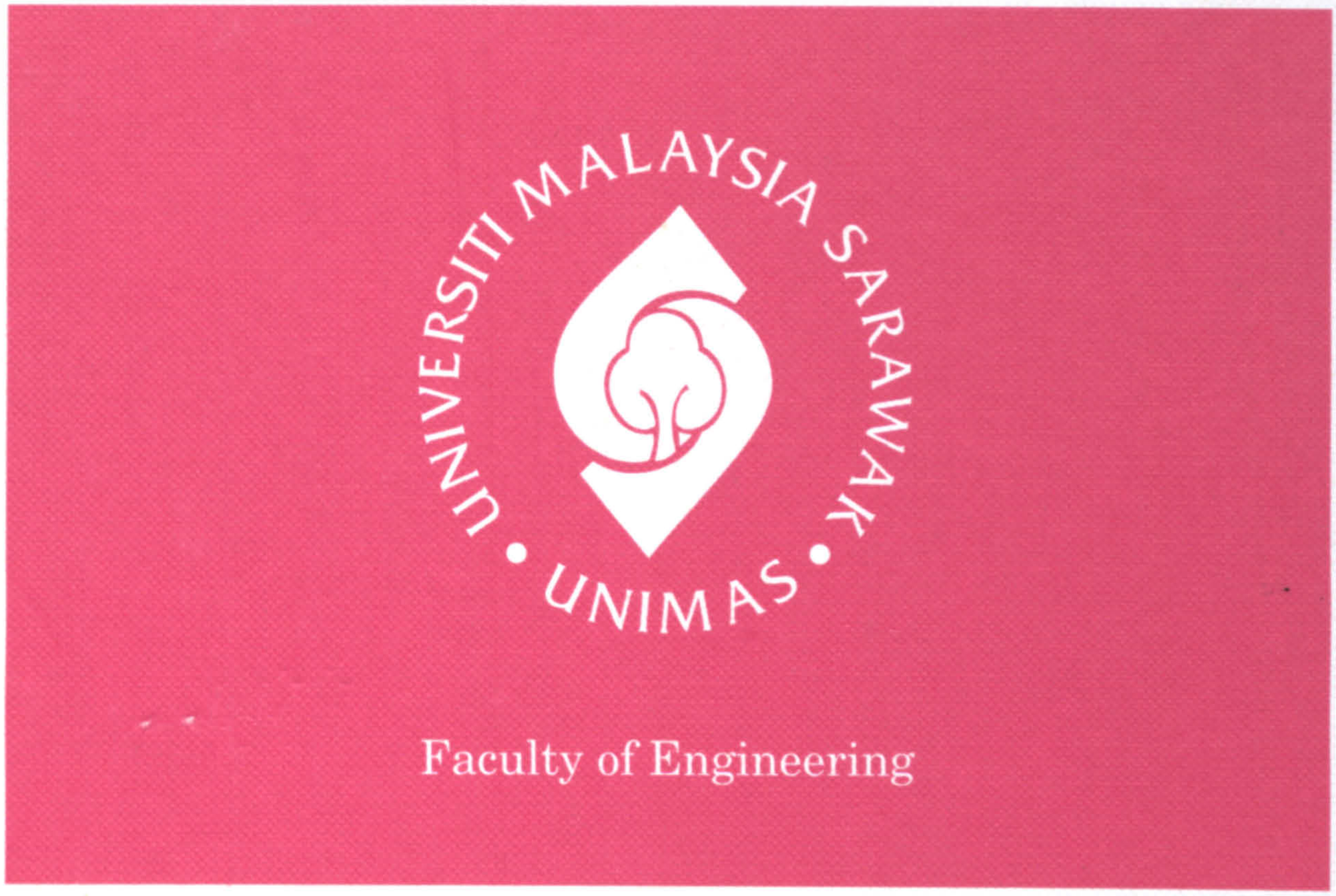

THE ROOF TECHNOLOGIES AT LOW COST HOUSES AND THE EFFECT ON THERMAL PERFORMANCE: STRUCTURES

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Bachelor of Engineering with Honours
(Civil Engineering)
2004

