A STUDY OF THE CHARACTERISTICS OF THUNDERSTORM

DAYANGKU SITI NUR BAIZURA BINTI AWANGKU MATALI

A report submitted in fulfillment the requirements for the award of the degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

ABSTRACT

In the period of 2010-2012, there are several cases reported where thunderstorms that occurred in the North of Peninsular Malaysia causes damage to the structure of the building, especially the roof and other structural parts of the building. There are several factors, which contribute to the thunderstorm occurrences such as the location and topography area. In Malaysia, there are two types of monsoon, which are Northeast Monsoon and Southwest Monsoon. Southwest monsoon blows from April-September and the Northeast monsoon occurs from November-March while April and October are the inter-monsoon. By using GIS technique, thunderstorm events that reported are collected as a data to establish a database by creating a database of locations of thunderstorms in the Northern region of Peninsular Malaysia and the related casualties or damages caused by thunderstorm. The results shows that the higher rainfall intensity, the larger radial thunderstorm covered at specific location. The correlation of these two variables shows the positive correlation. Therefore, this technique can be used to estimate thunderstorm radial based on rainfall intensity.

ABSTRAK

Dalam tempoh 2010-2012, terdapat beberapa kes yang dilaporkan di mana ribut petir yang berlaku di Utara Semenanjung Malaysia menyebabkan kerosakan kepada struktur bangunan, terutama bumbung dan bahagian-bahagian lain struktur bangunan. Terdapat beberapa faktor yang menyumbang kepada kejadian ribut petir seperti lokasi dan kawasan topografi. Di Malaysia, terdapat dua jenis monsun, iaitu Monsun Timur Laut dan Monsun Barat Daya. Monsun barat daya bertiup dari April-September dan monsun berlaku dari November-Mac manakala April dan Oktober adalah antara monsun. Dengan menggunakan teknik GIS, kejadian ribut petir yang dilaporkan dikumpul sebagai data untuk menubuhkan pangkalan data dengan mewujudkan satu pangkalan data lokasi ribut petir di kawasan utara Semenanjung Malaysia dan kecederaan yang berkaitan atau kerosakan yang disebabkan oleh ribut petir. Keputusan menunjukkan bahawa keamatan hujan yang lebih tinggi, ribut petir jejari lebih besar melitupi lokasi tertentu. Hubungan kedua-dua pembolehubah menunjukkan korelasi positif. Oleh itu, teknik ini boleh digunakan untuk menganggarkan ribut petir jejarian berdasarkan keamatan hujan.

TABLE OF CONTENT

CHAPTER 5 CONCLUSION AND RECCOMMENDATION

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

GIS	Geographical Information System
TRMM	Tropical Rainfall Measuring Mission
ITCZ	Intertropical Convergence Zone
NWS	National Weather Service
WGS	World Geographical System
TMPA	TRMM Multi Satellite Precipitation Analysis
PPS	Precipitation Processing System
N	North
NE	North-East
E	East
SE	South-East
S	South
SW	South-West
W	West
NW	North-West

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

A Greg storm that experienced by a population at Keningau, Sabah over the past decade was one of the worst tragedies that happened in Malaysia. The maximum sustained wind speed recorded then was 40 knots (46mph). There were estimated that more than 230 people were died while 70 people remained missing when Greg hit Keningau, Sabah (The Star, 2005). Thunderstorms frequently happened in Peninsular Malaysia especially in the Northern Region of Peninsular Malaysia and the East Coast of Peninsular Malaysia. The tragedy of thunderstorms that happened will cause many people died and injured, damaged of building and environment, crops and etc.

Generally, thunderstorm is a form of turbulent weather characterized by the presence of lightening and its acoustic effect on the Earth's atmosphere known as thunder (Wikipedia, 2012). A typical thunderstorm is first seen as a dense, ragged cloud in the west, extending to a height of over a mile (Hazen, 1890). Thunderstorms that usually accompanied by heavy rain and strong wind will go through three stages of thunderstorms and will take an average of 30 minutes to go through. Thunderstorm is considered as one of the natural disasters in Malaysia that could cause wide range and numerous damages. Many reports from mass media shows that thunderstorm was not only damage the building, blew off the roof and uprooted tree but also cause injury to the humans and raised several problems such as trauma and homeless to the victims. **Table 1.1** shows some detail of thunderstorm occurrences that happened in Malaysia.

