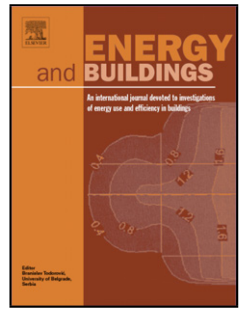


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# A Novel Design of Solar Chimney for Cooling Load Reduction and other Applications in Buildings

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## Abstract

Cooling load accounts for more than 70% of the electric energy used in buildings in the Middle East. This paper presents a passive method to reduce the cooling load in buildings. The proposed concept includes adding an external solar shield enclosing an air gap between it and the outer wall of the building. This external solar shield layer would absorb the solar radiation incident on the outer walls of the building and get heated inducing a convective airflow in the gap between the layer and the building. This is an example of solar chimney in a flat geometry with a superficial resemblance to Trombe wall. Conventional Trombe wall channel heats the building external wall and creates a convective flow in-between a transparent glass layer and the heated wall. This hot flow is used either as a warm inlet air to the building in winter or help inducing airflow from inside the building for ventilation in summer. However, in the present work, the solar chimney induced airflow is purely external to the building.

The proposed external solar shield starts with a glass layer from outside followed by an opaque porous metallic layer followed by an air channel before the building outer walls. The absorbing porous layer would get heated up quickly and transfer its heat to the air in the gap effectively due to its large surface area. The porous layer thickness is optimized at 15 cm while the air gap is optimized at 0.3 m. Numerical simulations based on finite volume analysis using ANSYS Fluent were carried out for a wall of 3 meters height. Comparisons of the performance of buildings with its outer walls shielded by white painted, black painted and glazed walls are presented and discussed with respect to that of buildings with bared outer walls as a control.

Putting glazing alone after an air gap, expectedly, increases the heat gained by 47-56% compared to 0.7 emissivity simple bared wall. Single white and black solar shielding walls reduce the heat gain by 30 and 67%, respectively. However, the proposed design of a solar chimney with a glass outer wall followed by a porous foam metal layer on its inner surface, reduced thermal gain by 67 to 79%. This results in electrical cooling load reduction by about 28%. Furthermore, the heated airflow induced by a solar chimney formed with a 20 × 3 meters south wall can be utilized to induce water evaporation of 625-1046 kg/day allowing active evaporative cooling and/or water desalination under solar irradiation condition of Dhahran, Saudi Arabia

## Abbreviations

| | |
|---|---|
| BWC | Black Wall Channel with emissivity of 1 |
| COP | Coefficient of Performance for air conditioning unit |
| LTE | Local Thermal Equilibrium |
| MMT | Million Metric Tons |
| MTW | Modified Trombe Wall |