The Springer Thermal Behaviour of Roofing Coatings on Dry Period: application in a House in Campinas, Brazil.

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ABSTRACT: This paper analyses the thermal behavior of fiber cement tiles on roofing. The roofing material is widely used on surfaces of houses, residential and commercial buildings and company installations of Brazilian cities. It is a light and not expensive material for this function in a construction and because its usage requires less loads to structure in general. The house is located in Southeast, in São Paulo state, at the city of Campinas. The objective of this paper is the monitoring of the thermal behavior of this roofing in spring season. The roofing was prepared for monitoring and it was divided in three areas. Each area received one kind of coating: two different white paintings and one natural coating of tile. It was used sensors of superficial temperature in each area. They were also monitored solar radiation, air temperature, wind speed and air humidity by the Meteorological Station IAC. It was observed a gradient around 6ºC between one coating tile and natural tile on no-raining days. This result was observed with the highest values of solar radiation for the period. The results allow concluding that the coatings were responsible for the difference on thermal behavior of roofing.
Keywords: roofing coatings, thermal behaviour, passive cooling

INTRODUCTION

Brazilian Technique Norm number 15220 [1] aims the thermal performance evaluation of single familiar houses up to two pavements. It was established in 2005 and was already revised in 2010. Besides it divides methodologically the Brazilian territory in eight homogeneous areas in relation to the climatic characteristics as it brings guidelines for: bioclimatic area; envelope typologies (vertical and horizontal); opening areas and solar protection; and passive techniques for conditioning.

There are only three classifications for the eight bioclimatic areas in relation to horizontal elements: heavy, slightly reflector and slight thermal insulated roofing, in spite of huge dimensions of country.

Campinas is included in bioclimatic zone number 3 [2] with cities as São Paulo, Belo Horizonte and Florianópolis, this last ones is on the South coast. Although some aspects seem do not make sense in this norm it is the unique tool for designers and it is complemented by NBR 15575 [3] which brings constructive guidelines for single homes up to five floors.

The roofing typology indicated for the bioclimatic zone 3 is slight thermal insulated. However several constructions are observed whose roofing is made with fibber cement tiles, almost always without any thermal insulation. This roofing material is widely used on surfaces of houses, residential and commercial buildings and company installations from North to South of Brazil. In general these tiles do not need robust structures for roofing and do not imply extra loads for building structures, in other words, they are slight and not expensive material for roofing.

The worst situation of this kind of roofing is observed in some commercial installations but since its distance from bottom to top is the double of normal ceiling height it contributes to minimize the thermal discomfort. However there are areas where the distance from bottom to top is around 2.30m in some humble houses in Campinas periphery. This distance is higher, around 2.60m when there is a concrete slab layer under the tiles (Figure 1).

In both cases the thermal discomfort is a reality. When they present concrete slab, this just increases the thermal delay to indoor conditions. These houses are always small, without generous distances from them to next neighbours and they have few openings for ventilation.

Figure 1: Usual view of Campinas periphery area: constructions with fibber cement roofing and unfinished walls.

Studies realized in test cells with fibber cement roofing showed that it is possible to get mitigation using this kind of tile under tropical climate conditions [4].

Several passive cooling studies have been conducted recently in an effort to reduce heat transfer through building roofs. In arid regions, where water or green roofing is not available or easy to do maintenance, passive cooling strategies such as white painting or thermal insulation have shown substantial potential [5-8]. These studies vary from white painting roof to the use of thermal insulation underneath or above roofs.

The potential benefits of the use of cooling roofs (high solar reflectance and high infrared emissivity) has been assessed by the direct and indirect effects on cooled buildings' energy demand and power peaks as studied by Akbari et al. [9] and others.

However besides weather conditions, this technique depends on building conditions too: its morphology, its thermal insulation, its ventilation system [10]. Simulations of thermal behaviour on summer and winter are necessary to analyse the potential of cooling roofing and energy saving for some climates.

In this study as well as in [11] the premise is implementation of passive cooling system with best thermal performance and low costs. Some cost for maintenance should be considered however the amount of energy saved without the use of air conditioned should be considerably enough to justify these costs.

METHODS

Campinas is located in Southeast region of Brazil at South latitude 22º48', West longitude 47º03' and it is 640m above sea level. The climate is considered subtropical with moderate temperatures in cold period. The cold period has low temperatures in the night but the temperatures are high, the sun shines usually every day and there are few clouds in the sky during the day.

The warm period is divided in the dry one, from September until December, and the humid one, from January until March. That division of warm period coincides with the spring and the summer period respectively.

