THE EFFECT OF WIND LOAD TO NON-ENGINEERING ROOF SYSTEM

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ABSTRACT

Roof collapse due to wind load impact on roof sheeting during thunderstorm was reported. This failure of roof sheeting was lead to destruction to the non-engineering house. In most cases, failure of roof sheeting based on two points, either on material roof sheeting or at connection of roof sheeting. It was observed that the most failure of roof sheeting is likely occurred for non-engineering building. Base on MS 1553:2002 wind load for building structure, structure element should be able to resist wind load up to 32.5 m/s. Therefore this study is conducted to identify the possibility of the failure of Corrugated Galvanised Iron roof sheeting for non engineering buildings. The study focus on the connection between roof CGI sheet and purlin. Nail connection are been used in this study, while 4 different spacing distance between connection are used which are 300 mm. 450 mm, 600 mm and 900 mm. Finite Element Software were used in this study to analyse and identify the load distribution. From the result it shown that the maximum spacing of nail connection is 500 mm to resist the wind load recommended by MS 1553:2002. From the result it can be conclude enclose by increasing the spacing of connection it will lead to increase the failure of CGI roof sheeting.

ABSTRAK

Kerosakan permukaan bumbung akibat angin kencang semasa hujan ribut telah direkodkan. Kerosakan tersebut selalu dikaitkan dengan rekaan bumbung pada rumah yang strukturnya dibina oleh rekaan bukan jurutera. Kebanyakan kerosakan bumbung berpunca dari dua faktor iaitu kerosakan melibatkan permukaan bumbung iaitu "bumbung zinc" dan satu lagi punca adalah sambungan antara paku dengan permukaan bumbung.. Berdasarkan MS 1553;2002 daya angin yang sepatutnya di tahan oleh struktur adalah sebanyak 32.5 meter dalam setiap saat. Oleh itu, kajian dijalankan adalah untuk mengetahui kerosakan bumbung "zinc" pada rumah kampung. Kajian juga memperincikan pemerhatian terhadap sambungan paku dan bumbung rumah. Empat jenis jarak pemasangan paku digunakan iaitu bermula dari 300 mm, 450 mm, 600 mm, dan 900 mm. Perisian komputer telah digunakan dalam kajian ini untuk menganalisis dan mengenal pasti taburan angin yang menyebabkan kerosakan pada bumbung. Dari hasil yang dianalisis, ia menunjukkan bahawa jarak maksimum sambungan paku adalah 500 mm untuk menentang beban angin yang disyorkan oleh MS 1553:2002. Kesimpulan yang dapat di kemukakan adalah dengan meningkatkan jarak sambungan paku ia akan membawa kepada peningkatan kegagalan bumbung zinc.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Roof collapse due to wind load impact on roof sheeting during thunderstorm was reported. This failure of roof sheeting was lead to destruction to the non-engineering house. Roof is a superstructure that needs be complete in structure design to protect building from damage, especially rain and storm. Roof will make buildings look aesthetically pleasing and also function as shelter with weather protection. Roof is the last part that being construct, so almost non-engineering roof construction not considers the wind load distribution which, there are so many damages occurred due to wind load on roofing system.

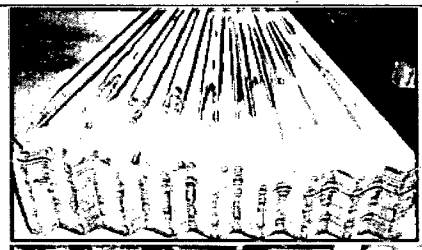
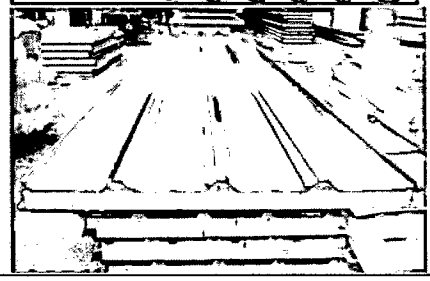
The rapidly increase in numbers of damage due to wind-related disaster events over the last few years in Malaysia has create the awareness from the numbers of parties. In order enhance the resistance of the building structure to withstand wind storms, further understanding on characteristic of wind structure interaction need to be discovered.

