AN EVALUATION OF FACTORS AFFECTING THE CHOICE OF THE DIFFERENT ROOFING MATERIALS IN RESIDENTIAL WITHIN KEDAH STATE OF MALAYSIA

FATIMAH NUR BINTI MOHAMMAD AMIN

SCHOOL OF CIVIL ENGINEERING

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By

FATIMAH NUR BINTI MOHAMMAD AMIN

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Name of Student: Fatimah Nur Binti Mohammad Amin

I hereby declare that all corrections and comments made by the supervisor(s)and

Signature:

(Signature of Student)

Name of Student : Fatimah Nur Binti Mohammad Amin

Date : 10/08/2022

Approved by:

(Signature of Supervisor)

Name of Supervisor : Ts. Dr. Md Sayuti Ishak

Date : 10/08/2022

Approved by:

(Signature of Examiner)

Name of Examiner : Assoc. Prof. Ts. Dr. Farid Ezanee Mohamed Ghazali

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ABSTRACT

The roof of the building is one of the most important structural elements that performs the protective and insulating functions for heat preservation and overheat protection, protection from external adverse factors for all types of precipitation, wind, melt water. There are two parts to a roof, its supporting structure and its outer skin, or uppermost weatherproof layer, which is directly exposed to atmospheric influences. This part of the roof shows great variation dependent upon availability of material, (J. Testa, 2017). The roof also has its own importance, according to Christopher Gorse (2012b) The roof is the very upper part of a building that protects structures and other elements from rain. Water had to be able to run off the structure, therefore it had to be appropriately sloped. However, if designed and built incorrectly, they might be a never-ending source of problems. The definition of a roof is a climax house, which is on top once and serves as the main protector from hot, rainy to the occupants in the house (Library). This study aims to identify the problem of roofing type and material from the perspective of the occupants to identify the suitability of the use of roofing material and type for residential houses. Respondents for this study were occupants of houses either self-built or completed houses from developers. This study uses questionnaire methods distributed on social media are presented in the form of tables and graphs. The results of the study found two the main problem is the problem in terms of the type and material of the roof of the house. While for the maintenance perspective for the roof problem because it is sloppy and not worth it. The suitability of the roofing material can be seen that the use of roofing this type is not very suitable for use in Malaysia due to hot climate factors and rainfall throughout the year simultaneously affecting the structure this type of roof.

ABSTRAK

Bumbung adalah salah satu elemen struktur yang paling penting yang melaksanakan fungsi perlindungan dan penebat untuk pemeliharaan haba dan perlindungan terlalu panas, perlindungan daripada faktor buruk luaran untuk semua jenis pemendakan, angin, air cair. Terdapat dua bahagian pada bumbung, struktur penyokong dan kulit luarnya, atau lapisan kalis cuaca paling atas, yang terdedah secara langsung kepada pengaruh atmosfera. Bahagian bumbung ini menunjukkan variasi yang besar bergantung kepada ketersediaan bahan, (J. Testa,2017). Bumbung juga mempunyai kepentingannya yang tersendiri, menurut Christopher Gorse (2012b) Bumbung adalah bahagian paling atas bangunan yang melindungi struktur dan elemen lain daripada hujan. Air mesti dapat mengalir dari struktur, oleh itu ia perlu bercerun dengan sewajarnya. Walau bagaimanapun, jika direka dan dibina secara tidak betul, ia mungkin menjadi punca masalah yang tidak berkesudahan. Definisi bumbung ialah kemuncak rumah, yang berada di atas sekali dan berfungsi sebagai pelindung utama dari panas, hujan kepada penghuni di dalam rumah (Pustaka). Kajian ini bertujuan untuk mengenal pasti masalah jenis dan bahan bumbung dari perspektif penghuni untuk mengenal pasti kesesuaian penggunaan bumbung bahan dan jenis bagi rumah kediaman. Responden bagi kajian ini ialah penghuni rumah sama ada bina sendiri atau rumah siap dari pemaju. Kajian ini menggunakan kaedah soal selidik yang diedarkan di media sosial dipersembahkan dalam bentuk jadual dan graf. Hasil kajian mendapati dua masalah utama iaitu masalah dari segi jenis dan bahan bumbung rumah. Manakala bagi perspektif penyelenggaraan bagi masalah bumbung kerana leceh dan tidak berbalaloi. Kesesuaian bahan bumbung pula dapat dilihat bahawa penggunaan bumbungjenis ini tidak berapa sesuai digunakan di Malaysia kerana faktor iklim panas dan hujan sepanjang tahun sekaligus memberi kesan terhadap struktur bumbung jenis ini.

