ENERGY PERFORMANCE AND THERMAL COMFORT EVALUATION OF UNIVERSITY LIBRARY BUILDING

MUHAMMAD ASYRAF BIN RAMLAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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MUHAMMAD ASYRAF BIN RAMLAN

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

Faculty of Mechanical Engineering

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DECLARATION

I declare that this project report entitled "Energy Performance and Thermal Comfort Evaluation of University Library Building" is the result of my own work except as cited in the references

Signature : ....

Name : MUHAMMAD ASYRAF BIN RAMLAN

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	:	PROFESOR MADYA DR TEE BOON TUAN
Date	:	....

DEDICATION

To my beloved mother and father

ABSTRACT

This study seeks to analyse the thermal comfort level in the University Technical Malaysia Melaka library and compare it with the ASHRAE Standard 55 (2004) and Malaysia Standard MS 1525:2014. Thermal comfort is very crucial for human health as well as productivity especially when people working in big building. Thermal comfort is not only depends on the air temperature but it can be obtained only when there have the proper balance between air temperature, humidity and the movement of the air. The physical measurements were carried out without occupant and with occupant condition. The Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) for physical measurements and Thermal Sensation Vote (TSV) through subjective assessment were involved in this study's analysis. Most of the PMV value were between -0 and -2, so the environment temperature in library mostly slightly cool and cool. The Indoor Air Quality measurements for air temperature, relative humidity and air velocity, most of this IAQ were not comply with Malaysia Standard range in both zone for both day and session. The operative temperature for thermal comfort cooling in University Technical Malaysia Melaka library was in the range 19^{o}C to 25^{o}C. The Building Energy Index (BEI) for University Technical Malaysia Melaka library was in range of energy efficient performance and had achieved the best Building Energy Index practice that recommended by Malaysia Standard. The Building Energy Index of University Technical Malaysia Melaka library in year 2015, 2016 and 2017 were 169.27 kWh/m^2/year, 141.92 kWh/m^2/year and 148.74 kWh/m^2/year respectively.

ABSTRAK

Kajian ini bertujuan untuk menganalisis tahap keselesaan terma di perpustakaan Universiti Teknikal Malaysia Melaka dan membandingkannya dengan ASHRAE Standard 55 (2004) dan Malaysia Standard MS 1525: 2014. Keselesaan terma sangat penting untuk kesihatan manusia serta produktiviti terutama ketika orang yang bekerja di bangunan besar. Keselesaan termal bukan hanya bergantung pada suhu udara tetapi ia hanya dapat diperoleh apabila terdapat keseimbangan yang tepat antara suhu udara, kelembapan dan pergerakan udara. Pengukuran fizikal dijalankan tanpa penghuni dan dengan keadaan penghuni. Pengiraan Undian Andaian Purata dan Peratusan Andaian Ketidakpuasan untuk pengukuran fizikal dan undian sensasi terma melalui penilaian subjektif terlibat dalam analisis kajian ini. Kebanyakan nilai PMV adalah antara -0 dan -2, jadi suhu persekitaran di perpustakaan kebanyakannya agak sejuk dan sejuk. Pengukuran Kualiti Udara Dalaman untuk suhu udara, kelembapan relatif dan halaju udara, kebanyakan IAQ ini tidak mematuhi julat Malaysia Standard dalam kedua-dua zon untuk kedua-dua hari dan sesi. Suhu pengendalian untuk penyejukan keselesaan terma di perpustakaan Universiti Teknikal Malaysia Melaka berada dalam lingkungan 19^{o}C hingga 25^{o}C. Indeks Tenaga Bangunan (BEI) untuk perpustakaan Universiti Teknikal Malaysia Melaka berada dalam julat prestasi cekap tenaga dan telah mencapai amalan Indeks Tenaga Bangunan yang terbaik yang disyorkan oleh Malaysia Standard. Indeks Bangunan Tenaga Perpustakaan Universiti Teknikal Malaysia Melaka pada tahun 2015, 2016 dan 2017 masing-masing adalah 169.27 kWh/m^2/tahun, 141.92 kWh/m^2/tahun dan 148,74 kWh/m^2/ tahun.

