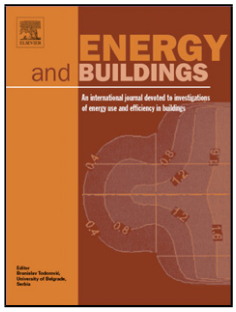

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Thermal and ventilation performance of combined passive chilled beam and displacement ventilation systems

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Abstract
Chilled beams provide sensible cooling to an occupied space by using chilled water flowing through modular beams mounted to a room ceiling. Previous studies show that active chilled beam systems can achieve larger sensible cooling than all-air systems. However, most studies have focused on active chilled beams and little information is available for performance of passive chilled beam (PCB) under varied ventilation conditions. The objective of the present study is to investigate ventilation and air conditioning performance of combined PCB and displacement ventilation systems. Using a validated and verified computational fluid dynamics (CFD) model, parametric analyses were performed to examine the ventilation and air conditioning performance depending on five major operating parameters: 1) ventilation strategy, 2) PCB cooling output, 3) supply air temperature, 4) supply diffuser type, and 5) internal heat source arrangement. The results show that thermal comfort and ventilation performance of a combined PCB-DV system notably vary with the PCB cooling output and supply air temperature. When the PCB cooling output increases from 33% to 53% of the total cooling load, air change effectiveness decreases from 1.6 to 1.2 and vertical temperature difference decreases from 4.0 °C to 1.5 °C in the breathing zone. However, spatial heat source distribution has a marginal effect on the air mixing and temperature distribution. The results suggest that a relatively high PCB cooling output (> 50% of the total cooling) combined with a low supply air temperature (*e.g.*, 17 °C) could disrupt thermal stratification of displacement ventilation and increase draft rate in the occupied zone.

Keywords: thermal comfort; age of air; ventilation effectiveness; vertical temperature gradient; computational fluid dynamics

1. Introduction

Chilled beam systems are an air conditioning system designed for buildings with a relatively large sensible cooling load compared to conventional all-air systems [1-5]. Chilled beams are mounted to the room ceilings with chilled water flowing through the coils embedded in a metal ceiling fixture [1]. This cooling strategy has received increasing attention as an energy-saving