WIND LOAD EFFECT TO THE PATIO COVER STRUCTURE

MOHD ERIE ADNIN BIN ZAMRI

Report submitted in partial fulfillment of the requirement
for the award of the degree of
B.ENG (HONS.) CIVIL ENGINEERING

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JULY 2014

ABSTRACT

Structural damage due to wind storm is often occurred in Malaysia. Base on previous study conducted, non-engineering structures are simply to fail due to wind load. One of the common non-engineering structures is patio or always be identify as awning. This type of structure is commonly used as additional extension to Malaysian building system for several purposes. The information related to this type of structure due to wind load is very rare. Therefore, further understanding of the wind load impact to patio need to be well understood before structural can be design to resist wind load. Therefore this study is conducted to identify the possibility of wind speed can caused the failure to the structure. Three type of dimension are used in this study which is 3m x 3m, 3m x 4.2m and 3m x 5,4m which are been identified as common size than widely used in Malaysia. Structural Design Software namely SAP 2000 are been used to examine the wind load effect to patio. From the result is shown that by minimum wind speed that cause possibility of failure to the patio structures is 16 m/s. Result also had shown that the distance between the trusses systems in patio structure need to be considered. Therefore the consideration of wind load design in patio structure need to be concern during construction stage. Further investigation need to be investigated in order to ensure the patio can able to withstand to wind load.

ABSTRAK

Kerosakan struktur akibat ribut angin sering berlaku di Malaysia. Berdasarkan kajian yang dijalankan sebelum ini, struktur bukan kejuruteraan mudah untuk gagal disebabkan oleh beban angin. Salah satu contoh struktur bukan kejuruteraan yang biasa digunakan adalah teras atau lebih mudah dikenali sebagai 'awning'. Kebiasaan jenis struktur ini digunakan adalah sebagai lanjutan atau atap tambahan kepada sistem bangunan Malaysia untuk tujuan tertentu. Maklumat yang berkaitan dengan struktur jenis ini berdasarkan beban angin adalah sangat jarang ditemui. Oleh itu, pemahaman selanjutnya tentang kesan beban angin ke atas patio perlu difahami dengan baik sebelum struktur ini boleh dijadikan reka bentuk untuk menahan beban angin. Oleh itu kajian ini dijalankan untuk mengenal pasti kemungkinan kelajuan angin boleh menyebabkan kegagalan kepada struktur. Terdapat tiga jenis dimensi yang digunakan dalam kajian ini iaitu 3mx3m, 3mx4.2m dan 3mx5.4m yang dikenal pasti sebagai kebiasaan saiz yang sering digunakan secara meluas di Malaysia. Perisian Rekabentuk Struktur iaitu SAP2000 telah digunakan untuk mengkaji kesan beban angin untuk patio. Dari hasil keputusan, ia menunjukkan bahawa kelajuan angin minima yang boleh menyebabkan kemungkinan kegagalan kepada struktur teres ialah 16 m/s. Keputusan juga menunjukkan bahawa jarak di antara sistem kekuda dalam struktur teras perlu dipertimbangkan. Oleh itu, pertimbangan reka bentuk beban angin pada struktur patio perlu dititikberatkan semasa peringkat pembinaan. Siasatan lanjut perlu disiasat untuk memastikan struktur patio dapat menahan daya beban angin

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPHS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Percentage of the temporary structures failure are reported increased in Malaysia and has drawn the attention of many parties. In order to ensure these problems can be overcome, further understanding of the wind load impact to the structure need to be well understood before structural can be design to resist wind load.

Malaysia is located near the equator. Two monsoon seasons and inter-monsoon thunderstorms are dominating wind climate in this country. The two monsoons generally blow from December to March and June to September. North-eastern monsoon that occurs in December usually accompanied by heavy rain while south-western monsoon comes in June 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). Regardless of their small size and short duration of thunderstorm which is about 15 to 30 minutes, and every thunderstorm produces lightning has the potential to kill people. From the previous study patio cover was the most components significant to damage due to wind storm (Majid et. al, 2012).

Weather nowadays is unpredictable. It experience rainy, high temperature and windstorm. Every family love to spend time together and most convenient place for them to spend time together is in their own home yard especially patio. To ensure patio more advantageous in variable weather conditions, homeowners commonly choose to cover them.

