AIR AND TEMPERATURE FLOW DISTRIBUTION INSIDE TERRACE HOUSE

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DECLARATION

I hereby, declared this report Air and Temperature flow distribution inside terrace house is the results of my own research except as cited in references.

Signature: ……………………………………

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APPROVAL

This report is submitted to the Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Honours. The member of the supervisory is as follow:

Signature: ……………………………………………….

Supervisor: Dr. Ernie Binti Mat Tokit

Date:

DEDICATION

To my beloved parents

(Mutussin Bin Junaidil and Setih Harija Binti Abd Hamid)

My beloved family,

(Muhammad Fakhruz Razi Bin Mutussin, Siti Nur Farahdiyana Binti Mutussin, Muhammad Fakhrul Haiyin Bin Mutussin, Siti Nur Farhain Binti Mutussin, Muhammad Fakhrul Iman Bin Mutussin and Muhammad Fakhrul Naim Bin Mutussin)

My Supervisor,

(Dr. Ernie Binti Mat Tokit)

My lectures,

And all my beloved friends

(Azrin Ahmadin, Mohamad Ikhwan Bin Mohamed Razak, Syafiq Firdaus, Mad Haniff bin Mad Rasi, Rais Adham, Azamuddin Nasir, Muthana Jumadil, Ahmad Afiq Amsyar dan Mohd Zairunshah Bin Bernados)

ABSTRACT

Thermal comfort can be a problem for the occupants of many residential buildings, especially for terrace house, in hot and humid climates. This paper therefore presents the results of ongoing research to investigate the distribution of air and temperature flow within the terrace house. The purpose is to achieve thermal comfort level in Malaysia's naturally ventilated residential house using computational fluid dynamics (CFD) method. CFD simulations on the house model allow us to visualize the house's temperature distribution and air flow pattern and velocity. The house's thermal comfort was found to be well beyond the limits set by ASHRAE standards. Simulations were used to investigate the effects of changing the terrace house's wall height. However, there is almost no significant change in the house's temperature distribution and air flow velocity. Result also shows that the use of two air conditioners installed on the front and back walls has significant effects on temperature distribution where the average temperature is 26.3ºC but still higher air velocity which is 3.1m/s than that specified by ASHRAE. Thus, the thermal comfort level in the house is not achieved.

ABSTRAK

Dalam iklim panas dan lembap, keselesaan haba boleh menjadi masalah kepada kediaman yang mempunyai banyak penduduk terutamanya bagi rumah teres. Oleh itu, kerja ini membentangkan hasil karya penyelidikan yang berterusan untuk menganalisis pengedaran aliran udara dan suhu di dalam rumah teres. Ini bertujuan untuk mencapai tahap keselesaan haba di dalam rumah yang menggunakan pengudaraan secara semula jadi di Malaysia dengan menggunakan kaedah dinamik bendalir berkomputer (CFD). Simulasi CFD terhadap model rumah teres itu membolehkan kita menggambarkan taburan suhu dan corak pengaliran udara dan halaju udara di dalam rumah. Didapati keselesaan haba di dalam rumah melebihi batas yang ditetapkan oleh piawaian ASHRAE. Simulasi digunakan untuk mengkaji kesan perubahan pada ketinggian dinding rumah teres. Walau bagaimanpun, hampir tidak menunjukkan perubahan yang ketara pada taburan suhu dan halaju aliran udara di dalam rumah. Keputusan juga menunjukkan bahawa penggunaan dua penghawa dingin yang di pasang pada bahagian depan dan belakang dinding mempunyai kesan yang besar ke atas taburan suhu dimana purata suhu ialah 26.3ºC tetapi mempunyai halaju udara yang lebih tinggi iaitu 3.1m/s daripada yang ditetapkan oleh ASHRAE. Oleh itu, ia tidak mencapai tahap keselesaan haba di dalam rumah teres.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CFD	Computational Fluid Dynamic
MRT	Mean Radiant Temperature
M	Metabolic Rate
TE	Thermal Environment
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
CIDB	Construction Industry Development Board

