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Energy Saving Potential with a Double-Skin Roof Ventilated by Natural Convection in Djibouti

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Abstract

In the Sub-Saharan African countries like Djibouti, the energy situation, the high rate of urban areas growth and the inadequate techniques of construction offer an exciting potential for the bioclimatic approach and sustainable construction. However, this poorly explored potential requires an investigation of different construction types in Djibouti and a good knowledge of the behavior of buildings components. Further a low energy building can be obtained because of the good realization of all its components. In fact, roofs call for attention as they represent a large part of a building's total surface area and amount of absorbed solar radiation. The goal of this paper is to investigate the benefit of using double skin-ventilated roofs for reducing cooling load under the Djiboutian climate. It is a first step towards ideas that will transform local construction practices to make them effective in energy, economic and functional dimensions. During investigation, we compared a ventilated roof assembly with traditional configuration after that the consistency of our model was validated with experiment of the literature findings. The computational fluid dynamics (CFD) model has been used for the characterization of the airflow and heat transfer phenomena in the ventilation cavity and provide fundamental information about the thermal performance of the roof. The results show the amount of the energy saving obtainable by the double-skin ventilated roof.

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Keywords: Natural convection; double-skin roof; Energy saving; CFD

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1. INTRODUCTION

Demands of economic growth and improvements in living standards people led to higher levels of energy consumption. To speed up economic activities' development with less energy, efforts must focus on energy buildings efficiency, particularly, in country like Djibouti with important level of solar radiation. The axes of research stretch from envelope to diverse types of mechanical equipment and the bioclimatic conception of the building. The ventilated roof is one of the construction method used to reduce envelope gains of building by creating an air gap over the conventional roof. By the shading effect and the free ventilation in the air gap, this structure reduces the heat flux into the building. The study aims to examine the potential benefits of a ventilated roof under the Djiboutian climate

Nomenclature

Es	Energy saving rate
Cp	Specific heat at constant pressure J/(kg.K)
g	Gravity acceleration constant m/s²
d	roof width m
I	solar radiation W/m²
hc	convective heat transfer coefficient between outdoor air and screen W/(m². K)
heq	convective heat transfer coefficient including the effects of radiation and convection upon the screen W/(m². K)
hi	convective heat transfer coefficient between indoor air and ceiling W/(m².K)
T	temperature K
Ta	outdoor air temperature K
Ti	indoor air temperature K
Tsky	sky temperature K
v	air velocity field m/s
P	pressure Pa
t	Time [s]
y	y-axis perpendicular to the sreen
Greek symbols	
β	Gas expansion coefficient K-1
λ	Thermal Conductivity W/m·K
ε	surface emissivity
μ	dynamic viscosity Pa.s
ρ	density kg/m3
θ	roof slope °
σ	Stefan–Boltzmann constant: σ = 5.67E-8 W/(m2. K4)
Subscripts	
us	Characteristic at the screen external surface
ls	Characteristic at the sheet metal surface
Superscripts	
e	external surface
i	internal surface