"Saya akui bahawa saya telah membaca karya ini dan pada pandangan saya karya ini adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Termal-Bendalir)

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POTENTIAL OF INDUCING NATURAL VENTILATION FOR LOW RISED HOUSE UNDER TROPICAL CLIMATE

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Laporan ini diserahkan kepada Fakulti Kejuruteraan Mekanikal sebagai memenuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Termal-Bendalir)

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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya"

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Abstract

This project is titled "The Potential of Inducing Natural Ventilation for Low Rise Buildings Under Tropical Climate" where it explains the fundamentals of natural ventilation and focuses in determining wind speed, temperature and humidity for different types of dwellings. Three experiments have been carried out in three different types of residential building to determine wind speed, temperature and humidity. The first experiment is carried out using only Anemometer where else the second and third experiment uses more equipments such as the MKII Weather Station, Ambient Weather Software and Wolfsense VeloCical Meters. Analyses are done to estimate the natural wind driven potential, temperature, and humidity for the three houses. Comparison is done between the second and third house as both these houses uses the same equipments. This study is limited to an experimental approach where possible factors that affect the wind speed, temperature and humidity in the three houses are discussed. Recommendation based on past works and journals is inserted together with this report where it explains possible steps that can be taken to induce natural ventilation for low rise buildings.

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CHAPTER 1

INTRODUCTION

Malaysia is divided into Peninsular Malaysia and East Malaysia. Peninsular Malaysia, adds up to 131,598 km2, bordering Thailand in the north and Indonesia in the west, Singapore in the south and the Philippines in the east. East Malaysia covers 198,069 km2 and borders the territory of Indonesia's Kalimantan in the south and the Kingdom of Brunei in the middle. In Peninsular Malaysia a mountainous spine known as the Main Range runs from the Thai border southwards, effectively separating the eastern part of the Peninsula from the western part.

The Tropics is located between 23.5°N and 23.5°S beginning from the Equator. The Equatorial Zone is located between 10°N and 10°S. Malaysia lies near the Equator between latitudes 1 and 7 °North and longitudes 100 and 119 °East, therefore Malaysian climate can be classified as warm-humid equatorial. (Abd.Rahman, 2004) This is characterized by the high ambient temperatures with air temperatures averaging at 23°C for the minimum and at 33°C for the maximum with small diurnal and annual ranges. Malaysia also experiences high humidity throughout the year averaging more than 80% relative humidity (Abd.Rahman, 2004). Malaysia is subjected to maritime influence and the interplay of wind systems, which originate in the Indian Ocean and the South China Sea.

Figure 1.0: Location of study area; Melaka in Peninsular Malaysia (from World Book Atlas,1993)

The year is generally divided into Southeast (April to October) and the North-east (October to February) Monsoon seasons. Winds are erratic and of varying speeds at ground level and at almost 50% of the year wind as low as 0.3m/s is experienced and this is considered calm. For the months April-May and September-October, less rain is experienced because of changes in monsoonal winds.

Most Malaysians spend the majority of their lives indoors where research has shown that in order for Malaysians to reach thermal comfort level, indoor temperature should be maintained between 25°C and 28°C. (Ann Surin, 2005)

1.1 Ventilation

Ventilation has historically been applied and viewed as both a desirable and effective technique in improving thermal comfort and general air quality and comfort in buildings. The desired effect of ventilation, whether it is natural or mechanically induced, is to enhance or protect the quality of air in the space being ventilated. Ventilation causes exchange of air within building spaces and between building interiors and the outside environment. (Godish, 2001) Ventilation is used to:

i) Dilute and remove contaminants
ii) Enhance thermal comfort
iii) Remove excess moisture
iv) Enhance air motion
v) Improve general comfort
vi) Maintain pressure difference between zones

1.2 Mechanical Ventilation

Mechanical ventilation can be defined as ventilation that is created by fans or other air-moving devices within a building, which can be divided into the following classifications:

i. Mechanical extract- induced inlet.
ii. Mechanical inlet – forced outlet.
iii. Mechanical inlet – mechanical outlet.

Most large commercial, offices, and institutional buildings constructed recently are mechanically ventilated. Use of mechanically ventilation is often required in building codes i.e. ASHRAE, BSI or BSRIA where it represents as what can be described as good practice for building system designers and architects. Buildings are being designed to provide year round climate control. To ensure optimum operation of heating, ventilating, and air conditioning (HVAC) systems, windows are sealed so they cannot be opened by occupants to provide ventilation. The availability of outdoor air for space ventilation depends on the design and operation of HVAC systems as well as air that enters by infiltration and exfiltration processes. (Fellow, 2001) Mechanical ventilation is used in buildings to achieve and maintain a comfortable and healthy indoor environment.

