THE INVESTIGATION ON EFFECT OF TERRAIN IN WIND RELATED DISASTER

NIK NOR AMALINA BINTI MUSTAFA

A report submitted in fulfillment the requirement for the award of the degree of

B.ENG (HONS.) CIVIL ENGINEERING

Faculty of Civil Engineering & Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2014

ABSTRACT

Topographic amplification of wind speed has been a significant contributing factor in the past experience. The concerning in actual wind speeds at wind-induced damage to buildings and structures incident spot are increased recently. Areal assessment of wind speeds due to topography effect need to investigate. The specific objectives of this research are as follows: To create a database of wind-induced damage and to quantify the wind speed at the incident spots. The wind-induced damage location and surrounding topography of spot had been map using Geographical Information System (GIS). Further, hill shape factor of topography at the incident spots had been calculated, based on MS 1553:2002. Finally, actual wind speeds at the spot were determined. The result show topography will increase the wind speed that effect building and structure at the spot. Therefore the considerations due to the topography effect in wind loads at design stage are vital.

ABSTRAK

Penguatan Topografi kelajuan angin telah menjadi faktor penyumbang yang penting dalam pengalaman yang lalu Sejak akhir-akhir ini kelajuan angin sebenar pada kerosakan angin didorong oleh bangunan dan struktur tempat kejadian.Oleh itu, penilaian sebenar kelajuan angin disebabkan oleh kesan topografi perlu siasat Objektif khusus kajian ini adalah seperti berikut: Untuk mewujudkan pangkalan data kerosakan angin teraruh dan untuk kuantiti kelajuan angin di tempat kejadian. Lokasi kerosakan angin teraruh dan topografi sekitar tempat telah peta menggunakan Sistem Maklumat Geografi (GIS). Seterusnya, faktor bentuk bukit topografi di tempat kejadian telah dikira, berdasarkan MS 1553:2002. Akhir sekali, kelajuan angin sebenar di tempat yang telah ditentukan. Menunjukkan hasil topografi , akan meningkatkan kelajuan angin dan kesan kerosakan pada bangunan dan struktur di tempat kejadian. Oleh itu, pertimbangan disebabkan oleh kesan topografi dalam beban angin pada peringkat reka bentuk adalah penting.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

GIS	Geographical Information System
MMD	Malaysia Meteorology Department
SRTM	Shuttle Radar Topography Mission
Z_o	Roughness length
N	North
S	South
E	East
W	West
NE	North-East
NW	North-West
SW	South-West
SE	South-East
Mh	Hill Shape Multipliers
$M_{z,cat}$	Terrain/ height multipliers
MS	Malaysian Standard

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The investigation on effect of terrain in wind related disaster. Wind is a phenomenon of a great complexity because of the many flow situations arising from the interaction of wind with the building or structure. Wind can categories as a composed of a multitude of eddies of varying sizes and rotational characteristics carried along in a general stream air moving relative to the earth's surface or known as "terrain".

Trade winds also one of the effect of the wind movement thorough the earth. The trade winds or trades are the prevailing pattern of the easterly surface winds founds in the tropics, within the lower portion of the earth's atmosphere, in the lower section of the troposphere hear the earth's equator. The trade winds blow predominantly from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere, strengthening during the winter and when the Arctic oscillation is in the warm phase. Historically, the trade winds have been used by captains of sailing ships to cross the world's oceans for centuries, and enabled European empire expansion into the Americans and also the China to Malaysia cross the South China Sea.

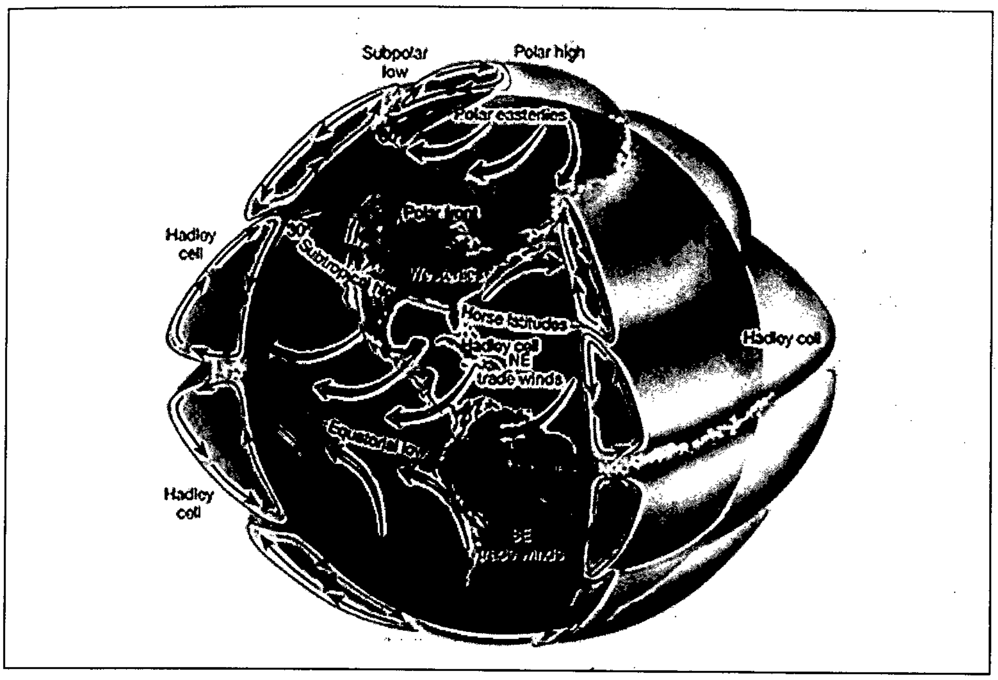

Figure 1.1: Trade Winds Diagram
Source: https://www.fas.org (20-Jan 2014)