UNIVERSITI MALAYSIA SARAWAK

BORANG PENYERAHAN STATUS TESIS

Judul: **The Roof Technologies at Low Cost Houses and the Effect on Thermal Performance: Structures**

SESI PENGAJIAN: 2003-2004

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MOHAMAD AYUB BIN ISHAK

This project is submitted in partial fulfillment of
The requirements for the degree of Bachelor of Engineering with Honours
(Civil Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2004

Dedicated To My Beloved Family

ACKNOWLEDGEMENT

Firstly, I would like to express my sincere and appreciation to my supervisor, Dr. Azhaili Baharun for his guidance and advice in completion of my final year project.

In addition, special thanks to my project partner, Mr. Zulhatta b. Marzoki, a hardworking and creative person, for giving useful and valuable helps, co-operation and information when difficulties encountered. Thanks to Mr. Ahmady Asrul for advices and ideals in my project. Special recognition also goes to the civil lab technicians Mr. Roslan, Mr. Hafiz and Mr. Affendi that provided help during the implementation of this project. I would like to forward my heartiest thanks to all those friends for giving me support and contribute directly or indirectly to the project.

Finally, I owe a great debt of gratitude to my supportive family for giving me the spiritual support through out the entire course.

ABSTRACT

This project is a preliminary research on roof technologies on low cost houses and the effects on thermal performance, which is carried out at low cost housing area around Kuching. The main aim of the project is to explore the roof structure that can maintain the indoor temperature inside the house at or below the comfort temperature. The project involves a field study, which is carried out on four types of roof structures and later an analysis is done from the data obtained. This research shows that most of the roof structures designed contributed to the increment of temperature above comfort level. However, there is one type of roof structure design, through this investigation that able to maintain the indoor temperature near to the comfort temperature zone. Through these data collection of indoor temperature are also due to the building orientation and human activity. Since the scope of this project is to do the investigation on the roof structure design contributing to comfortable temperature, it is conclude that the roof structure design for houses in Kuching area should have changes.

ABSTRAK

Projek ini merupakan satu kajian permulaan terhadap teknologi bumbung yang digunakan di rumah kos rendah dan kesan haba terhadap bumbung tersebut yang dijalankan di kawasan perumahan kos rendah sekitar Kuching. Tujuan utama kajian ini adalah untuk mengenalpasti struktur bumbung yang dapat mengekalkan suhu dalaman rumah pada atau di bawah suhu selesa. Dalam projek ini, kerja balapan pada empat struktur bumbung telah dijalankan dan diikuti dengan analisis terhadap data-data yang telah diperolehi. Hasil daripada penyelidikan ini mendapati bahawa kebanyakan rekabentuk struktur bumbung menyumbang kepada peningkatan suhu melebihi dari tahap selesa. Walau bagaimanapun, terdapat satu rekabentuk struktur bumbung yang mampu mengekalkan suhu dalaman rumah pada tahap suhu selesa.

Hasil dari pengumpulan data, didapati bahawa suhu dalaman juga dipengaruhi oleh orientasi bangunan dan juga aktivi manusia. Memandangkan skop projek ini adalah untuk membuat penyelidikan ke atas rekabentuk struktur bumbung yang menyumbang kepada suhu selesa, sebagai kesimpulannya rekabentuk struktur bumbung untuk rumah-rumah di sekitar Kuching seharusnya diubahsuai.

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CHAPTER ONE

INTRODUCTION

1.0 Introduction

Housing is a major concern for all people in every corner of the world as the wellbeing of a country is reflected in its people enjoying a certain standard of living. Among the indicators of wellbeing is housing which provides shelter as well as being a major potential for expanding the construction industry, generating jobs and contributing to capital formation. The construction industry including housing contributed about 3.4% of Gross Domestic Product of Malaysia for the year 2000.

The housing constructions in Malaysia today are more on the low cost houses apart from medium and high cost due to the increment of the people needs. Most of the house buyers are in blue collar group which their monthly income in a range RM 750 to RM 1500. The prices of low cost houses are in a range of RM 35000 to RM 60000 according to the types, location, per capital income, materials and etc.

