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Analysis of the influence of roof tile color on room thermal performance

Análise da influência da cor da telha no desempenho térmico do ambiente

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ABSTRACT

Studies prove that colors directly influence the thermal behavior of surfaces, a factor that should always be considered in any area, especially in civil construction. Based on these factors, this project is inserted in the context of thermal energies and its main objective is to evaluate the interference of colors in the thermal performance of the environments. For this, four prototypes of houses were built and covered with fiber-cement tiles with different colors (white, brown, red and black). In each prototype was placed a glass with water that was used to submerge the infrared thermometer to measure the temperatures, twice a day, for four days. Data were collected, validated and organized in tables and graphs. After analyzing the data, it was noticed that the environment covered by black tile presented higher temperatures on all days of measurement during all times, followed by brown, red and white colors, converging with the literatures studied. In the end, it can be concluded that the color of the roof has a great influence on the temperature of the internal environment and must be observed at the time of an architectural project.

Keywords: Thermal performance, Asbestos cement tiles, Temperature.

1 INTRODUCTION

Color schemes can give substrates important and very useful properties. In architecture, color influences, above all, the thermal behavior of environments. This is because color directly influences the change in temperature of surfaces in general. Heat exchange between surfaces

occurs through three physical mechanisms: conduction, convection, and radiation. Among these, radiation stands out in the process mentioned above. It is defined as the process of heat transfer in which the energy of the radiation field is transported by electromagnetic waves and does not require a medium to occur (INCROPERA, 2008).

It is noticeable that darker colors tend to heat the surface or medium more, while lighter ones provide lower temperatures. This can be explained through knowledge of the coefficients of absorptivity and emissivity. Absorptivity refers to the fraction of irradiation that is absorbed by a surface. While emissivity is the property of the material related to the ability to emit energy by radiation on the surface. In particular, the black color absorbs about 95 % of the incident solar radiation while the white, of the order of 18 % (KREITH, 1973). Solar radiation is the first and main natural phenomenon that directly interferes with the external surface of roofs. In this sense, the treatment of the surface, as well as the selection of the material influence the thermal behavior of the buildings.

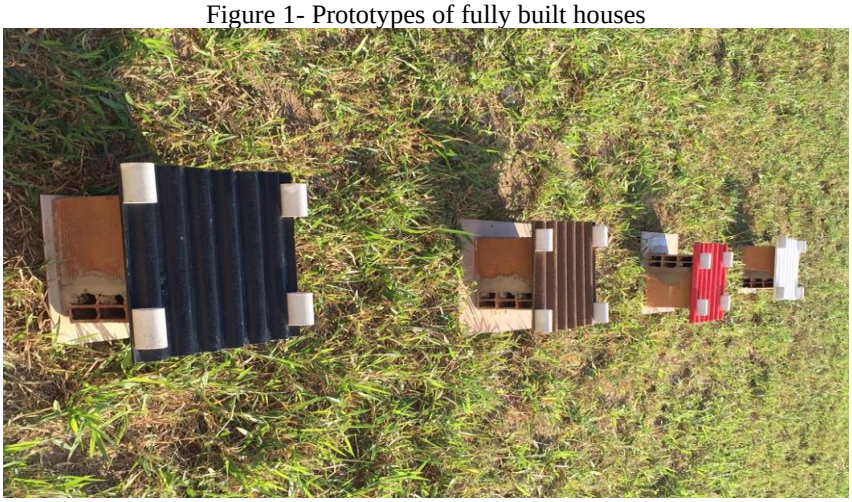
In this work is used samples of roofs painted in different colors. Through daily mediation, made with a thermometer, in each environment their respective temperatures were measured.

In this context, the general objective of this work was to analyze how much the influence of colors on roofs affects the thermal performance of the environment. This was accomplished through daily measurements at different times in the city of Cruz das Almas-BA.

2 MATERIALS AND METHODS

Initially, four prototypes of houses were built, where four ceramic blocks (19x11.5x19 cm) were used per prototype. The blocks were laid on a ceramic plate with laying mortar, and joined together with the same mortar. Soon after for the upper sealing was used fiber-cement tiles of the brand Eternit, which to suit the prototype were cut in equal dimensions of 50 x 50 cm. Then the paintings of the tiles were made with acrylic paint in white, brown, black and red. Four weights of mortar were placed on the tile to prevent the wind from removing the roof. Figure 1 shows the prototypes fully built and with the roofs properly painted in different colors.

