WIND HAZARD RISK ASSESSMENT DUE TO TOPOGRAPICAL CONDITION

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ABSTRACT

The number of wind related disasters in Malaysia has increased suddenly. The further understanding related to wind characteristic in Malaysia are very significant in order to improve the quality of building to resist wind load. Previous study has shown that the topographical location give a significant impact to wind speed. Wind speed variations caused by small scale topography and roughness changes. This study was carried out to determine the relationship between geographical condition, its effect on the wind speed and damage ratio. By using Geographical Information System (GIS) software, 38 cases of wind related disasters in peninsular Malaysia from 2010 to 2013 were identified and analyzed. From the result, it sums up that topography are favourly significant to the wind speed and damage ratio. Then it can be conclude that the topography effect wind speed and affecting the damage ratio.

ABSTRAK

Bilangan bencana berkaitan dengan angin di Malaysia telah meningkat secara tiba- tiba. Pemahaman yang lebih terperinci berkaitan dengan sifat angin di Malaysia amat penting bagi meningkatkan kualiti bangunan untuk menahan beban angin. Kajian terdahulu menunjukkan bahawa topografi memberikan impak yang signifikan terhadap kelajuan angin. Bentuk topografi dan perubahan kecil pada kekasaran muka bumi menyebabkan variasi dalam kelajuan angin. Kajian ini telah dijalankan untuk menentukan hubungan antara bentuk topografi dan kesannya terhadap kelajuan angin dan nisbah kerosakan. Dengan menggunakan perisian Geographical Information System (GIS), sebanyak 38 kes bencana berkaitan angin di semenanjung Malaysia (2010-2013) telah dikenal pasti dan dianalisis. Keputusan yang diperolehi merumuskan bahawa bentuk topografi memberi kesan yang ketara kepada kelajuan angin seterusnya menjejaskan nisbah kerosakan bangunan.

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LIST OF ABBREVIATIONS

GIS	Geographical Information System
ASCE	American Society of Civil Engineers
AS/NZS	Australia/New Zealand Standard
AIJ	Architectural Institute of Japan
MPM	Moving Patch Method
LULC	Land Use Land Cover
KBC	Korean Building Code
MS	Malaysian Standard

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Extreme wind is one of the major natural hazards experienced in Malaysia. 80% of natural disaster economic losses in the world are caused by extreme wind and its relevant events, in example combined effects of wind and water (Tamura, 2005). (New Strait Times, 2013) reported on 13th June 2013, an hour-long thunderstorm wreaked havoc several areas in Georgetown, Penang, killing two people and injuring nine. The 6.45pm thunderstorm resulted in traffic congestion all over the state as old trees were uprooted, felling of electric posts and roofs being blown off. A victim is believed to have died of head injuries after his lorry was hit by a 40m section of a pole which ran alongside the 21-storey Menara Umno in Jalan Macalister. Six other cars were seen crushed by the giant white pole, which officials said was a lightning conductor. Just 2 days later, on 15th June 2013, (Kosmo, 2013) reported that another wind related disaster occurred in Sungai Dua, which is situated approximately 20 Km from Georgetown. (Nusi, 2013) from Kosmo reported that the 7.45 pm incident saw large chunk of roofs and ceilings of Blok C Flat Hamna were blown off by wind due to thunderstorm. Meanwhile on 26th June 2013, (New Strait Times, 2013) reported in Putrajaya, the roof of a 15-storey building housing civil servants was blown off, near Presint 15, during a downpour . It was reported that a thunderstorm had also wreaked havoc in nearby areas. In Kampung Datuk Abu Bakar Dengkil, 15 houses were damaged by strong winds.

Wind is basically caused by the temperature gradient of the atmosphere due to variable Solar heating of the earth's surface. It is initiated, in a more immediate sense, by density difference or pressure gradient between points of equal elevation. (Tamura, 2010)

In Malaysia, Wind speed is measured in metres per second or knots. Calm is reported when the wind speed is less than 0.5 metres per second or less than one knot. Instruments used for measuring the surface wind speed are called anemometers, the most common of which is the cups mounted symmetrically at right angle to a vertical shaft. The difference in wind pressure from one side of the cup to the other causes the cup to spin about the shaft. The rate at which they rotate is directly proportional to the speed of wind. Wind direction is the direction from which the wind is blowing. It is expressed in degrees measured clockwise from geographical north. Wind vanes do not respond to changes in wind direction when the wind speed is less than one metre per second or two knots. (Malaysian Meteorological Department)

Strong winds are a danger associated with some thunderstorms. Thunderstorm is defined as one or more sudden electrical discharges, manifested by a flash of light or known as lightning and a sharp or rumbling sound or known as thunder (World Meteorological Organization). In Malaysia, thunderstorms are a common phenomenon occurring all year round, frequently during the afternoon and early evening. Despite their small size, all thunderstorms are dangerous. Every thunderstorm produces lightning which has the potential to kill people. Heavy rain from thunderstorms can lead to flash flooding and landslides.