Due to limited budget, the housing provided to the buyers has been built without taking the comfort standard into consideration. This will cause the problem of thermal comfort due to inappropriate selection of building materials. The lightweight construction that is adequate for the rural warm humid climate region is seen to be unsuitable for the urban conditions *(Mufida, 1999)*. The author also indicates that the use of massive thick walls increases the temperature inside the building.

Most of the low cost houses are designed to have three bedrooms, two bathrooms, living and kitchen. Having the size of usually 8m length and 6m width, the houses constructed will become smaller and more compact. This causes a problem to the ventilation system inside the house due to the limited space to cycle the air movement within the house and subsequently increases indoor temperature. The raised indoor temperature above comfortable level creates some energy usage of a house as fans are used to circulate warm air.

Most of the heat transferred indoor is through roof because it is exposed directly to the sun radiation. In order to achieve indoor minimum comfortable level, there should be a mechanism to minimize the heat transfer at the roof level. This project is just at the level of investigating the roof structural design and the heat transferred indoor in existing low cost houses around Kuching area.

This chapter will focus on the introduction part which includes the overview on pitched roof technologies, solar radiation and comfort temperature in order to find out the effect of heat from the sun to the roof structure.

1.1 Overview on Pitched Roof Technologies.

Roof is a part of building structures that is very important to resist the solar radiation from the sun to travel directly into the building. Besides that, roof also shelters the building from the act of weather. Generally, there are many roofs technologies used for the buildings around the world nowadays. This study will only focus on the pitch roof technologies at the low cost houses in Kuching area.

Roof designs have an important influence on the appearance of the houses, both in regard to the form and shape of the roof, and as to the colour and texture of the covering material. Usually, the material chosen for the cover are such as plain tiles, double clay interlocking, concrete tiles, natural slates, fiber-reinforced cement slates, thatch, profiled material (protected metal) and wood shingles. The material chosen depend on the minimum slopes of the pitched.

Roof structures can be formed very simply using trussed rafters. These are made from small section timber and comprise the rafters on the roof slopes, a horizontal to support the ceiling, and various combinations of cross members to form a frame or truss. The members are usually fixed together using metal plate connectors. The

trusses are designed and produced by the manufacturer to suit the span and profile of a roof. They are a very cost effective way of forming roofs of houses and are often seen on building sites. Their major drawback is that they fill the loft and reduce the useful space available.

Steel purlins can span further than timber ones and are often used to support roofs, spanning between the walls of the building without the need for intermediate trusses. Glulam and plyweb purlins are engineered forms of timber and are factory made. Their advantage is that the imperfections in natural timber are removed and large sizes can be manufactured. This allows long lengths to be used similar to steel purlins. Figure 1.1 illustrates the pitched roof trusses.