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LIST OF ABBREVATIONS

HVAC	Heating Ventilation Air Conditioning
ACMV	Air conditioning and Mechanical ventilation
IAQ	Indoor Air Quality
SBS	Sick Building Syndrome
IEQ	Indoor Environment Quality
MRT	Mean Radiant Temperature
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
MS	Malaysian Standard
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
FR	Free Running
CL	Cooling
BEI	Building Energy Index
CLO	Clothing insulation
MET	Metabolic rate

LIST OF SYMBOL

%	Percentage
m	Meter
s	Second
ºC	Degree celcius
Ta	Ambient temperature
Tg	Globe temperature
Va	Air velocity
Tr	Radiant temperature
Pr	Pressure

CHAPTER 1

INTRODUCTION

1.0 Background

Air-conditioning (AC) and mechanical ventilation (ACMV) is the common systems that provide occupants with better thermal condition with sufficient inflow and outflow of air within buildings by channelling treated air into the building while extracting exhaust air out, controlling and maintaining the temperature and humidity of air within buildings. This ACMV systems are placed or installed inside a building or others space is used to control the air temperature and improve the indoor air quality (IAQ) (Ismail Abdul Rahman J. C., 2014). The buildings that have high quality design concept should take into account the thermal condition or thermal comfort because they are one of the important factors.

The definition of thermal comfort in the room or buildings means above three quarter of the occupants inside the building could accept the environment. Generally, thermal comfort provides a comfortable environment and better air that will never affect people's health inside the buildings. There are six major factors directly affect thermal comfort that can be classified in two categories, there are environmental factors and personal factors (Szokolay, 2007). The environmental factors are the conditions of the thermal environment, there are four important thermal environmental factors, air temperature, air speed, mean radiant temperature and relative humidity (Szokolay, 2007). Then, the personal factors are the characteristics of the occupants such as clothing insulation value and metabolic rate.

Even air-conditioning and mechanical ventilation (ACMV) systems give us better air quality and control air temperature inside space but it still have its own weakness and disadvantages. People in buildings will tends to get suffer conditions from headache, dizziness, stuffed nose, nose irritations, flu, coughing, fatigue and many more symptoms that related to breathing. These symptoms are basically called “Sick Building Syndrome” (SBS), which is a medical condition where occupants in a building suffer from symptoms of illness or feel unwell for no apparent reason.

The energy performance of a building can be defined as the total amount of energy consumed to meet the different needs based on a standard use of the building including heating or cooling system, lighting and electrical appliances (Tort-Ausina, 2016). The building sector is one of the massive energy usage region, it is also considered for larger percentage from the total energy consumption from both the industry and transportation in many countries (S.Moghimi, 2013). Buildings required about 40 percent of the global energy consumption such as coal, natural gas, hydro, solar, or biomass and provide more than 30 percent of the carbon dioxide (CO_2) emissions (Yang, 2014). A huge portion of this energy is used for thermal comfort in buildings through heating or cooling system (Zahra Sadat Zomorodian, 2016).

1.1 Problem Statement

Thermal comfort of human in library needs to be evaluated to prevent thermal discomfort among occupants in library and to know how occupants reacts with current environment whether the current environment is too hot or too cold as well as the indoor air quality. Unacceptable thermal conditions can lead to occupant dissatisfaction which, in turn, ha a serious effect on their productivity, performance as long as their healthy (M.Budaiwi, 2007). The indoor air quality is important parameter need to be control at acceptable level to improve the productivity of occupants. There are six main parameters that affects human thermal comfort, air temperature, relative humidity, air velocity, radiant temperature, clothing insulation and metabolic rate. By implementing this case study in UTeM's library, thermal discomfort can be restrain therefore students can perform their study and work at their best performance. Thermal comfort can be evaluate by using Predicted Mean Vote (PMV) and Predicted Percent of Dissatisfied (PPD) approaches as mention in ASHRAE Standard.

1.2 Objectives

i. To conduct a thermal comfort and indoor air quality (air temperature, air velocity, relative humidity and atmospheric pressure) analysis for university library building.
ii. To compare the measurement data with ASHRAE Standard 55 and Malaysia Standard MS 1525
iii. To conduct an energy analysis of the university library building.

1.3 Scope

The scope of this study are as follows:

i. The study will focus on energy consumption and thermal comfort in the university library building.
ii. Evaluating the air-conditioning and mechanical ventilation system for energy consumption.
iii. The thermal comfort parameters such as air temperature, air velocity and relative humidity will be measured by using thermal comfort meter.