CHAPTER 1

INTRODUCTION

1.1 Background Study

In the last 40 years, accelerated urbanization has led to the percentage of urban population in Malaysia, from 27 % in 1970 to 71 % in 2010 (Razali, 2016). In order to satisfy housing settlements due to the growing national population, more land will be created for urbanisation. Terraced houses in Malaysia are the most common types of residential buildings. The Malaysia terraced house is originated from the townhouses of Malacca dating back to the 17th century and the Chinese shops of the 19th century (Saji, 2012). They are also known as row houses in some areas. Terrace houses are the most living areas in urban areas in mass housing schemes. The house in Malaysia is reasonably modest and basic accommodation is an optional. In the tropical climate area, terrace houses generally encountered the hotter indoor condition caused by higher vitality contribution from sun powered.

In warm and humid climates, thermal comfort is necessary in residential and commercial buildings. The majority of residential buildings do not have air conditioning systems. They mainly rely on natural ventilation and passive cooling to achieve certain thermal comfort levels. In order for occupants to be thermally comfortable in an interior space, four environmental parameters are generally accepted to be present in adequate proportions (Halipah, 2004). Environmental parameters for thermal comfort are air temperature (Ta), mean radiant temperature (MRT), pressure (Pa) and relative air speed (Vt) and personal parameters: clothing or thermal resistance and activity or metabolic rate (M) (Fanger, 1972) . It is reasonable to consider, however, that all variables in design are interdependent. This paper used the simulation to determine the temperature flow and comfort zone within a terraced house in Malaysia. As the main variables for determining the thermal environment, the air temperature and the relative air velocity were selected. Computational Fluid Dynamic (CFD) simulations were carried out to account for indoor thermal environment (TE) and thermal comfort.

In Malaysian climate, a reasonable temperature of thermal comfort in a house ranges from 25.5°C to 28.5°C (Jones, 1993). Earlier researchers recommended similar values, such as 28.7°C (Humphrey, 1994), 26.3°C and 28.5°C (Gail, 1998). The effect of air speed in the room is well known and critical in promoting thermal comfort. For convenience, indoor air speeds between 0.15 and 1.5 m/s are recommended (Olgyay, 1963). In a warm climate, indoor air speeds of 1.0 m/s are very pleasant and up to 1.5 m/s is acceptable (Szokolay S. , 1980). Rajeh (Rajeh, 1994) suggested that air movement of 1.0 m/s would generally provide a satisfactory condition in Malaysia's terrace housing. The data published is reasonably consistent and most researchers agree that the temperature range for thermal comfort in tropical climates should not exceed 28°C and that the air velocities are in between 0.15 and 1.5 m/s.

1.2 Problem Statement

Nowadays, the hot and humid tropical climate in Malaysia is a problem for residents of many residential buildings who do not have air conditioning systems. Poor passive design of the terrace house causes heat to be trapped, which influences the indoor temperature increment and makes the occupant uncomfortable. Passive cooling in a tropical climate is difficult to achieve in terms of the design of mass housing. A good design of the house keeps the indoor environment pleasant and comfortable for most of the year without any mechanical devices. Terraced houses are typical examples with a problem of low comfort that must be taken into account. Low air velocity and high air temperature are observed during the day and the wind effect, especially in single-sided ventilation, is not well captured. The use of natural ventilation as an energy-efficient means of providing thermal comfort and a healthy indoor environment has been increasingly investigated.

1.3 Objective

The aim of this work is to analyse the air and temperature flow inside a terrace house. This general objective can be broken down into a specific objective as follow:

i. To investigate the effect of terrace house wall height on the air flow and temperature distribution, and
ii. To predict the effect of air conditioner in the terrace house in order to achieve thermal comfort

1.4 Scope of Project

The scope of the project is the limitation that must be put to ensure the project meet the objectives. The several scope of this project is:

i. The design of the terrace house based on the past study
ii. Mean velocity of air flow is around (0.3m/s –0.8m/s).
iii. Temperature mean 29°C -32°C.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter reviews the analysis on the flow and temperature distribution inside terrace house.