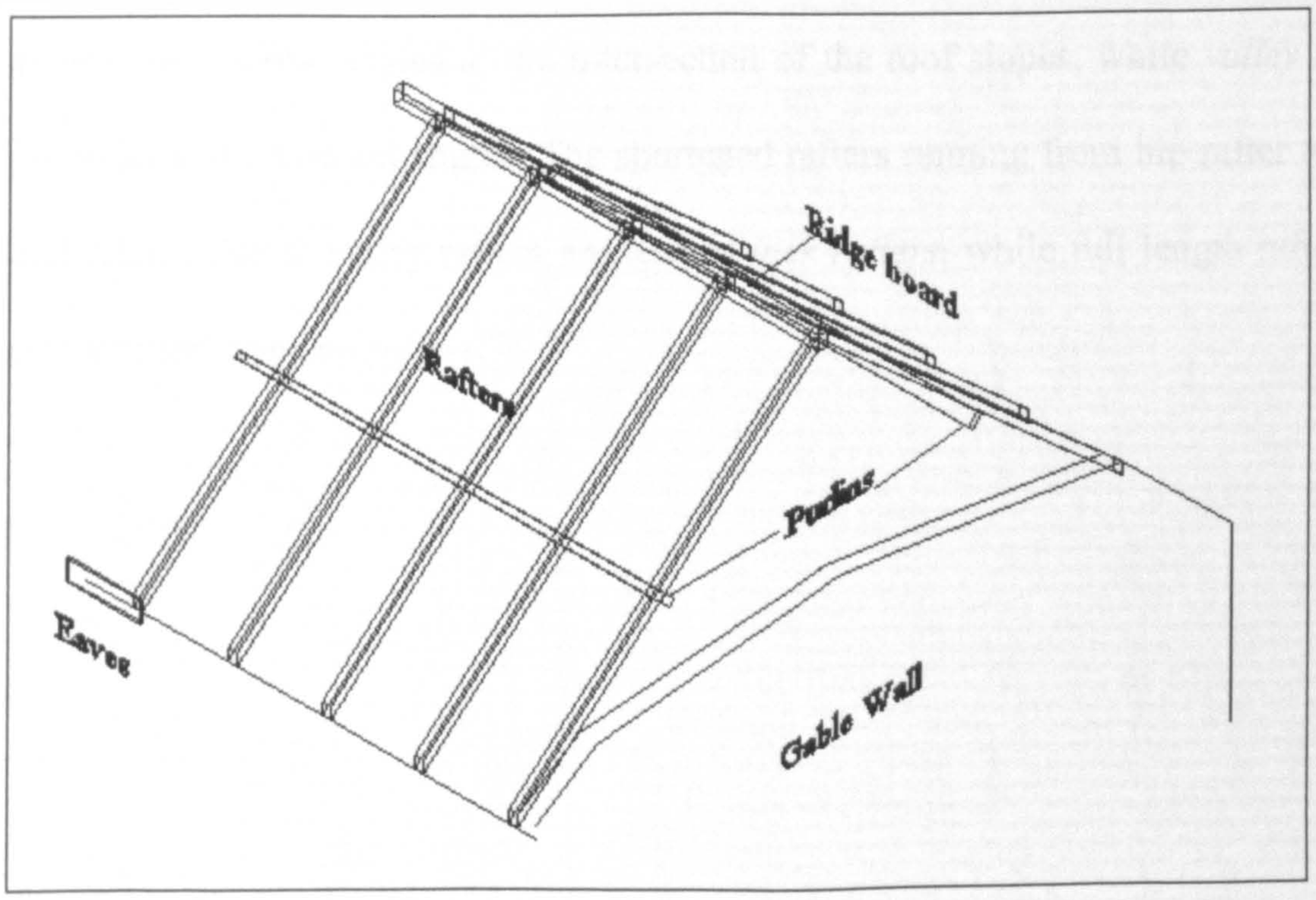

Figure 1.1 Pitch Roof Trusses

The roof structures also can be a used for purposed of ventilation system for the houses. The proper design of roof can reduce the air temperature to make it more comfortable condition inside the houses. The roof will be a natural or passive ventilation system of the houses depends on the shape, space and the covering material used.

1.1.1 Pitched Roof Terminology.

Some of the more common roofing terms are explained by reference to Figure 1.2. *Hipped end* is where the roof slope is continued around the end of a building, whereas the wall is carried up to the underside of the roof at a *gable end. Hip rafters* frame the external angles at the intersection of the roof slopes, while *valley rafters* are used at the internal angles. The shortened rafters running from hip rafter to plate and from ridge to valley rafters are termed *jack rafters*, while full length rafters are often called *common rafters*.