Air in motion is called wind. Wind flow becomes disturbed and its qualities are changed when wind flows around an object or structure. Wind is composed of varying sizes and rotational characteristics carried along of air moving relative to the earth's surface. Wind kinetic energy converted into potential energy of pressure, thus it will produce wind load. Wind load depend on geographical location and wind condition such as monsoon seasons. Thunderstorm in Malaysia occurs in micro scale (Yusoff, 2005) with small size and short duration which is between 15 to 30 minutes. 90 % of

housing in rural area is non-engineered building. Most of the house used Corrugated Galvanize Iron (CGI) and metal deck as roof sheathing. (Muhammad, 2014,)

Therefore, material use for roof sheathing is one of importance factor that affect roofing systems. There are many types of roof sheathing can be used in roofing system structure. There are as shown in table 1.1.

Table 1.1: Typical Types of Corrugated Metal Roofing System

Roofing material	Description	Picture
Corrugated CGI	CGI coating : 40-80 g/m² Thickness : 0.15-0.6mm Width : 762mm	
Corrugated Metal Deck	CGI coating: 30-300 g/m² Thickness : 0.14-4.0mm Width : 600-1250mm	

1.2 PROBLEM STATEMENT

Natural disaster surveys of wind storms have shown that residential roof structure in rural area, always failed due to wind pressure distribution. CGI roof material is the common failures during high velocity wind in rural area. . In most cases, failure of roof sheeting based on two points, either on material roof sheeting or at connection of roof sheeting. It was observed that the most failure of roof sheeting is likely occurred for non-engineering building. The structures of CGI roofing non-engineered residences are believed to be able to resist the effects of severe winds. However, Malaysia has a freak wind storm where the duration takes a short period and the condition is unpredictable which can cause damage to roof.

For instance, there are some cases in Malaysia related to the effect wind load to non-engineering roof system. First cases of non-engineering roof system that failure is at Pasir Mas, Kelantan where this place is rural area and the roof structure is design by non-engineered designer. Unproven material also one of the factors that may be the reasons for the failure due to wind loads. The family member in that house is consisting of one huge family. When this disaster occurred, it is not secure for the family to stay in that house.

Figure 1.1: Roof Damage (1) (Sinar Harian, 2014)

Moreover, another residential with same type of roofing sheathing also failed due to effect on wind load. This failure related to number of joint. When the joint located so far, the strength to resist the wind load is slightly reduced and become easy to fail. This situation will be harmful to another people when thing flew and the worst part when the family members of the residential is trap inside the house. Therefore it is very unsafe to design the roofing system with non-engineered designer.

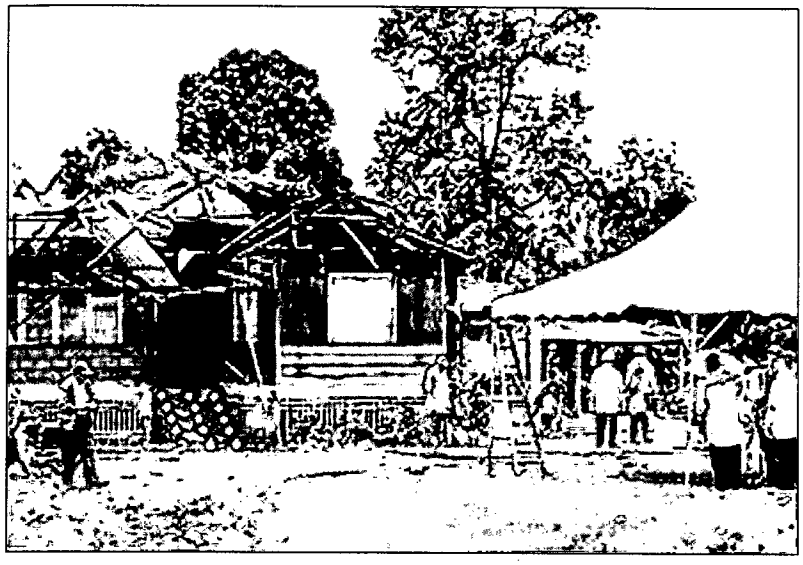


Figure 1.2: Roof Damage (2) (Utusan Malaysia, 2010)