Topography or large vertical displacements of the ground surface can have significant effect on the wind speed profile. The wind flow in realistic environment is not merely over a single ground feature such hills, ridges, escarpment, but as well over undulating and mountainous terrain. The presence of hills, ridges and escarpments can have significant number of effects in different scales of topographic factor (Maharani et al., 2009)

1.2 PROBLEM STATEMENT

The significant of this study is to identify the relationship between the topographical condition of site and its effect on the wind speed as well as the damage ratio. Throughout the years there might be certain locations in Malaysia that have a higher percentage of wind related disasters compared to other places. Despite that, the number of occurrences still increases and no improvements or actions were made to reduce the damage level. This may cause by:

1. The design and position of building did not consider the wind speed that may cause damage.
2. The increase of Wind Speed causing damages, which is due to its' topographical condition have not been identified critically.

1.3 OBJECTIVES OF STUDY

The number of occurrence and level of damage (Figure 1.1 and Figure 1.2) due to strong wind may be reduced if safety precautions were taken. Designers must consider factors such as the location of site which can have a significant impact on wind speed thus affecting the wind loading during the construction of building, as well as the type of roofing system. The objectives of these studies are:

1. To produce wind hazard disaster map in peninsular Malaysia by using the Geographical Information System (GIS) software.
2. To determine the relationship between topographical location (surface roughness) and damage ratio.
3. To determine the relationship between topographical location (surface roughness) and wind speed.
4. To determine the relationship between topographical location (slope coefficient) and wind speed.

Figure 1.1 Damages caused by thunderstorm in Penang (June 2013)

Source: New Straits Time 2013

Figure 1.2 A portion of the roof structure from a building in Putrajaya (June 2013) which was blown off

Source: New Straits Time 2013

1.4 SCOPE OF STUDY

The scopes of this study are:

1. The area of study is limited to Peninsular Malaysia only.
2. The ArcGIS database system that complete with information that related to surface roughness coefficient, slope coefficient, wind speed data and damage ratio.
3. The ArcGIS software to produce map and zoning area.
4. Microsoft Excel to produce Scatter Charts

1.5 STUDY AREA

The study area is limited to peninsular Malaysia only (Figure 1.3). The east of Malaysia that consists of Sabah and Sarawak are not included in this study.

Figure 1.3 Peninsular Malaysia

1.6 SIGNIFICANT OF STUDY

This study is to determine the topographical effect on the wind speed and damage ratio. The two factors of topographic taken into account are the surface roughness coefficient and slope coefficient. By conducting this study, the pattern and speed of wind in Malaysia that caused by the topographical condition can be determined and wind hazard damage can be reduced if the right action is taken. As an example, a place with a history of repetitions in terms of wind related disaster, the structure of building in the area should be design vary with the sustainability to withstand it's high wind speed.

1.7 THESIS STRUCTURE

This thesis is divided into five chapters:

1. Introduction	: This chapter includes overview of problem statement, objective and scopes of the study, significance of the study and study area.
2. Literature review	: This chapter is the previous study material related to objectives.
3. Methodology	: The flow of the thesis production using GIS software.
4. Discussion	: Discuss the result obtained based on case study.
5. Conclusion	: Conclusion of the discussion based on thesis result and provides the future suggestion.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Wind is the perceptible natural movement of the air, especially in the form of a current of air blowing from a particular direction. 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. Wind engineering is best defined as the rational treatment of interactions between wind in the atmospheric boundary layer and man and his works on the surface of Earth (Dr Jack E. Cermak). Wind engineering is roughly subdivided into the following sub-fields, structural wind engineering, environmental wind engineering and wind energy, although the wind energy field is somewhat a stand-alone field of its own.