This research will discuss most about the recent wind-induced damage to buildings and structures, including that due to tropical cyclones. Characteristics of wind (i.e.: Wind speed and direction) varies with height and that the variation is related to the drag on the wind as it blows over upstream areas. As the drag, among other things is related to the roughness of the ground, the different types of terrain produces different roughness effects.

Lately event of damage to the structure raised questions about the cause of the incident (eg: Stadium Terengganu, Menara Umno, Dewan Canselor Kolej Universiti Tati (Tatiuc) at Teluk Kalung, Kemaman collapse, etc). Based on the place and time of the incident, the possible effect of wind into the cause of the incident could be high. So, wind characteristic information required for verification assumptions.

Table 1.1 below shows the summary of damage due to windstorm in 2010 (Jan – Aug).It can be shown that most of the damage occurs in Northern region on Peninsular Malaysia.

Table 1.1: Damage due to Wind Storm in Malaysia (Jan- Aug 2010)

Date	Place	Region	Numbers of Affected	Structure Damage
27-Jan-2010	Sungai Petani, Kedah	Northern Peninsular	350 Houses	Roof and Truss
5-Apr-2010	Bukit Mertajam ,Penang	Northern Peninsular	21 Houses	Roof and Truss
5-Apr-2010	Mergong, Kedah	Northern Peninsular	13 Houses	Roof and Truss
12-Apr-2010	Baling, Kedah	Northern Peninsular	200 Houses	Roof and Truss
13-Apr-2010	Merbuk, Kedah	Northern Peninsular	150 Houses	Roof and Truss
22-Apr-2010	Sg Besi – Kg Melaysia	Middle Peninsular	18 Houses	Roof and Truss
1-May-2010	Ulu Bernam, Selangor	Middle Peninsular	Secondary School	Roof and Truss
31-May-2010	Parit Buntar – Perak	Northern Peninsular	*	Roof and Truss
11-Jun-2010	Batu Gajah – Perak	Northern Peninsular	30 Houses	Roof and Truss
13-Jun-2010	Temerloh, Pahang	Eastern Peninsular	9 Houses and School	Roof and Truss
7-July-2010	Beaufort, Sabah	Eastern Borneo	50 Houses	Porch, Roof
15-July-2010	Kuala Perlis,Perlis	Northern Peninsular	150 Houses	Roof and Truss
12-Aug-2010	Termerloh, Pahang	Eastern Peninsular	20 houses Canopy Damage	Roof Night Market
13-Aug-2010	Malacca	Southern Peninsular	Canopy Damage 3 Kills 30 injured	Night Market (Flying Debris)
14-Aug-2010	Jerlun, Kedah	Nothern Peninsular	1 Houses, Crop	Roof
14-Aug-2010	Petaling Jaya, Selangor	Middle Peninsular	*	Roof and Truss
31-Aug-2010	Tanjong Malim	Middle Peninsular	Canopies Damage	Night Market

(Source: Malaysia Country Report 2010 by T.A. Majid, Noram I. Ramli, M. I. Ali, M. Syamsyul H. Saad M. Hashim I. Zakaria)

Here is also some of the wind-induced damage to buildings and structures issues that happen recently in Malaysia:

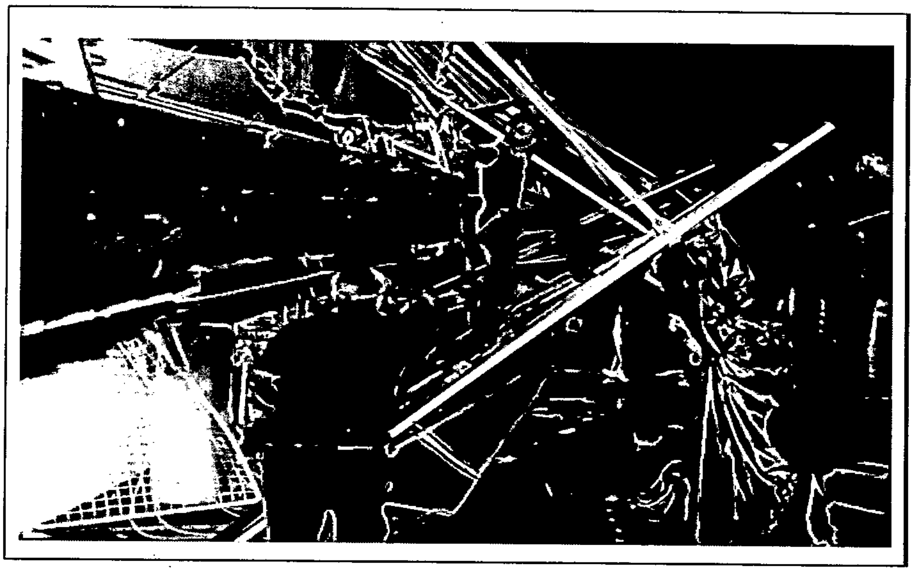

Figure 1.2: Roof off supermarket in Kuala Berang collapse

Source: Sinar Harian (1 October 2013)