Table 1.1: Thunderstorm occurrences that occurred in Malaysia (2010-2012)

TIME	LOCATION	DAMAGES	TOTAL DAMAGES	ESTIMATION LOSS
7 Mei 2012 (0130)	Taman Wira, Mergong, Alor Setar	Roof	20 houses and a mosque	Not stated
23 Mei 2012 (0230)	Balik Pulau, Penang	Roof	20 houses in 3 villages	Not stated
19 Oktober 2006 (1700)	Pendang, Kedah	Roof, Wall	Houses of 20 family	Not stated
25 Februari 2012 (1630)	Sungai Petani, Kedah	Roof	191 houses and a food stall	RM100,000
5 Oktober 2006 (0500)	Bukit Mertajam, Seberang Prai	Roof	Several houses, mosque and a seafood restaurant	Not stated
18 Mac 2012 (1900)	Kangar, Perlis	Roof	30 houses	Not stated
5 Mei 2006 (1630)	Petaling Jaya, Selangor	Roof, car damage and uprooted tree	30 houses, 10 cars	Not stated
7 Februari 2012 (1530)	Shah Alam, Selangor	Roof, house damages, uprooted tree	120 units of apartment	Not stated
1 Februari 2012 (1800)	Kulim, Kedah	Roof,	57 houses damages in 4 parish	Not stated
12 April 2012 (1880)	Kuala Nerang, Alor Setar	Roof, uprooted tree	20 houses, stall and shop	Not stated
18 oktober 2011 (1630)	Kulim, Kedah	Roof, uprooted tree	20 houses at Mukim Padang China and Sidam Kanan	Not stated
27 Jun 2012 (1130)	Bandar Baharu, Kedah	Roof, uprooted tree	Double storey school, 10 houses, in 3 location	Not stated
29 Ogos 2012 (1630)	Dungun, Terengganu	Uprooted tree, canopy	5 shop at R & R area	Not stated
26 Mac 2012 (1730)	Jitra, Kedah	Roof, uprooted tree	60 houses	Not stated
3 April 2012 (1500)	Kangar, Perlis	Roof	20 houses	Not stated
26 Januari 2011 (1905)	Kuala Lumpur	Roof	12 units of PPR houses, 30 motorcycles, 10 cars	RM 500, 000 – RM 1,000, 000
28 September 2011 (2045)	Kuala Trengganu, Besut, Dungun	Roof	100 houses	Not stated
3 November 2011 (1630)	Alor Setar, Kedah	Roof, wall	15 houses	RM30, 000
19 Februari 2012 (1700)	Kangar, Perlis	Roof	20 houses and food stall	Not stated
21 Jun 2007 (1730)	Bahau, Selangor	Roof	163 houses	Not stated
29 Mac 2011 (1915)	Kuala Nerang, Kedah	Roof	24 houses, trees, signboards, facilities	RM100, 000
14 Jun 2010 (1845)	Bagan Datoh, Perak	Roof	18 houses, 32 hectare of crops, stalls	RM180, 000
24 November 2010 (1830)	Kangar, Perlis	Roof, wall	16 houses	Not stated
18 September 2011 (1800)	Kuantan, Pahang	Roof, wall, car damage	27 houses	Not stated
26 September 2010 (1510)	Sg. Petani, Kedah	Roof	36 houses	Not stated

Source: Metro Online (2010-2012)

In addition, Geographical Information System (GIS) is a software system which uses computer technology to integrate, manipulate and display a wide range of information (Goodchild, 1993). The information then is to create a picture and displaying all forms of geographically referenced information in very simple way, interesting and better understanding as well as easy to manage. In this study, the Geographical Information System (GIS) application will be utilized to record all the information and detail of thunderstorms' incidents that happened in Northern Region of Peninsular Malaysia since 2006 until 2012. Furthermore, the data of rainfall intensity in Peninsular Malaysia since 2006 until 2012 also will be inserted to investigate the relationship between the radius of rainfall from the thunderstorms' area with the intensity of rainfall.