Figure 1- Prototypes of fully built houses



Source - Authors (2016).

The prototypes were positioned in an open area, so that they were exposed to weather conditions, without interference of shadows and with geographical positioning that does not allow difference in the temperature conditions that affect each one. Inside each prototype was inserted a container with 150 ml of drinking water to submerge the thermometer. .

Then, the temperature of the water in the container inside the prototype was measured with a digital infrared thermometer with laser sight, twice a day, at the times and 10:00 and 16:00 hours, during a period of four days. With the values obtained it is possible to analyze the influence of the different colors of the roofs on the internal temperature of each prototype.

Results and Discussion

After the data collected and analyzed, it was noted that the prototype in which the white tile was presented the lowest temperatures on all days and times measured, on the other hand the one with the black color, presented the highest temperatures, converging with the literatures studied. Table 1 shows the data obtained after the collections.

Table 1: Data obtained after data collection

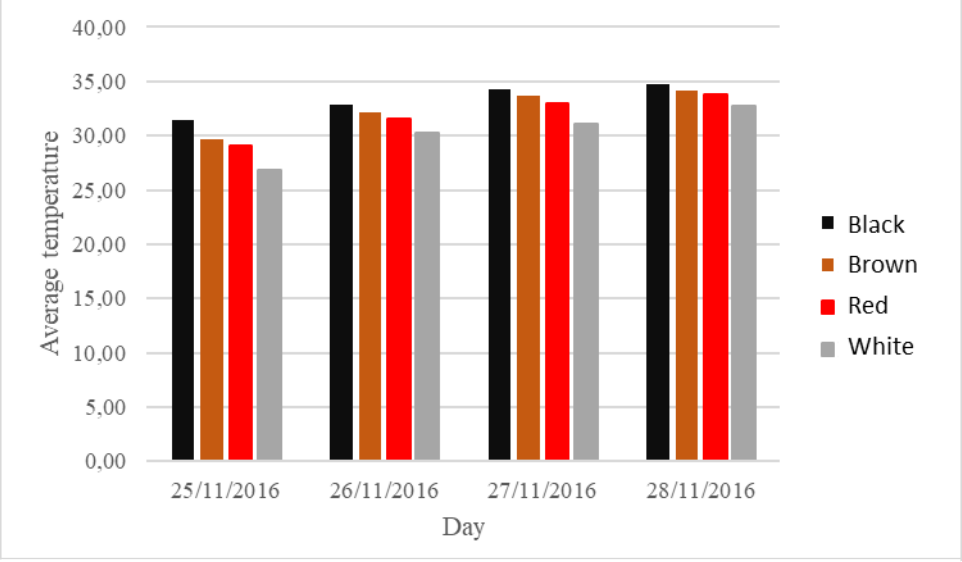
	Temperature (°C) 25/11/2016		**Average Temperature**
Roof	10:00	16:00	
Black	29,50	33,30	31,40
Brown	28,90	30,50	29,70
Red	28,20	30,00	29,10
White	26,70	27,00	26,85
	Temperature (°C) 26/11/2016		**Average Temperature**
Roof	10:00	16:00	
Black	32,40	33,20	32,80
Brown	31,90	32,40	32,15
Red	31,50	31,70	31,60
White	30,10	30,50	30,30

	Temperature (°C) 27/11/2016		Average Temperature
Roof	10:00	16:00	
Black	33,60	35,00	34,30
Brown	33,00	34,40	33,70
Red	32,30	33,60	32,95
White	29,80	32,40	31,10
	Temperature (°C) 28/11/2016		**Average Temperature**
Roof	10:00	16:00	
Black	33,80	35,60	34,70
Brown	33,30	34,90	34,10
Red	33,20	34,50	33,85
White	31,30	34,10	32,70

Source - Authors (2016)

From Table 1 we can observe that the black color obtained the highest mean temperature values inside the prototype, followed by the colors brown, red and white respectively. In addition, the temperatures measured at the time of ten hours are lower than those at the time of sixteen hours, this is because the amount of heat absorbed by the water increases with the greater time of solar incidence received and with the increase in temperature. With the data in Table 1, a graph of the average temperature per day of measurement of each roof color was obtained. Figure 2 shows the comparison of the average temperatures of each roof color by the day of measurement day.