1.3 OBJECTIVE OF STUDY

Non-engineering roofing system for residential houses located in rural area were relatively unsheltered. Analysis of wind effect is also considered using Malaysian standard when designing. Roof failure will give unique opportunity to make a research on wind load to non-engineering roofing system based on type material.
The objectives of study are:

i. To analyse wind pressure distribution over non-engineering roofs

ii. To identify the optimum spacing of roof joint connection

1.4 SCOPE OF STUDY

The scope of study is to investigate the ways to succeed the objectives. The study will focus on distribution wind load on roofing system. There are some variables that can affect the wind pressure distribution at rural area such as freak wind storm. The simulation was running based on wind pressure distribution using CGI roofing materials. For maximum wind load at Malaysia will give maximum force and uplift force due to wind load in CGI roofing system.

One of the objectives is to know that CGI roof sheathing connection capacity. For rural area houses, presumed the connection using the nails. The nails have its own weakness that may be the strength in main focus on the research.

Moreover, strong wind distribution will give the effect of failure pattern on joint roof connection. The test on the connection between CGI roof sheeting and purlin will be determined using SAP2000 software. The result that test in software has its limit. The maximum load that the joint in CGI roof sheeting can resist will be taken from previous research that had been done by others.

1.5 SIGNIFICANCE OF RESEARCH

This study will give more understanding about the wind load distribution to non-engineering roof structure at rural area. Non-engineering roof mostly use CGI as roof sheathing and truss timber to support load from roof such as wind load and rain load. The non-engineering roof can only support some amount of wind pressure distribution. Therefore this research is conduct to know what the ultimate pressure distribution that the non-engineering CGI roof sheeting can support. With this research, it can help community to be aware about the wind speed and will know the consequences failure of CGI roofing system. To avoid the failure happen again, strengthening the roof may needed with related to number of joint. Other than that, this experiment will give benefits to residential house at rural area for their information or knowledge about engineering roof system.

CHAPTER 2

LITERATURE REVIEW

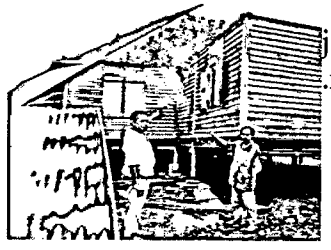
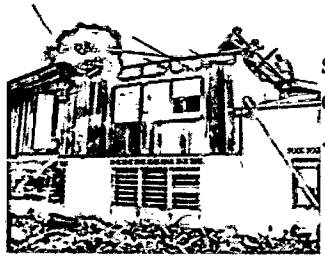
2.1 WIND HAZARD

This literature review chapter will discuss all that related to wind hazard. Windstorms can cause damages for structure and injuries for persons when the wind blow and carry the other material that broken from the effect of windstorms. This phenomenon will become worse if the windstorm cause the tree fall and crash onto persons properties such as house or car. This windstorms cannot be imagine how terrible when it become worse because wind is complicated. Moreover, thunderstorm also contributes as one of possibility wind induced damage to structure in Malaysia. As the changes of landform, wind hazard become one of the contributor to natural disaster. Wind hazard in Malaysia is freak windstorm where the duration takes short period, so people incautious about the wind hazard that can give impact on belongings and assets. All risk should be considered when natural hazard occur in reality.

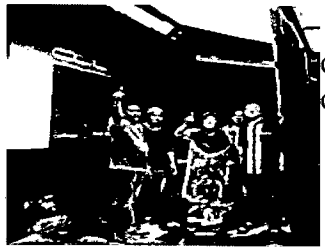
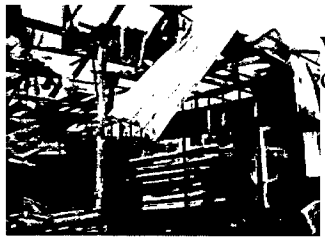
Design building superstructure such as cladding and roof always give little intensify to minimize wind prevail upon building damage. From study made by several earlier researcher, there are several cause founded to be partly responsible for damage on building structure. Several previous researches have been come to conclusion, which is failure of structure due to wind hazard base by insufficiency of attentiveness to wind effect during design stage.