The experiment was carried out on a house roofing which is inserted in suburbs consolidated over 30 years in the context of Campinas. In this popular neighbourhood most constructions have passed by reform to expansion or to addition of rooms. From this original design the house has 2 more rooms behind the monitored roofing. The monitored roofing is in the frontal part of the house with garage and balcony facing west. It measures 11m x 4,5m (Figure 2).

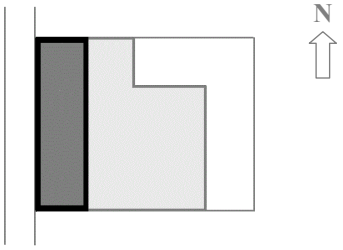

Figure 2: Localization of roofing area in house. Dark gray area is the monitored roofing; Light gray area is house.

The medium age of the tiles is around 30 years. The tiles contained dirt and limbo accumulated, they were washed and cleaned for installation of cooling system. The roofing was divided in 3 parts for different kinds of coatings: white impermeable painting on area number I, white acrylic painting on area number II and natural tile colour on area number III (Figure 3). It was fixed a surface temperature sensor in each part. A sensor NTC of surface temperature that measures from -25ºC to 70ºC was fixed on inferior surface of roofing and over it was fixed a layer of expanded polystyrene to protect it of outdoor temperatures. The sensors were connected to portable and individual mini data loggers and its precision is +/- 0.3ºC.

Figure 3: Monitored roofing areas: I received the white impermeable painting; II received the white acrylic painting and III, the natural tile colour.

The passive technique through reflective cooling was monitored on spring season, corresponding to a drier period, because it had most of the higher temperatures of air during the day than summer season. And the summer period usually has long rainy and cloudy period which interferes on measure of passive technique. There is not any element to shading the roofing.

RESULTS AND DISCUSSION

Solar radiation (SR), relative humidity (RH), Wind speed (WS) and air temperature (Air T) were collected by meteorological station, from Agronomic Institute of Campinas (IAC), for analysing together surface temperatures: impermeable white painting on tile (Imp T); acrylic white painting on tile (Acry T) and natural tile (Nat T) in dry period.

The roofing was monitored during the spring season and the data present correspond to 3 consecutive days monitored in October, 2010. It was not done corrections of values of solar radiation on roofing surface because it was made by fibber cement and it requires minimal inclination of horizontal surface (3%). Figure 4 shows the thermal behaviour of tile coatings and solar radiation for period.

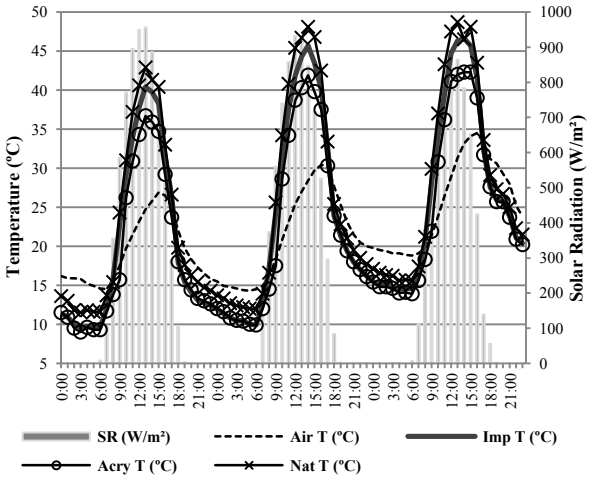

Figure 4: Reflective cooling on roofing and solar radiation on 3 consecutive days on dryer period.

It can be observed that the curves for the tiles show maximum values almost at the same time with the maximum values of solar radiation and before the outdoor air temperature (Figure 4). This behaviour can be explained by the high thermal transmittance of the tile material, which is the external coating.

The surface temperature for natural tile reached top values of 42.9ºC, for impermeable white painting 40.4ºC and for acrylic white painting, 36.7ºC on the first day of monitoring. At the moments before and after the peak temperature it was not registered air movement (Figure 5). It rained a little at night before the first day. The water absorbed by the tile surface was responsible for the attenuation of tile temperature curves.

The data for the following two days were similar for solar radiation and relative humidity of air (Figures 4 and 6). The maximum temperature values for the tiles were respectively 48.1ºC and 48.7ºC with natural coating; 45.7ºC and 46.6ºC with impermeable white painting; and 41.9ºC and 42.3ºC with acrylic white painting.