1.2 PROBLEM STATEMENT

The effect towards building structure and casualty due to the thunderstorm become serious issues almost every year. The thunderstorm might not only blow off the roofs and destructed the building structure but also caused injuries and killed people. The losses value caused by the damages can reach from a thousand up to a million ringgit. Besides, several social problems which are trauma and homeless to the victims also occurred. Thunderstorm is usually accompanied by strong winds and heavy rain during its occurrences. But there are several cases where thunderstorm will be accompanied by strong wind only and there is no rainfall at the thunderstorm's location. By referred to several cases, the location of rainfall and thunderstorm sometimes occurred in different location which is distance apart. There was no rainfall reported at the location of thunderstorm incident but exist in a radius within the incident happened. **Figure 1.1** and **Figure 1.2** below shows the effect of thunderstorm that happened in Malaysia and news of thunderstorm incident that had been reported.

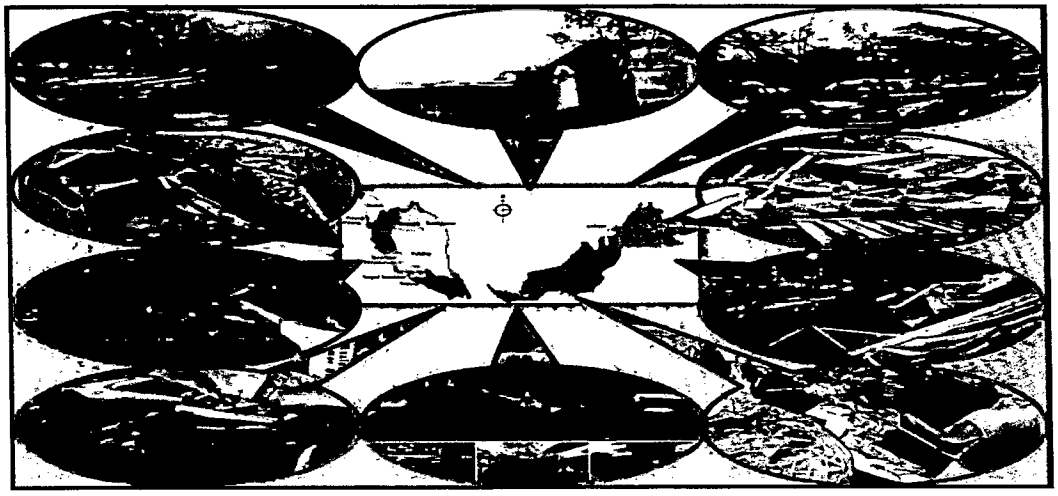

Figure 1.1: Effect of thunderstorm that happened in Malaysia

Source: Metro Online (2010-2012)