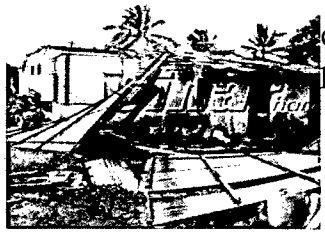
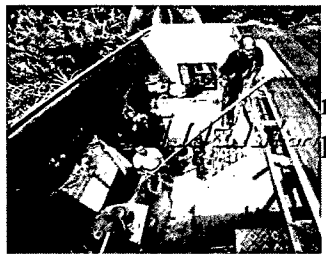
Table 2.1 is the effect of wind hazard in Malaysia for CGI roof sheeting where the place that occur the failure is rural area. From the table, all of the failure is cause by windstorm which is clearly stated on CGI roofing sheeting. Data in table 2.1 is the data from 2012, 2013 and 2014.

Table 2.1: Effect of Wind Hazard in Malaysia from 2012, 2013 and 2014

YEARS 2012	LOCATION	DAMAGE	PICTURE	REFFRENCE
(16 JANUARY)	PINANG LEREH, MELAKA	Non-engineering roof failure		johor.home.net.my
(29 JANUARY)	PONTIAN, JOHOR	Non-engineering roof failure		sharpshooterblogger.blogspot.com
(5 MARCH)	TELUK BAHANG, PENENG	Non-engineering roof failure		www.tranungkite.net

2013

(15 APRIL)	PORT DICKSON	Non-engineering roof failure		dialograkyat.blogspot.com
(16 JULY)	MIRI, SARAWAK	Non-engineering roof failure		www.theborneopost.com
(18 OCTOBER)	TUMPAT, KELANTAN	Non-engineering roof failure		malaysiaedition.net

2014				
(10 MARCH)	ALOR SETAR, KEDAH	Non-engineering roof failure		www.siakapkeli.com
(17 MARCH)	ENDAU, PAHANG	Non-engineering roof failure		duniaitu.blogspot.com
(1 APRIL)	MUAR, JOHOR	Non-engineering roof failure		muarkini.blogspot.com

2.2 MALAYSIAN WIND SPEED

Malaysia is tropical climate country, so Malaysia will receive monotonous rainfall every year. Malaysia located in Southeast Asia, which surrounded by sea that make Malaysia obtain a lot of rained. "The rainfall is heavy and usually occurs in the form of thunderstorm."(Shafii, 2006). Basic wind speed in MS 1553:2002 state that Malaysia is divided into two parts, which the basic of wind speed, is 33.5m/s for zone one and basic wind speed for zone two is 32.5m/s. The basic wind speed of zone one is near to seaside which covered the outer of Malaysian map. Base on MS 1553:2002 wind load for building structure, structure element should be able to resist wind load up to 32.5 m/s which is fifty years return periods. Therefore this study is conducted to identify the possibility of the failure of Corrugated Galvanised Iron roof sheeting for non engineering buildings.

Table 2.2 : Wind speed in (m/s) for 20, 50, and 100 year's returns periods (MS 1553, 2002)

Station	V_{20}	$Vs = V_{50}$	V_{100}
Temerloh	25.1	27.4	29.1
Tawau	24.6	26.6	28.1
Subang	29.2	32.1	34.3
Sri Aman	27.6	30.3	32.4
Sitiawan	23.3	25.3	26.7
Sibu	27.0	29.3	31.0
Senai	26.9	29.1	30.7
Sandakan	23.4	25.8	27.7
Petaling Jaya	28.8	31.4	33.4
Muadzam Shah	22.6	24.4	25.8
Miri	26.9	29.0	30.5
Mersing	29.5	32.0	33.8
Melaka	26.7	29.4	31.3
Labuan	26.0	27.7	29.0
Kudat	27.1	29.1	30.6
Kuala Terengganu	25.5	27.2	28.5
Kuantan	27.5	29.8	31.6
Kluang	29.6	32.5	34.9
Kuala Krai	27.2	29.5	31.3
Kuching	29.5	32.5	34.9
Kota Bharu	30.0	32.4	34.2
Kota Kinabalu	28.3	30.5	32.2
Ipoh	30.6	33.5	35.7
Chuping	23.8	25.6	27.0
Cameron Highlands	25.2	26.8	28.0
Butterworth	24.6	26.4	27.7
Batu Embun	25.3	27.5	29.2
Bayan Lepas	25.6	27.5	28.9
Bintulu	23.9	25.6	26.9
Alor Setar	27.2	29.9	31.8