The structure that can provides covering the patio area from rain and sun is patio cover. It is considered as non-engineering structure. The common materials that used for patio cover are zinc, metal deck, fabric and polygal. Nevertheless, there is no specific guidance of choosing patio cover dimension with suitable distance of trusses system.

The most common types of patio covers are often referred to as awnings. Awnings are the most common types of patio cover that covering patio area as permanent structure. A permanent structure means they are built out from the house below the gutter and extends the width and length of the patio, supported by posts along the longest edge. In Malaysia, there are varieties of materials to construct the awning, but most frequently used is hollow steel section and timber. Patio covers are fully independent group of structure that cannot be interpreted as a subsection associated with canopies or maybe eaves. Applying the design pressure alone is not sufficient. It is mostly mild and vulnerable to wind-induced by loads that required strict design and considering the economical and safety during construction.

This study is the part of the study of research was conducted to investigate the wind load effect on the structures and wind speed that can causes failure to patio cover structures in Malaysia. This study included the descriptions and the results of finite element. The analysis carried out the covering various loading and geometry configuration, it conducted on patio cover are using SAP2000 software. All the values used for the design is taken from the norm in Malaysia. For this project, the title is 'Wind Load Effect to the Patio Cover Structure'. The method for this analysis is using Finite Element Method into the SAP2000 software. Outcome for this project involved analyzing and designing patio cover, wind speed and wind load.

1.2 PROBLEM STATEMENT

Malaysia is the Tropical Country that has rainy season. Many problems may occur in rainy season like windstorm, flood, damage of material and et cetera. Patio cover is one of the common structures that built in Malaysia. In my study about the patio cover, during rainy, windstorm will occur first with the rain. The high speed of wind can cause the damage of patio cover structure. Plus, the less of awareness about the proper estimation of wind speed that can cause failure is the main factor for this problem. The materials used for patio cover also can be a factor of failure structure. However, in construction field, the important stage should be considered before the process can be proceed to the next level is the analysis of structure. It is intended to identify the deflection, stress and strain for the structure before it can be design. The available wind provisions included are insufficient information regarding design load for such structural components.

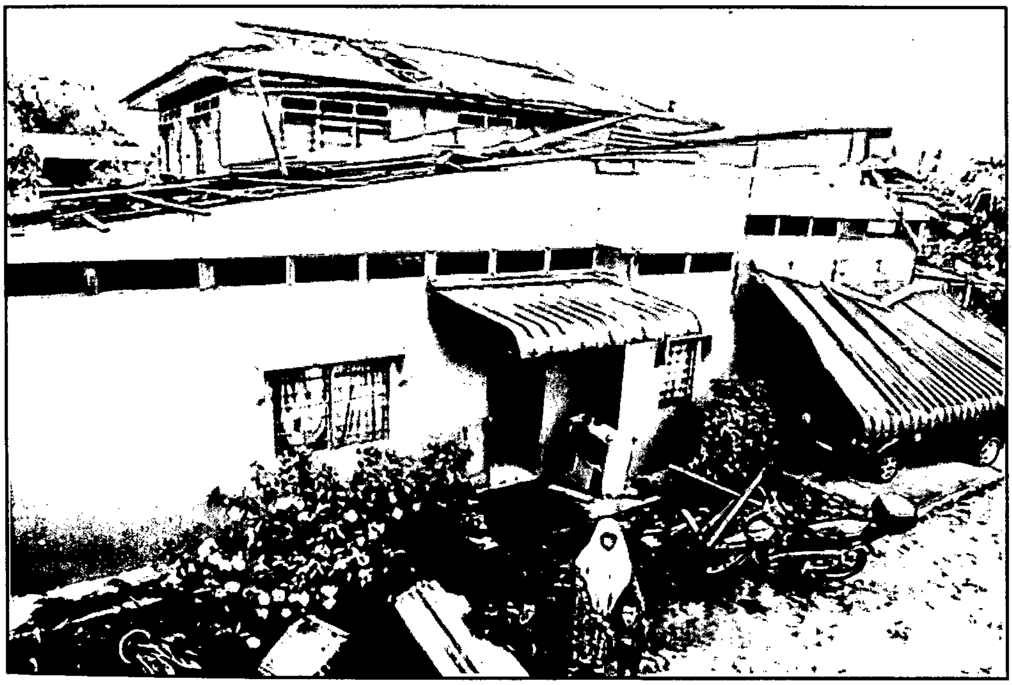


Figure 1.1: Patio Cover Structure Failure

Source: Kosmo, April 2014

1.3 OBJECTIVE

The main objectives for the study are:

1. To analyze the effect of wind load on patio cover structure
2. To identify the possibility of wind speed can caused the failure to the structure.

