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ANALYSIS OF ROOF THERMAL PERFORMANCE WITH INNOVATIVE TECHNOLOGY

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ABSTRACT

The roof is the surface most exposed to solar radiation in a home; therefore, evaluating the thermal performance of different roofing technologies can significantly improve the building's thermo-energetic behavior. This work presents an experimental study that analyzes the thermal behavior of a single-family home that modifies the roof surface properties. Comparison of the thermal performance of the house is made under two roof solutions: (i) base case presents an albedo of 0.49 and thermal emissivity of 0.25; (ii) optimized case presents a cladding with smart technology that incorporates bituminous gas microspheres to its composition in addition to being a material with cool characteristics, the albedo of 0.85 and thermal emissivity of 0.90. During the evaluated summer period, the optimized roof solution shows a more efficient thermal performance than the base roof. Optimized roof achieves drops of up to 18°C in the outdoor surface temperature and up to 5°C in the indoor surface temperature, while the indoor air temperature goes down to 3°C.

Keywords: Building performance; Cool roof; Surface temperature; Indoor air temperature.

INTRODUCTION

In the21st century, environmental and energy problems became more evident, which led to a greater interest in the international academy in investigating the scope, limitations, and potential of different construction materials as a measure of adaptation and mitigation of cities to the growing global warming [1].

It is known that buildings consume a large amount of energy throughout their useful life, from the manufacture of raw materials to their demolition. However, the use and maintenance (or operational) stage is the one with the greatest energy impact. In a building with a useful life of 50 years and an annual energy consumption of 50 kWh / year, operational consumption represents 83% of the total energy consumed by the building during its entire useful life. In response to this, the construction materials industry is directing its technological efforts to the development of smart materials through the incorporation of nanotechnology to increase their thermal and optical characteristics.

The application of cool materials - high albedo (â) and high thermal emissivity (ε) -on surfaces of roofs, walls, streets are at the forefront of building energy-saving techniques [2] and urban cooling [3]. Numerous theoretical models and field studies have quantified the benefits of such measures, including emission reductions and improvements in air quality and mitigation of the urban heat island effect [4].

The roof is the surface most exposed to solar radiation in a home, therefore evaluating the thermal performance of different roofing technologies can significantly improve the building's thermo-energetic behaviour [5,6]. This research presents an experimental study that analyzes the thermal behavior of a single-family home that modifies the surface properties (â and ε) of its roof. Comparison of the thermal performance of the house is made under two roof solutions: base and optimized (Figure 1)

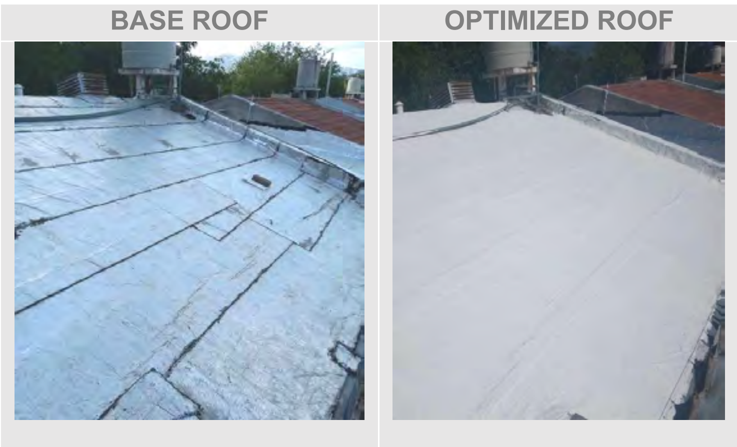

Figure 1. Base roof with aluminum membrane and optimized with smart cladding.

EXPERIMENTAL STUDY

The sample unit studied corresponds to a type of social housing, with a compact and attached floor plan and with an east-west orientation, located in the city of Mendoza, Argentina (lat 32°54' 55"S, lon 68° 52' 19 "W). Base roof is made of a 3 mm aluminum membrane; 10 mm lightened mortar; 50 mm expanded polystyrene; pinewood boards ¾" (U-value = 0.55 W/m^{2}K), the wall is uninsulated brick (U-value= 2.08 W/m^{2}K). Base roof presents an â=0.49 and ε= 0.25. The optimized roof presents a cladding with smart technology that incorporates bituminous gas microspheres to its composition in addition to being a material with cool characteristics (â =0.85 and ε= 0.90).

The thermal monitoring of the house was carried out from January 1 to 30, 2021. The environmental characteristics of the measurement days were recorded with a mobile meteorological station type ONSET Weather HOBO®, model H21 -001. Three points of the house were monitored: (i) outdoor surface temperature of the roof (Tso), with a data logger type Onset HOBO® UX120; (ii) roof indoor surface temperature (T_{si}), with LASCAR® EL-USB-TC type data loggers; and (iii) indoor air temperature (T_{ai}), with data logger type Onset HOBO® H08-003-02. Table 1 describes the thermal ranges monitored during the test.

Table 1. Thermal behavior of houses with base roof (left) and optimized (right). Indoor air temperature (T_{ai}), indoor surface temperature (T_{si}) and outdoor (T_{so}).

Statistics	Base Roof			Optimized Roof		
	T_{ai} (°C)	T_{so} (°C)	T_{si} (°C)	T_{ai} (°C)	T_{so} (°C)	T_{si} (°C)
Mean	29.9	34.1	31.1	28.1	25.4	27.5
Max	33	57.5	37	30.1	39.3	32
Min	26.2	17.5	25	25.7	12.6	22.5

CONCLUSIONS

During the tested summer period, the optimized roof solution shows a more efficient thermal performance than the base roof. The innovative cladding achieves drops of up to 18°C in the T_{so} and up to 5°C in the T_{si} of the inner wood ceiling. The T_{ai} drops to 3°C, this indoor reduction could improve the comfort conditions of homes without additional conditioning, or optimize the efficiency of air conditioning equipment, causing large savings in energy consumption for refrigeration. In future work, it is planned to develop a theoretical model through software building energy simulation to calculate the annual balance of the application of this technology, considering the benefits in summer and the penalties in winter.

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