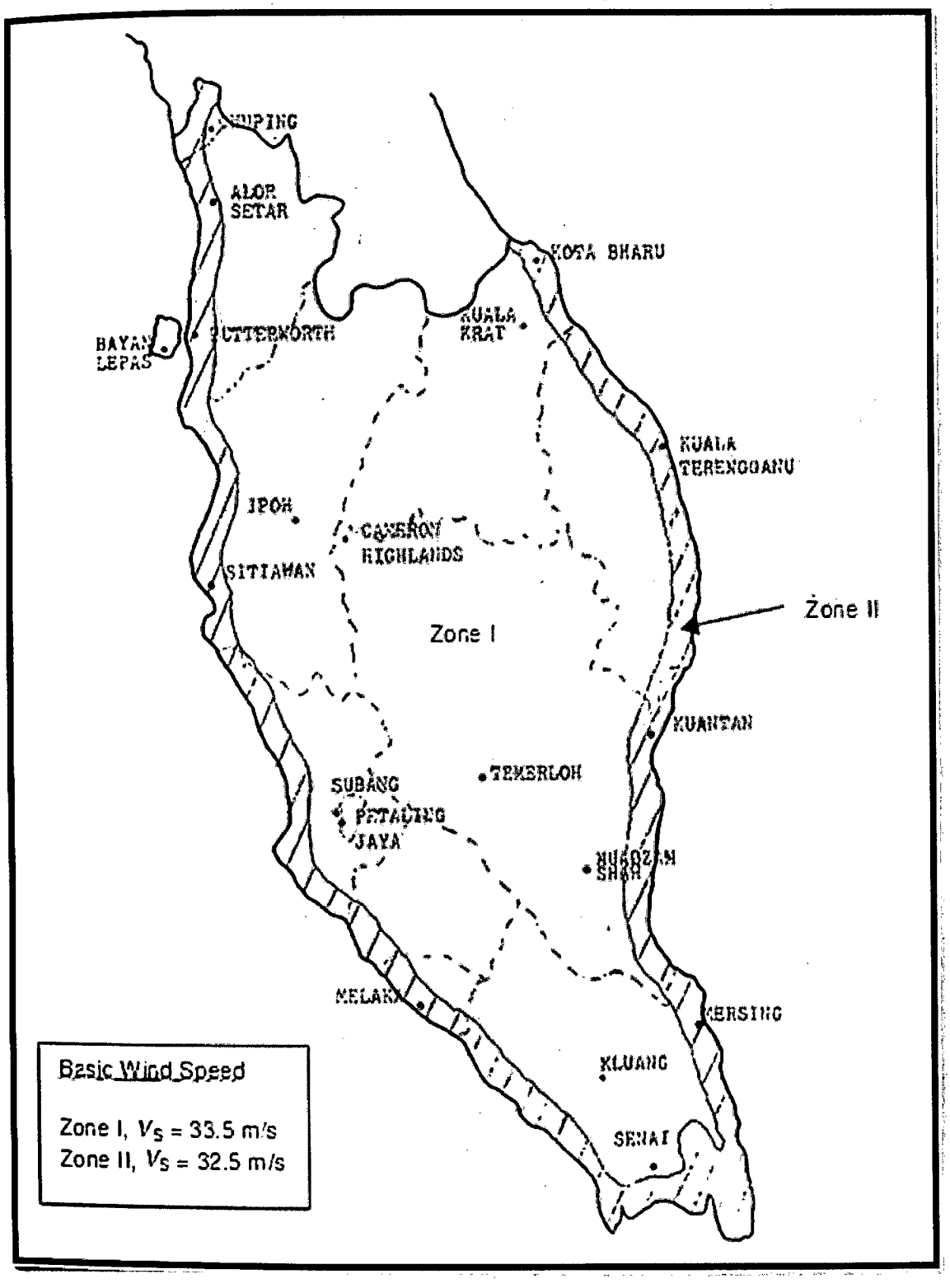


Figure 2.1: Peninsular Malaysia (MS 1553, 2002)