The severity and increased frequency of wind related disaster events over the last few years in Malaysia has shifted the attention from several researchers towards investigating its patterns and causes. The topography of the area where the damage occurred is highly considered as one of the main reasons why these incidents happened in the first place. Certain type of topography and terrain will increase the wind speed thus increases the risk and damage of wind hazard disaster. Thus, a study can be carried out to investigate the relationship between the topographical condition and the wind speed as well as damage ratio.

2.2 MALAYSIA

Malaysia a country located in Southeast Asia. There are two distinct parts to this country being Peninsular Malaysia to the west and East Malaysia to the east. Peninsular Malaysia is located south of Thailand, north of Singapore and east of the Indonesian island of Sumatra. East Malaysia is located on the island of Borneo and shares borders with Brunei and Indonesia. The total land area of Malaysia is 329,847 square kilometres, the 67th largest country in the world in terms of area. Peninsular Malaysia makes up 132,090 square kilometres or 39.7% of the country's land area, while East Malaysia covers 198,847 square kilometres or 60.3%

Peninsular Malaysia is divided to eleven states and 1 federal territory, Pahang is the biggest state (Figure 2.1) and Perlis is the smallest state. The climate of Malaysia is driven by its equatorial position, extensive coastlines on tropical seas and monsoonal winds. Because Malaysia is situated between one and six degrees North latitude (Figure 2.2) and (Figure 2.3), Malaysia has an equatorial climate with uniformly high temperatures, high humidity, relatively light winds, and abundant rainfall throughout the year. The average rainfall is 250 centimetres (98 in) a year and the average temperature is 27 °C (80.6 °F). The climates of the Peninsula and the East differ, as the climate on the peninsula is directly affected by wind from the mainland, as opposed to the more maritime weather of the East.

The main causes of climatic variation within Malaysia are differences in altitude and the exposure of the coastal lowlands to the alternating southwest and northeast monsoon winds. Malaysia faces two monsoon winds seasons, the Southwest Monsoon from late May to September, and the Northeast Monsoon from November to March. The Northeast Monsoon brings in more rainfall compared to the Southwest Monsoon, originating in China and the north Pacific. The southwest monsoon originates from the deserts of Australia. March and October form transitions between the two monsoons.

