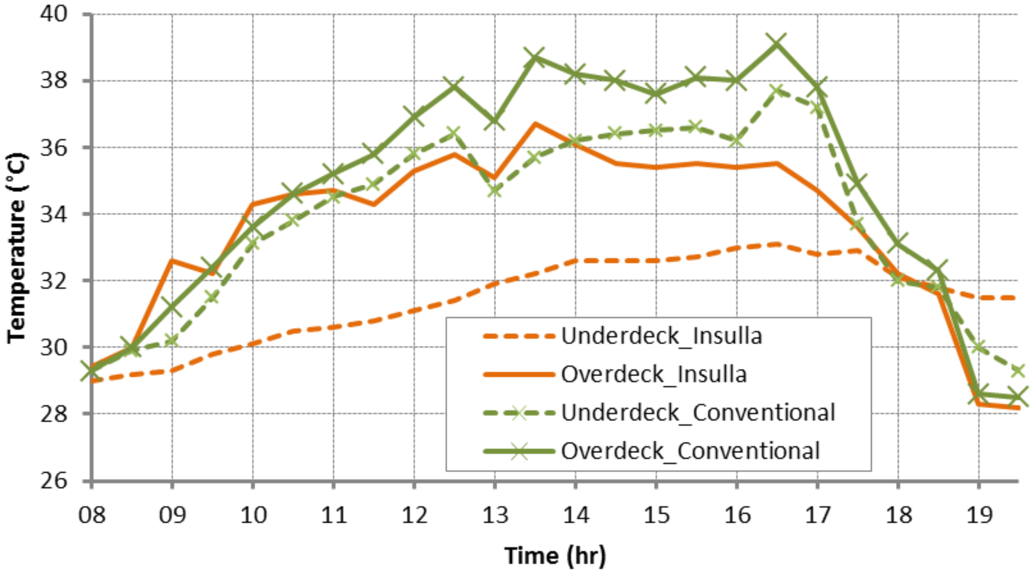

Figure 4. Surface temperatures observed during experimental monitoring

Thermal Performance Index (TPI) as defined in IS 3792-1978 is an indicator which depends on the total heat gain through the building section both by steady state and periodic flow. This indicator is evolved on a comparative basis and holds good for variations in sol-air temperature that occurs often in Indian climates. The TPI calculated for Insulla tiled roof is 38.75 and for the conventional roof is 96.25. The recommended value for the good performing roof is less than 75.

Assessing the thermal performance by comparing the peak degree hour is a common practice, but this alone does not provide a comparison of the overall performance of the roofing materials. Hence, the integrated effect of duration and intensity of peak temperature form a rational basis while comparing thermal performance of two materials. In this calculation the peak temperature above 30°C at each hour is added together leading to Integrate Degree Hours (IDH). The IDH for Insulla tiled roof is 21.15 whereas for the conventional roof is 49.3. Figure 5 presents the comparision between the two thermal performance indices defined as per Indian Standards.

Thus Insulla tile would benefit the buildings by reducing air conditioning load in conditioned buildings and by improving thermal comfort in unconditioned buildings

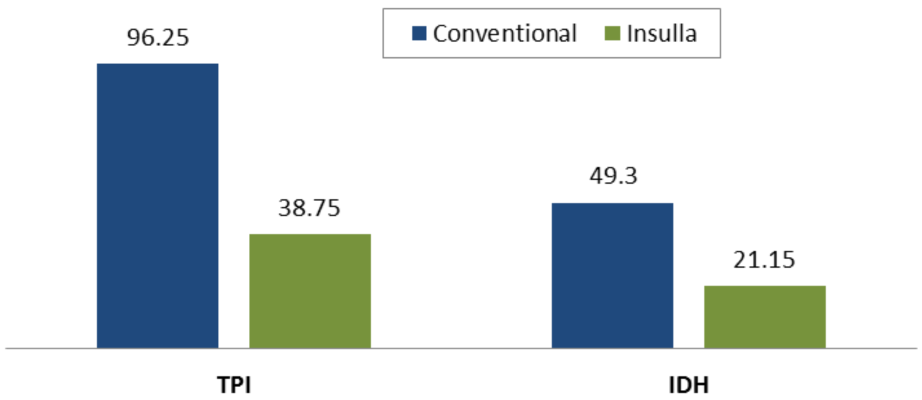

Figure 5 Thermal Performance Indices for the Insulla tiled roof in comparision with conventional roof