Malaysia is located near the equator area which almost every day has clouds although in dry seasons. Malaysia is a country with high humidity, uniform temperature and equivalent rainfall. Changing position of sun along the annual seasons around the equator is cause of monsoons. Difference in water temperature on the oceans, and pressure areas which is mountain and valley, can cause strong winds and over regional air streams. In general, the wind climate is dominated by the two monsoon seasons and the inter-monsoon thunderstorms. The north-eastern monsoon blows from December to March, usually accompanied by heavy rains. Around June to September, there blows the south-western monsoon which is slightly tranquil. Thunderstorms frequently occur during the inter-monsoon periods. Although thunderstorms are localized phenomena, they often produce significant strong and gusty surface winds. These winds from thunderstorms are relatively stronger and more turbulent than those of monsoon winds. (Choi, 1999) Unlike in cyclone prone region, the thunderstorms in Malaysia occurs in micro scale (Yusoff , 2005). Despite their small size and short duration of thunderstorm which is about 15 to 30 minutes. Every thunderstorm produces lightning which has the potential to kill people. From the previous study roof was the most components significant to damage due to wind storm (Majid et. al. 2010)

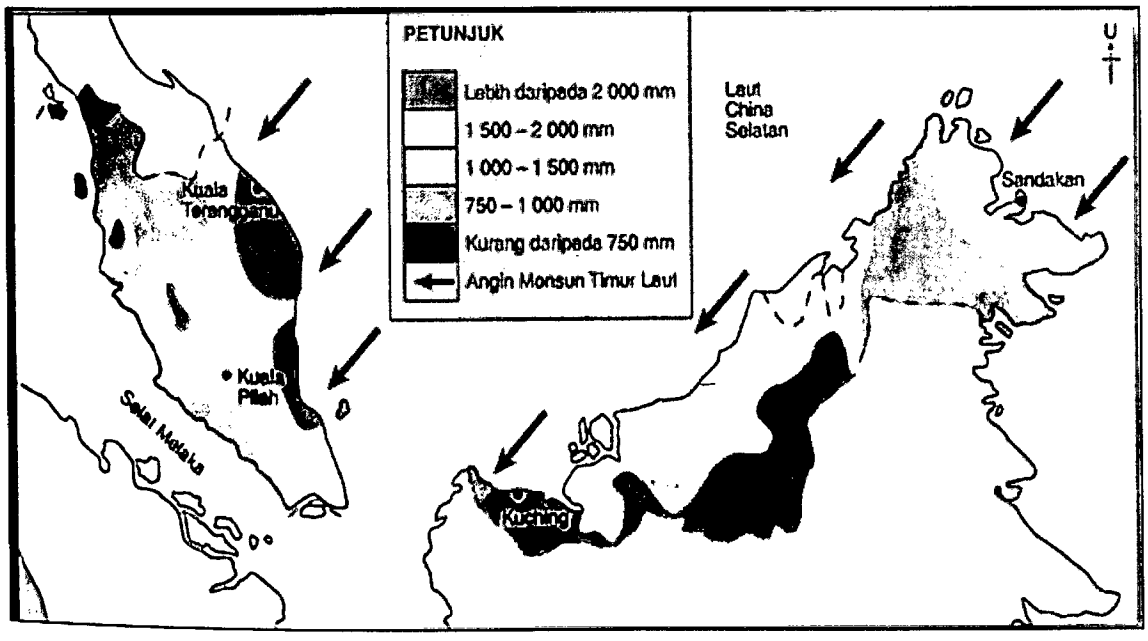


Figure 2.2: Northeast Monsoon Seasons (eoearth, 2011)

One of maritime country is Malaysia. Wind in East Malaysia may reach 20 knots or more when in high wind blow. Land breeze will cover all over the coastal area when at night, because at sunny, sea breezes take place and this sea breezes may rich maximum 15 knots. This phenomena sea breezes and land breezes made Malaysia in high humidity which the average temperature is 20 degree Celsius until 30 degree Celsius. Malaysia is located in tropics area which the tropics means heavy rainfall received all the year. Rainfall in Malaysia is covered with 328550 sq. km, which is plenty rainfall and the annual rainfall is 2500mm. normally thunder and lightning will go along with raining and eventually this thunderstorm will make higher wind blow. When wind blow stronger, it is normal to have some failure in structure especially on roof.