1.3 Natural Ventilation

Natural ventilation can be classified as ventilation achieved by means of wind forces or density differences or combination of the two, as opposed to mechanical ventilation, which depends on rotodynamic device. In other words natural ventilation uses natural means to maintain temperature within the thermal comfort range without any mechanical or forced ventilation. Natural means can be achieved by air exchange (movement of wind) through designed inlets and outlets in a building. The air exchange is caused by buoyancy and wind induced forces. The predominant buoyancy force is due to thermal difference and the chimney effect. Naturally ventilated buildings have indoor temperatures within a few degrees of the outside temperature. (Abd Rahman, 2004)

1.4 Wind

Wind is the movement of air from high-pressure area to low pressure area. The greater the differences in pressure between the two areas, the stronger the wind will be. (Godish, 2001) Air movement is the most important element for natural ventilation. It increases cooling by increasing evaporation rates. Wind originates from the sun's energy. The solar radiation heats up the earth. The earth absorbs, reflects and reradiates the heat thus creating a zone of low pressure due to the heated air above the earth becoming less dense and buoyant. The hot air will ascend to the higher levels of the earth atmosphere. The vacuum it creates while leaving its original position is filled up by air from a zone of high pressure. The movement of air from the zone of high pressure to the zone of low pressure is called wind. Therefore wind occurs only when there are these two zones happening naturally (Fellow, 2001). Good orientation, passive shading, insulation and design of the building provide adequate cooling during hot seasons. An air speed of 0.5m/sec equates to a 3 degree drop in temperature at relative humidity of 50 percent. (Kreider, Curtis, 2002) .

1.5 Problem Statement

Malaysia's climate is a tropical climate with hot and humid conditions all year long. Under these weather conditions, ventilation plays a crucial role in providing Malaysian homes with fresh and clean air. More and more houses are being built in Malaysia with double storey house being the popular choice with both the developers and house buyers.

Houses that are not carefully designed or do not include natural ventilation as a factor will end up with poor air circulation and the internal temperature rise during

the day making the occupants of the house uncomfortable (Surin, 2005). Air is required in houses for people to breath and for certain appliances (cloths dryers, kitchen hood, and exhaust fan) to function as designed. Air moving through houses can remove moisture and increase the longevity of the building materials.

Most house owners nowadays install air conditioning unit to keep the indoor temperature cool and comfortable. For these air conditioning units to work efficiently all the openings should be closed, thus preventing fresh air from entering the premise.

The appliances used in the house can suck air from the house. For an example a dryer can suck cubic feet of air per minute (cfm) out of the house when it is running where else a kitchen hood can suck air from 500-1000 cfm out of the house (Jacobson, Janni, 2003). With that level of mechanical exhaust, naturally appliances such as water heater or furnace can easily back draft, bringing carbon monoxide and other harmful gases into the house. Turning on a mechanical ventilation system or exhaust fan at that point will only increase the problem.

With an increase awareness of the cost and environmental impact of air conditioners and other appliances alike, natural ventilation has become an increasingly attractive method in reducing energy use and cost and for providing an acceptable indoor temperature in maintaining a healthy and comfortable lifestyle.(Abd Rahman, 2004)

This project is to determine the wind speed, temperature, and humidity of various types of houses found in Malaysia and identifying the factors that influence it and coming out with suggestions to improve the thermal comfort level in these dwellings.

1.6 Importance of Study

The study is beneficial where the data such as temperature distribution and wind speed can be used as a guideline by house developers to come up with more energy conserving buildings or design. Also with the findings of the study the specific area in a house which is more prone to receive less ventilation can be identified and steps can be taken to overcome it. This is particularly useful for those who are involved in the planning and design process of a house or building. This study focuses on three different types of houses in Melaka with different location and construction make.

1.7 Objectives

1) To study the potential level for inducing natural ventilation for a residential building under local climate.
2) To determine and visualize the indoor ventilation rate using experimental method.
3) To determine Wind speed, temperature, and Humidity in residential building
4) To identify factors that influence Wind speed, temperature and humidity in residential buildings.

1.8 Expected Result

From the experiment, the ventilation rate required in a residential building is obtained. The temperature, humidity and wind speed data is obtained in the houses for comparison. Comparison is then done to compare the wind movement in these houses and also to determine the factor that influence its speed. Data related to climate such as humidity and temperature is also obtained. Surrounding factors is also identified that influence ventilation in the houses experimented. Graphs showing these data's are also drawn for analyses and comparison purpose.

1.9 Scope of Study

i) The survey of local climate i.e. temperature distribution, wind direction wind speed and humidity.

ii) The study of natural ventilation principle.

iii) Estimate the amount of ventilation in a residential building using experimental method.

iv) Compare result/findings with existing case studies and also between the houses measured

CHAPTER 2

LITERATURE REVIEW

Ventilation is the movement of air within a space where contaminated air is replaced by fresh air. Ventilation can be generated either naturally or mechanically. Mechanical ventilation is where air movement is created by fans or other moving devices within a space or building where else natural ventilation is air movement created by wind forces, thermal forces or a combination of both as opposed to mechanical ventilation.

