Analysis of indoor environment condition towards thermal comfort level in an air-conditioning office building

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Abstract. Office workers spend most of their time indoor with average of eight hours spent inside the office buildings. Therefore, the indoor environment condition will be one of the factors contributing to comfort level inside the building. Since air conditioning system is commonly used to maintain the indoor condition, the selection of appropriate and right capacity of the system is crucial. The purpose of this work is to conduct an analysis of the indoor environment condition towards the thermal comfort level inside office building. The case study building for this study is the Chancellery Building of Universiti Teknikal Malaysia Melaka (UTeM) which is installed with the central air-conditioning system. The thermal condition was measured by using the thermal microclimate instrument. The parameters involved in this study include air temperature and humidity. Based on the data measurement, the temperatures were range between 25.7 °C to 26.2 °C while the humidity recorded is between 68.1% to 70%. Comparing with ASHRAE Standards 55 and ASHRAE Standards 62.1 the thermal and humidity condition fall outside of the comfort range.

1. Introduction
Working in an office and spending most of the time indoor is the current city lifestyle trend [1]. The world is shifting in the economy from the manufacturing-oriented towards the service and knowledge-based sectors which operate mostly in indoor environment [2]. Hence, this triggers the interest in the indoor environmental condition. As the condition recorded to have effect on occupant health and productivity attention on the indoor environment quality had been more than ever [3].

Indoor thermal comfort is one of the components in indoor environmental quality and the most important factor that determines the overall indoor environment quality [4]. Thermal comfort is described as a “state of mind which expresses satisfaction with the thermal environment” [1]. It documented by Zhang, et al. (2017) [5], that higher temperature might incur a significantly reduce in cognitive capability. This will also be affecting the perception of the occupant on another indoor environment quality. The several parameters which are important factor in accessing the indoor thermal comfort are:
1.1. Air temperature
The thermal comfort generally is known as the temperature condition which occupant feels comfort to stay. Thus, the air temperature is one of the key conditions in evaluating thermal comfort. One of the standards which frequently used by researcher who studying indoor environment quality is a standard issued by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE 55 (2017) which specifically focusing on thermal comfort.

1.2. Air Speed
Air speed is also one of the important parameters in evaluating indoor thermal comfort. According to previous studies, air speed is closely related to thermal comfort [6]. By increasing the air speed human can tolerate wider range of temperature [7].

1.3. Relative Humidity
Relative humidity (RH) is the ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at a given temperature. Too much humidity makes the environment feels ‘heavy’ and muggy while too little humidity results in dry and ‘crisp’ sensation.

By evaluating all the parameters listed, the indoor thermal comfort condition can be evaluated. This is aligned with the primary target of this study, which is to analyse the thermal comfort condition in the air-conditioned office building.

2. Methods
The experiments were conducted in University Teknikal Malaysia Melaka (UTeM) Human Resource Office. The office located on the basement floor of UTeM’s four-story Chancellery Building with total room area is approximately 61.91 m². Located in the middle of UTeM main campus, the Chancellery building home several offices with the total building area about 11212 m². Ideally the air conditioning system used by the Chancellery building is the central air-conditioning system with three main compressors that are working alternately according to demand. During this study, two of the compressors was phase out leaving only one compressor to cater all the workload.

Figure 1. UTeM’ Chancellery building (source: LENSA UTeM)
For the office room with approximately 61.91 m², two sampling points were established. The probes were set at 1.5 meters in height which is the average height of the worker. The conditions were recorded for an hour with an interval of five minutes. The procedure then repeated for three days at the same time. Figure 1 demonstrates the equipment setup for the experiment. The instrument that made up from four different probes evaluate the condition and recorded in the data logger.

![Image of experimental setup]

**Figure 2.** Experimental setup

### 3. Results and Discussions

#### 3.1. Air temperature

The air temperature condition was measured in degree Celsius (°C) in the office during the day. In this study, ASHRAE 55 (2017) is used as the benchmark for the office thermal comfort condition. According to ASHRAE 55 (2017) the air temperature suggested for thermal comfort is between 22-25.5 °C [8].
Figure 3 shows the mean temperature from every reading taken. The suggested range temperature by ASHRAE Standard 55 is marked with stripes in Figure 3. From the graph, it shows that all the readings of the temperature in the office fall out above the suggestion range by the code. This indicates that the temperature in the office is not comfortable and too hot for the occupant.

3.2. Air Speed
ASHRAE 55 (2017) also had listed out ranges of air speed for thermal comfort that change with respect to air temperature to achieve thermal comfort. For the air temperature which is above 25.5°C ASHRAE 55 (2017) suggested that the air speed to be 0.8m/s [8].

Figure 4. Office air velocity
Figure 4 shows the mean air velocity measured at the office building. The suggested air speed was marked as a dotted line in the graph. Referring to the graph, it is shown that all of the air speed falls below the suggested range by ASHRAE [8]. This indicates that the thermal comfort level is not in the range suggested by the standard. According to Indraganti and Boussaa (2017) [7], the condition of lack in air speed can be improved by using standing fan in the office. Increasing the ventilation by opening the window will also help significantly.

3.3. Relative Humidity
For the RH condition, another standard by ASHRAE was used as the benchmark for the office condition. ASHRAE 62.1 is the standard issued by ASHRAE which contain the regulation of indoor air quality. The air quality regulation including the percentage of RH which is suggested to be below 65% [9].

![Relative Humidity (%)](image)

**Figure 5.** Relative humidity condition in the office.

Figure 5 shows all the mean readings of RH condition that had been recorded during the study. The suggested range of the relative humidity is marked with stripes on the graph. From the graph all of the reading fall above the suggested range which having more percentage of water. This indicates the condition is too humid. It may cause discomfort to occupant and damaging equipment as the humid condition may cause the formation of mold [10].

The condition with the office area is not properly cooled and dehumidifying in the study indicates the incapability of the central air-conditioning unit to cater to the demand from the office building. Besides the function as cooling system, air conditioner is also supposed to act as dehumidifying system. Unsuitable capacity in the system has contributed to the failure to properly cooling and dehumidifying the office.

4. Conclusions
Comparing to the international standard the temperature, air velocity and relative humidity in the office are not in the comfort range. The correct capacity of the air conditioner is crucial in having an optimum indoor environment generally and thermal comfort specifically.
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6. References
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