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Chapter 1

INTRODUCTION

1.1 INTRODUCTION

One of a building's most critical components is the roof assembly. It is an assembly of interconnected components used as part of a building structure to protect the interior, materials, and human occupants of a structure from the surroundings. All roofs can be divided into two categories are flat and pitched roofs (Tong,1990b). The roof of the building is one of the most important structural elements that performs the protective and insulating functions for heat preservation and overheat protection, protection from external adverse factors for all types of precipitation, wind, melt water. There are two parts to a roof, its supporting structure and its outer skin, or uppermost weatherproof layer, which is directly exposed to atmospheric influences. This part of the roof shows great variation dependent upon availability of material, (J. Testa, 2017). A roof is a flat or steep structure that protects a structure from the surroundings. To sustain self-load, roof covering loads, and wind loads. Roof structures are made of steel, concrete, or wood. The roof that is constructed should meet the following requirements and functions of stability, durability, strength, weather resistance, fire resistance, thermal insulation properties, and the building's appearance (Stephen emit,2018). The most common roof

system for most tropical homes in Malaysia is a pitched roof. The roof's varying angles and colours have different effects on the internal environment.

The structure of the house plays an important role in addition to ensure the stability of the house. The structure is a self -supporting part of the building made of reinforced concrete, steel, wood. The structure also has two important parts, namely the substructure and the superstructure which has its own function. Substructures are located underground like foundations besides serving to support superstructures, while superstructures are the main frame of a building that is above ground such as exterior walls, roofs or steel frames supported by foundations or substructures (LLP, 2012).

Both elements play an important role for support each other. For example, the frame element becomes the main structure of the house in addition to further strengthening the construction of the house. Apart from the frame elements, the roof elements are also important to provide comprehensive protection to the entire house. Roofs can be designed in a variety of different shapes to look beautiful, have a long durability but there may be some situations where the design of the roof is not suitable for its original function.

The roof also has its own importance, according to Christopher Gorse (2012b) The roof is the very upper part of a building that protects structures and other elements from rain. Water had to be able to run off the structure, therefore it had to be appropriately sloped. However, if designed and built incorrectly, they might be a never-ending source of problems. According to Patterson (2003), roof drainage, water vapor transmission, wind uplift, hail impact, fire resistance, foot traffic, and chemical pollution prevention are all significant factors to consider when designing and selecting a roof.

Furthermore, roofing systems are the primary component of a city's structure that interacts directly with solar radiation. As a result, roof angles and claddings are among the most important factors that can have a significant impact on the inside atmosphere. In hot, humid climates, the pitched roof system is the most frequent construction design for both traditional and modern buildings.

According to Vijaykumar, Srinivasan, and Dhandapani (2007), the roofing system accounts for 70% of a building's overall heat gain. The colour of external surfaces, particularly the roof, has a significant impact on the amount of heat gain in buildings and the internal temperature, especially in unheated spaces. Concrete, clay, and metal sheets are common roofing materials are used in hot and humid climate zones, particularly in Malaysia. Roofing materials are often chosen based on the needs of the home buyer and the climate condition. The type of roof material tiles chosen is also influenced by the budget.

1.2 PROBLEM STATEMENT

Malaysia is a hot and humid country with high ambient temperatures and relative humidity, and the building roof is exposed to direct sunlight throughout the day. As heat passes through the roof tiles, it becomes trapped in the attic space and flows into the ceiling material. On hot days, people in residential structures suffer from significant thermal discomfort due to heat radiated from the ceiling. Malaysia is in the tropical zone, 3 degrees north of the equator, and receives an even distribution of rainfall throughout the year. High temperatures of 22 to 33 °C are experienced due to intense solar radiation and high relative humidity. (Al Yacouby et al., 2011). With up to 8.7 hours of sunlight

per day (Malaysia Meteorological Department, 2014)., the average annual solar radiation level for a tropical climate ranges from 4.21 kW h/m^2 to 5.56 kW h/m^2 (Azhari et al., 2008). The hottest period of day, according to Abdul Rahman et al. (2009), is between 11.30 a.m. and 4.30 p.m. The recommended comfort temperature for residents under climatic conditions is roughly 24±1 °C, according to ASHRAE 55-1992 (1992) standards. According to Noor Aziah (2008), Malaysian concrete terrace houses are thermally comfortable enough to be occupied for only a few hours per day. Before it reaches the comfort temperature level, the interior temperature inside the thermal comfort temperature is only for a short time.

The house's poor passive design is to blame for the rise in temperature. The passive design may assist in keeping the temperature within the house within a tolerable range. The discomfort of residents in a non-air-conditioned building is mostly caused by heat transmitted via the roof structure and poor passive design of the structure (Vijaykumar et al., 2007). Because of the poor ventilation provisions in modern low-income housing design, a roof design challenge arises (Ibrahim, 2004). As a result, the current study's major focus is on the top half of a building that is exposed to direct sunlight. The attic region traps a portion of the heat that is transmitted from the roof surface. As a result, the temperature in the top section of the house rises. The trapped heat causes a higher temperature in the attic area because of poor passive design, especially during peak hours in a hot climate location. Because of stagnant air, heat transmits from the roof to the ceiling, stores inside the concrete walls and floor slabs, and provides a higher internal temperature (Abdul Wahab and Ismail, 2012).