Figure 2.1 Peninsular Malaysia Map

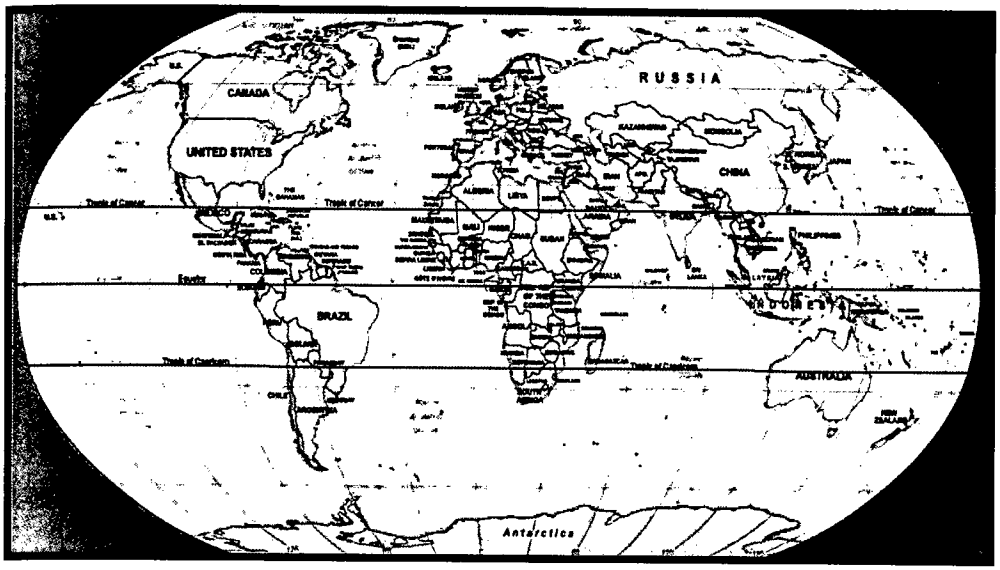

Figure 2.2 World Map

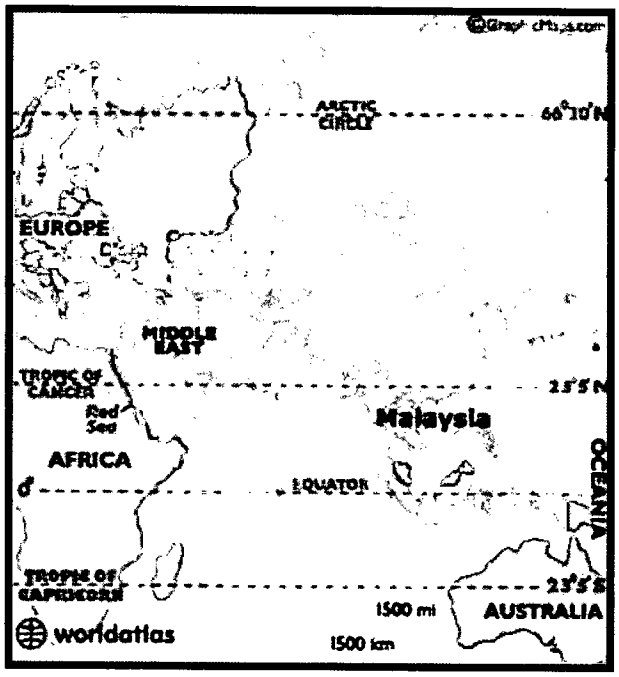

Figure 2.3 Malaysia Location's Near the Equator

2.3 WINDS IN MALAYSIA

Malaysia is a country situated in South East Asia. There are two distinct parts to this country being Peninsular Malaysia to the west and East Malaysia. The characteristic features of the climate of Malaysia are uniform temperature, high humidity and over rainfall. Winds are generally light. Situated in the equatorial doldrums area, it is extremely rare to have a full day with completely clear sky even during periods of severe drought. On the other hand, it is also rare to have a stretch of a few days with completely no sunshine except during the northeast monsoon seasons. (Malaysian Meteorological Department).

2.3.1 WIND FLOW 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 southwest monsoon season is usually established in the latter half of May or early June and ends in September. The prevailing wind flow is generally south westerly and light, below 15 knots. The northeast monsoon season usually commences in early November and ends in March (Figure 2.4). During this season, steady easterly or north easterly winds of 10 to 20 knots prevail. The winds over the east coast states of Peninsular Malaysia may reach 30 knots or more during periods of strong surges of cold air from the north (cold surges). During the two inter monsoon seasons, the winds are generally light and variable. During these seasons, the equatorial trough lies over Malaysia.

