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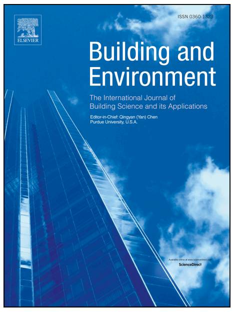

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Abstract Breathing is the most common but essential activity of human body. People can't leave without breathing. The breathable air quality around the occupant should be maintained high to avoid the respiratory diseases transmission. This paper reports an experimental study on the flow behavior of breathing activity produced by a thermal manikin. Measurements were performed in the breathing zone of the manikin by employing particle image velocimetry (PIV) system, and the temporal and spatial distributions of breathing airflows both with and without the convective boundary layer (CBL) was characterized by using the phase averaging approach. In addition, a quadruple decomposition methodology extended from proper orthogonal decomposition (POD) was adopted to divide the instantaneous flow fields of breathing flow into four parts, the flow characteristics as well as cycle-to-cycle variations upon each part studied respectively. The results showed that the breathing flow at different phases presented different flow behavior during breathing process. CBL had a larger influencing area and played a key role in promoting the upward spread and transmission of exhaled contaminants, which cause the inhaled flow mainly come from more the lower chin region and block the contaminants inhaled from other directions, thus reducing the risk of infection. It was found through the POD results that CBL enlarged the scale and magnified the energy of coherent structures at the transition stage between expiration and inspiration, and the large scale coherent structures were dominant and made more contribution to the contaminant dispersion in the entire breathing process.

Keywords: Breathing flow; Flow behavior; Particle image velocimetry; Convective boundary layer; Proper orthogonal decomposition

1. Introduction

Nowadays, modern buildings are constructed with airtight and thermal insulated construction materials from the viewpoint of energy conservation, which can cause indoor air pollution when insufficient consideration of the ventilation aspects. Therefore, indoor air quality (IAQ) has become a rising concern for public health as people spend an increasing amount of their time indoors along with exposure to contaminants. The contaminants involved in indoor air quality can be considered as particles, droplets or substances contained in the air that may affect occupants' health in the indoor environment. Exhalation flows produced by respiratory activities of an infected person, such as breathing, coughing and sneezing, can carry pathogens that are responsible for the infectious disease transmission, and the particles/droplets carrying the infectious agents exhaled by the contagious individual can be inhaled by other close occupants, thus generating a risk of infection.

Over the past few decades, both experimental and numerical research has been widely carried out to study the flow characteristics and contaminant dispersion for various respiratory events in different indoor environments. Marr et al. [1] conducted particle image velocimetry measurements in the breathing zone of a thermal breathing manikin, and the PIV results in the exhalation part were presented yet lacking of quantitative measurements in the inhalation part. Özcan et al. [2] measured mean velocity data around the head of a real-life size breathing thermal manikin for 'no breathing' case and 'continuous exhalation' case by employing particle image velocimetry and described the physical structure of the

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