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Phase-change drywalls in a passive-solar building

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Abstract

Integration of phase-change materials (PCMs) into building fabrics is considered to be one of the potential and effective ways of minimising energy-consumption and CO_2-emissions in the building sector. In order to assess the thermal effectiveness of this concept, composite PCM drywall samples (i.e., randomly mixed and laminated PCM drywalls) have been evaluated in a model passive-solar building. For a broader assessment, the effects of three phase-change zones (narrow, intermediate and wide) of the PCM sample were considered. The results showed that the laminated PCM sample with a narrow phase-change zone was capable of increasing the minimum room temperature by about 17% more than the randomly mixed type. Even though there was some display of a non-isothermal phase-change process, the laminated system proved to be thermally more effective in terms of evolution and utilisation of latent heat. A further heat-transfer enhancement process is, however, required for the development of the laminated system.

Keywords: Phase-change material; Phase-change zone; Heat-transfer

1. Introduction

Passive architecture can be interpreted as architecture which tempers the external environment in order to create a relatively stable environment internally. Therefore,

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Nomenclature

A	area (m^2)
C	specific heat-capacity (J/kg K)
I	intensity of solar radiation (W/m^2)
N	number of air changes (Ac/h)
Q	heat leak (W)
T	temperature (°C)
t	time (s)
U	U-value (W/m^2 K)
V	volume (m^3)
Greek symbols	
α	heat-transfer coefficient (W/m^2 K)
ρ	density (kg/m^3)
τ	transmission coefficient through glass
Subscripts and superscripts	
eff	effective
g	glazing
i	initial
j	nodal point
L	latent
l	liquid phase
m	melting phase
r	room
s	solid phase
su	sundry
w	wall

a passively-designed building, incorporating such features as exposed walls, ceiling and floor slabs with energy-storage capabilities could help stabilize the internal environment and thus minimise energy consumption. The integration of phase-change material (PCM) into building fabrics has been discussed and reported as a potential method of reducing energy consumption in passively designed buildings [1–6]. The characteristics of PCMs make them inherently suitable for use for energy conservation purposes without the complications brought about by other thermal storage devices requiring separate plant and space.

Although the principles of latent-heat storage can be applied to any porous building material, most PCM research work has been concentrated on integration with gypsum wallboard and concrete blocks. For instance, experiments have been carried out by Feldman et al. [7], who found gypsum wallboard to be compatible with a