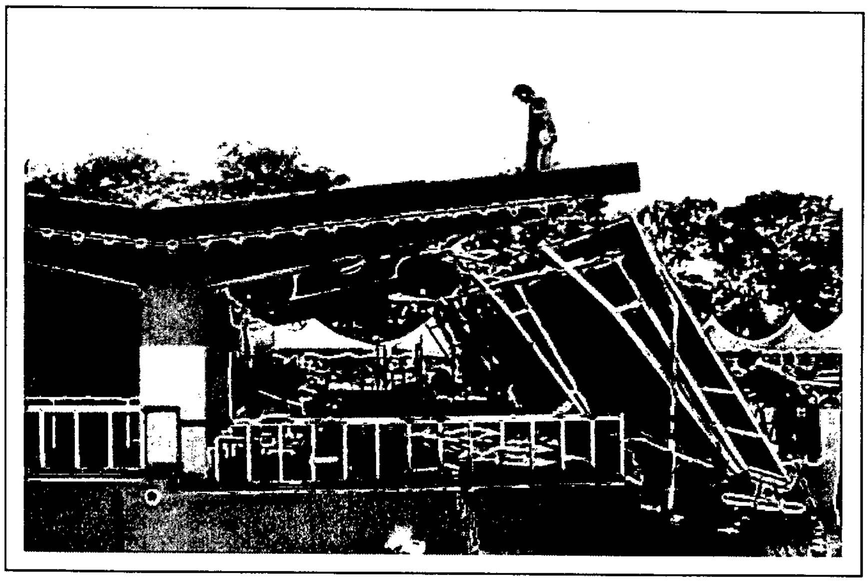

Figure 1.3: Pavilion roof canopy collapse

Source: Sinar Harian (1 Januari 2013)

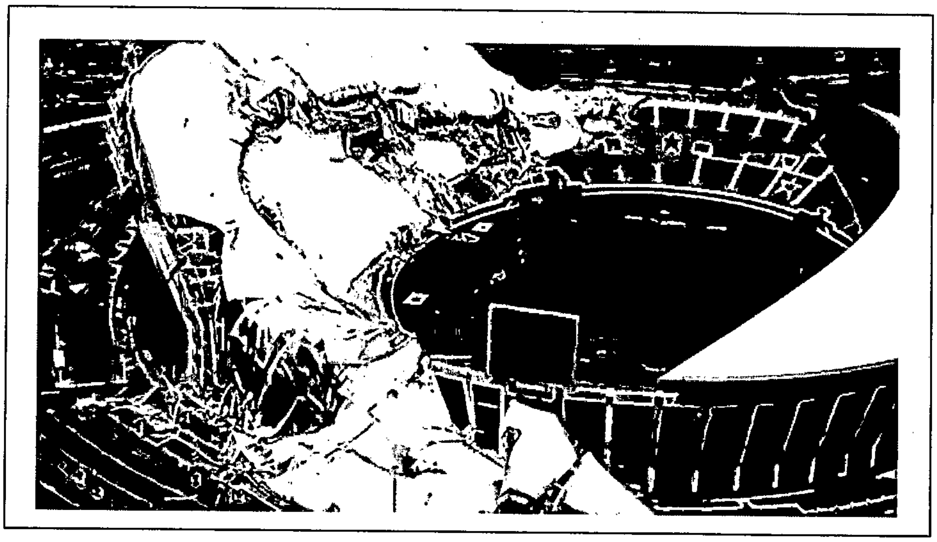

Figure 1.4: Terengganu Stadium collapse

Source : The Star (Jun 3, 2009)