2.1 Terrace House

The Malaysia terraced house or originated from the townhouses of Malacca dating back to the 17th century and the Chinese shops of the 19th century (Saji, 2012). In some areas they are also known as link-houses or row-houses. Terrace houses are the most living areas in urban areas in mass housing schemes. It is also the most common typology of housing in Malaysia and has been constructed linearly in rows, sharing common walls and can be in the form of a single or multiple story as shown in Figure 2.1. According to the fire department regulation, the length of each row cannot exceed 96 meters, so that a maximum of 16 houses can be built in a row. The unit width is over 6 meters for high-cost housing and 4.3 meters for low-cost housing. The built-up area of each unit is normally 130~170 square meters. The minimum built-up is 50 square meters for low cost house (Omar, 1990).

The finishing unit plot size is larger than the intermediate units in the middle of a row. The design and planning of a unit is almost repeated due to the restriction of space and the monetary dimension. In the ground floor there is usually a combination of living and dining area and a kitchen. On the second floor, there is the front main bedroom and two back bedrooms if the built terrace house has two floors. This limited planning often resulted in the owner extending the buildings to the space to increase the living space. One local expert explained that this phenomenon was considered the freedom of self-transformation of a resident and also demonstrated one of the reasons for the general preference for a terrace house.

Figure 2.1 Terrace House (PropertyGuru, 2016).

2.2 Thermal Comfort

Thermal comfort is defined as 'the state of mind,' which expresses thermal environment satisfaction by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE, 2004). It also define as “a state in which there are no driving impulses to correct the environment by the behaviour” (Hensen, 1990) where thermal comfort is the absence of heat or cold irritation and discomfort, and the state of pleasure. Alternatively, the person is not fully aware of the thermal condition of the environment and does not consider whether the space in which he or she stays is too hot or too cold.

Personal differences, such as mood, culture and other individuals, organization and social factors, influence thermal comfort. Environmental parameters for thermal comfort are air temperature (Ta), mean radiant temperature (MRT), pressure (Pa) and relative air speed (Vt) and personal parameters: clothing or thermal resistance and activity or metabolic rate (M) (Fanger, 1972). The purpose of this paper is to simulate the indoor thermal environment and the comfort of a terrace house. As the main variables for determining the thermal environment, the air temperature and the relative air velocity were selected. It is therefore reasonable to consider that all variables of the design are interdependent.

2.2.1 Comfort Zone

The comfort zone can be defined as "a thermal condition in which the occupants make little or no effort to adapt their bodies to the surrounding environmental conditions". The greater a person's efforts, the less comfortable the climate is. Usually, maximum comfort cannot be achieved. However, it is the designer's job to build homes that offer an indoor climate close to an optimum within a certain range of thermal comfort. It also depends on the clothing worn, the physical activity, health condition and age. It also depends on the wear of clothes, physical activity, health and age. Although the ethnic difference is not so important, the geographical location plays a role due to the habit and the capacity of individuals to acclimatize. In addition to psychological and physiological factors, the comfort zone is determined by four main factors:

- Air temperature
- Temperature of surrounding surfaces (radiant heat)
- Relative humidity

- Air velocity

For comfort zone a number of scales have been developed, some of which are shown in Table 2.1.

