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A parametric study of Trombe walls for passive cooling of buildings

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Abstract

Air movement in a naturally-ventilated room can be induced through the use of a solar chimney or Trombe wall. In this work Trombe walls were studied for summer cooling of buildings. Ventilation rates resulting from natural cooling were predicted using the CFD (computational fluid dynamics) technique. The renoramlization group (RNG) k-ϵ turbulence model was used for the prediction of buoyant air flow and flow rate in enclosures with Trombe wall geometries. The CFD program was validated against experimental data from the literature and very good agreement between the prediction and measurement was achieved. The predicted ventilation rate increased with the wall temperature and heat gain. The effects of the distance between the wall and glazing, wall height, glazing type and wall insulation were also investigated. It was shown that in order to maximize the ventilation rate, the interior surface of a Trombe wall should be insulated for summer cooling. This would also prevent undesirable overheating of room air due to convection and radiation heat transfer from the wall. © 1998 Elsevier Science S.A.

Keywords: Air movement; Solar chimney; Trombe wall; Computational fluid dynamics technique; Renormalization group k-ϵ turbulence model

1. Introduction

Passive solar heating has increasingly been used internationally in the last two decades. Even in the UK solar energy has been utilized for space heating. However, summer overheating is often a problem in many passive solar houses due to excessive south-facing glazing [1]. This problem can be alleviated by shading, for example, but in buildings with internal heat sources a better approach to tackle the problem without using mechanical means may lie in making use of solar energy to increase air movement indoors through a Trombe wall or solar chimney. Passive solar heating has been widely studied but very few studies have been carried out for passive solar cooling.

A Trombe wall is a south-facing concrete or masonry wall blackened and covered on the exterior by glazing. The massive thermal wall (storage wall) serves to collect and store solar energy. The stored energy is transferred to the inside building for winter heating or facilitates room air movement for summer cooling. Fig. 1 shows operations of a Trombe wall for heating and cooling. In the heating mode, air enters the space between the wall and glazing from the bottom vent

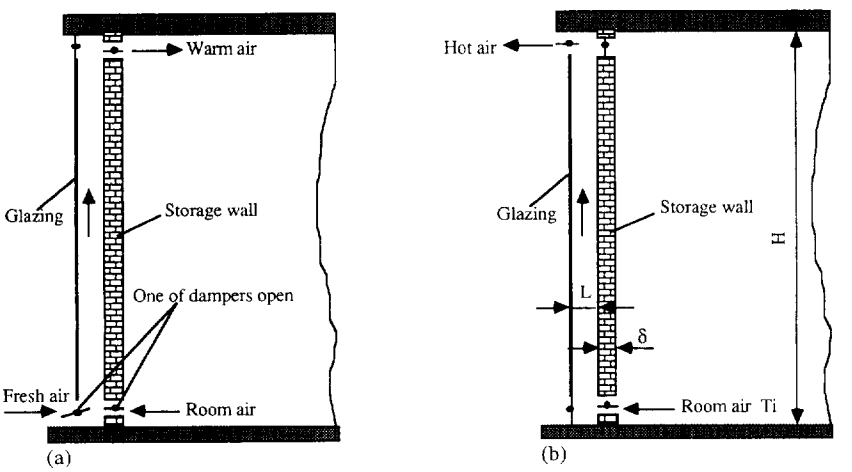

Fig. 1. Schematic diagram of Trombe wall for (a) winter heating and (b) summer cooling.

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