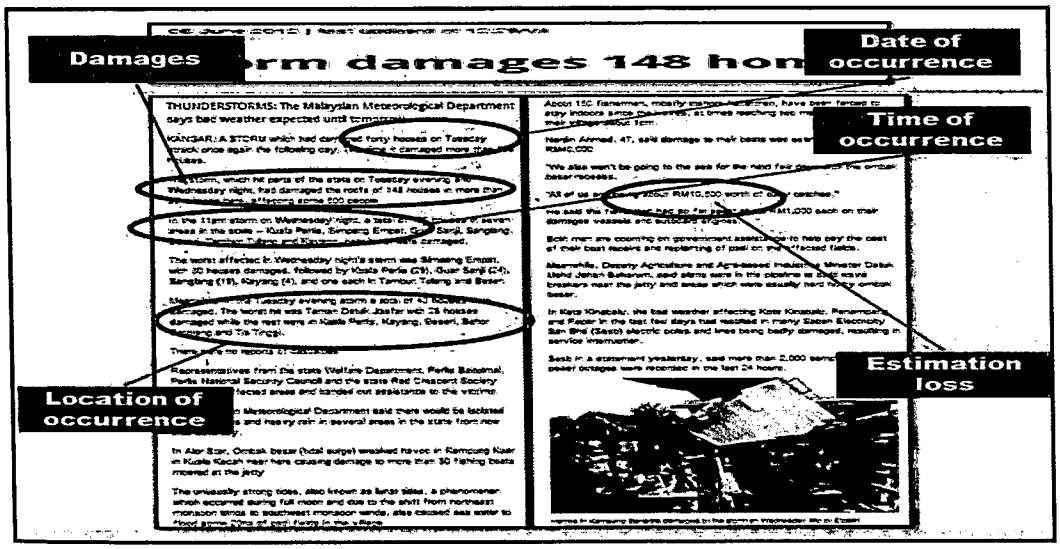

Figure 1.2: Thunderstorm incident

Source: Metro Online (2010-2012)

1.3 OBJECTIVES

This study was conducted to achieve the following objectives:

i. To establish a database of thunderstorms location in Northern region of Peninsular Malaysia and related casualty or damages using GIS technique.

ii. To investigate the relationship between the intensity of rainfall with the radial of thunderstorm covered at specific location.

1.4 SCOPE OF STUDY

Scope of study describes about the location of project, parameter, data and technique to display the result. The location of project is in the northern region of Peninsular Malaysia, which is the most affected area of thunderstorm in Malaysia. Besides, the parameter to be considered is the intensity of annual rainfall data from year 2010-2012 (Source: Tropical Rainfall Measuring Mission Satellite image) while the data of thunderstorm occurrences since year 2010-2012 will be collected. Furthermore, GIS technique will be applied to produce representation model of thunderstorm incident and related damages.

1.5 SIGNIFICANT OF STUDY

This study will be carried out to investigate the location of thunderstorm incidents that occurred in Northern region of Peninsular Malaysia. The frequency of thunderstorm occurred in Northern region of Peninsular Malaysia also will be investigate and come out with a database by using GIS application. From this study, we will be able to show the thunderstorm location and related casualties or damages that happened during thunderstorm event by using GIS software. This study will display the radius of rainfall to the thunderstorm location with the high intensity of rainfall. The information is expected to provide an early knowledge about the areas with high risk of an impending thunderstorm so

that people can take early precautions from any impact that will happened. This information also can be applied in Civil Engineering by consultant and construction department by considered the location before construct the structure.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The literature review presented to explore the information and facts that used in the study. This chapter also explains the background of the study and related theories about thunderstorm as well as GIS observed. It also gives general ideas about the study as well as previous works done related to the study. This study can be divided into seven categories, which are location of Malaysia, climate in Malaysia, wind system in Malaysia, topography of Malaysia, thunderstorm occurrences in Malaysia as well as its characteristics and effect of occurrences. The Tropical Rainfall Measuring Mission (TRMM) satellite image at fine scales ($0.25^{\circ} \times 0.25^{\circ}$) in three hourly also discuss here. Finally yet importantly, this chapter describes the elements in Geographical Information System (GIS) consist of computer hardware and software, method in implementing the GIS and the application of GIS.

2.2 LOCATION OF MALAYSIA

Malaysia is located in the tropics, between 1° N and 6° N in Southeast Asia, bordered by Thailand in the north, Indonesia in the south, and the Philippines in the east. Malaysia situated near the equator and has a tropical climate with high temperatures and rainfall all year round, which the rainfall is heavy and usually occurs in the form of thunderstorms (Faridah, 2004). **Figure 2.1** shows the location of Malaysia.

