ENERGY AND THERMAL COMFORT ANALYSIS FOR UNIVERSITY LIBRARY

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Draft Final Report
Projek Sarjana Muda II

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JUNE 2015

SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design and Innovation)"

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This Technical Report is submited to
Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka
In partial fulfilment for
Bachelor of Mechanical Engineering (Design & Innovation) with honours

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

JUNE 2015

DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : .....
Author : .....
Date : .....

For my beloved Dad and Mum

AWKNOWLEDGEMENT

I would like to express my heartfelt gratitude to all those who have helped me complete this project. First and foremost, I would like to express my deepest gratitude to my supervisor Dr. Tee Boon Tuan for his patient guidance, enthusiastic encouragement and valuable suggestions during the project period. His willingness to give his time so generously has been very much appreciated.

Besides that, I would also like to send my sincere gratitude to Dr.Mohd Basri Ali as my project examiner for evaluating my final year project. He had given some suggestion and advice in order to improve my project. I am so grateful to the Faculty of Mechanical Engineering (FKM), Universiti Teknikal Malaysia Melaka (UTeM) for providing the necessary tools for data measurement and analysis. Furthermore, I would also like to extend my deepest thanks to the technician of the HVAC laboratory, En.Asjuri Bin Muhajir. Thanks for his help in assisting for data collection by using the required equipment.

In addition, I would also like to thank to various people for their contribution to this project such as the Mechanical Engineer, En Ainuddin Abu Kasim and Assistant Electrical Engineer, En Mohd Ibrahim of University Development office in giving me the information and answering my enquiries. Special thanks to all the respondents who took part in the questionnaire survey.

Finally, I wish to thank to my beloved parents and siblings for their support and encouragement throughout the completion of this project.

ABSTRACT

The main purpose of this study is to investigate the thermal comfort level in the UTeM's library and compare with the ASHRAE Standard 55 (2004) and Malaysia Standard MS 1525:2014. The physical measurements were carried out with occupants and without occupant condition. The analysis of this study included the Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) for physical measurements and Thermal Sensation Vote (TSV) through subjective assessment. Besides that, the linear regression analysis is conducted between PMV and TSV with operative temperature by using SPSS software. The Building Energy Index (BEI) of UTeM's library is 260kWh/m^2/year in year 2014. Based on the findings, technical design improvements are recommended in this study in order to improve the thermal comfort inside the library at the same time reduce the energy consumption.

ABSTRAK

Objektif kajian adalah untuk mengkaji keselesaan keadaan dalam bangunan perpustakaan UTeM dan membandingkannya dengan ASHRAE Standard 55 (2004) and Malaysia Standard MS 1525: 2014. Pengukuran fizikal dijalankan dalam keadaan kehadiran orang dan ketiadaan orang. Pengiraan Undian Andaian Purata dan Peratusan Andaian Ketidakpuasan bagi pengukuran fizikal and Undian Sensation haba mengikut kaji selidik subjektif telah digunakan untuk menganalisis kajian ini. Seperkara lagi, Statistical package for Social Science (SPSS) telah diaplikasikan untuk menganalisis linear regresi antara Undian Andaian Purata dan Undian Sensation Haba. Tenaga indeks bagi bangunan perpustakaan UTeM adalah 260kWh/m^2/year pada tahun 2014. Berdasarkan dapatan kajian, peningkatan reka bentuk teknikal akan dicadangkan bagi meningkatkan keselesaan keadaan dalam bangunan perpustakaan dan juga mengurangkan pengambilan tenaga.

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LIST OF SYMBOLS

SYMBOLS	DESCRIPTION
°C	Degree Celcius
°F	Fahrenheit
h	Hour
K	Kelvin
k	Kilo
m	Metre
%	Percent
s	Seconds
W	Watt

LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AC	Air-conditioned
ACH	Air Exchange Rate
ACMV	Air-conditioning and Mechanical Ventilation
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ATO	Ayala Tower One
BEI	Building Energy Index
CET	Corrected Effective Temperature
CLO	Clothing Insulation Value
CO2	Carbon Dioxide
DR	Draft Rate
HVAC	Heating, ventilation and air-conditioning
IAQ	Indoor Air Quality
ISO	International Organization of Standardization
MET	Metabolic Rate
MRT	Mean Radiant Temperature

MS	Malaysia Standard
NV	Natural Ventilated
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatified
RH	Relative Humidity
SBS	Sick Building Syndrome
SPSS	Statistical package for Social Science
TA	Dry Bulb Temperature
TC	Thermal Comfort
TG	Globe Temperature
TSV	Thermal Sensation Vote
UPM	University Putra Malaysia
UTEM	Univeristy Teknikal Malaysisa Melaka
V	Air velocity