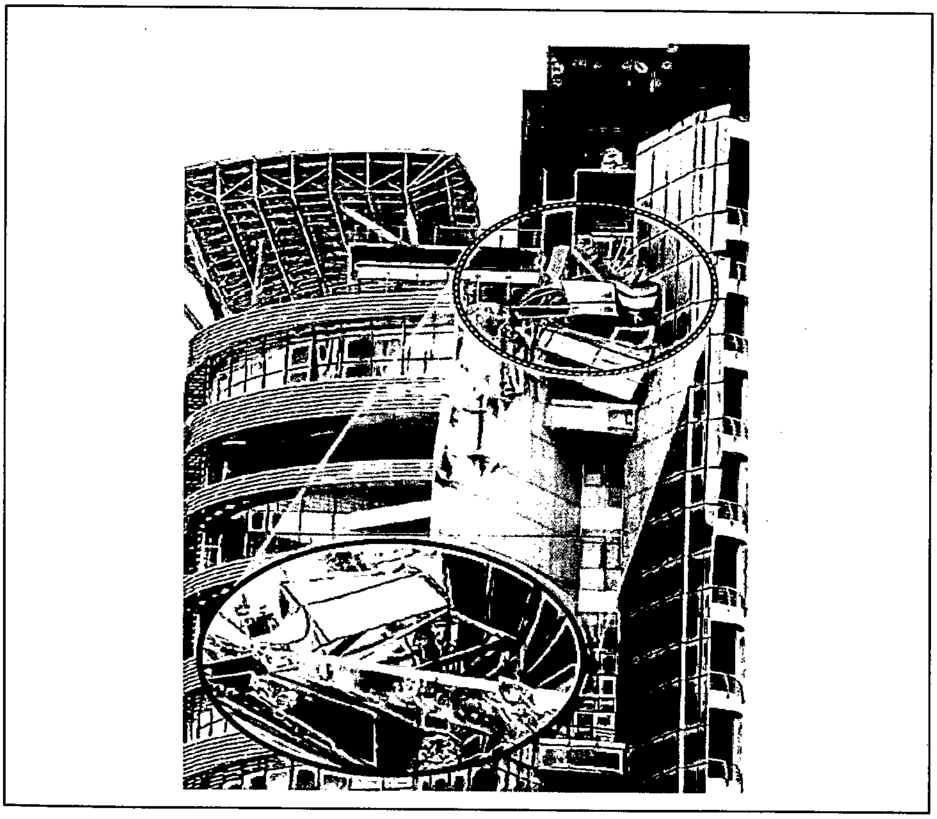

Figure 1.5: Menara Umno in George Town, Penang collapse

Source: New Straits Times (13 June 2013)

1.2 PROBLEM STATEMENT

Topographic amplification of wind speed has been a significant contributing factor in the past experience. The concerning in actual wind speeds at wind-induced damage to buildings and structures incident spot are increased recently. Areal assessment of wind speeds due to topography effect need to investigate.

1.3 OBJECTIVE OF STUDY

The main objective of study was the investigation on effect of terrain in wind related disaster. The specific objectives this study was as follow:

i. To establish a database and damage related to the disaster.

ii. To quantify the wind speed at the wind-induced damage incident area

1.4 SCOPE OF STUDY

The study carried out at east coast of Peninsular Malaysia. Wind-induced damage incidents collected from related archive of news, for period 2009 to 2013 while, wind speed data collected from the Malaysia Meteorology Department (MMD). The topography data was used Shuttle Radar Topography Mission (SRTM), from public domain.