Table 2.1 Scales of thermal sensation (ASHRAE, 2004)

	ASHRAE	Fanger	Rohles & Nevins	Gagge's DISC	SET* (°C)
Painful			+5	+5	
Very hot			+4	+4	37.5-
Hot	7	+3	+3	+3	34.5 – 37.5
Warm	6	+2	+2	+2	30.0 – 34.5
Slightly warm	5	+1	+1	+1	25.6 – 30.0
Neutral	4	0	0	0.5	22.2 – 25.6
Slightly cool	3	-1	-1	-1	17.5 – 22.2
Cool	2	-2	-2	-2	14.5 – 17.5
Cold	1	-3	-3	-3	10.0 – 14.5
Very cold			-4	-4	

*SET: Standard Effective Temperature

2.2.2 Air Temperature (Ta)

Malaysia in the equatorial region with warm and humid weather all year round. The climate has been characterized by high temperature and moisture. Malaysia is situated between 1 and 7 degrees North latitude and extends from 100 to 119 degrees East longitude. It has a minimum diurnal temperature range of 23 to 27°C and a maximum temperature of 30 to 34°C. Figure 2.2 shows changes in the average ambient air temperature in the different sections of the terrace house, when the house is naturally ventilated. In all sections, the air temperature decreases from about 29°C at 12AM to about 27°C at 6AM. Thereafter, the air temperature increases and reaching the highest value of about 31°C at 6PM. The air temperature limits for acceptable thermal comfort as specified in the ASHRAE standard are also shown in Figure 2.2 (ASHRAE, 2004). It can be seen that the average ambient air temperature inside the house is well beyond the limits of acceptable thermal comfort at any given time.

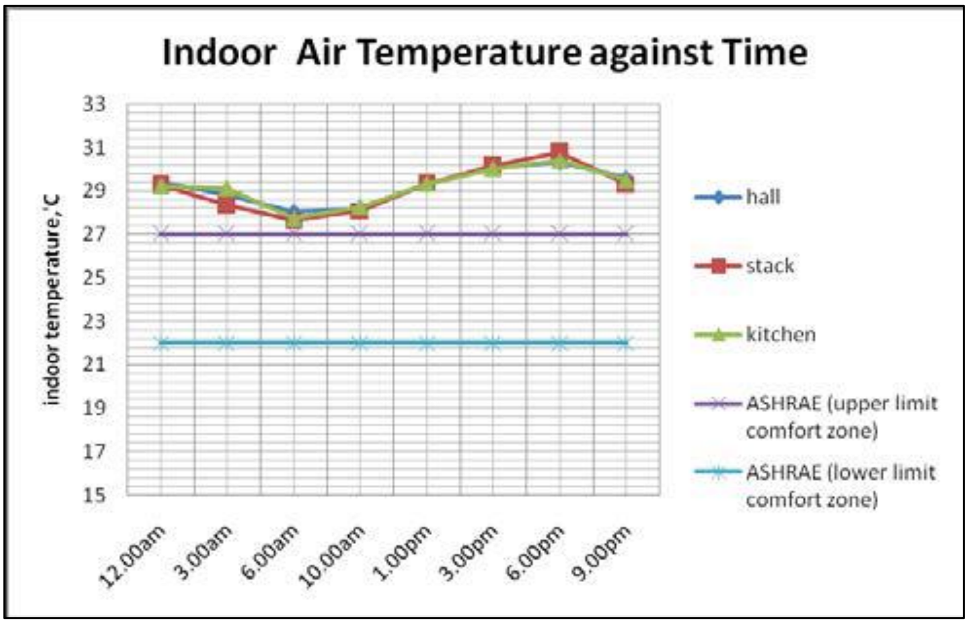

Figure 2.2 Average air temperature variation inside the terrace house (Haslinda Mohamed Kamar, 2011)

2.2.3 The Relative Air Velocity

Malaysia is experiencing seasonal, monsoon-dominated climate change. The seasonal pattern of wind and rainfall in this region is a predominant climate characteristic. Winds of monsoon occur twice a year, i.e. Monsoon northeast and southwest. The Southwest Monsoon comes from Australia and blows from May to September over Sumatra Island and the Straits of Malacca. The North - East Monsoon originates from the Central Asian continent and blows from November to March through the South China Sea through Malaysia to Australia. Inter-monsoon winds occur during the months of April and October.