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CHAPTER 1

INTRODUCTION

1.0 OVERVIEW

Air-conditioning (AC) and mechanical ventilation (ACMV) systems are installed inside a building is used to control the air temperature and improve the indoor air quality (IAQ) in order to create a better thermal condition. Thermal comfort is an important factor for designing a high quality building in order to provide a comfortable environment and good health for the people who stay inside the building. A room with thermal comfort means where 80% of the occupants inside the building could accept the environment (Sookchaiya, Monyakul, & Thepa, 2010). In order for occupants to be thermally comfortable within the available space, four environmental parameters need to be present in adequate proportion (Ibrahim, n.d.). These parameters are air temperature, air movement, mean radiant temperature, and relative humidity. Air conditioning is used to control the indoor temperature which provided comfort and good health for the occupants but there are still many people in such condition suffer from nose irritations, stuffed nose, rainy nose, eye irritations, coughing, and tightness in the chest, fatigue, headache, rash, and a lot more. These symptoms are normally called “Sick Building Syndrome” or SBS which is affected by humidity (Sookchaiya et al., 2010).

British Standard BS EN ISO 7730 defines the term “Thermal comfort” as : ‘That condition of mind which expresses satisfaction with thermal environment’. (Shaharon, M.N et al., 2012) Thermal comfort was also defined by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) as the state of mind which expresses satisfaction with thermal environment. (Shaharon, M.N et al., 2012). The ANSI /ASHRAE Standard 55 ,Thermal Environmental Conditions for Human Occupancy is used extensively as a reference for comfort levels (Andamon, 2006). According to ISO 7730, ASHRAE standards and Fanger theory there are six variables that affect on thermal comfort. These six factors can be divided into two sections which are environmental factors and personal factors. The environmental factors are air temperature, relative humidity, air movement and globe temperature. On the other hand, the personal factors are clothing insulation value (CLO) and metabolic rate (MET) (Azizpour, Moghimi, Mat, Lim, & Sopian, n.d.).

According to ASHRAE standard, a recommended comfort operative temperature for human living under climate condition such as those found in tropic country like Malaysia is around 24°C±1°C. The recommended indoor air velocity is between 0.15 and 1.5 m/s. A relative humidity between 40%-60% is considered healthy and comfortable in a comfort controlled environment according to ASHRAE standard. The Department of Standard Malaysia recommended indoor design temperature range from 23°C to 26°C.

Basically, the building sector is an energy intensive sector as huge amounts of energy need to generate in order to maintain artificial indoor climates that provide thermal comfort for its occupants that would allow them to conduct various activities in a conductive environment(RS Wafi et al., 2008). Electricity consumption in residential and commercial sectors is mainly come from the electric usage of the air-conditioning system. The design and installation of air-conditioning system to control thermal environment to achieve human thermal comfort and health inside the building should comply with the ASHRAE Standard 55-2004 which is most appropriate (Sookchaiya et al., 2010).

The main purpose of designing buildings is to make sure that most of occupants in the building are satisfied with the thermal condition. This is because most people generally spend 85-90 % of their time indoors and then providing a comfortable and healthy environment is imperative.(RS Wafi et al., 2008) Staff and students also spend most of their time in indoor. University library is a place for the university students to do their research and also a place for them gains knowledge, search for information and a lot more. Therefore, a more comfort environment is needed. A better environment can increase student's attention, concentration and productivity and minimize the possibility of heat stress when they are doing homework or research in the library. Hence, air–conditioning and mechanical ventilation system is installed into the library building especially in tropical country like Malaysia.

There are two personal factors will affect the thermally comfortable in a space, hence subjective assessment is carried out to investigate how many people dissatisfied the condition. A questionnaire survey that is to seek occupant input for the level, the frequency and the time of the thermal comfort problem as well as the general condition of the thermal environment. (Shaharon, M.N et al., 2012)Statistical package for Social Science (SPSS) is used to analyze the data collected from the subjective assessment. On the other hand, there are also various indices have been developed to describe the thermal comfort experienced inside a building such as Effective Temperature Index, Comfort index, Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD) and Corrected Effective Temperature (CET) index are common indices. (Ibrahim, n.d.)

1.1 PROBLEM STATEMENTS

This project is focusing on the air-conditioning system as it plays an important rule for providing a comfortable indoor environment for the occupants. By improving the Air Conditioning Mechanical Ventilation (ACMV) control, it can save the energy consumption in a building. Human thermal comfort needs to be evaluated so that the occupants of the building will not feel too cold or too hot. The Human thermal comfort level can be evaluated by using the ANSI/ASHRAE standard and