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Assessing the thermal comfort and ventilation in Malaysia and the surrounding regions

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ABSTRACT

Proper ventilation system is required to provide good indoor air quality. However, unnecessary ventilation can consume a huge amount of energy. Potential saving can be achieved by ensuring that efficient heating, ventilation and air-conditioning systems are used. Moreover, reducing the energy consumption by adopting energy-efficient buildings can improve the thermal comfort of the occupants. In the hot and humid climates, natural ventilation by opening the windows and doors may enhance the humidity inside the building and affect comfort, consequently. Since humidity contributes to poor indoor quality and may be a major cause of discomfort, application of mechanical ventilation systems is increased compared with natural ventilation in tropical climates. Further, the power consumption of the air conditioners is increased. Accordingly, it is necessary to scrutinize the factors that influence the thermal comfort and indoor air quality that can be endured by the residents. In the current study, a review of the available literature on the thermal comfort and ventilation of the offices, classrooms and residential buildings in Malaysia and the surrounding regions was conducted. Additionally, prospective researches on different new cooling technologies were marked. Based on the findings, it concluded that thermal comfort range is higher than expected by international standards for hot-humid climate. It was also found that proper ventilation and healthy indoor air quality has great influence of sensation of thermal comfort via occupants of buildings. In point of fact, this work revealed that further research in these fields can provide a chance to improve thermal comfort and indoor air quality for occupants in hot and humid climate and minimize the energy consumption due to the application of air conditioner.

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1. Introduction

The development of energy problem in the early 1970s led to several considerations related to poor indoor air quality (IAQ) in buildings [1]. As people spend a significant portion of their time in buildings, the indoor environments of rooms are needed to be more thermally comfortable and healthy [2].

In order to enhance the energy efficiency, the building interior is sealed tightly against the outdoor air and the amount of fresh air coming in is decreased. This allows the air to become stagnant as a result of the accumulation of pollutants such as excess dust, bacteria and chemicals. When there is a strong likelihood that the concentration of pollutants in the building air space increases, the occupants' health will be jeopardized, and when a high frequency of clinically proven complaints are made by the occupants, such a building would be labeled as a "sick building" [3]. Ventilation engineering is required to assess the infiltration characteristics of a given building and to design the ventilation openings required. The design process of ventilation systems should be able to avoid most of the sick building syndromes [4].

The challenge is to raise the level of thermal comfort, optimum energy usage and psychological acceptance of occupants, and the indoor environment of the building which plays a key role in achieving these goals. A ventilation system performs a vital role in the removal of pollutants originating in the air-space [3]. In addition, thermal comfort is influenced by the performance of mechanical ventilation system. Studies have shown that ventilation systems in buildings are largely responsible for the Sick Building Syndrome (SBS). The importance of good indoor air quality has become more apparent in countries which have great reliance on manpower resources as they strive for a knowledge-based economy in the 21st century [5]. To date, most people spend 90% of their time indoors, often in shared spaces. By offering mechanical environmental control over the indoor environment, the occupants will be able to raise their expectations for a thermally comfortable indoor climate. Individual thermal comfort within a building enclosure is limited to a narrow range [6,7]. Despite the existence of extensive environmental control systems in buildings, grievances about the indoor climate are still commonplace [8,9].

Thermal comfort as well as indoor air quality (IAQ) have become a topic of interest. Building facades were gradually well insulated and often well air-sealed. Natural or local mechanical ventilation was replaced with central mechanical ventilation. As a further measure, the air flow rate was also reduced. Fresh air cannot be directly provided to the occupants. Furthermore, correction of the conditions via opening the windows and doors is no longer possible because of the fastened facade [10]. Of the many factors that must be considered in the design of a built environment, thermal environment and indoor air quality are of great importance. Most of the older buildings do not contain suitable devices for natural and/or mechanical ventilation, which means air exchange rates are only dependent upon the air moving through spaces and cracks [11]. In temperate climates the window is possibly the most common thermal control device in any building [12]. A beneficial interaction between the indoor and the outdoor environments and energy saving can be obtained by using windows opening arrangements [13].

The increased demand for artificial cooling through the use of air conditioning units in order to provide comfort would also mean increased energy usage and increased electricity cost to the occupants in a hot and humid climate like that of Malaysia [14]. Cooling by natural ventilation and passive cooling is a good energy conserving design strategy to improve the indoor thermal comfort and air quality in a tropical country like Malaysia, which has high daytime temperatures of 29–34 °C and relative humidity of 70–90% throughout the year. With good air movement, the occupants can be more comfortable at higher temperatures and humidity than in still air conditions. Most of the present and past designers and architects do not give enough consideration to the air flow and structural control in their design, either due to lack of understanding and research in this area, or that they are more concerned with the esthetic value of the building rather than the occupants' comfort. As a result, massive air-conditioning systems are installed to correct ill-designed buildings. In addition, the air-conditioning systems are installed simply by using the size of rooms as the main criteria, resulting in systems that are oversized, thereby leading to wastage of energy [15].

Both thermal comfort and air quality can have important impacts on productivity. The privative effect of insignificant indoor climate conditions on the efficiency of the occupant is described in several earlier investigations [16,17]. Acceptable indoor environmental conditions for occupants should be gained as the significant portion of the Gross National Product is earned by people working in the office buildings [10]. It is of common knowledge that the ventilation and thermal comfort matters are consequential in each type of building, but in hot and humid climate where reducing cooling energy consumption is mandatory, they became even more considerable. A few works have considered the ventilation parameters, air quality and thermal comfort together. Therefore, the objective of this work was to review the development of the ventilation parameters and thermal comfort with an emphasis on the combined thermal comfort-ventilation parameters, particularly the impact of ventilation parameters on thermal comfort, which have been confirmed in the hot-humid climate of Malaysia and the surrounding regions. Thus, it was essential to review thermal comfort and ventilation parameters in hot and humid climate and to identify the research needs in these areas. Besides, in order to develop thermal comfort and ventilation standards in these regions, future outlook and directions were provided.

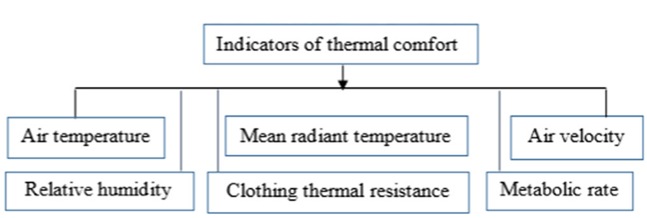

Fig. 1. Human response to the thermal environment.

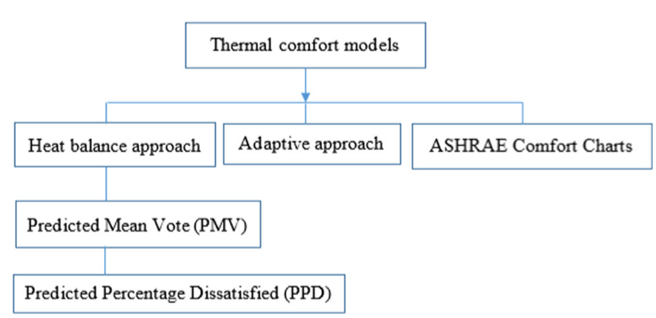

Fig. 2. Classification of thermal comfort models.