A good roof system, it is widely agreed, necessitates adequate design, quality materials, quality installation, regular inspection, and proper maintenance (NRCA,2000).

Because the building owner's budget was insufficient, many organizations were unable to do preventive maintenance (James, W.P, 2004). Certain can be decreased if the contractor has a good preventative maintenance scheme in place. As a result, preventive maintenance is critical for detecting faults and extending the service life of the roofs.

Malaysia's roofing system has not been thoroughly researched and implemented. According to Isa et al. (2010), there were over 1.6 million terrace houses in the country, housing over seven million people, and most of the roofs were made of cement or clay tiles. Furthermore, except for some modified thin layer insulations beneath the roof tiles, most of these structures have no insulation materials. Roofing materials in Malaysia are characterized as 85 % concrete roof tiles, 10% clay tiles, and 5% metal tile, according to a survey done by Allen et al. (2008). Most roof tiles, according to Al Yacouby et al. (2011), were dark in colour which means they absorb more heat. As a result, Malaysian houses have substantial solar radiation gains, particularly from the roofs, making the occupants uncomfortable.

1.3 AIMS AND OBJECTIVES

The goal of this study is to develop a set of recommendations for the best roofing option for consumers in terms of cost, maintenance, design, system, insulation, and materials, which will help to establish a standardized assessment for houses roof in Malaysian weather conditions.

Two objectives were set to fulfil the study's ultimate purpose:

I. To evaluate factors affecting roofing materials faced by the house occupant.

II. To recommend the best choice of roofing materials used under Malaysian weather conditions.

SCOPE OF THE RESEARCH

According to Al Yacouby et al. (2011), roughly 75% of Malaysians rely on air conditioning to keep their indoor temperatures at a comfortable range. Residents in the residential sector utilize electricity to operate the mechanical cooling system, which raises the cost of operation and maintenance (Cowan and Smith, 1983). Concerns about modern comfort standards, social conventions, and design practices have increased the demand for energy issues, making mechanical cooling one of the most essential components in daily living (Abdul Rahman et al., 2013). As a result, this research is critical in identifying the flaws in present passive design and developing recommendations for improving local practice, particularly in modern house design. The results of this study will help to reduce and maintain the indoor temperature in current housing designs. Furthermore, it would reduce and lessen the cost of electricity usage.

This study focuses on residential homes that use roofing materials and roofing systems. This is because various roofing materials are seen as an option among developers as well as consumers for most housing projects today. The respondents involved are the public and contractors carrying out housing projects. The suitability of the roofing material will be seen from five aspects such as suitability in terms of design, maintenance, safety, installation, and comfort. This study focuses on the problem of roofing material from the aspect of occupants and its suitability for residential houses. The study area covers the whole of Malaysia.

1.4 LIMITATION OF THE STUDY

The purpose of this study is to identify the issues that users have with roofing materials, systems, and roof ventilation design, as well as to determine the suitability of this type of roofing material for residential houses. This can give an indication of the problems that may arise, which can then assist the parties concerned in reducing and preventing these issues from recurring. Furthermore, the practicality of this roof's use can be shown, and it can be employed as a backup if necessary.

1.5 RESEARCH CONTRIBUTION

The research has made contributions to the body of knowledge, society, and research community. The body of knowledge on roofing materials is enhanced by the establishment of quantification and understanding of the effect of design systems and insulation on building heat transfer in Malaysian weather conditions. Projection in cost savings and reduction of electricity consumption towards inducing awareness and preparedness among the society to implement insulation in buildings and appreciate the benefits of conserving electricity. The research has contributed to the research community through the publication of indexed book chapters and conference items. Publications produced from this work are listed in Appendix A.

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

Roofs can be designed in a variety of shapes either shaped pitched or flat. The combination of these forms may or may not be suitable for use over a long period of time. The roof is the most important element in the construction of the house because it provides protection and comfort to the occupants while giving aesthetic value to the physical of the house. Roofs can be classified into three main components namely roof structure, roof covering and roof pipes. The roof is the most important part of a building because it is the roof that protects its occupants from rain and sun. According to (Merriam-Webster) the roof is the cover of the building, the highest point. The roof is also defined as is the top of the house, which is on top once and serves as the main protection from heat and rain to the occupants inside the house (Pustaka). Basically, the roof serves to provide protection to the occupants of the house.

2.2 TYPE OF ROOFS

According to (Greeno, 2010) roofs are classified by type as flat roof and pitched roof. According to (Sperling), roof can also be classified as flat roof, pitched roof and shell roof. (Tong, 1990b) divides roofs into pitched roofs and flat roofs. There are various

opinions about these types of roofs, but it can be concluded that the most important types of roofs are flat roofs and pitched roofs.