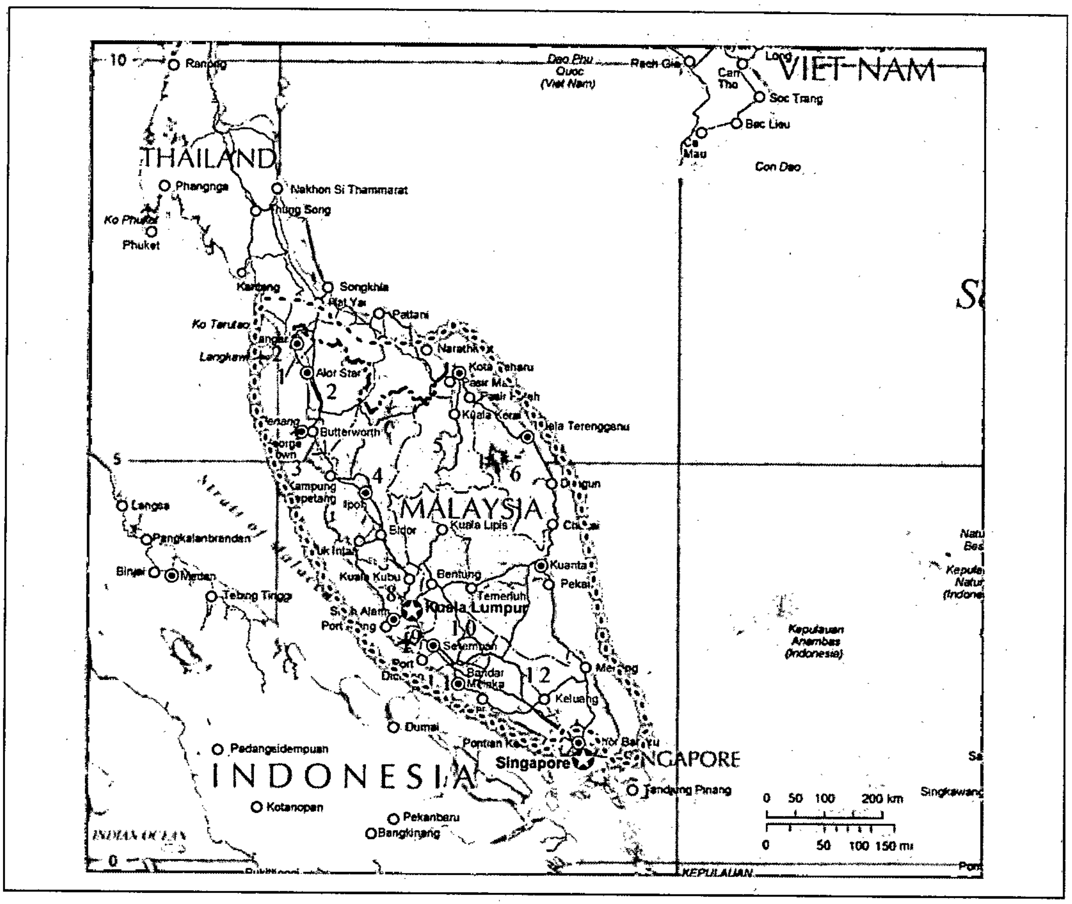

Figure 1.6: Peninsular Malaysia

1.5 THESIS STRUCTURE

This research consists of five chapters. Chapter one comprises the introduction section. It states the study background, problem statement, objectives of study and lastly scope of study. For chapter two, describe the key term in- purpose of these research and comprises the literature review that related and suitable for these research. Chapter three explains the research methodology that used for planning research type of data collected and the method of data analysis to be employed. For chapter four present the result that obtained from the study area and year of study and discussed the result from analysis. Finally, chapter five comprises the conclusion from the overall chapter and relates some recommendation for future work on research field.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Air may not seem like anything at all, in fact we look right through it all the time but during windstorm air really makes its presence known. A hand full of wind can overtake roofs of buildings; blow down power lines and even trees. Wind also can cause highways accident as gusts push around cars and trucks.

Wind is a moving air and is caused by the difference in air pressure within our atmosphere. Air under high pressure moves toward areas of low pressure, the greater the difference in pressure, the faster the air flows.

Natural wind in the open air is a three-dimensional vector that has the directions of north, south, east and west in addition to vertical components and magnitude (i.e., wind speed). As the vertical component is ignored for most operational meteorological purposes, surface wind is practically considered as a two-dimensional vector. Wind blowing over the earth's surface is turbulent, and is characterized by random fluctuations of speed and direction. This can be seen in smoke drifting from a chimney, for example, as it fluctuates from quick to slow and backward, right, left, up and down.

2.2 CHARACTERISTIC OF WIND

For any kind of wind study, be it wind loading, environmental wind or pollution dispersion problem, a precise knowledge of the characteristic of the approaching wind is necessary. The approaching wind characteristic is largely controlled by the roughness of the upwind fetch over which it had blown (terrain). The way that the wind profile of the approaching wind is being taken care of by various characteristic:

a) Direction

b) Speed

2.2.1 Direction

Wind direction is an indicator of the direction that the wind is coming from. For example, a northerly wind is coming from the north and blowing toward the south.

The direction of wind is usually indicated by a thin strip of wood, metal or plastic called a weather vane or weathercock or more specific is wind vane that is free to rotate in a horizontal plane shown in **Figure 2.1**. When mounted on an elevated shaft or spire, the vane rotates under the influence of the wind such that its center of pressure rotates to leeward and the vane points into the wind.

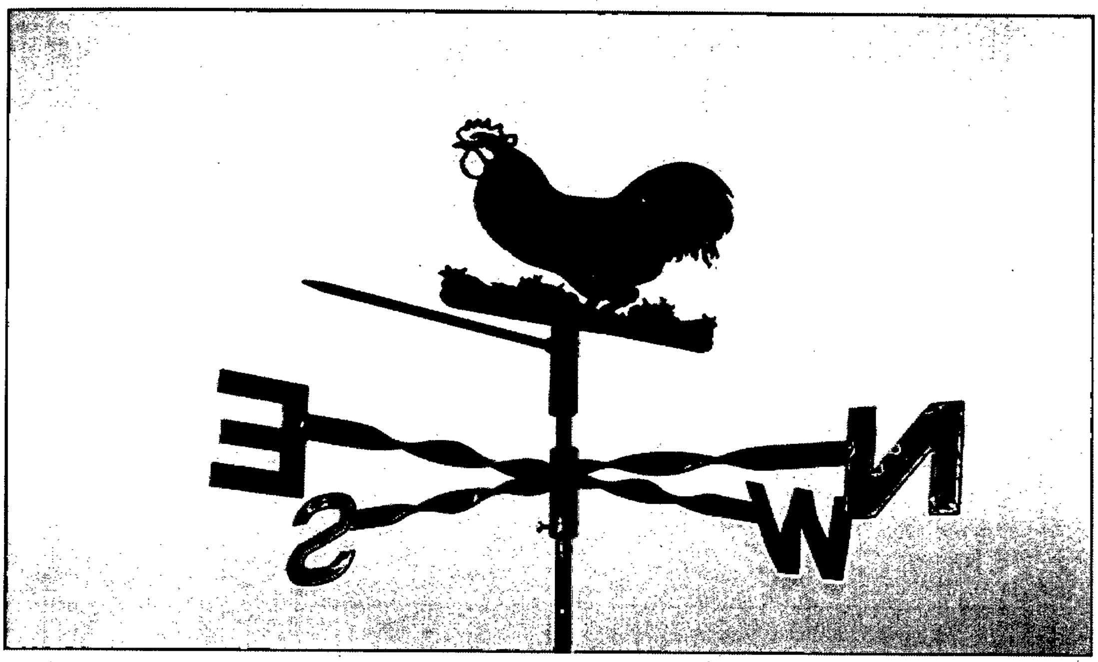

Figure 2.1: Wind vane

Source: http://en.wikipedia.org (3 February 2014)

2.2.2 Speed

Wind speeds are the measure motion of the air with respect to the surface of the earth covering a unit distance over a unit time. Wind direction is an indicator of the direction that the wind is coming from. For example, a northerly wind is coming from the north and blowing toward the south.

