INVESTIGATION ON INDOOR ENVIRONMENTAL QUALITY OF TEACHING LABORATORY

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Projek Sarjana Muda II

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This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Thermal and Fluid)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2016

DECLARATION

I declare that this project report entitled "Investigation On Indoor Environmental Quality Of Teaching Laboratory" is the result of my own work except as cited in the references.

Signature : .....

Name : KARTHIGEYAN A/LSINGARAVELU

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal & Fluid).

Signature :. .....

Name of Supervisor : DR. TEE BOON TUAN

Date : .....

DEDICATION

To my beloved mother and father

ABSTRACT

The main purpose of this study is to investigate the indoor environmental air quality and thermal comfort level in the laboratories located at Kompleks Makmal Kejuruteraan (KMK), Faculty of Mechanical Engineering, UTeM. The selected laboratories are CAE laboratory for the condition of air conditioned system and fabrication laboratory for the condition of naturally ventilated system. The experiments for physical parameters measurements were carried out with occupants and without occupants condition. A questionnaire survey form was also given to students at the both laboratories to compare the thermal comfort responses by the laboratory occupants. The results obtained were compared with the ASHRAE Standard 55 (2004) and Malaysia Standard MS 1525:2014. The analysis of this study were done by using DeltaLog10 software. This includes the results of Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) index for physical measurements and Thermal Sensation Vote (TSV) through subjective assessment. Besides that, carbon dioxide (CO_2) concentration and dust level were also measured at CAE laboratory and fabrication laboratory in order to evaluate the amount of ventilation and general comfort. According to the results obtained, CAE laboratory satisfy the range of values set by the ASHRAE Standard 55 and MS1525:2014. However, the physical air parameters obtained in fabrication laboratory did not comply the range set by the standards. Besides that, the results obtained for PMV and PPD index for both of the laboratories were did not comply with the standards. Yet, the CO_2 concentration and dust level are still in range and comply with the standards. Based on the findings, technical design improvements are recommended in this study in order to improve the indoor environmental condition and thermal comfort level in the laboratories.

ABSTRAK

Tujuan utama kajian ini adalah untuk mengkaji kualiti udara alam sekitar dalaman dan tahap keselesaan terma di makmal yang terletak di Kompleks Makmal Kejuruteraan (KMK), Fakulti Kejuruteraan Mekanikal, UTeM. Makmal-makmal yang dipilih ialah makmal CAE untuk keadaan sistem penghawa dingin dan makmal fabrikasi untuk keadaan sistem pengudaraan semula jadi. Eksperimen untuk parameter fizikal ukuran telah dijalankan dengan keadaan kehadiran orang dan ketiadaan orang. Satu kajian soal selidik juga diberikan kepada pelajar-pelajar di kedua-dua makmal untuk membandingkan keselesaan haba oleh pelajar yang menggunakan makmal. Keputusan yang diperolehi dibandingkan dengan ASHRAE Standard55 (2004) dan Malaysia Standard MS 1525:2014. Analisis kajian ini dilakukan dengan menggunakan perisian DeltaLog10. Ini termasuk keputusan Undian Andaian Purata dan Peratusan Andaian Ketidakpuasan untuk ukuran fizikal dan Undian Sensasi Haba melalui penilaian subjektif. Selain itu, karbon dioksida (CO_2) tumpuan dan tahap debuan juga diukur di makmal CAE dan makmal fabrikasi untuk menilai jumlah pengudaraan dan keselesaan umum. Menurut keputusan yang diperolehi, makmal CAE memenuhi julat nilai yang ditetapkan oleh ASHRAE Standard55 dan MS1525:2014. Walau bagaimanapun, parameter udara fizikal diperolehi di makmal fabrikasi tidak mematuhi julat yang ditetapkan oleh piawaian. Selain itu, keputusan yang diperolehi bagi indeks PMV dan PPD untuk kedua-dua makmal adalah tidak mematuhi piawaian. Namun, kepekatan CO_2 dan tahap debuan masih dalam julat dan mematuhi piawaian. Berdasarkan dapatan kajian, penambahbaikan reka bentuk teknikal telah disyorkan dalam kajian ini untuk memperbaiki keadaan alam sekitar dalaman dan tahap keselesaan terma di makmal.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBEREVATIONS

AC	Aural Comfort
ACMV	Air Conditioning and Mechanical Ventilation
AHU	Air Handling Unit
ASHRAE	American Society for Heating, Refrigerating and Air-Conditioning Engineering
BRI	Building Related Illness
CO_2	Carbon Dioxide
ETS	Environmental Tobacco Smoke
HVAC	Heating, Ventilating and Air-Conditioning
IAQ	Indoor Air Quality
IAC	Indoor Air Contaminants
ICOP	Industrial Code of Practice
IEQ	Indoor Environmental Quality
KMK	Kompleks Makmal Kejuruteaan
MS	Malaysia Standard
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
RH	Relative Humidity
SBS	Sick Building Syndrome
TC	Thermal Comfort
TSV	Thermal Sensation Vote
VC	Visual Comfort
VOC	Volatile Organic Compounds