2.2.1 FLAT ROOF

A flat roof is a roof that has a gradient of 0° to 10° (Greeno, 2010). Flat roofs can be designed large or small depending on the design of the building. Flat roofs are also defined by having a roof below 1.5 degrees or a fall of 1 in 40 and can consist of different products ("Flat Roofs-Definition & Types," 2014). According to (Seeley, 1995a), flat roofs have two types of namely wooden flat roofs and concrete flat roofs. Nevertheless, concrete flat roofs are more widely used nowadays. For some owners' house, a large space on a flat roof surface can be used as additional space for resting, a space to hang clothes or any other activity that can optimize the use of such space.

The flat roof frame consists of wood, iron, beams, concrete, or concrete slabs and covered with waterproof materials such as sheets of asbestos, zinc, galvanized iron asphalt, copper and so on (Tong, 1990b). Flat roof construction is very common because the flat surface provides an additional floor that can be used for re-purposes, and flat roof thermal insulation is generally not waterproof and responsible for cracking (Hunter, 1947)

Flat roof construction does not require skilled labour or special transportation facilities, or the use of machinery and tools which is special and expensive except in special circumstances (Sperling). This matter shows the installation of a flat roof does not require high costs because of cost savings in terms of labour and machinery. Generally, the roof flat is a flat -shaped roof and has less than 15°.

2.2.2 PITCHED ROOF

A pitched roof is a roof that has a slope exceeding 10° (Greeno, 2010). According to "Dictionary of the English Language" 2011) a pitched roof is defined as a roof that has two sides roof and have a sailing stock or have two slopes forming a triangle at both ends. Pitched roofs have various types and have varying roof designs. Pitched roofs are usually easy to find in any building as it is widely used in Malaysia.

2.3 ROOFING MATERIALS

Roofing materials such as concrete, clay, and metal sheets are readily available and commonly used in hot, humid climate zones, particularly in Malaysia. Roofing materials are usually chosen based on the needs of home buyers and the weather conditions. In choosing the type of roof tiles, the budget is also significant. The ability of the roof material to reject solar radiation, on the other hand, is not a deciding factor in choosing a roof colour. This is due to a lack of knowledge about the impact of roof color on thermal heat gain. Allen et al., (2008) conducted an observation survey on roofing systems and materials for residential buildings within the state of Selangor and Wilayah Persekutuan Kuala Lumpur in Malaysia from December 2006 to March 2007. According to the report, concrete roof tiles are utilized in 85 % of residential buildings, followed by 10 % clay and % metal deck sheets, which are mostly used in bungalows.

2.4 THERMAL COMFORT

Thermal comfort is a state of mind that expresses satisfaction with the surrounding environment, and it can be described as the range of climatic conditions that are considered comfortable and acceptable, according to the ANSI/ASHRAE Standard, (2005). The owners of the home value thermal comfort above anything else. It has the potential to influence work levels of distraction, as well as their everyday performance and productivity. Environmental (air and ambient) temperature, humidity, air speed, clothing, and metabolic rates may all influence thermal comfort. Human thermal sensibility is mostly determined by the overall thermal balance of the body. When the body's internal heat generation equals the heat loss to the environment, thermal equilibrium is achieved. In a mild thermal climate, the PMV (Predicted Mean Vote) and PPD (Predicted Percentage Dissatisfied) indices are the most often utilized. Jorn (2005), Roonak et al. (2009), and Cao et al. (2010) are examples of current thermal comfort research (2010).

2.5 ENERGY CONSUMPTION

Electricity is a necessary component of nation-building and civilisation, but energy generated from fossil fuels has two primary consequences. On the one hand, fossil fuel reserves are decreasing; for example, Malaysia was ranked 24th in the world in terms of oil reserves and 13th in natural gas reserves in 2004, while PETRONAS claimed that Malaysia's oil and gas reserves were 20.18 billion barrels equivalent in January 2007. According to Malaysian government projections, at current production rates, the country

will be able to produce oil and gas for another 18 years and 35 years, respectively (Cha and Oh, 2010). On the other side, the production of greenhouse gases (GHGs) by the process of power generation using fossil fuels harms ecosystems. Furthermore, according to the CO_2 emission report published by the International Energy Agency in 2010, (International Energy Agency, 2010). It is self-evident that CO_2 emissions are closely proportional to power usage, with China emitting 6508.24 MT of CO2 in 2008, followed by the United States with 5595.92 MT of CO_2. Furthermore, Ong et al. (2010) discovered that Malaysia's energy industry is still significantly reliant on non-renewable fuels including crude oil, natural gas, and coal, which are gradually diminishing and contributing a significant amount of greenhouse gas emissions. Furthermore, Saidur et al. (2007) found that refrigerators and freezers consume the most energy, followed by air conditioners, in their study on energy and associated greenhouse gas emissions from household appliances in Malaysia for an expected period of 17 years (1999-2015). In 1999, there were 493,082 air conditioner units in Malaysia; by 2015, that number is estimated to rise to 1,271,746 units (Saidur et al., 2007), a 68 % increase over 1999.