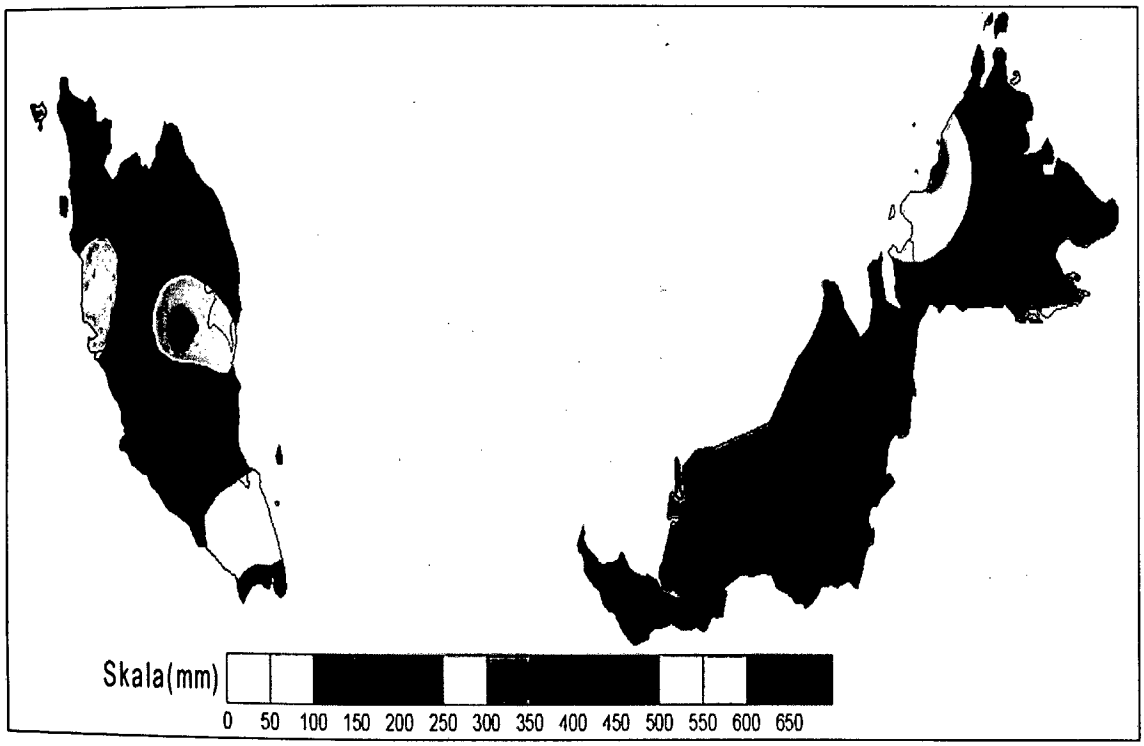


Figure 2.3: Malaysia Daily Rainfalls (Jabatan Meteorology Malaysia, 2013)

2.3 CORRUGATED GALVANISED IRON (CGI) ROOF SHEETING

Corrugated galvanised iron roof sheeting is the best user in non-engineering roof in Malaysia. This CGI roof sheeting is probably the cheapest roof material in industry, so the villagers can afford to buy this CGI roof sheeting. CGI roof sheeting has its advantages and disadvantages in term of characteristics and strength, but CGI roof sheeting is the best user because CGI roof sheeting is an old material that had been made for about century. Floppy sheet of thin iron transform into roofing with some simple process of forming corrugated CGI roof sheeting. In Malaysia, most of the rural houses are considered as non engineering structures. Corrugated Galvanised Iron (CGI) sheet metal is commonly used in rural house roofing system. However there are no specific guidance of how the sheet CGI metal are been assemble. CGI metal frequently was pull-through failure during the thunderstorm due to uplift forces. From the previous study the each of single nail connection can be withstand up to 0.67 kN (Lee, 2008). "Corrugated galvanised iron describes the original product that was wrought iron plate coated with CGI and then roll formed into corrugated sheets." (Lee, 2008).