1.4 SCOPE OF STUDY

In order to achieve the objectives of this study, the highlighted scopes have been identified related to this study. The decision made to include in the scopes is analyzing the design of patio covers (awning) structure by using SAP2000. It intended to make simulation on patio cover with different parameter (3mx3m, 3mx4m, 3mx5.4m). The objective of simulation is to determine the relationship between wind speed and the dimension of the patio cover (distance between trusses to trusses system). The study also shows how wind load whether uplift load, downward pressure and moment will affect the structure. Before the analysis begins, the tutorial about SAP2000 must be learned first.

1.5 SIGNIFICANT OF STUDY

Rural area is the most advantage site to get more understanding about the wind load distribution on the non-engineering structure. This study more focuses on patio cover structure as the non-engineering structure. Patio cover also known awning are commonly use Corrugate Metal Deck as awning sheeting and steel hollow section as trusses member to support load from upper such as rain and wind loads. Without the sufficient information and proper design load, the possibility for structure to get fail is higher than the proved structure. Therefore, the study is conducted to determine the minimum wind load that the non-engineered structure can withstand from it. It can be a guideline to the people about the relationship between wind speed and the failure of structure. It also can reduce the failure if people had the guideline.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Wind engineering analyzes the effects of wind in the natural and the built environment and studies to the possible damage, inconvenience or benefits which may result from wind (Wikipedia, 2014). The other definitions of Wind Engineering disbursed by Jack Cermak in 1975, "Wind engineering is best defined as the rational treatment of the interactions between wind in the atmospheric boundary layer and man and his works on the surface of the Earth" (Cermak, 1975)

Wind engineering also do the study of the actions and effects of wind on built-up and natural environment at the present, with the engineering panorama, one of the most relevant as well as pressing on lines of research because of the importance and amount of the scientific, technological along with technical problem it concerns. Drawing its principles from several disciplines like physics of the atmosphere and fluid mechanics, meteorology and micro-meteorology, urban planning, aerodynamics and aeronautics, physiology and psychology, architecture and bio-climatic studies, civil, environmental, energy and mechanical engineering, wind engineering develops autonomous concepts and methods which are applied in all sorts of contexts (Solari, 1998)

It dealings with forecasting in addition to reduce damage caused coming from storms, of which alone are generally responsible intended for a lot more than 80% of a human casualties and also economic losses that world suffers from natural events, with the representation and measure of the wind, its related meteorological phenomena, the forecasting of weather and climatology, the aerodynamics associated with constructions and vehicles, wind tunnel experiments, the computer simulation of any flow fields as well as of step associated with wind from bluff bodies, the wind behavior connected with all constructions, inside particular towers, skyscrapers, bridges, large roofs in addition to almost all structures whose safety depend from wind, the current diffusion connected with atmospheric pollutants, the current quality of air and environmental protection, ones employ involving wind energy and the selection of sites pertaining to wind turbines, the current land planning pertaining to wind problems (Solari, 1998).

2.2 WIND

Wind is the motion in air. Wind is formed by air flowing from high pressure to low pressure. It can be changed the direction and speed when hit any obstacle around it. These actions give wind its turbulent or gusty character. According to (Mendis, 2007), the gustiness are tends to decrease with height while the average wind speed more tends to increase with height or increase speed over a time period of the order of ten minutes. Wind kinetic energy converted into potential energy of pressure, thus it will produce wind load. Patio covers are fully independent group of structure that cannot be interpreted as a subsection associated with canopies or maybe eaves. It is mostly light and vulnerable to wind-induced loads.

