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Solar chimney and building ventilation

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Abstract

This study is concerned with the design of a solar chimney to induce ventilation in a building. CFD modelling techniques were used to assess the impacts of inclination angle, double glazing and low-emissivity finishes on the induced ventilation rate. It was found that for a south-facing chimney, an inclination angle of 67.5° from the horizontal was optimum for the location chosen, giving 11% greater efficiency than the vertical chimney, and that a 10% higher efficiency was obtained by using a low-emissivity wall surface.

Keywords: Building; Energy; Solar; Chimney; Ventilation

1. Introduction

The prospect of global warming has induced architects and building engineers to search for ways of heating, cooling and ventilating buildings by passive means rather than energy-consuming mechanical devices. Among these is the solar chimney, essentially a solar energy absorber with open top and bottom, which induces airflow through a building when solar radiation impinges on it. A relatively large item, it also has a function as an architectural feature and may influence the appearance of the building to which it is attached (Fig. 1). In order to minimise both costs and visual intrusion, it is important to maximise airflow for a given set of weather conditions and size of chimney. Design of the solar chimney is therefore important both in providing efficient air movement and in preserving the architectural integrity of the building. A number of factors influence

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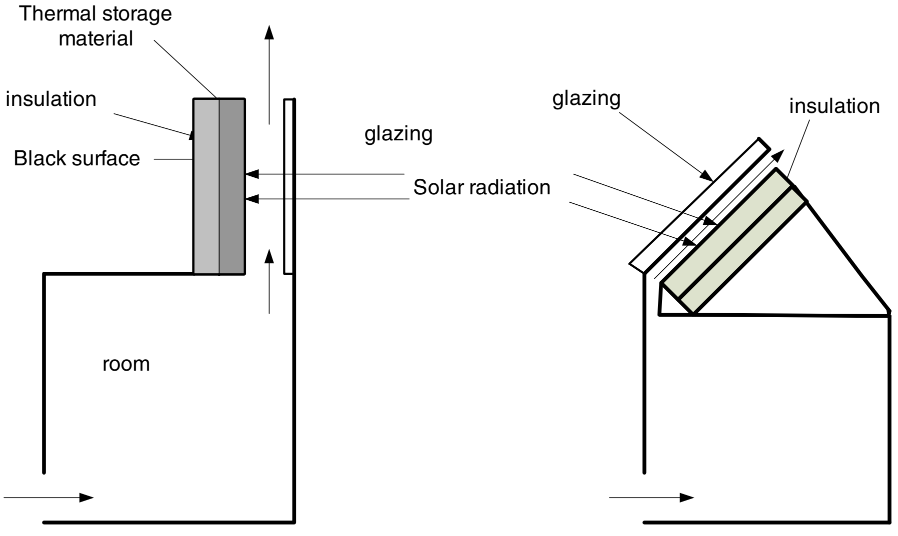

Fig. 1. Solar chimney configurations.

the design of the chimney—the location, climate, orientation of the building, size of building to be ventilated, and internal heat-gains, among others.

1.1. Basic operation of a solar chimney

Fig. 2 illustrates the basic operation of a solar chimney. Solar radiation passes through glazing and is absorbed at the wall surface. The air in the chimney is then heated by convection and radiation from the absorber. The decrease in density experienced by the air causes it to rise, whereupon it is replaced by air from below, i.e. from the attached room. The rate at which air is drawn through the room depends upon the buoyancy-force experienced, (i.e. dependent upon the temperature differential), the resistance to flow through the chimney, and the resistance to the entry of fresh air into the room. Solar chimneys are generally used to provide ventilation for cooling, but also sometimes for heating, when a fan can be used to direct the warmed air into the building. A significant advantage of a chimney used only for cooling is that the demand for cooling and the supply of solar radiation are in phase.

There are many choices to make in the design of a solar chimney, including height, width and depth of cavity, type of glazing, type of absorber, and the inclusion of insulation or thermal mass in the solar chimney. In this work, computer simulations were carried out in order to assist in the design process. The variables studied were slope angle, emissivity of the absorber surface, and the use of single or double glazing on the cover.

A solar chimney may be thought of as a special case of a Trombe wall or thermosyphoning air panel. However, a Trombe wall normally constitutes part of the wall of a building and has the disadvantage that it occupies wall area normally taken up by glazing, so causing a loss of daylight and view. Also it usually possesses significant thermal mass. A thermosyphoning air panel typically has a metal absorber and low mass, and