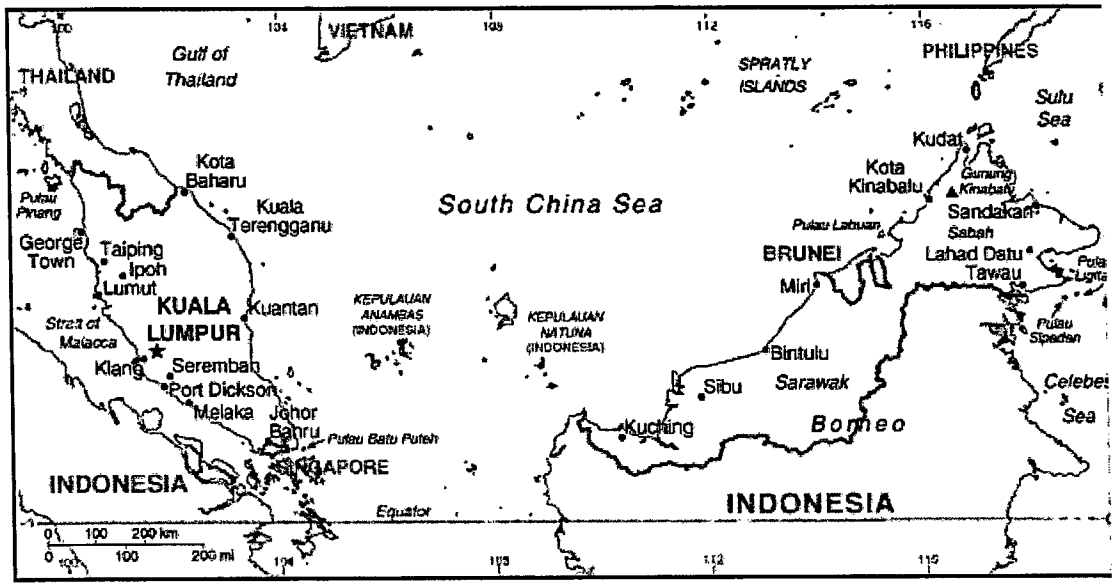

Figure 2.1: Location of Malaysia

The average location of the Inter Tropical Convergence Zone (ITCZ) is 5°N (Pickard and Emery, 1990). Malaysia is also situated in ITCZ since Malaysia is between 1° N and 6° N in Southeast Asia (Faridah, 2004). A surface low pressure system known as the Inter Tropical Convergence Zone is enhanced at approximately the equator (Alejandro L. et al, 1998). The ITCZ is known as a zonal band of convection and precipitation in the tropics which occurs where the northeasterly and southeasterly trade winds meet (Peter J. L. et al, 2012). The figure below shows the Intertropical Convergence Zone. The trade winds of both the southern and the northern hemispheres converge on a latitudinal band of highly convective cumulonimbus clouds (Pettersen, 1956).