Wind speed patterns can be depicted as a wind speed spectrum shown **in Figure 2.2**. A high value indicates a significant change in wind speed over the corresponding time period. Although this graph is obviously site-specific, there are distinctive similarities. A typical graph is shown on the right. The peaks in the wind speed spectrum account for annual, seasonal and daily patterns as well as short-term turbulences. A striking phenomenon is the spectral gap between time periods of 10 minutes to 2 hours. These patterns are important not only for yield estimations, but also for forecasting of wind power output.

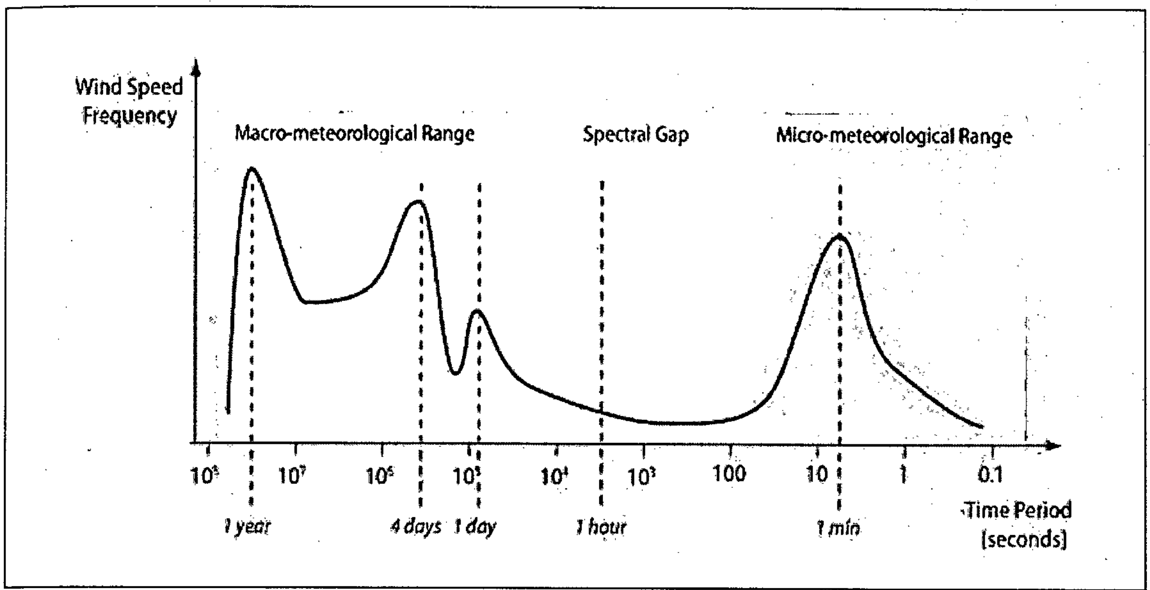

Figure 2.2 : Wind Speed Pattern

Source : http://en.wikipedia.org (3 February 2014)

2.3 METHOD ON HOW TO GET THE CHARACTERISTIC OF WINDS

2.3.1 Measurement for surface wind

Surface wind is usually measured using a wind vane and a cup or propeller anemometer. When a measuring instruments malfunctions, or when no such instrument is available, the wind speed may be estimated subjectively.

2.3.1.1 Wind Estimation

If a measuring instrument becomes faulty or is not available, wind can be estimated by visual means such as observing smoke as a guide to wind speed and using Beaufort scale. It is also possible to estimate wind direction by observing the flow of smoke or the movement of a flag. Streamers at airport can also be used when a wind speed is high enough.

When wind is monitored visually, the following points should be noted:

- Stand directly under the indicator to eliminate any perspective-related error
- Do not mistake local eddies resulting from the surrounding conditions (buildings) for the general wind direction
- Do not use the direction of cloud movement as an indicator even if their altitude seems low.