Simulation Studies

Software simulations were carried out to observe cooling load patterns for a typical buildings in Chennai climate using VisDOE energy simulation tool. Table2 provides the input data considered for developing two sample building models for the analysis. The overall U- value of the roof assemblies were calculated from the layer wise properties taken from the standard data base and the manufacturer catalogues where certified lab tested properties were mentioned. This exercise was carried out for both residential as wells commercial office buildings.

Table 2: Input data of the software models used for the comparative study

	Standard Roof		**Roof with Insulla tiles**	
Room area	100 m2		Zone Area	
Height (floor to floor)	3m		3m	
External wall	Standard brick wall (U value = 2.33)		Standard brick wall (U value = 2.33)	
Roof section (outside to inside)	8 mm brick tile + 50 mm mortar + 125 mm RCC (U value = 3.35 W/m2/K)		27 mm insulla tile + 50 mm mortar + 125 mm RCC (U Value = 2.39 W)	
SRI	25		95	
	Office Schedule	Residential schedule	Office Schedule	Residential schedule
Lighting power density	21.5 W /m2	19.35 W /m2	21.5 W /m2	19.35 W /m2
Equipment power density	8.06 W /m2	8.06 W /m2	8.06 W /m2	8.06 W /m2
Occupants	23 m2/person	23 m2/person	23 m2/person	23 m2/person
Occupancy Schedule	Default office schedule	Default residential schedule	Default office schedule	Default residential schedule

It was observed that about 9% reduction in the peak cooling load possible with with Insulla tiled roof with office type of occupancy and about 11% reduction was possible with residential occupancy. Figure 6 presents the reduction in energy consumption with Insulla tiled roof in comparison with a conventional roof.

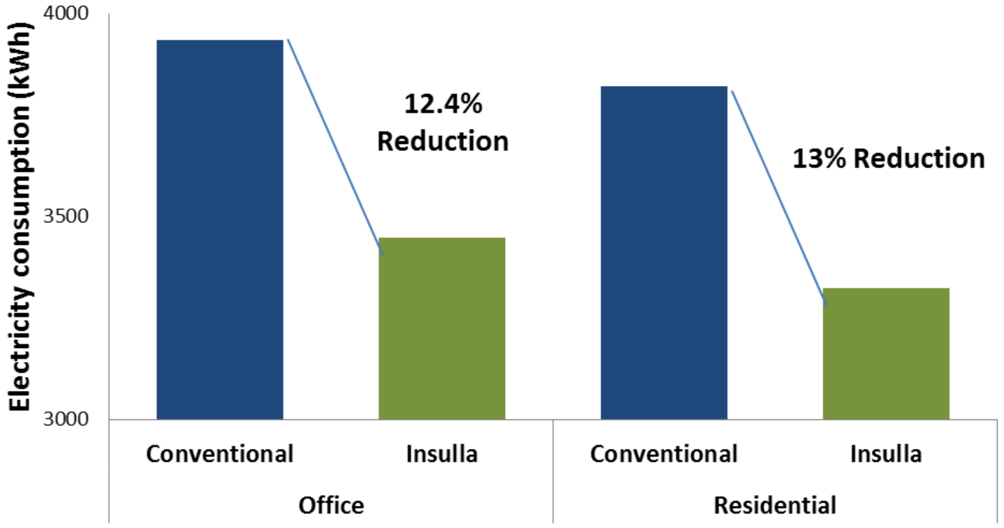

Figure 6. Reduction in energy consumption with Insulla tiled roof in comparison with a conventional roof

Similar observations were made with the data collected from the Chennai Corporation Building (Annexure to Rippon Building)