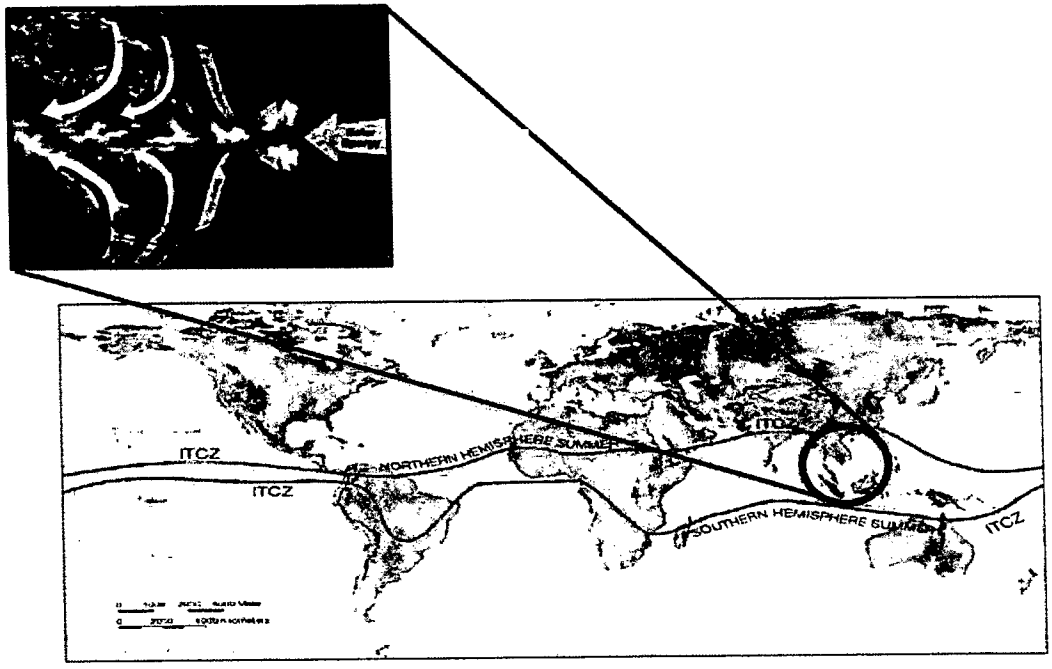

Figure 2.2: Intertropical Convergence Zone

2.2 CLIMATE IN MALAYSIA

Malaysia consists of dry and wet seasons that caused by the Northeast and Southwest monsoon. Therefore, Malaysia has a warm and humid climate throughout the year. The wet season with low maximum dry bulb temperature, usually falls in November while in May and June, the hot and dry season usually occurred (Aliyah et al., 2012).

There are four characteristics elements of the climate of Malaysia, which are high humidity, uniform temperature, numerous rainfall, and light winds. It is extremely rare to have a full day with completely clear sky even during periods of severe drought because Malaysia is situated in the equatorial doldrums' area. Besides, it is also rare to have a stretch of a few days with completely no sunshine except during the northeast monsoon season (Malaysian Meteorological Department, 2012).

2.3 WIND

Malaysia experienced two types of main monsoon, which are North-East Monsoon and South-West Monsoon thus consequences to the rainfall intensity. The North-East Monsoon wind blow from Decembèr-March while the South-West Monsoon wind blow from June-September a year. During the North-East Monsoon season, the exposed areas like the east coast of Peninsular Malaysia, Western Sarawak and the North-East Coast of Sabah experience heavy rain spells. There are frequent occurrences of tropical thunderstorm especially during inter-monsoon periods between April-May and October-November. The monsoon winds are not stronger and turbulent than winds that produced by thunderstorm occurrence. Therefore, thunderstorm will be considered as one of a natural disaster that happened in Malaysia.

Wind is the term used for air in motion and is usually applied to the natural horizontal motion of the atmosphere (B.S Taranath, 2005). Wind is often referred to according their strength and the direction from which the wind is blowing. Wind occurs on a range of scales, from thunderstorm flows lasting tens of minutes, to local breezes generated by heating of land surfaces and lasting a few hours, to global winds resulting from the difference in absorption of solar energy between the climate zones on Earth (Wikipedia, 2012). Trees and man-made structures are damaged or destroyed when wind becomes strong.

Wind engineering analyzes effects of wind in the natural and the built environment and studies the possible damage, inconvenience or benefits which may result from wind. In the field of structural engineering it includes strong winds, which may cause discomfort, as well as extreme winds, such as in a tornado, hurricane or thunderstorm which may cause widespread destruction.

In Malaysia, though the wind over the country is generally light and variable, there are, however, some uniform periodic changes in the wind flow patterns. Based on these

changes, four seasons can be distinguished, namely, the southwest monsoon, northeast monsoon and two shorter periods of inter-monsoon seasons.

The flow of wind is complex because many flow situations arise from the interaction of wind with structures. However, in wind engineering, generalizations are made to arrive at design wind loads by distinguishing the variation of wind velocity with height.

2.3.1 Variation of wind velocity with height

When the wind blows close to the ground, obstructions near the ground create turbulence and friction, lowering the average wind speed. Wind speed will be lower if the obstruction is higher and the turbulence is greater. As a general rule, wind speed increases with height. The wind is defined in terms of a vector of its direction and speed. The continuous wind measurements are taken, as per international agreement (World Meteorological Organization, 1983) at fixed, least disturbed stations at a height of 10 m above the ground.