2.3.1.2 Vanes

Vanes are classified into wind vane and aero vane types. Wind vanes are used alone, while aero vanes are used with a propeller anemometer and a wind direction plate, which looks like the vertical tail part of an airplane.

a) Wind Vanes

A one-vane weathercock is the most basic wind vane. There are many types of vanes have been developed as shown:

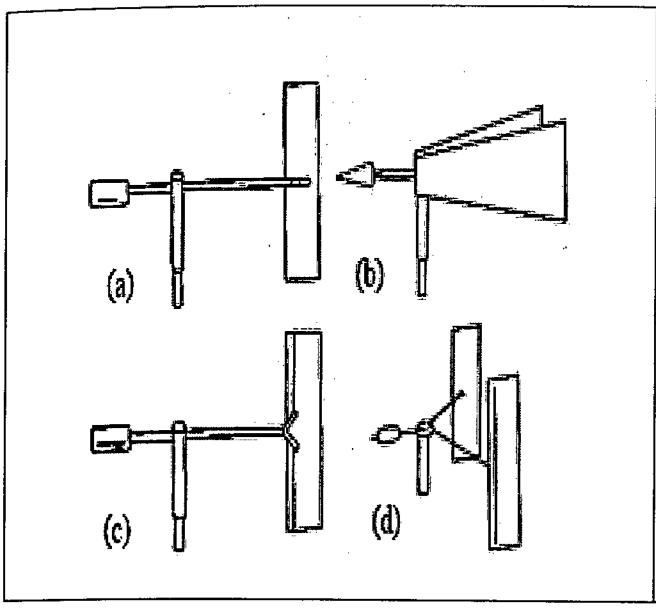

Figure 2.3: Type of wind Vane

Source: http://www.jma.go.jp/

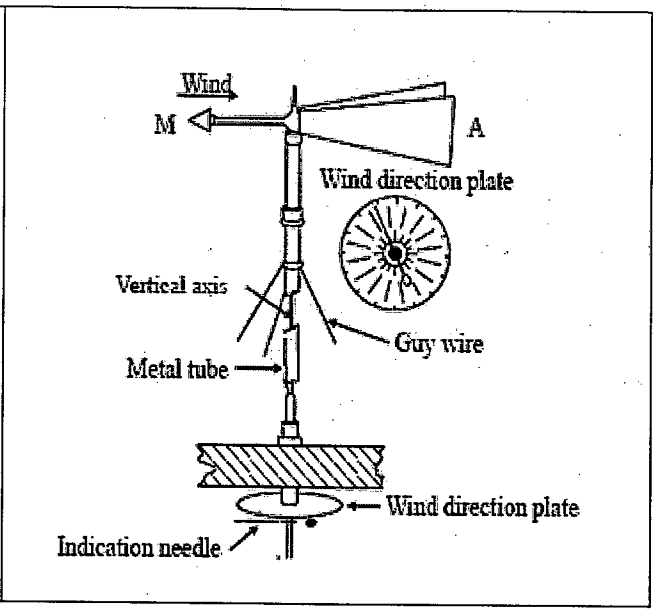

Figure 2.4 : Y-shaped Wind Vane

Source: http://www.jma.go.jp/

Type of Wind Vane in **Figure 2.3(b)** is the Y- shaped vane and in the **Figure 2.4** is fitted in such a way that the two metal plates A are positioned to form an angle of about 20 degree. A weight, M, is attached to the top of the vane for balance. A steel pipe passes through the top and is attached to the roof, and the axis is fitted thought the steel. To indicate the rotation angle of the vane, a compass is directly mounted on the axis. The enable remote indication of the vane's angle of rotation, a potentiometer or Selwyn motor is mounted on the rotation axis.

b) Wind Direction Signal Converters

A wind direction transmitter is a device used to convert the angle of the wind direction axis into an electrical signal. Equipment used in this purpose including;

- A potentiometer

  A vane with a potentiometer is designed to generate a voltage proportional to the change in the angle of the potentiometer's sliding contactor mounted in the wind direction.

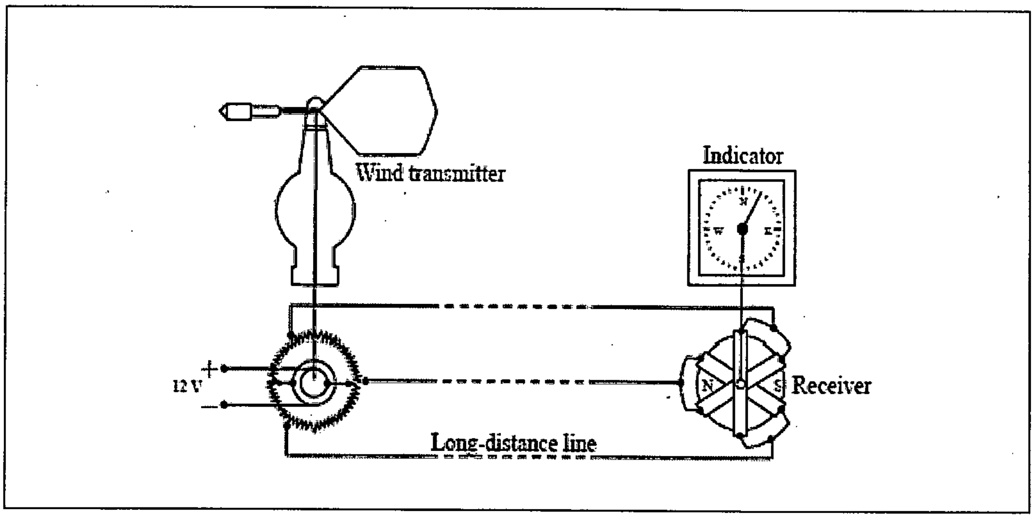

Figure 2.5 : Ring-Potentiometer assembly

Source : http://www.jma.go.jp/

Figure 2.5 shows a ring potentiometer, which consists of a transmitter and a receiver. The transmitter has three taps, and the receiver consist a rotor encompassing a permanent magnet and a stator with three 120° coil windings. This rotor has a pointer that indicates the wind direction. The advantages of this type of indicator are that it is simply designed and can be installed easily as a signal converter. And its disadvantages are that the sliding contactors wear quite rapidly and that the torque of the receiver to move the indicator pointer is small.