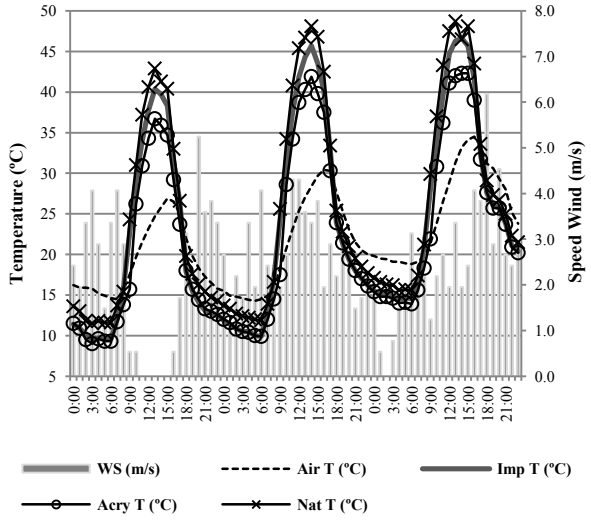

Figure 5: Reflective cooling on roofing and wind speed during 3 consecutive days on dryer period.

The average relative humidity of air was 55% for this period and the minimum values were around 30% for the three days as showed Figure 6. As expected the thermal behaviour of the relative humidity of air is opposite to the air temperature for this season. The biggest the length of the straight line connecting the two extreme points of each curve the greater is the thermal discomfort in human beings as showed the annotation "a" on Figure 6.

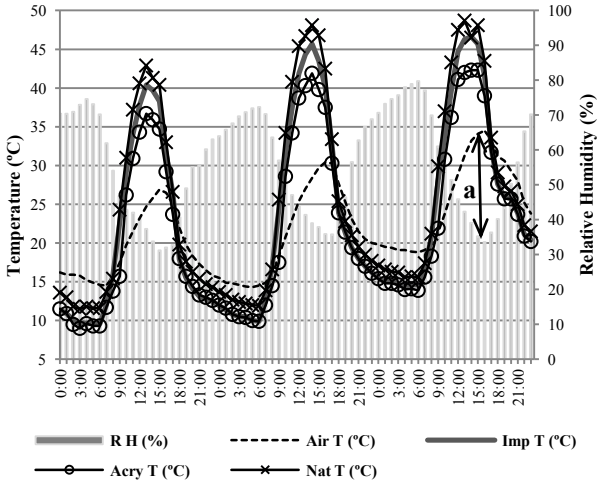

Figure 6: Reflective cooling on roofing and relative humidity air during 3 consecutive days on dryer period.

The extreme point for temperature is slightly above 30ºC and the extreme point for relative humidity of air is slightly less 30%, but other meteorological parameters should be considered too for the analyses of outdoor environment so theses values can be modified.

In Springer period the air temperature is high during the day mainly because the direct solar radiation is available with few clouds. The outdoor temperatures attain the highest temperatures when there is such a prolonged exposure of the constructive elements used.

Clear sky also favours the lost of a large amount of heat to space during nights. So the air temperatures are lower than at nights in wet period (in this case summer period) when clouds work as thermal blanket.

In this dry period the thermal amplitude is high, around 15ºC, this favours use the natural ventilation for night cooling. If the air temperature gets around 35ºC during the day, it is possible to make use of passive cooling at night. The fresh air, around 15ºC-20ºC, gets into the buildings by generous openings and removes the anthropogenic heat in insulated building. And it is also favourable for easier cooling of constructive elements after sunset.

CONCLUSION

The authors have monitored and published results of passive techniques on roofing in Campinas since 2005. It was monitored since there much different kind of composition and coatings as well as different periods of year. And in this case, it was observed that the solar radiation on the three days was nearly constant and the difference between the surface temperatures in acrylic white painting and the natural tile was 6.2ºC on first day; 6.2ºC on second and 6.4ºC on last day in spite that the temperature curves presented different values on three days.

The colour should not be the unique parameter to be analyzed for the choice of the kind of construction element. Distinct values of reflective solar coefficient and chemical components should make difference in thermal behaviour of tiles with white painting. The thermal behaviour of both white coatings have presented differences that may be explained through chemical composition: one is ordinary acrylic painting and other is made of elastic emulsion.

The relative humidity of air also was nearly constant in the three days. Only the wind speed was variable on this period. The surface temperature curves of second and third days were much closed when measured meteorological variables have presented regular distribution during those days. However on first day the surface temperature curves have presented fewer values even when the solar radiation has presented values

similar to other days. This fact makes to think that the speed wind may be responsible for those results however it is necessary more studies and any affirmation about this should be done carefully.

The global solar radiation should not be the unique weather parameter to be analyzed on thermal behaviour of construction materials. However in this case the solar radiation and the relative humidity of air were important for these data.

This house roofing influences mainly the thermal comfort of users of the two rooms besides the roofing. It was also perceptive the temperature attenuation for either one staying under the roofing.

It is important to care for the maintenance of roofing as well as cleaning or re-painting so to keep the best results. Particularities of some areas could influence on time of exposure of coatings for example suspension particles of pollution, dust or chemical product.

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