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A Parametric Study of Passive Airflow Within Trombe Wall Air Channels

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Abstract

Trombe Walls are passive solar structures that reduce active heating loads and indoor ventilation requirements. These building envelopes harness solar radiation to increase the air temperature within a narrow channel positioned between a glazed window and a thermal storage wall. Numerous research articles explored design variations of Trombe walls with different geometries. These articles typically report the passive airflow produced by a transient solar heat flux, whereas the goal of this work is to determine the passive airflow and heat that can be provided by a Trombe wall for a given constant solar irradiance and temperature of the thermal storage wall. Herein we conduct three-dimensional CFD simulations to determine the effects of air channel thickness and the temperature of the thermal storage wall on the airflow within the channel. The simulated Trombe wall is 3 m wide and 3 m tall. It comprises multiple rectangular intake and outtake vents located at the bottom and top edges of the wall to enable passive ventilation to any compatible interior spaces. Each vent is 0.3 m wide and 0.2 m tall with a vent depth of 0.3 m long, which corresponds to the storage wall's thickness. A parametric study is performed to determine the passive airflow velocity and flow rate for different Trombe wall air channel depths, ranging from 0.05 to 0.3 m, at increments of 0.05 m. The effects of the storage wall temperature on airflow and heat provided to an indoor environment are determined as its temperature is raised from 25 °C to 75 °C in increments of 10 °C. The parametric study aims to determine the optimal air channel depth that produces the most passive airflow upon exiting the upper vents, and how higher storage wall temperatures enhance the airflow speed. These results provide insight to determine if the produced natural convection is sufficient to fulfill ASHRAE indoor air ventilation requirements within an interior space under certain temperature conditions. However, under the circumstances that passive airflow is insufficient, integrating fans into the Trombe wall air vents can compensate for that difference to fulfill the indoor ventilation thresholds.