2.3 WIND LOAD

Wind loads at buildings are tested utilizing codes and standards whose specifications are usually in accordance with wind-tunnel tests conducted on isolated structures and do not carry in accounts interference effects. As pointed out by (Prem Krishna, 1995) the knowledge of the mean pressure alone can be inadequate in order the protection of the building as well as it is necessary to realize the fluctuations as well as the peak values just as well, particularly any time severe winds usually are concerned and also the current dynamic reaction becomes important.

Notwithstanding the kind of development, structures are subjected to two essential sorts of loads under high winds. Uplift loads result from air streaming over the roof, bringing on a suction force. Parallel loads result from wind blowing on the windward divider, and in addition wind blowing past the leeward divider. These two parallel powers act in the same bearing and join together to make compel that tried to push the building over or slide it toward the wind. Horizontal loads can likewise come from the wind blowing on a steep pitched top (Shackelford, 2007).

Shear force are transferred from the highest point of the building to the base. It is opposed by nailing boards at their edges to the divider confining (diminished nailing at the board inner part is likewise given to oppose board clasping and wind suction loads). By differing the nailing and board thickness, diverse levels of shear safety could be attained. The measure of shear in each one board relies on upon the wind speed, presentation, building height (and size in the perpendicular course), and the measure of sheathing on the shear divider. The all the more sheathing on the divider, the less each one board needed to work. Since current plans regularly require numerous openings in the dividers, there is less and less sheathing to go about as shear dividers, so each one board has a tendency to need to oppose more force (Shackelford, 2007).

There are the differences types of wind load on building structures:

- Pressure and Suction
- Uplift load
- Overturning
- Shear force
- Sliding force

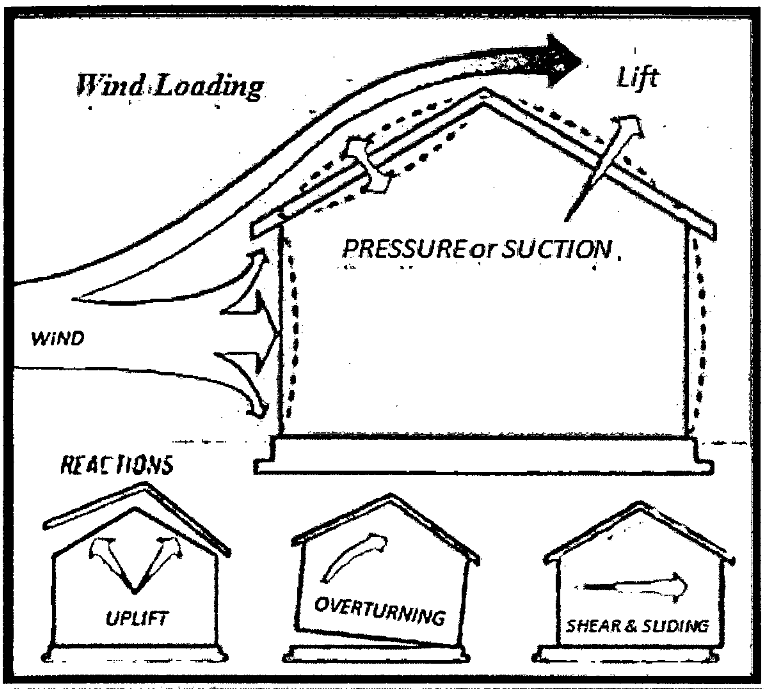


Figure 2.1: Types of wind load on building structures

Source: hurricanehotline.org/windforces.html, (March 2014)

2.4 WIND GUSTS AND AIR TURBULENCE

Wind steps in the structure creates occurrences in which the flow of any wind interact because of the surrounding structures as well as environment of which gives rise to whirls involving varying sizes along with some other rotation patterns. The behavior creates the current gusty in addition to turbulent character of a wind and also an example associated with whirls developed around a building can be visualized in Figure 2.2. The tall building that has a slender shape will probably respond dynamically to wind-loads as well as may lead to the failure whether a great coupled torsional along with flexural mode involving oscillation is actually developed (Mendis, 2007)