LIST OF SYMBOL

℃	=	Degree Celsius
%	=	Percentage
m	=	Meter
s	=	Seconds

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Indoor environmental quality (IEQ) refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. IEQ is determined by many factors, including lighting, air quality, and damp conditions. Indoor environmental quality (IEQ) is nowadays universally recognized as an important issue that affects the comfort and health of people, as well as their productivity. The indoor environmental quality (IEQ) and occupant comfort are closely related. The current indoor environmental assessment includes four aspects, namely thermal comfort (TC), indoor air quality (IAQ), visual comfort (VC) and aural comfort (AC). IAQ, as the nature of air in an indoor environment with relation to the occupant health and comfort is not an easily defined concept. In a broad context, it is the result of complex interactions between building, building systems and people.

Over the past decades, exposure to indoor environmental pollutants increased due to a variety of factors including: construction of tightly sealed buildings, reduction of ventilation rates (for energy saving) and use of synthetic building materials and furnishings as well as chemically formulated personal care products, pesticides and household cleaners. The effect of chemical pollutants on the perceived IEQ was investigated in several studies. The volatile organic compounds (VOCs) were suspected to cause ‘‘sick-building’’ symptoms, like headache, eye and mucous membrane irritation, fatigue and asthmatic symptoms. Other factors such as indoor temperatures, relative humidity, and ventilation levels can also affect how individuals respond to the indoor environment (Krzaczek and Tejchman, 2012).

Indoor air quality (IAQ) is a term which refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. IAQ can be affected by gases (including carbon monoxide, radon, volatile organic compounds), particulates, microbial contaminants (mold, bacteria), or any mass or energy stressor that can induce adverse health conditions. Source control, filtration and the use of ventilation to dilute contaminants are the primary methods for improving indoor air quality in most buildings. The importance of Indoor Air Quality (IAQ) in buildings arises from the fact that people spend more than 90% of their time in indoor environment (Marchetti et al., 2015).

Energy-efficient buildings are only effective when the occupants of the buildings are comfortable. If they are not comfortable, then they will take alternative means of heating or cooling a space such as space heaters or window-mounted air

conditioners that could be substantially worse than typical Heating, Ventilation and Air Conditioning (HVAC) systems. According to the ANSI/ASHRAE Standard 55-2010, thermal comfort is defined as "that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation1."

The international standard ISO 7730:2005, developed in parallel with the revised ASHRAE 55 standard, considers that a room provides thermal comfort if not more than 10% of its occupants feel discomfort. These studies establish a relationship between the outcome of the energy balance of the body and the trend of dissatisfaction. ISO 7730 standardizes the PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfaction) as the method for evaluation of moderate thermal environments. The PMV is calculated based on the value of energy accumulation in the body, thermal resistance of clothing and metabolism through a correlation. Thus, the PMV isn't more than a quantitative measure of the heat and cold sensation (Dias et al., 2009).

The indoor CO_2 concentration is also often considered to be a surrogate for the rate of ventilation per occupant. However, the indoor CO_2 concentration will vary with time even if the ventilation rate and occupancy are constant and, the CO_2 concentration is often a poor indicator of ventilation rate (Seppanen, Fisk and Mendell, 1999).

1.2 PROBLEM STATEMENT

Universities are designed for higher education learning, and improving university indoor environmental quality (IEQ) is essential to the enhanced performances of students and staff members alike. The majority of IEQ problems are due to inadequate ventilation in university buildings. Carbon Dioxide (CO_2) and thermal comfort measurements have become a commonly used screening test of IEQ because measurement levels can be used to evaluate the amount of ventilation and general comfort. This project examines IEQ field measurement for teaching laboratories in Mechanical Engineering Faculty, UTeM.

1.3 OBJECTIVE

The objectives of this project are as follows:

i. To characterize the physical indoor environmental conditions of laboratories that represent two typical conditioning regimes, natural ventilation and air-conditioned laboratories.

ii. To compare measured physical conditions to the comfort zone specifications of the MS1525:2014 for each laboratory.

iii. To compare thermal comfort responses by the laboratory occupants (subjective response) to criteria specified by MS1525, using a variety of comfort scales and environmental indices.

1.4 SCOPE OF PROJECT

The scopes of this project are as follows:

i. A study is to be carried out at laboratories in Mechanical Engineering Faculty, UTeM.

ii. Laboratories with naturally ventilated and air-conditioning system with and without occupants will be chosen as the main case studies in order to assess the environmental conditions.

iii. The focus will be mainly on collecting data and measurements related to IEQ aspects such as indoor air thermal comfort, CO_2, percentage of relative humidity to be related with naturally ventilated and air-conditioned laboratories.

iv. Comparing the data collected from the measurements with current comfort zone specifications in the MS1525:2014.