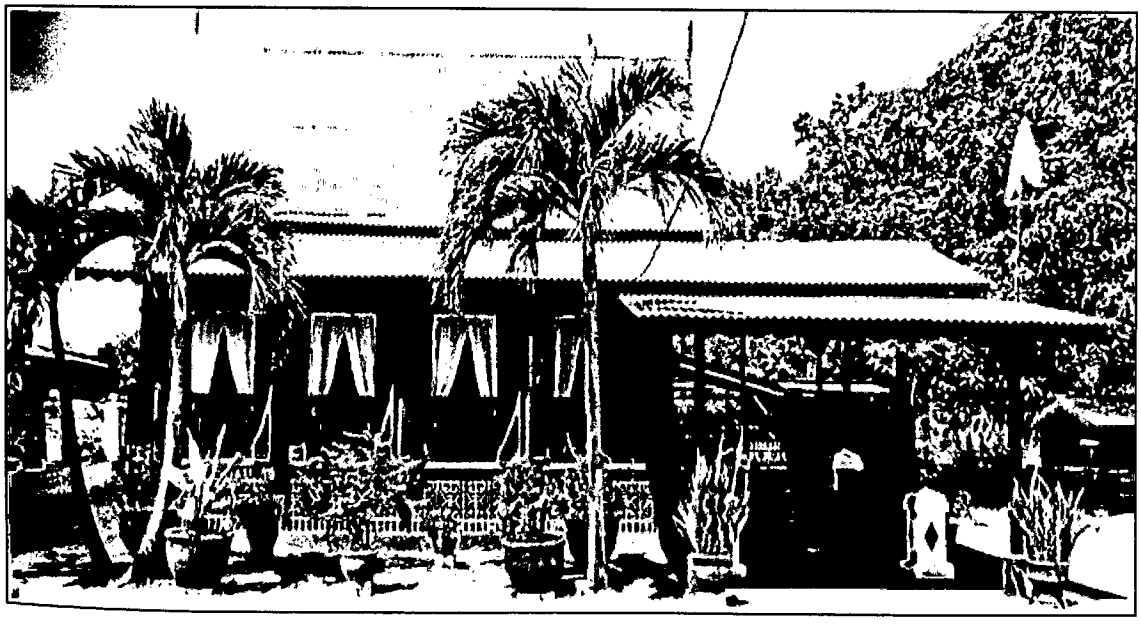


Figure 2.4: an example housing of non-engineering CGI roof system (fotomedia, 2009)

Wind load distribution on CGI roof system will give pressure on CGI roof and suction at another side of CGI roof area. Roof joint is important factor that involved to failure of non-engineering after its own material that is CGI roof sheeting. The distance of joint is an important role in determine the failure on CGI roof sheeting with same maximum wind speed in Malaysia which is 32.5 metre per second. This maximum wind speed is the speed of fifty years returns period wind speed. Performance under strong wind conditions is required to ensure the CGI roof sheeting can prevent large deformation of wind load distribution. "The fatigue phenomena on the connecting elements between the roofing system and the frames due to daily solar heating effects should be also taken seriously." (Tamura, Cao, 2009).

The principle solution which has changed the old galvanised in terms of iron (CGI sheeting) will be known as "CGIalume". This particular name being produced from each main pieces of the actual shell method, that involves CGI 55% or aluminium 43% or silicon 1.6% which fur the steel foundation. The particular product will be routed from the steel work with large comes associated with toned linen. The principle distinction within the coils products are usually:

- CGIalume: This can be an organic colour in the linen which seems to be similar to the old galvanised in terms of iron. This weathers using occasions and also manages to lose it is vibrant gleaming seem.
- Collarbone: Fundamentally it can be CGIalume that has a colour exterior added. This can be purchased in concerning 20 numerous hues. It has an ordinary painted finish off on the bottom.
- Collarbone Metal: The material sheen which alterations below unique light circumstances.
- Collarbone Ultra: For significant resort and also professional conditions.
- Metal: For significant resort and also professional conditions.
- Width: For the most part I'm sure which regarding individual home work the 0. 42mm dense will be the most prevalent. As you're able see it will be fairly thin goods, fewer than half a new millimetre most of the idea.