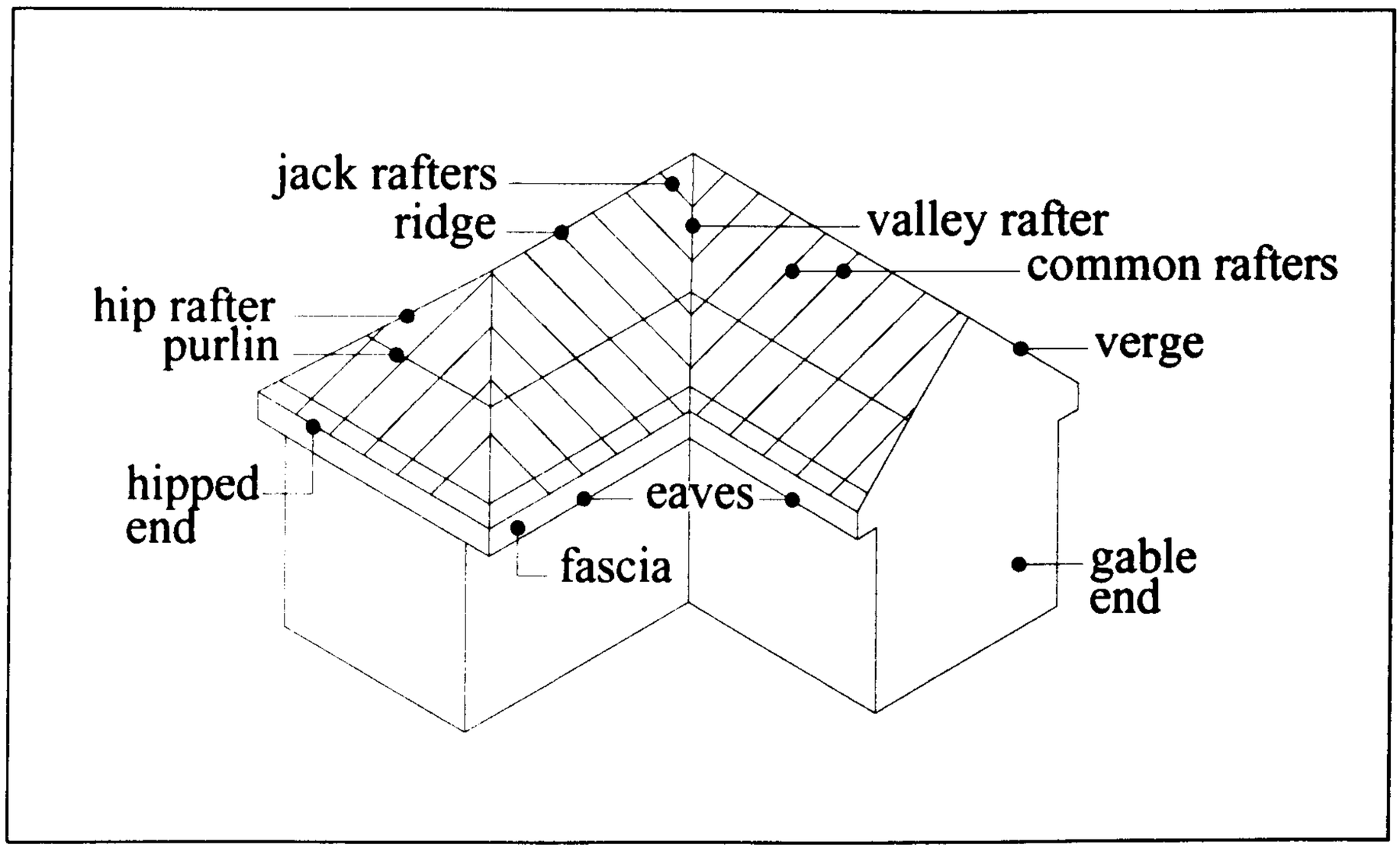

Figure 1.2 Pitch Roof Terms

The bottom portion of the roof overhanging the wall is known as *eaves*. Where the roof covering overhangs the gable end, it is term *verge*. *Purlins* are horizontal roof members which give intermediate support to rafters. Rafters are splay cut or beveled and nailed to the ridge board at the upper end and birds-mouthed and nailed to the wall plate at the lower end.

The slope of the roof is usually given in degrees, whereas the pitch is the ratio of rise to the span. The rise is the vertical distance between the ridge and wall plate, while the span is clear distance between walls. In a half pitch or 'square pitched' roof, the span is twice the rise, for example 3.5 m rise with 7 m span. The minimum pitch or slope is determined by the roof covering material, as shown in Table 1.1.