2.6 SUSTAINABLE ROOFS

Given the growing public awareness of climate change and global warming, worldwide conferences are pressuring the construction sector, notably the roofing industry, to translate consumer requests for lower energy usage into realistic recommendations and solutions (Hutchinson, 2004). To comprehend the significance of sustainable roofs, various conceptual definitions have been presented, but the most

applicable description comes from the proceedings of the Sustainable Low-Slope Roofing Workshop, held at Oak Ridge National Laboratory in October 1996. A sustainable roof, according to one source, is "a roofing system that is designed, constructed, maintained, rehabilitated, and demolished with an emphasis on using natural resources efficiently and maintaining the global environment throughout its life cycle."

According to Hutchinson, this definition is difficult to grasp, and its values are difficult to put into practice on a large scale. In 2002, an international committee (CIB W83/RILEM 166 RMS) summarized a document called Tenets of Sustainable Roofing to address the demands of sustainable development. This paper has aided architects and designers in making progress in three key areas of sustainability: (i) reducing environmental impact, (ii) conserving energy, and (iii) increasing roof system life spans (Hutchinson, 2004). Building owners, according to Liu K (2010), seek more environmentally friendly and low-impact roofing systems to promote the idea of sustainable development. Designers and manufacturers have responded by (i) employing more environmentally friendly materials, (ii) making longer-lasting products, and (iii) devising methods and system designs to reduce life-cycle costs.

Green roofs (garden roofs), reflecting roofs (cool roofs), and roof photovoltaics are just a few examples of sustainable roofs that rely on a variety of solar solutions to allow usable natural light to enter occupied spaces from the roof while reducing heat effect.

Ong (2011), Ismail et al. (2011), Al Yacouby et al. (2011), Sheng (2012), Ismail et al. (2013), and Yew et al. None of these studies, however, combined daylighting with passive cooling in a single roof design. Because no roofing system in the world combines a roof light and ceiling light integrated with glass technology, pigment process, and attic

ventilation strategy as a design idea, the proposed design is unique. For Malaysia, Al-Obaidi et al. (2013) designed and recommended an innovative roofing system (IRS). However, as optimization research, the study was solely based on simulation.

2.7 ENVIRONMENTAL CONDITIONS

To test a system in an existing building and validate the significance of this study, we must identify weather conditions in the study area. Malaysia is a tropical country with a hot and humid environment. It is positioned at 3 ° N of the Equator. High temperatures, exposure to significant amounts of solar insolation, high humidity, an abundance of rainfall throughout the year, and erratic wind movement characterize Malaysia's two seasons, dry and wet. In the humid tropics, the air temperature is consistently high. Seasonal temperature changes are low, and diurnal temperature differences are small. Because changes in the amount of net radiation received are minimal, temperature within areas does not fluctuate.

The recorded normal temperature, notably with diurnal air temperature, ranging from 20 °C to 36 °C, according to a 10-Day Agromet Bulletin issued by the Malaysian Meteorological Department (MMD) (2010), and the relative humidity is exceptionally high and normally reaches 90% (2010). Malaysia receives a significant amount of solar insolation, with an annual average of 1643 kW h/m^2 (A. H. Haris, 2008) and more than 10 hours of sun exposure every day (N. Amin et al, 2009).

Furthermore, wind velocity in the humid tropics is low and erratic. This is a delicate problem because different parts of the wet tropics have varying climates. Malaysia is a maritime country, according to the MMD (2010). The impacts of land and

sea breezes influence the overall wind flow pattern. This characteristic, according to Azusa (2009), is only considered in coastal and mountainous places, but not in metropolitan areas. Malaysia, according to Akorede et al. (2013), is a low-profile wind speed country. According to Abdul Rahman (1994), the wind in Malaysia is unpredictable, multi-directional, and lacks sufficient velocity at ground level.

2.8 PASSIVE DESIGN SYSTEM

Malaysia's total population increased from 23.3 million in 2000 to 28.3 million in 2010, according to the 2010 Census (Department of Statistic Malaysia, 2015). In recent years, Malaysia's urban centres have seen an increase in demand for residential housing due to population and economic expansion. Roofs and pavements cover 60 percent of metropolitan areas, according to Akbari et al. (2008). Furthermore, due to population growth, the surface temperature in urban areas will rise dramatically in the next 10 years or less (Tursilowati, 2007).

The colour of the roof surface is one of the factors to consider in passive design. Most roof tiles in Malaysia are black, which means they absorb more heat(Al-Yacouby et al., 2011). Table 1 depicts the various colors of roof tiles used in Malaysia.

Table 2.1:Colour of roof tiles in Malaysia.

Roof color	Percentage (%)
Red	38.0
Brown	25.9
White	9.5
Beige and blue	7.8
Black	4.9
Gray	2.9

Source: Al-Yacouby et al. (2011).