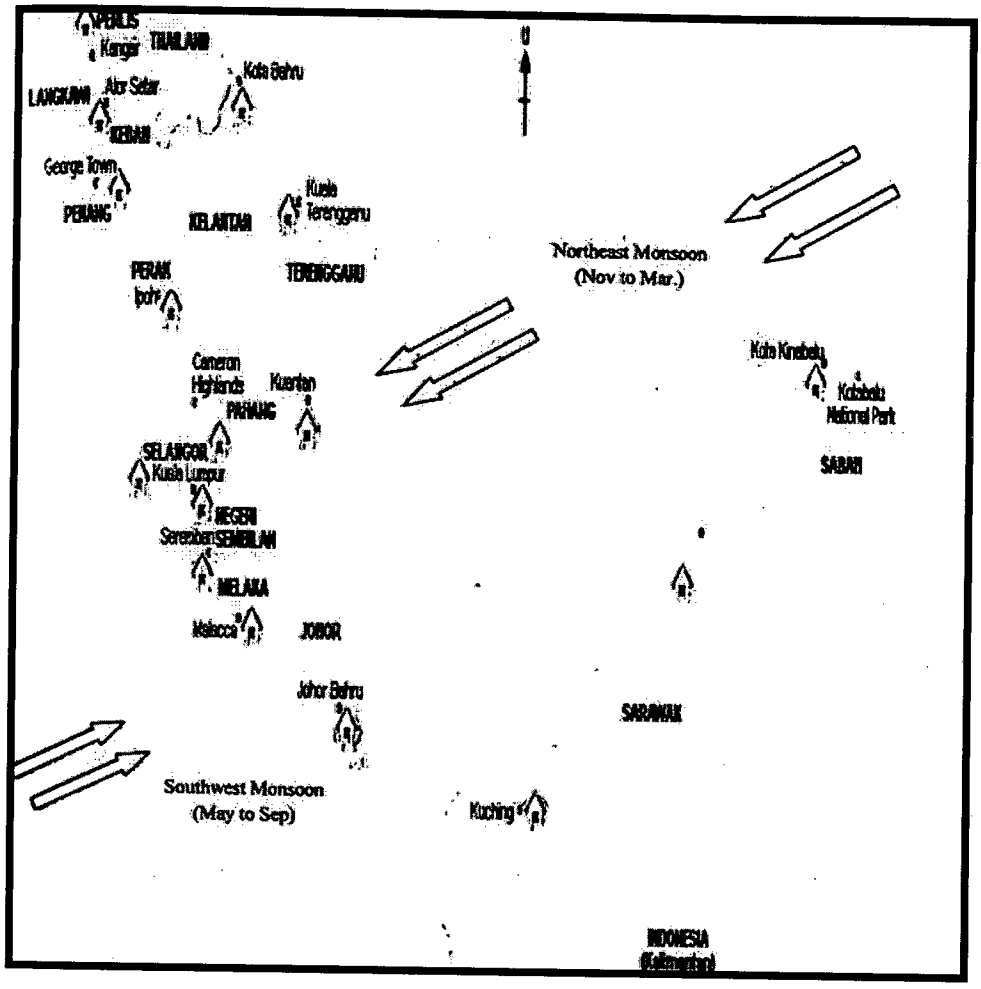

Figure 2.4 Malaysia Wind Map

It is worth mentioning that during the months of April to November, when typhoons frequently develop over the west Pacific and move westwards across the Philippines, south westerly winds over the northwest coast of Sabah and Sarawak region may strengthen to reach 20 knots or more.

As Malaysia is mainly a maritime country, the effect of land and sea breezes on the general wind flow pattern is very marked especially during days with clear skies. On bright sunny afternoons, sea breezes of 10 to 15 knots very often develop and reach up to several tens of kilometres inland. On clear nights, the reverse process takes place and land breezes of weaker strength can also develop over the coastal areas.

2.4 TOPOGRAPHY OF MALAYSIA

The topography of Peninsular Malaysia is dominated by mountain ranges, running from the north down half the length of the peninsular. The northern regions are divided by a series of mountain ranges that rise abruptly from the wide, flat coastal plains. The highest peaks, Gunong Tahan (2,190 m/7,185 ft) and Gunong Korbu (2,183 m/7,162 ft), are in the north central region. The main watershed follows a mountain range about 80 km inland, roughly parallel to the west coast. The rivers flowing to the east, south, and west of this range are swift and have cut some deep gorges, but on reaching the coastal plains they become sluggish. Heavily populated coastal lowlands border the range on the west. The western coastal plain contains most of the country's population and the main seaports, George Town (on the offshore Penang) and Kelang (formerly Port Swettenham). On the east the coastal lowlands are narrower and forested. The eastern coastal plain is mostly jungle and lightly settled. It is subject to heavy storms from the South China Sea and lacks natural harbours. In the south, the peninsular is relatively level.

2.5 WIND RELATED HAZARDS

Wind hazard damage is one kind of natural disaster that cause by wind. Known as hydro-meteorologal, hazards wind storm including cyclones, hurricanes and typhoons contribute to percentage of damages by natural disaster around the world (Bosher, 2008)

Most of possibility risk of wind hazard base on recent wind-induced damage to buildings and structures in Malaysia is due to thunderstorm (Majid, 2010). There are very little emphasizes of design building structure such as roof and cladding to minimize wind induced damage to buildings. Several study had made by previous researchers in Malaysia. From the study made there are several factors are founded to contribute damage to building component. It can be conclude most of the failures cause by lack of the consideration due to wind effect during design stage.

Environmental wind studies-investigate the wind effects on the surrounding environment caused by erection of the structure (e.g. tall building). This study is particularly important to assess the impact of wind on pedestrians, motor vehicles and architectural features such as fountains, etc, which utilize public domain within the vicinity of the proposed structure. (Mendis et al., 2007)

High wind speeds can cause significant damage to property. Hurricanes, cold fronts, strong areas of low pressure and even simple thunderstorms can produce winds strong enough to cause damage and threaten buildings and boats. Understanding the level of threat posed by sustained winds at high speeds can help you to minimize the risks to property and physical well-being. (McBride, 2012)

Malaysia only experience wind speed between 24-32 m/s and. It has been concluded based on 50 year gust values for 20 stations of the Malaysian Meteorological Service around Malaysia but as we can see almost every month there are storm occurs and cost a lot of money (Holmes, 2007)

Figure 2.5, Figure 2.6. Figure 2.7 and Figure 2.8 are the analysis data related to human and economic losses from disasters that have occurred in Malaysia between 1980 and 2010.