The surface roughness length z_0 will depend on both the size and the spacing of roughness elements such as grass, crops, buildings, etc. The decisive determinant of the vertical profile of the wind speed is the respective terrain roughness. The wind speed profile within this layer is given by:

$$v = v_0 (\frac{z}{z_0})^{1/\alpha}$$

where:

$v = mean\ wind\ speed\ at\ height\ z\ aboveground$

$v_0 = gradient\ wind\ speed\ above\ boundary\ layer$

$z = height\ above\ ground$

$z_0 = nominal\ height\ of\ boundary\ layer$

$\alpha = power\ law\ coefficient$

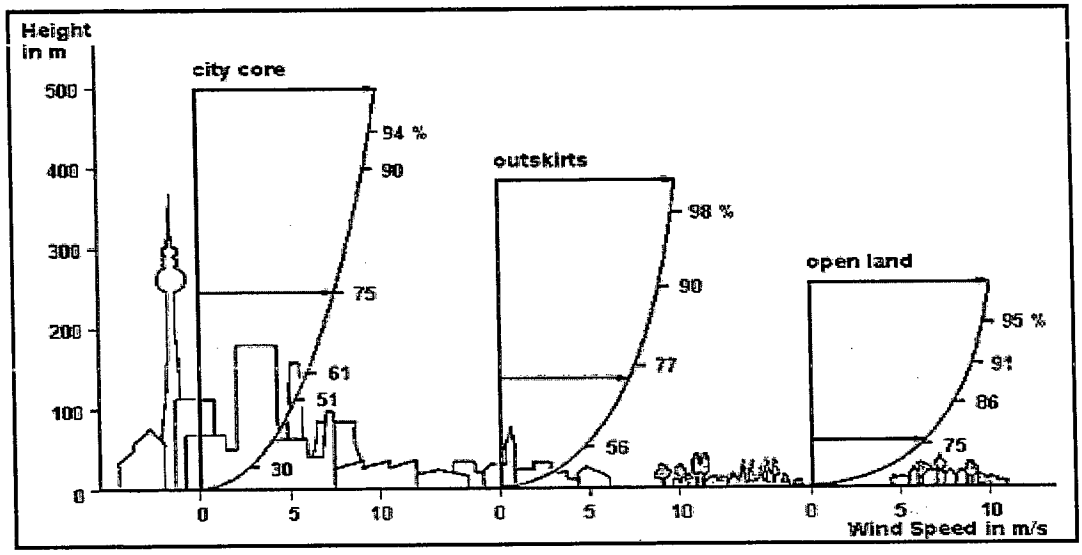

Figure 2.3: Decreases in Wind Speed as Influenced by Varieties of Terrai Roughness

Source: Baumbach (1991)

2.4 THUNDERSTORM

Thunderstorms usually form when the combination of moisture, an unstable air mass and a lifting force (heat) exists. The three components will formed a thunderstorm which usually followed by a strong wind or heavy rain. A thunderstorm is a vicious local storm produced by a cumulonimbus cloud and always accompanied by lightning and thunder. It represents extreme activity where the process by which the very small parts in a liquid or gas move and give out heat in the atmosphere, with both updrafts and downdrafts reaching high speeds.

All thunderstorms require instability (potential) and lift. The lift is the mechanism that releases the instability. Lift is produced by such things as fronts and low pressure troughs, or by air rising upslope. The atmosphere is unstable when air rising in a cloud is warmer than its environment, like a hot-air balloon. It is the heat released by condensation

within a cloud that permits the rising air to stay warmer than its surroundings, and thus to be buoyant through great depths.

In the same way, air that is cooler than its environment tends to sink as long as it can stay cooler than its surroundings. The upward moving air in a thunderstorm is known as the updraft, while downward moving air is the downdraft. The atmosphere can be unstable for updrafts but stable for downdrafts, stable for updrafts but unstable for downdrafts, stable for both, or unstable for both. The degree of atmospheric instability is one of the two major factors in determining the strengths of thunderstorm updrafts and downdrafts. Furthermore, vertical draft strengths determine the degree of storm severity. There are four possible combinations of weak and strong draft strengths for generic storm.