A roof painted in a grey or dark hue records a higher ceiling temperature than a roof painted in a lighter tint, according to Givoni (1994). The fact that a dark-coloured roof has a higher inside temperature than the outside climate was also justified. According to the findings, the incidence of solar radiation on the roof surface is influenced by the roof's colour and thermophysical qualities (Givoni, 1994).

The highest indoor temperature is recorded on a black aluminium sheet for a level roof or a 0° roof pitch (Al-Obaidi et al., 2014c). Because of the huge quantity of heat absorbed, Ibrahim et al. (2014a) found that the inside temperature reading is greater than the outdoor temperature for a lower roof pitch. Most components of the roof are designed within a 10° roof angle in today's modern house design in Malaysia. According to Abdul Rahman et al. (2009), a flat roof design in a tropical environment may not be deemed a good elemental design due to several variables that would cause leaks, such as water ponding on the flat roof surface, and would necessitate additional costs for substantial restructuring. Apart from saving money on construction, developers favour the simplest and most straightforward manner of designing and building residences, particularly on the upper levels.

The roofing system's construction material is a concern. According to Lau et al. (2008), concrete roof tiles account for 85 % of modern house roof materials, while clay tiles and metal tiles account for 10 % and 5 %, respectively. Roof tiles are preferred by contractors because they can extend the life of the roofing system and require less maintenance than other roofing materials. In comparison to concrete or clay roof tiles, spandex or metal roofs are favoured for the design of modern low-cost dwellings in Malaysia because of their cheaper construction costs. According to Lau et al. (2008), most houses are afflicted by high solar radiation transmission due to the non-reflective materials utilized, resulting in a high temperature inside the structure. According to Ibrahim et al. (2014a), spandex is unsuitable as a roofing material in modern low-cost housing design because it raises the internal temperature over the outdoor temperature.

Ceramic roof tiles, it is suggested, would perform better in terms of reducing heat transmission into a home. Miller et al. (2007) found that the heat transfer from the roof surface to the ceiling is reduced by up to 60% or less when compared to asphalt shingles. Ceramic roof tiles that become wet at night and dry during the day would aid to reduce heat transmission from the roof surface to the attic area. The ability of the material to bounce back the radiated heat to the atmosphere causes the heat transfer to be reduced. Even though the Chinese have used ceramic as a roofing material for millennia, due to industrialization and huge development, this decision is not generally recognized (Miller et al., 2007).

A modern terrace house's passive design is not well suited to a hot and humid climate like Malaysia's (Davis et al., 1997). The indoor temperature in a house with a current low-income architecture can reach 31 °C, while the outdoor temperature is around 30 °C with air velocity as low as 0.1 m/s (Tinker et al., 2004). The reported indoor temperature is higher than a human's thermal comfort temperature. Even though the house has several openings, such as windows and doors, it is unable to attain thermal comfort since the upper portion of the house is poorly built. In two distinct places, similar research is undertaken on the same design for a modern low-cost dwelling. The lack of natural ventilation design, according to Ibrahim et al. (2014a), raises the indoor temperature.

According to Aziah (1994), traditional Malay house designs have a lower internal temperature than modern terrace house designs. Furthermore, the traditional Malay house design is the best example of good natural ventilation, as it relies heavily on natural cooling via air movement through windows, doors, roofs, and other openings (Lim, 1987). However, due to modernization of house design and limited supply of building materials, such as wood and Nipa palm leaf, the use of the traditional Malay concept house has become unpopular (Nypa fruticans). The apertures in a typical Malay house seen in Fig. 2 could help with mobility and heat removal.

