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The impact of temperature on mean local air age and thermal comfort in a stratum ventilated office

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ABSTRACT

The influence of the supply air temperature on the mean local air age and thermal comfort of a typical individual office under stratum ventilation is investigated by a numerical method, which is validated by an experiment carried out by the authors. The results show that for an office, when the supply air temperature is increased from 19 °C to 21 °C, the corresponding mean occupied zone temperature rises from 24.5 °C to 26.5 °C. The inhaled air quality for the occupant is improved when supply air temperature rises from 19 °C to 21 °C. Also, the thermal comfort indices (predicted mean vote or PMV, predicted percentage of dissatisfied or PPD and predicted dissatisfied or PD) fulfill the requirements of ISO 7730 and CR 175 1998. For summer cooling operation, stratum ventilation may offer a feasible solution to elevated indoor temperatures, which are recommended by several governments in East Asia.

1. Introduction

The earth is already showing many signs of worldwide climate change. The Intergovernmental Panel on Climate Change (IPCC) has used its strongest language to link human activities to the current planetary warming [1]. There is international consensus to reduce carbon emission (Kyoto Protocol, Copenhagen Accord, etc.). Minimizing the energy consumption by air-conditioning systems will help to reduce CO_2 emission. Proactive actions have been taken by several governments in East Asia. Several recommendations have been made by various government bodies, including the Electrical and Mechanical Services Department (EMSD) of the Hong Kong S.A.R. government (25.5 °C), the National Development and Reform Commission of the Chinese State Council (26 °C), the "Office of President" in Taipei (27 °C), the Ministry of Knowledge and Economy of Korea (26–28 °C) suggesting a more radical change the Ministry of the Environment (MoE) of Japanese cabinet (28 °C). [2–6]. Also, many facility professionals are adjusting the thermostat to higher settings in the summer to cut energy consumption in the United States [7]. This policy seems to be in line with the principle of sustainable development, but at least one question still remains:Are there any ventilation system(s) suitable for the recommended elevated indoor temperatures that can avoid the deterioration of indoor environmental quality, especially thermal comfort?

To answer the question, ANSI/ASHRAE Standard 55-2004 has been updated with new provisions that allow elevated air movements to broadly offset the need to cool air in warm conditions [8]. Several recent publications provide theoretical basis for such a move [9–11]. The side directions of an occupant [12], and maybe also the front direction [13], are known to be considerably less sensitive to air movements. The aforementioned literature is summed up to set the criteria for a suitable air distribution method for warm conditions:

1. comparably higher temperatures and air movements in the occupied zone which are still within the reasonable ranges as stipulated in Addenda *d, e, f,* and *g* of ANSI/ASHRAE Standard 55-2004 [8]; and
2. horizontal air flow(s) from the side and/or front direction(s) towards the occupant(s).

For displacement ventilation, air for breathing is transported by the boundary layer around an occupant. Horizontal airflows would defeat the working principle of displacement ventilation. It is also difficult to have horizontal airflows with mixing ventilation because of its ceiling-mounted supply terminals. Significantly more fan power is needed if higher air movements in the occupied zone

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