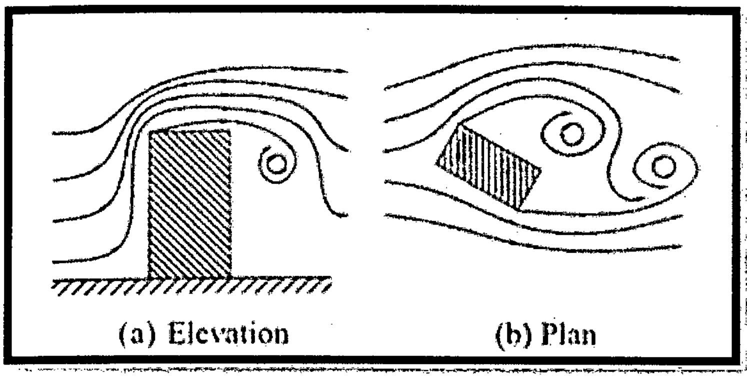


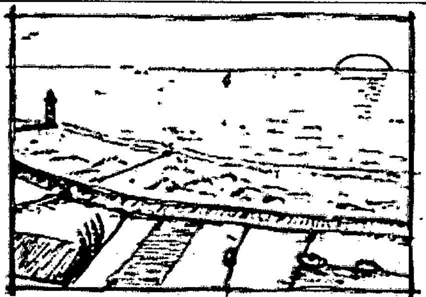
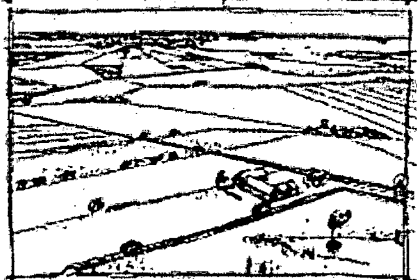
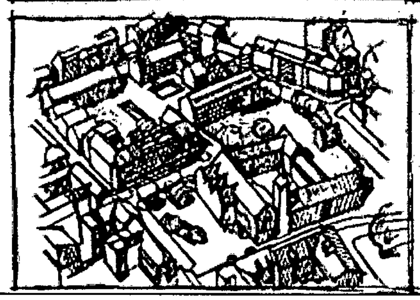
Figure 2.2: Generation of whirls

Source: Mendis, (February 2014)

The wind will be taken as a lateral dynamic stress during which the pressure for the building is divided into a great mean section and a great fluctuating part according to Eurocode 1 (EC 1). The mean section can be calculated by pressure in addition to complete coefficients and the fluctuating part can be taken into account by similar to the intensity connected with turbulence at site, size reduction factors as well as dynamic amplification.

Wind pressure from external and internal surfaces must be calculated as outlined by EC1. The current pressure delivered to the surface is usually taken in the same way positive and suction routed away because of the surface as negative. The roof and walls tend to be subdivided into other zones inside were made pressure coefficient to be able to calculate the current wind-loads on the structure. The current internal pressure is actually dependent for the area and location of an opening with the structure. The surrounding terrain is categorized in line with the associated roughness length and varies through open terrain to help close surrounding buildings and obstacles. Throughout EC 1 there are discover all 5 different terrain categories that happen to be visualized in Table 2.1.

Table 2.1: Assessment of Terrain Category

NA to I.S. EN 1991-1-4 and for use with Draft TGD A	Annex A1 of I.S. EN 1991-1-4 descriptive and illustrative reference	
Sea Terrain	**Terrain category 0** Sea, coastal area exposed to the open sea	
Country Terrain	**Terrain category I** Lakes or area with negligible vegetation and without obstacles	
	Terrain category II Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	
Town Terrain	**Terrain category III** Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	
	Terrain category IV Area in which at least 15% of the surface is covered with buildings and their average height exceeds 15m	

Source: Comhshaol, (April 2014)

2.5 WIND HAZARD

Probability for every year a certain part in Malaysia can be expected associated with damages caused by the wind speed. The damages can affect either to the properties (vehicles destroyed and roof blown off), environment (uprooted trees from the roots) and also involves human (people killed and injured). The current losses caused by a typical damage value can reach from thousand in order to million ringgits. The impacts regarding wind speed also could give the social problem just like trauma or the victims become homeless (Bachok et. al, 2012)

Most of possibility risk involving wind hazard based on the latest news is the cause to the destruction of buildings and also structures in Malaysia. There is little emphasis on the design of building structures such as patio cover structure to minimize the wind-induced damage to the buildings. Some studies had made from earlier researchers in Malaysia. Because of the study had made there are many details are usually proven contribute damage to be able to building component. The risk of wind hazard problems due to wind storm is become important issues in Malaysia. The lack of information regarding wind hazard are rigorously needed in order to reduce the risk reduction. It can be concluded most of the failures cause by the lack of information had result the weakness consideration in design stage (T.A Majid, 2012)