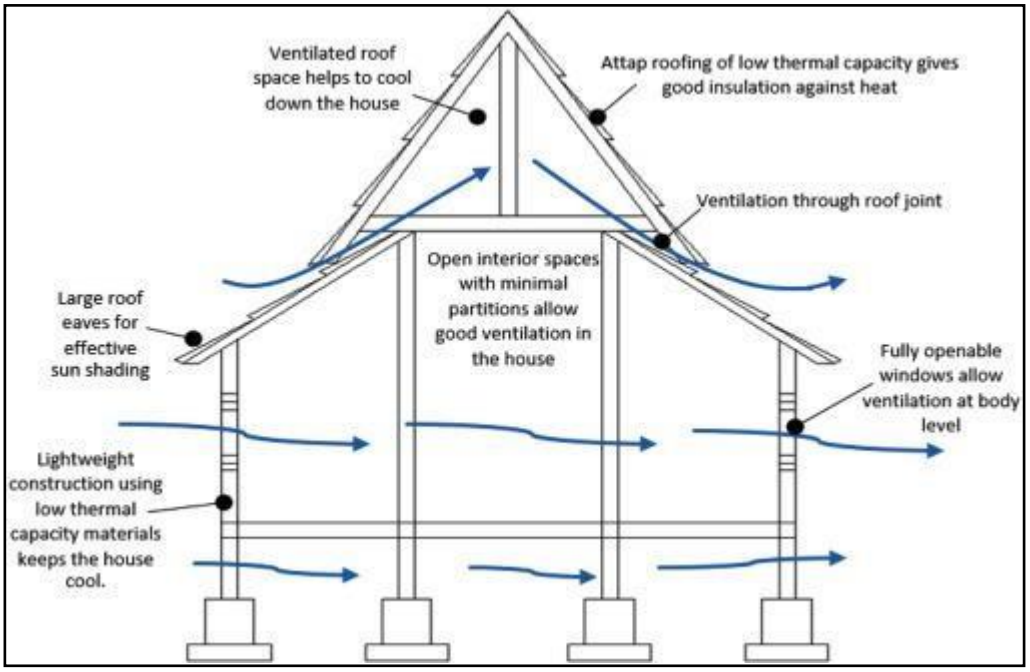

Figure 2.1: Air movement for traditional Malay house

Source: The traditional Malay house, rediscovering Malaysia's indigenous shelter system (Lim, 1987).

To save money on construction, fire resistance, rain protection, and security, Malaysian modern roofing systems are now designed with reduced ventilation or unvented attics. The modern concrete house constructed in Malaysia would endure large temperature rises during the day and then gradually cool down at night (Abdul Rahman et al., 2009). According to Wolfert and Hinrichs (1974), the roof sheathing temperature and ceiling temperature in an unvented attic can reach up to 71°C and 66 °C, respectively, whereas the external temperature is only around 32 °C. A well-designed vented roof, on the other hand, can help to alleviate the overheated condition in the attics, especially if the building is of moderate height and spans a large area (Ciampi et al., 2005).

The most affected element because of poor passive design is the energy demand for the mechanical operation. When the condition of the indoor temperature is higher than the comfort level, a large amount of energy is needed to generate mechanical

ventilation to achieve the level of comfort (Tinker et al., 2004). However, the condition could become worse because of poor ventilation and air circulation design. The openings in Malaysian houses are located mostly at the front and back parts of the houses, especially in intermediate terrace house design.

2.9 TYPES OF ROOFING MATERIALS USED IN MALAYSIA.

Homeowners in Malaysia have a variety of roofing material alternatives to choose from. These materials differ in terms of longevity, aesthetics, and cost.

2.9.1 ASPHALT SHINGLES

This type of roof shingle is the most frequent and least expensive alternative for both residential and commercial buildings. This choice, which is made of organic or fiberglass materials, can endure up to 20 years on average. This is the go-to roofing material because it comes in a variety of styles and colours.

2.9.2 METAL SHINGLES

Metal roofing comes in two varieties: shingles and solid form. This type of roofing is gaining popularity in the area, as more developers choose this attractive and cost-effective option. These are lightweight, long-lasting, and come in a variety of colors.

2.9.3 WOOD SHINGLES

Wood shingles are an attractive option with a 30-year average life expectancy, but they have several disadvantages. Aside from being more expensive, they also require more upkeep and are more susceptible to weather damage and deterioration.

2.9.4 SLATE SHINGLES

Although more expensive, this popular alternative has a lifespan of over 100 years and is the most durable option, as seen by buildings with slate roofs dating back to the Shakespearean era that are still standing strong. Its fire-resistant quality, which is made of actual stone, makes it a front-runner.

2.9.5 TILE (CLAY) SHINGLES

Tile or clay shingles are another popular choice among builders and homeowners. Tiles, like slate, have a long lifespan (almost 100 years) and require little to no upkeep. However, because most of them are constructed of terracotta, they are prone to cracking.

Chapter 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter the author will focus on how this study will conducted to obtain information as well as provide insights to analyse information.

Research methodology is one of the processes in research to analyse the research approaches and methods used to achieve the objectives of the study. The ability to produce successful research is about how to manage the research process (Ruddock, 2008). This can be evidenced in the importance of research methodology selection. Research design in designing a research methodology describes the way in which data will be collected and analysed to answer the stated research questions (Bryman and Bell, 2003).

The study design consisted of information gathering stages until the process of data analysis. According to Piaw (2011), the outcome of a study is determined by the method and design of the study, while the design of the study is determined by the objectives of the study.

The study form chosen for this study is qualitative because this method tends in producing information only on the specific cases studied.

3.2 RESEARCH METODOLOGY

The research methodology is important to determine the direction of the study and answer the objectives of the study discussed in chapter 1. This study involves several stages before reaching to the report writing stage at the end of the stage.