- A Selsyn motor

These vanes have two selsyn (self-synchronus) motor with the same structure–one mounted on the vane (the transmitter) and the other on an indicating device (the receiver). Torque generated in the motor on the vane in response to changes in the vane's angle of rotations is electrically transmitted to the recorded or indicator so that the wind direction can be ascertained.

Selsyn motors are used to electrically transmit the angle of rotation of the transmitter's axis to the receiver so that the angle of the receiver's axis can be made to match it.

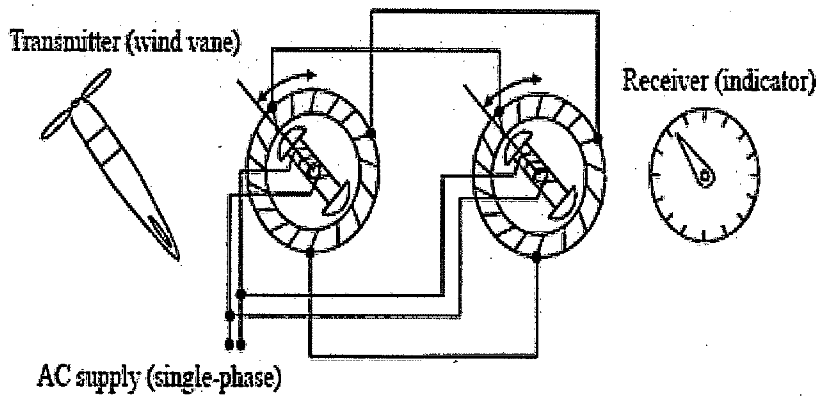

Figure 2.6 : Selyn Motor

Source: http://www.jma.go.jp/

One selsyn motor is connected to the other as shown in **Figure 2.6.**The selsyn system is capable to synchronizing the rotation angle of one selsyn motor with that of the other

- An encoder system

As shown in **Figure 2.7**, an optical pulse encoder consists of a disk featuring a special pattern of concentrically cut slits with light-emitting diodes (light transmitters) and phototransistors (light receivers).

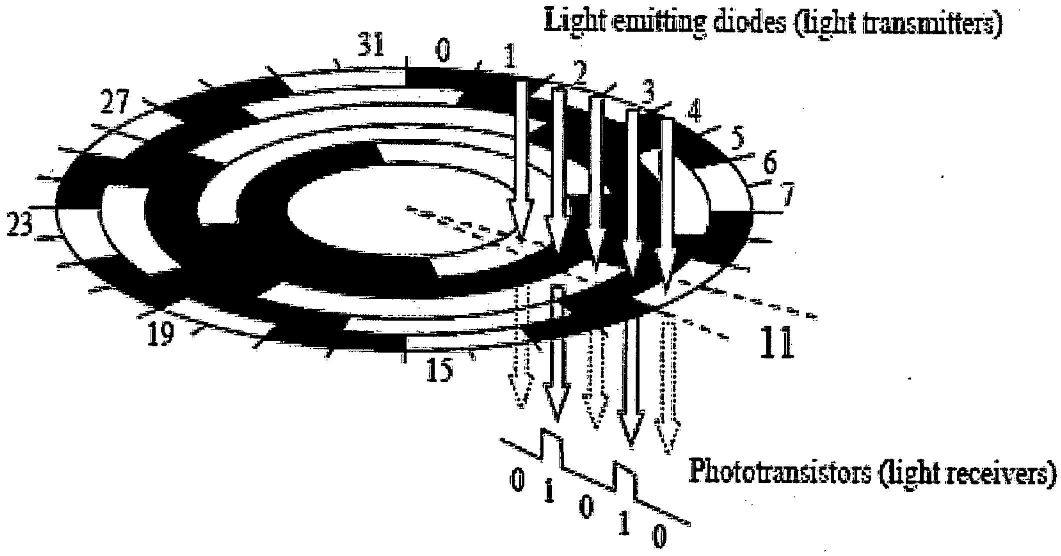

Figure 2.7 : Digital angle-encoder disk (5bit)

Source: http://www.jma.go.jp/

The pulse encodes used with the view is designed to have a specific number of the bits that meets the required angle resolution. Optical pulse encoders have several advantages which they are free of mechanical friction because they have no contacting parts, and superior response characteristics can achieved by making the unit small and lightweight. In addition, they are suitable for data processing with a computer because the output can be processed as digital signals.

c) Vane Response Characteristic

Propeller anemometer and wind vanes cannot respond to rapid change in wind direction. Delayed response to such changes significantly affects errors in wind speed observation, especially with propeller anemometer.