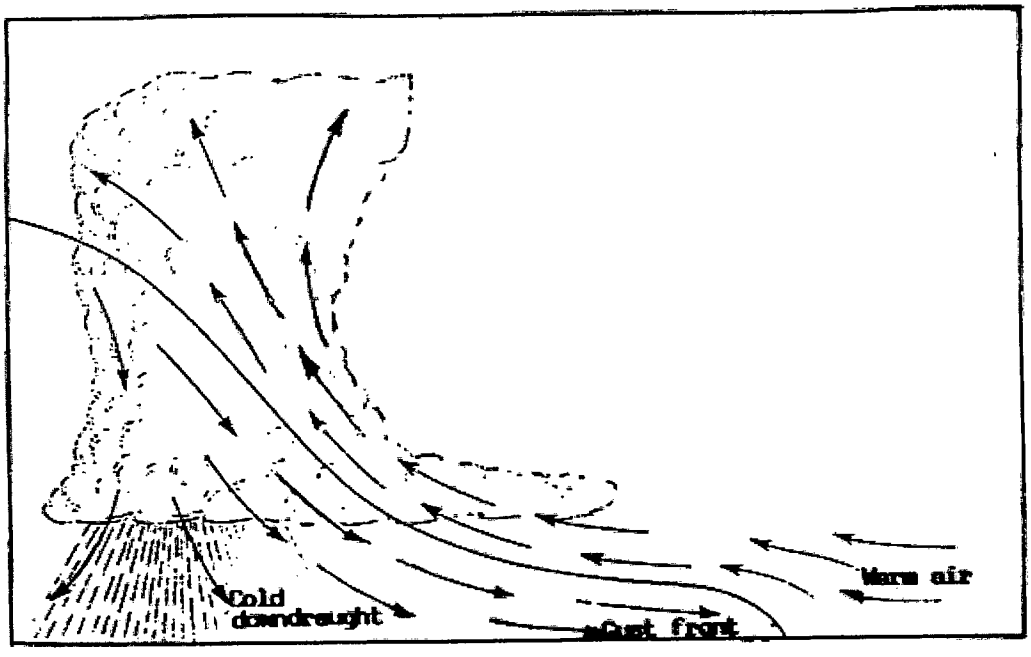

Figure 2.4: Schematic diagram showing downdraught during thunderstorm

Source: Choi (1990)

The thunderstorm depends upon the release of latent heat, by the condensation of water vapour, for most of its energy. Each pound of liquid water condensed from vapour, more than 1,000 B.T.U's of heat energy released. A thunderstorm is composed of one or more individual convective cells or units. A cell may range from a few miles to 10 miles in diameter.

Thunderstorms have their origins in cumulus clouds. Only a few cumulus clouds develop into thunderstorms. Certain atmospheric conditions are necessary for this development to take place. These are conditionally unstable air, some triggering mechanism to release the instability, and sufficient moisture in the air.

2.4.1 Effects of thunderstorm occurrence

Thunderstorms that occurred usually cause damages to the structure of building especially roof and wall. A strong wind can blew away the roofs and building structure, which are not strong enough to withstand wind load towards the structure. Besides, thunderstorm also can cause death or injured regarding the incident that happened. According to the issued that happened at Jasin, Melaka in August, 2010, there were three deaths reported due to the tragedy of thunderstorms that suddenly happened at Bazaar Ramadhan, Jasin Melaka thus cause a loss in various cases.

Dua Maut dan 18 Cedera Ribut Landa Bazar Ramadan Jasin
13/08/2010 8:16pm
Oleh RIZANIZAM ZAKARIA

JASIN 13 Ogos – Dua orang maut manakala 18 orang lagi cedera termasuk seorang kritikal dalam satu kejadian ribut kencang yang berlaku di bazar Ramadan Stadium Jasin, di sini petang tadi. Dalam kejadian pada pukul 4.45 petang itu, kira-kira 40 buah gerai peniaga di kawasan tersebut musnah dipukul angin.

Sumber: Utusan Malaysia Online, 13/8/2010

Figure 2.5: Thunderstorms at Jasin Night Market

Source: Utusan Malaysia Online (2010)

This tragedy had opened many eyes of Malaysian that this natural disaster could cause various damages and should be taken seriously. Thunderstorm not only blew off roofs, damages building structure, uprooted tree, but also cause secondary damage such as injury and loss life. Furthermore, thunderstorm also will cause social problem such as trauma and homeless to the victim as been reported by mass media.