Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 111 (2017) 520 – 529

Energy Procedia

8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11-13 September 2016, Turin, ITALY

Thermal comfort evaluation of a mixed-mode ventilated office building with advanced natural ventilation and underfloor air distribution systems

Xiang Deng[a,*], Georgios Kokogiannakis[a], Zhenjun Ma[a], Paul Cooper[a]

[a]*Sustainable Buildings Research Centre, University of Wollongong, Wollongong 2522, NSW, Australia*

Abstract

This study uses field monitoring and post occupancy evaluation (POE) surveys to investigate the indoor thermal comfort of an office building that is located in subtropical zone. The building is special as it combines advanced natural ventilation (ANV) strategies and underfloor air distribution (UFAD) systems. A comparison between a static thermal comfort model and a dynamic thermal comfort model is also conducted. The results show that the thermal comfort conditions in the case study building are satisfactory in summer while in winter there is evidence of thermal discomfort. For the case study building, the static thermal comfort model gives outputs that matched well with the responses of the occupants during the POE survey in winter while the dynamic model is more representative of the sensation of the occupants in summer,

Peer-review under responsibility of KES International.

Keywords: Mixed-mode ventilation; Thermal comfort; Post-occupancy evaluation (POE)

1. Introduction

The use of natural ventilation could reduce energy consumption and operating cost of air conditioning systems [1] and it is often more pleasant and acceptable to building occupants than using mechanical ventilation [2]. However, natural ventilation is often limited by the outdoor climate and it is therefore often necessary to employ mixed-mode ventilation strategies in buildings.

Previous studies have evaluated thermal comfort in mixed-mode ventilation buildings by using thermal comfort modelling techniques, e.g. [1]. Thermal comfort models were normally categorized into static models and dynamic

* Corresponding author. Tel.: +610415484106.
E-mail address: xd902@uowmail.edu.au

Peer-review under responsibility of KES International.
doi:10.1016/j.egypro.2017.03.214

models [3]. Static models make use of data collected from people within air-conditioned environmental chambers, while dynamic models are derived from field studies [4]. The details of both approaches have been well-documented in the literature, e.g. Ref [5].

It is worth noting that static and dynamic models are normally limited to mechanically ventilated buildings and pure naturally ventilated buildings, respectively [6]. Currently, there are no explicit standards declaring the most suitable thermal comfort model for buildings with mixed-mode ventilation systems. As a result, both static and dynamic thermal comfort models have been employed in research for mixed-mode ventilation (e.g., Ref [7-9] used a static model and Ref [10, 11] used a dynamic model). Comparisons between static and dynamic models have been reported in the literature [1, 12, 13] to identify the most suitable model for mixed-mode ventilated buildings. The general conclusion from these studies was that dynamic thermal comfort models are more applicable to mixed-mode ventilated buildings. However, this conclusion was drawn from mixed-mode ventilated buildings that use conventional fan coil units (FCU) and can not be generalized for mixed-mode ventilated buildings that use underfloor air distribution (UFAD) systems. UFAD, as a special mechanical ventilation method, supplies air into the space with an airflow velocity that is lower than conventional mechanical ventilation systems. Furthermore, the air is provided normally from swirl diffusers and can become well-mixed with the air in the occupied space. With UFAD systems, the conditioned air is supplied to locations close to the occupants and it therefore has a strong effect on the thermal sensation of occupants.

This study tries to expand existing research on indoor thermal comfort in mixed-mode ventilated buildings by investigating a case study office building where advanced natural ventilation strategies are combined with UFAD systems and the thermal perception of the occupants is evaluated by field measurements and POE survey. The performances of two types of thermal comfort models were evaluated to identify the most representative comfort model for the specific building.

2. Methods

Long-term monitoring of indoor thermal parameters was conducted in a case study building to analyse the indoor conditions and the associated ventilation control strategies. POE survey was also carried out to document the perception of the occupants on indoor conditions and correlate the responses with the monitoring data. Section 2.2.1 provides the details of the monitoring study and section 2.2.2 gives an overview of the POE survey.

2.1. Case study building and location

The selected building is located at the University of Wollongong, Australia. Wollongong is on the eastern coast of Australia (34S, 151E) and experiences an oceanic climate with a mean summer daily maximum temperature of 25.9°C, a mean winter daily minimum temperature of 8.3°C and an annual mean daily maximum temperature of 21.7°C. The monthly average relative humidity ranges from 50% to 70% indicating that the air is usually dry and fresh. As the area is close to the ocean, the sea breeze lasts over the whole year and approximately 78% of the time the wind speed is between 1 and 8 m/s. Natural ventilation could therefore be a possible option in Wollongong due to the moderate climate and gentle sea breeze throughout the whole year.

The Sustainable Building Research Centre (SBRC) building is a two-storey building comprising of research laboratory spaces, meeting rooms and an open-plan office (Fig. 1). The open-plan office is 12 meters wide and 52 meters long, and it is occupied by about 39 staff and research students.