Natural Ventilation is the controlled flow of air through doors, windows, vents, and other purposely provided openings caused by stack effect and wind pressure.(Fellow,2001) Natural Ventilation is used in spaces with a significant heat release, when process and hygienic requirements for indoor air quality allow outdoor air supply without filtration and treatment. Natural Ventilation allows significant air change rates for heat removal. Though airflow through the buildings with natural ventilation is caused by both wind effect and buoyancy forces, design principles typically do not include a wind pressure component. Wind speed and direction can change over wide ranges and thus wind does not provide a stable force to move air through the building (Godish, 2001) In general, maximum air change in the building is required in the summer, with a maximum heat load and minimal temperature difference between outdoor and indoor air.

With a change in the heat load, natural ventilation allows for self adjusting air flow through building. Airflow through an opening used for natural building ventilation is approximately turbulent. Air outlets are designed such that their pressure characteristics are negative, which improves their performance in the presence of wind (Fellow, 2001).

2.1 Thermal Comfort

Fanger (1970) defines thermal comfort as a state of mind of a person who is comfortable with his surroundings. Givoni (1976) on the other hand states that thermal comfort as a surrounding which is neither too hot nor too cold which is pleasant to the human body. The required ventilation rate in a space or building depends on the thermal comfort level of humans. In Malaysia, the thermal comfort range has been determined at between 25°C and 28°C. (Ann Surin, 2005).

2.2 Factors that influence Thermal comfort

a) Air Temperature
b) Mean Radiant Temperature
c) Air Flow Rate
d) Activity Level
e) Clothing
f) Relative Humidity

a) Ambient or Air Temperature

Scientifically there is no ideal "ambient temperature". The temperature that most people are comfortable with is taken as the ideal temperature. Ambient temperature can be measured using normal dry bulb thermometer. Malaysian thermal comfort temperature is between the range of 25.5°C to 28°C (Abdul Rahman, 2004)

b) Mean Radiant Temperature

Mean radiant temperature is the average surface temperature of a space or room. Mean radiant temperature can also be classified as a constant temperature of a surface in an enclosed space where there is heat exchange between human and the surface mentioned and the heat exchange is the same with heat exchange through radiation in an actual environment.Heat exchange happens between room surfaces such as wall, ceiling, floor and other heat source (i.e. computer and other electrical equipments). Heat source from the sun through windows is the biggest contributing factor for mean radiant temperature.. If the sun ray is reduced, the temperature will also be reduced. In terms of measurement, mean radiant temperature is difficult to measure precisely because it involves characteristic of shape and surface which radiates.

c) Air flow rate

Air flow rate influences the thermal comfort level in a space or room. High air flow rate will reduces the thermal comfort level and low air flow rate will create a draught effect. Air flow rate with the value around 0.1m/s will create stuffiness where else value above 0.8m/s will disperse the surrounding air. Normally the value of air flow rate in a room will be in the range of 0.1-1m/s (15-25fpm). (Dean, 2005)

d) Activity

Human have to carry out activities (i.e. working, walking, etc) all day. When these activities are carried out, heat is produced by the body depending on the level of activity that is being done. To carry out any kind of activity human need energy and these energy is obtained through food where it function as a fuel as fuel to the human body. The metabolism process includes the breakdown of protein, fat and carbohydrate molecules to smaller particles to feed the body.

Energy that is saved needs to be released. Even when seated, the human body still generates heat. The metabolic heat is divided into Wet heat generation and Activity heat generation.

e) Clothing

The unit for clothing is given as "clo". This unit is the measurement of the thermal resistance which include the insulation given by any layer of air which is trapped between the skin and clothing. 1 clo is equivalent with 1 met activity with temperature at 21°C (69.8°F), relative humidity at 50 % RH and air flow rate of 0.01m/s (20fpm)

f) Relative Humidity (RH)

Human are more sensitive towards temperature compared to relative humidity (RH). Humidity is the amount of moisture in air. Relative humidity can be defined as the ratio of the partial pressure of the water vapor in moist air at a given temperature to the partial pressure of water vapor in saturated air at the same temperature. The ability of air to evaporate sweat and cool the body decreases with the increase of humidity in a space or room.High relative humidity (>70%) tend to make human feel sticky where else if relative humidity is low (< 20%) sweat is easily evaporated and making the skin dry. This will cause illness to humans such as fever, headache and etc.

Relative humidity can be measured using a sling psychrometer or other digital devices or other digital devices such as Amometer and Barometer. For this thesis the velocical meter is used to determine the relative humidity level in the houses experimented.

2.3 Factors Influencing Indoor Room Air Flow

Air and contaminant (i.e., dust mixtures, vapors and gasses) movement in a ventilated space are affected by different external and internal forces such as

a) Air flow forced through intended and unintended openings in the building envelope, which depends on the pressure difference across the opening resulting from wind pressure on the building envelope.

b) Temperature difference between the indoor and outdoor air.

c) Air currents produced by process equipment or moving people (Air currents from process equipment are usually found in industrial ventilation i.e. office and factories which uses heavy machinery. For naturally ventilated residential building the movement of people is usually the factor for air currents.