Conclusions

The peak ceiling temperature of the insula tiled roof was observed to be 33°C. It is therefore understood that indoor thermal comfort could be maintained in naturally ventilated buildings with Insulla tiles covered on the roofs. Insulla tile would benefit the buildings by reducing annual cooling energy consumption by almost 13% in air conditioned office buildings. The TPI calculated for Insulla tiled roof was 38.75 and for the conventional roof was 96.25 whereas the recommended value for the good performing roof should be less than 75. The IDH for Insulla tiled roof was 21.15 whereas for the conventional roof was 49.3. Thus the study concludes that Insulla tile would benefit the buildings by reducing air conditioning load in conditioned buildings and by improving thermal comfort in unconditioned buildings. Authors previous experience of studying reflective roofs indicates that such roofs would improve micro climate by reducing the peak air temperature by 1degC and give a combined benefit of reducing heat Islands and cooling loads in air conditioned buildings.

Sustainable Building Science: Overview

One of the prime areas of activity within the Energy Environment Technology division is adoption of efficient and environment-friendly technologies in new and existing buildings. The activities of this area focus primarily on energy and resource use optimization in existing buildings and design of energy efficient sustainable habitats.

The Centre for Research on Sustainable Building Science (CRSBS) comprising architects , planners, engineers , environmental specialists , specialised in urban and rural planning, low energy architecture and electro-mechanical systems, water and waste management and renewable energy systems has been offering environmental design solutions for habitat and buildings of various complexities and functions for nearly two decades. The group also undertakes LEED facilitation for buildings.

The Green Rating for Integrated Habitat Assessment (GRIHA) cell, also comprising professionals from the above-mentioned fields is actively involved in facilitation of green rating for buildings under the GRIHA framework. Inputs from CRSBS feed into the processes undertaken at GRIHA cell. The different services offered by the Sustainable Building Science (CRSBS and GRIHA) are as follows:

Environmental design consultancy

- Specialised environmental design consultancy and building performance analysis are conducted. A wide range of computations and simulation tools including DOE2, TRNSYS, ECOTECT, RADIANCE, FLOVENT, AGI32, LUMEN DESIGNER, BLAST, Phoenics, RETScreen are used to assess the environmental and cost impact of the design decisions.

LEED and GRIHA facilitation

- The team has experience in technically facilitating LEED accreditation [LEED India for New Construction (LEED India NC) and LEED India for Core and Shell (LEED India CS)] for buildings. The group also assists and administers GRIHA, an indigenous green building rating system for buildings, developed at TERI. GRIHA has now been now endorsed by the Ministry of New and Renewable Energy, Government of India, as the national building rating system for India.

Energy audits and energy management programs

- Energy conservation studies for a large number of buildings are conducted. There exists a vast experience in conducting energy audits and evaluating a whole range of building upgrade options including envelope retrofit and system retrofit or changes in operational patterns. In addition to establishing operating efficiency of electrical, HVAC, lighting and thermal systems, recommendations to improve upon the same by suitable retrofit measures or by refinement of operational practices are also offered. The group also has expertise in development of energy management programs for service industries like hotels and the corporate sector.

Capacity building

- Capacity building for architects, building developers and service engineers on issues such as energy efficiency in building envelopes and systems has been undertaken. Over 1000 architects, developers and engineers in the area of green buildings, energy efficiency and sustainability aspects of built environment have been trained through training programmes, refresher courses, seminars and workshops.

Policy inputs

- Several policy initiatives at central and state governments' level towards mainstreaming high performance buildings in India have been successfully completed. Senior members of the group are members of the Committee of experts for development of the Energy Conservation Building Code (ECBC) of India (2007). The manual for environmental clearance of large construction for the Ministry of Environment and Forests, Government of India has also been developed at CRSBS.

Climate Change related projects

- Climate change is increasingly being recognized as a major global challenge. The group has provided inputs to the National Mission on Sustainable Habitat (a part of the recently released India's National Action Plan on Climate Change). Project Design Documents (PDD) are prepared in order to facilitate trading in carbon through the Clean Development Mechanism (CDM).