Table 1.1 Minimum slopes for pitch roof coverings

Material	Slope
Plain tiles	40°
Pantiles (double clay interlocking)	22 ½°
Concrete single lap tiles (interlocking), clip fixing, 75mm lap	I 7 ½°
Natural slates, green and blue (minimum 300mm wide)	20°
Natural slates in diminishing courses	30°
Fibre-reinforced cement slates (larger sizes)	I 7 ½°
Thatch	45°
Profiled material (protected metal)	15°
Wood shingles (with 125mm gauge)	30°

Source: (Building Technology, 1995)

1.2 Solar Radiation.

The sun is the source of the vast majority of the energy used on earth. Most of the energy has undergone various transformations before it is finally utilized, but it is also possible to tap this source of solar energy as it arrives on the earth's surface.

Heat from the sun can be transferred by three methods which are conduction, convection and radiation. It will travels to the outer roof surface by radiation in the form of either direct or diffuse sunlight. Then, it will heat the inside roof surface through conduction and heated the roof void and into the house through convection.

If there are no time lag and decrement factors, the heat will travel inside the house immediately.

1.3 Comfort Temperature.

The comfort environment is the result of simultaneous control of temperature, humidity, cleanliness and air distribution within the occupant's surrounding area. This set of factor includes mean radiant temperature as well as the air temperature, odor control and the control of the proper acoustic level within the occupant's vicinity.

Physical comfort requires continuing dissipation of body heat by convection, radiation and evaporation. Convection is circulation of liquid or gasses caused by temperature different. When the air temperature is less than skin surface temperature, body heat can be lost by convection to the surrounding air. Radiation is heat transfer by electromagnetic wave, from a warmer to a cooler surface. Body surfaces radiate heat to cooler surroundings and receive radiant heat from warmer surroundings. The magnitude of radiant heat flow is dependent on the temperature difference between source and receiver.

The human body also dissipates heat by evaporation. Evaporation is a change of state from liquid to vapor. Water vapor is expelled with each breath, and the evaporation rate can be increased by increased respiration or by perspiration.

Humidity, the amount of water vapor in the air can affect comfort. However, the human body tolerates a wide range of humidity before becoming uncomfortable in very wet or very dry air.

Comfort temperature is a subjective quantity which is depends to the individual or occupant and it is hard to be determined. Most of the researcher found that the definition for comfort temperature is a satisfactory feeling of occupant to the surrounding environment.

The comfort of an individual is affected by several factors such as environment, physical factor and subjective factors. The environment factor includes the air temperature, relative humidity, air flow and radiation. However, the subjective factors depend on each individual and their ability to adopt in the environment.

Hanafi (1999) mentioned that comfort temperature for Malaysia is in a range of 24°C to 27°C during daytime and 20°C to 23°C at night. This range is determined according to Mahoney table and the average temperature taken from eight cities over Malaysia.

1.4 Aim and Objectives

Knowing on how critical the effect of thermal performance on roof to the indoor temperature, this project aims to determine the efficiency of the roof in resisting and retaining the direct solar radiation from the sun for the low cost houses in Kuching. The objective of this study is to find the factors which govern the increasing of indoor temperature inside the house. The factors are:

a) Type of roof structure

b) Orientation of the house

c) Human factors

1.5 Structure of the Final Year Project.

The Final Year Project Report consists of five main chapters which are implemented during these two semesters.

The first chapter contains introduction, overview on pitched roof technologies, terminology, solar radiation, comfort temperature, aim and objectives and also the structure of this thesis.

The second chapter contains the literature review which focuses on the roof construction in tropical climate, study of thermal performance on roof and the study of thermal comfort in tropics.

Chapter three is on the methodology of conducting this study. Here, the explanation on how the data is being collected and the importance of each data is emphasized. Also described here are the procedures of inside and outside temperature was measured using available equipments.

Chapter four is the elaboration of gathered data of this project, presented in the form of case studies. The analysis of the data gathered also discussed lengthy here.

Chapter Five is on the conclusion of this project which also includes the recommendation for future related work.