Figure 2- Comparative data of the average temperature of each roof by the day of measurement.



Source - Authors (2016)

The graph in Figure 2 reinforces the comment made above about the predominance of the highest values of black color temperature in relation to the others. In addition, it is possible to notice that the temperatures are directly proportional to the frequency that each color emits, that is, the greater the frequency range of the color, the higher temperatures.

Table 2 was created using the R Software, which lists minimum, maximum, median and mean data.

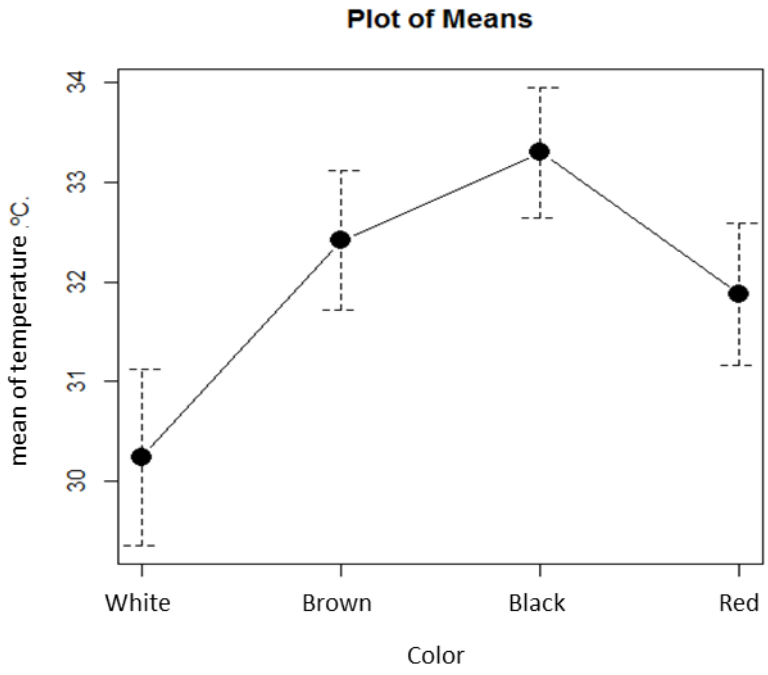
Table 2: Minimum, maximum, median and mean data.

Colour	Black	Brown	Red	White
Min.	29.5	28.90	28.20	26.70
Median	32.70	33.45	32.00	30.30
Average	33.30	32.41	31.87	30.24
Max.	35.60	34.90	34.50	34.20

Source - Authors (2016).

From Table 2 it is possible to verify that the minimum and maximum values observed were increasingly white, red, brown and black. It also shows the median and mean values. evidencing what is in the theory, that the white color presents the lowest temperatures, soon after the red, brown and black, due mainly to coefficients such as emissivity and wavelength. From these data, the graph in Figure 3 was generated.

Figure 3- Graph of the colors with their respective average temperatures.



Source: -Authors (2016)

This graph brings the averages of all temperatures obtained in the experiment for each roof color, that is, it makes a general approach for all temperatures collected during the 4 days, at 2 different times for each color. The graph shows the maximum and minimum temperature (represented by the upper and lower strokes) of each roof color during the entire data collection and averages between them (represented by the point). Considering all the days of data

collection, it can be inferred that the internal temperature of the prototypes increased in the following order: white, red, brown and black.

3 CONCLUSION

The results showed that in all four days of temperature measurement and both times of 10:00 and 16:00 hours, the prototype that had white tile presented lower temperature inside followed by red and brown colors, with black presenting higher temperature value.

As expected, the performance of each roof occurred according to the absorptivity and emissivity of each color, concepts that were explained earlier and that indicate that the black color, because it has greater emissivity, also has greater absorptivity. Thus, by absorbing more energy the black color provides a warmer internal environment.

Thus, having that the analysis of the energy consumption of a building is of extreme importance, through the results it can be concluded that the color of the roof has a great influence on the temperature of the internal environment, and that a light color roof, such as the white roof used, provides lower temperature in the internal environment than a darker color. These results are very relevant because according to the solar incidence, the tropical or temperate climate, it may be more convenient to use light or dark colors, improving thermal comfort and reducing energy consumption

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