Table 2.2: Effect of Wind Hazard in Malaysia

DATE	LOCATION	TYPE OF DAMAGE	IMAGE	SOURCE
13 OCTOBER 2010	Baling, Kedah	Awning structure failure		utusan.com. my/utusan
03 JULY 2012	Sungai Petani, Kedah	Awning structure failure		utusan.com. my/utusan
27 SEPTEMBER 2012	Butterworth Pulau Pinang	Awning sheeting failure		utusan.com. my/utusan
20 JUNE 2014	Balik Pulau, Melaka	Awning and roof failure		kosmo.com. my/kosmo

Table 2.3: Series of selected windstorm occurrences in Malaysia and its damages

State	Date	Damage	Estimation loss (RM)
Perak	29 April 2000	People killed, house destroyed, roof blown off, power pole brought down, power cable snapped and power failure	Not stated
Kelantan	19 May 2001	House damaged and roof blown off	200,000.00
Kuala Lumpur	31 March 2002	People killed, people injured, roof blown off, vehicle destroyed and tree uprooted	Not stated
Kedah	10 April 2003	House collapsed, house damaged, roof blown off, roof damaged, tree uprooted and goal post blown away	1,000,000.00
Johor	28 May 2004	People injured, house collapsed, roof damaged, gate damaged, vehicle destroyed, road crashed, road closed, tree uprooted, tree trunk broken, power pole brought down and booth blown away	100, 000.00
Malacca	1 May 2005	Animal killed, house damaged, fence damaged and tree uprooted	60, 000. 00
Penang	11 July 2006	People injured, vehicle destroyed and tree uprooted	100, 000.00
Sarawak	14 January 2007	Vehicle destroyed, tree uprooted and power pole brought down	Not stated
Perlis	7 October 2008	House damaged and roof blown off	40,000.00
Terengganu	30 September 2009	Uprooted tree, house collapsed, house damaged, roof blown off, vehicle destroyed and vehicle damaged	200, 000.00
Pahang	22 August 2010	People injured, house damaged, roof blown off, vehicle destroyed, tree uprooted and canopy blown away	500, 000.00
Negeri Sembilan	30 July 2011	House damaged, roof blown off, vehicle destroyed, vehicle damaged, uprooted tree, power pole brought down, traffic light brought down, signage brought down and canopy blown away	1, 500 000.00
Selangor	7 February 2012	House damaged and roof blown off	250, 000.00

* Newspaper, (2000-2012)

2.6 WIND SPEED

Wind speed, or wind velocity, is a fundamental atmospheric rate. Wind velocity influences climate forecasting, maritime operation and aircrafts, growth and metabolism rate of many plant species, construction projects, and incalculable different ramifications.

In the case of study, at great heights above the surface of the earth, in which frictional effects usually are negligible, air movements are usually driven through pressure gradients for the atmosphere, which throughout turn are usually ones thermodynamic consequences regarding variable solar heating of the earth. The upper level wind speed will be known in the same way ones gradient wind velocity. Some other terrains may be categorized according in order to their associated roughness length. Throughout practice, the idea has been found useful to be able to labor and birth throughout a great reference wind speed based on statistical analysis associated with wind speed accounts consumed on meteorological stations half a dozen over the country. The definition of the reference wind speed varies via sole country to another. Basic design wind speeds with regard to additional directions and some other return periods can always be derived applying the rigorous analysis incorporating probability distributions intended for wind speed and direction.

Below are provides procedures for defining gust wind speeds appropriate to the area in which a structure is to be constructed. Station wind speeds for all directions based on 3-second gust wind data is given in Table 2.4 for the areas shown in Figure2.3. V_{20} is the wind speed for a return period of 20 years, V_{50} for 50 years and V_{100} is for 100 years.

Table 2.4: Wind speed (m/s) for various return periods

Station	V_{20}	$V_s = V_{50}$	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
Kuala Krai	27.2	29.5	31.3
Kuching	29.5	32.6	34.9
Kota Bahru	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

Source: MS 1553:2002, (April 2014)