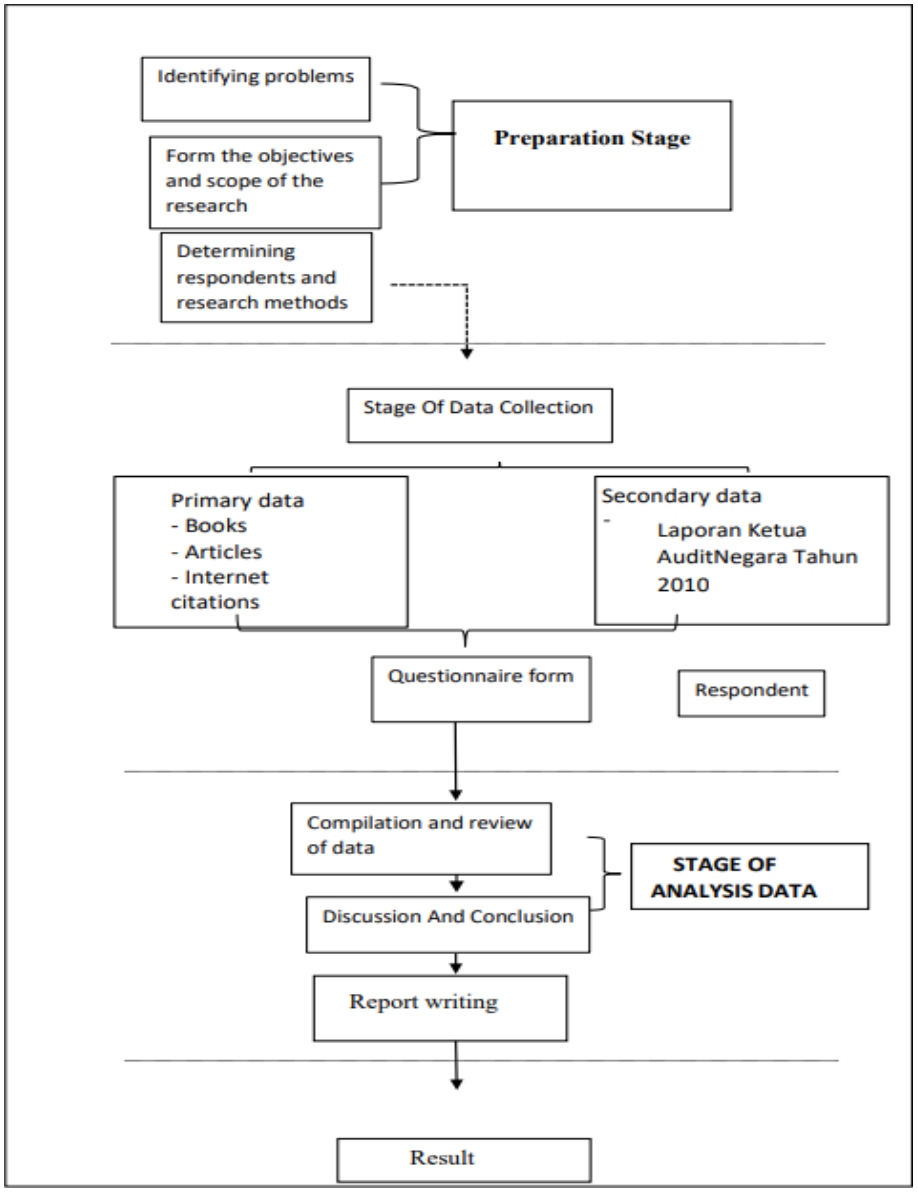

Figure 3. 1: Research methodology flow

3.3 SURVEY APPROACH

The author will use a survey approach to achieve the objectives first and second. The survey approach is to collect data from a relatively large number of respondents in a limited period (Naoum,2007). In addition, the author will also use observation to achieve the first objective to further strengthen the results of the study. For this study, the authors have a limited period to achieve both objectives, so the approach to using surveys is very much in line with existing time constraints.

3.4 SURVEY TECHNIQUES

Survey techniques are probably the most widely used data collection techniques to conduct research (Naoum, 2007). Questionnaires will be distributed to respondents to achieve the first objective. Problems in the selection of roofing materials and have been identified in chapter 2 and will be brought to the questionnaire form. Through the questionnaire form that will distributed to respondents, the author will be able to find out the main problems of the selection of roofing materials.

In addition, the Author will create a checklist and identify problems physically significant. To achieve the second objective, the author will also be using a questionnaire form and will be distributed to respondents.

3.5 SAMPLING

Sampling only prioritizes residents who are in Kedah State which will contain 3 sections, in each section will consist of 10 questions. The minimum target of respondents is 150 publics from 300 publics of sample size. Survey forms will be distributed via online following the covid-19 outbreak that hit worldwide. Among the platforms used to distribute survey forms are on Facebook, Telegram, WhatsApp etc. This survey will choose random sampling where, sample characteristics are different of respondent's background, property, and type of work. The sampling selection process is one an important process in a study.

3.6 RESEARCH METHOD

There are various methods that can be used in a study but must be consistent with the objective to be achieved. In relation thus, to achieve the objectives of this study, the authors only use the method that is using the questionnaire method. This method was chosen because it suits the objectives of the study achieved that is to identify the problem of selection of roofing materials and suggest the best choice of types and roofing materials used in Malaysia.

3.7 CASE STUDIES

For this study, the authors chose a case study method where the study data were obtained from the survey questionnaire. Accordingly, the scope this case study is focused