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Effect of the occupant and the inside faces coating of a multi-alveolar structure on the unsteady thermal behavior of a bi-zone building

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Abstract

The aim of this work is to study the unsteady thermal behavior of a bi-zone building exposed to sunshine under clear sky conditions. The walls in South and West frontages are equipped with a multi-alveolar structure with a variable insulation depending on the heat flow direction. The structure has blades which are inclined relative to the horizontal direction. The results show the effects of the optical properties of the inner surfaces of the alveolar structure, the position of the alveolar structure with regard to the stone layer and the occupant on the unsteady thermal behavior of the bi-zone building.

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Keywords: Solar energy; bi-zone; occupant; building; alveolar structure; thermal inertia.

1. Introduction

The control of the energetic consumption of buildings is a major priority. This control requires knowledge on the energy performance of the envelope of buildings and the knowledge of the effect of different parameters that permit to save energy. Many previous works concerning the study of the thermal behavior of mono-zone or multi-zone

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buildings have been carried out in recent decades. Many researchers are interested in thermal behavior of the alveolar structure. Among them are those who are involved in studying rectangular cavities. Their faces are tilted or not active against the gravity field, others are rather interested in inclined cavities. Taking into account the aero-thermal phenomena in the alveolar structure, D. Gutierrez [1] determined, temperature and speed fields in the alveolar according to different angles of inclination and report shape. Seki and al [2] experimentally studied the heat transfer by natural convection in a cavity of size (H=72mm, L=50mm) performed with fluid of Prandtl number (air, distilled water, refined oil). The angle of inclination takes the values:0, ± 0,25, ± 45, ± 60 and ±70 degree. The high and low passive walls (lamellas) are constituted by an insulating material. Chochung and Trefethen [3] showed the influence of the thermal boundary conditions in cavities on transfer by examining numerically various conductance between superimposed cavities.

Bairi [4] experimentally studied the natural convection in the closed alveolar structure when the active walls remain vertical. He brought out correlations of type Nusselt number according to the Grashof number for different obtained configuration by varying the angle of inclination, the report of shape and the temperature difference ΔT between both warm and cold vertical walls. He also showed the influence of the thermal boundary conditions at the level of the passive walls (lamellas) on the convective transfer. Several studies considered the unoccupied building, but others have taken into account the presence of the occupant as an internal load. The calculations become much more complicated because the building has obviously a direct influence on the subject and, in return, it is involved in the heat balance of the environment and it is very important to know how the human body reacts. To refine the calculations, several human thermoregulation models have been created since decades and they were coupled with thermal models of the building envelope like in the work of Thellier [5] who inserted a human thermoregulation model created by JAJ Sttolijk in TRNSYS habitat simulation program to characterize the impact of the atmosphere settings on the human physiological reactions and the influence of the presence of the occupant on the physical quantities characterizing the building as the rate of the relative humidity which allowed the prediction of thermal comfort. In this work, the calculation of the radiative exchange between the piece and a standing occupant was based on the method of MONTE CARLO to calculate view factors and the assessement of the impact of solar radiation on the thermal comfort was based on solar spot model and a view factors model developed by Mavroulakis et al. [6].

Serres et al. [7] studied the thermal supply to the human body consisting of flow absorbed by an occupant assimilated to a parallelepiped assembly, facing a bay and for different positions. In the same context of thermal comfort study and dynamic thermal simulation, Tulumoglu et al. [8] analyzed the thermal behavior of the individual and its interaction with the environment; the model was coupled to the building neglecting thermal exchanges by conduction and evaporation.

Nomenclature

A	corporal surface	m^2
S	thermal load of the human body	Wm^{-2}
M	metabolism	Wm^{-2}
C	convection	Wm^{-2}
R	GLO radiation between occupant and inner environment	Wm^{-2}
E_{vap}	evaporation	Wm^{-2}
T_i	real time temperature	K
$(mc)_i$	heat capacity	JK^{-1}
Ci,j	conductive and/or convective coefficient between nodes i and j	WK^{-1}
Ki,j	radiative coupling coefficient	WK^{-4}

2. Analysis and modelling

2. 1. Position of the problem

In this work, we are interested in studying the thermal behavior of bi-zone buildings in which walls of two zones