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A study of thermal comfort and occupant satisfaction in office room

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Abstract

This paper presents an investigation regarding the effect of indoor thermal to building's occupant satisfaction which is equipped by mechanically ventilated. The investigation is consisted of two parts, in which the first part is to visualise the indoor environmental quality of the office room in-term of air velocity distribution and indoor temperature distribution. Whereas, the second part is to obtain the perception of building's occupants regarding their satisfaction to the indoor air and thermal inside the building. An approach of modelling and simulation was carried out using COMSOL Multiphysics software to visualise indoor environmental quality and an approach of questionnaire was adopted to obtain the perception of building's occupants. The results show that the geometry model also affects to the air circulation and maintain indoor temperature distribution. This evidence occurred when the distribution of indoor air of office room didn't distributed homogeneously to the hallway as impact of the streamline, but the distribution of indoor temperature is still uniform. Additionally, the condition of temperature inside office room is not a single factor that contribute to the dissatisfaction of building's occupants. Since most of office workers are unauthorized to adjust temperature and air velocity of the air-conditioning system, this contributes to 40 % of respondents that are dissatisfaction with temperature and air velocity. Finally, this study found that the relationship amongst indoor environmental quality to produce occupant satisfaction is a complex system that need to be assessed comprehensively. Besides, it is invaluable to advance our understanding of the relationship amongst ventilation system, occupant behaviour, and building energy in tropical climate in assessment of occupant satisfaction.

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Keywords: Thermal Comfort; Air Velocity; Occupant Satisfaction; COMSOL Multiphysics; Modelling and Simulation.

1. Introduction

In recent years, the investigation regarding energy efficiency is being studied and developed due to the limitation of fossil fuels. An excessive consumption of fossil fuels has raised the emission of carbon dioxide [1] and impacted in increasing global temperature [2]. One of the highest consumption of energy existed in office buildings, this is due to the building's occupants need to work in comfort condition. Hence, indoor thermal condition needs to be controlled in order to provide occupant satisfaction in an office building. Furthermore, the easiest and least expensive way to solve "energy problem" is not to augment energy supply, but to reduce the amount of energy needed. This is due to respond to the increased requirement for local control of indoor heat load, and to meet the thermal preferences by individuals [3].

Thermal comfort is described as state of mind which express satisfaction with the thermal environment [4]. According to ASHRAE standard 55, "Thermal Environmental Conditions for Human Occupancy" [5], people mostly feel comfort when temperature shows in the range of 70°F - 79°F (21°C-26°C). However, achieving overall thermal comfort in a building is a complex task due to its related to various aspects such as age, sex, metabolism rate, time of the year [6]. Subsequently, Al Horr et al., [7] proposed an approach to estimate indoor thermal comfort through analyze a number of discomfort complaints. It is

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influenced of six factors namely air temperature, air velocity, relative humidity, mean radiant temperature, clothing insulation, and metabolic rate.

An initial work instrumental to estimate indoor thermal comfort was developed by Fang [8]. He developed an analytical model to predict thermal comfort by elaborating four physical parameters such as air temperature, mean radiant temperature, air velocity, and relative humidity with human variables namely clothing insulation and activity index to define the Predicted Mean Vote (PMV) index. Besides, due to the comfort of indoor thermal affects the satisfaction of building's occupant, Fanger also calculated Percentage of Dissatisfied Occupants (PPD) that is derived from PMV index [8].

It predicts the percentage of people who could be dissatisfied with a thermal environment. It predicts if a large group individual are likely to feel "too warm" or "too cold", defined by voting +3, +2, -3, -2 on the scale [9].

In this paper, an approach of Fanger's work instrumental is modified by adding modelling and simulation to visualise the distribution of air velocity and indoor temperature to assess the indoor environmental. Additionally, perception regarding occupant satisfaction in office room building is determined through questionnaire survey.

2. The model of study

2.1. Site Description

The model subjected of this study is an Office for Research, Innovation, Commercialization, and Consultancy Management (ORICC) at Universiti Tun Hussein Onn Malaysia. The selection of this office is based on its location which is situated at near the factory that frequently emits air pollutants as in Figure 1.

Fig. 1. Location of ORICC office with evergreen factory in 200 m distance

2.2. Geometry Model

The geometry model of one of ORICC's room was constructed by using COMSOL Multiphysics software and validated on previous study [10]. This selection is based on the highest temperature of indoor air recorded during the measurement period.