THE APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEM (GIS) MAPPING THE WIND HAZARD IN PERLIS, MALAYSIA

NURIASNIZAM BIN MAT DIN

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ABSTRACT

In past a few years records there are reported the wind hazard occurred across Malaysia due to strong wind storm that uplifting of roof structure and also others parts of structures in building. There are numbers of factors that contribute the wind hazard development such as the roughness of terrain and the topographical location. The factor such as terrain roughness can also contribute and cause of wind hazard. The topographic effect are also have considers in this study. The understanding of wind characteristic behaviour is not well defined. Mostly, the designers or engineers only considered the wind direction and wind speed in design structure. Therefore, the study is to produce the database of wind hazard map in Perlis state by using Geographical Information System (GIS). From this result, it shown that area that have highest numbers of wind hazard occurred and the effect of topographical factors and roughness of terrain contribute to the wind hazard. Form analysis had been done, wind damage frequently occurred around Kangar area where the terrain category is Category 4, where the terrain with numerous larges, high (10.0 m to 30.0 m high) and closely spaced obstruction such as large city centres and well-developed industrial complexes. It can be concluded the the topography and roughness of terrain will be significant factor that contribute to wind hazard.

ABSTRAK

Dalam rekod beberapa tahun lalu, ada melaporkan bahaya angin yang berlaku di seluruh Malaysia kerana ribut angin kencang yang mengakibatkan kerosakkan pada struktur bumbung dan bahagian-bahagian struktur yang lain di dalam bangunan. Terdapat bilangan faktor yang menyumbang kepada kejadian angin bahaya seperti kekasaran muka bumi dan lokasi topografi. Faktor seperti kekasaran muka bumi juga boleh menyumbang dan menyebabkan bahaya angin. Selain itu, kesan topografi juga diambil kira dalam kajian ini. Pemahaman ciri-ciri angin tingkah laku tidak ditakrifkan dengan baik. Kebanyakannya, pereka atau jurutera hanya mengambil kira arah angin dan kelajuan angin dalam struktur reka bentuk. Oleh itu, kajian ini adalah untuk menghasilkan peta pangkalan data tentang bahaya angin di negeri Perlis dengan menggunakan Sistem Maklumat Geografi (SMG). Daripada keputusan kajian ini, ia menunjukkan bahawa kawasan yang mempunyai bilangan kejadian angin kencang tertinggi dan kesan faktor topografi dan kekasaran muka bumi menyumbang kepada bahaya angin. Berdasarkan analisis yang telah dilakukan, kerosakan angin sering berlaku di sekitar kawasan Kangar di mana kategori muka bumi yang tergolong di dalam Kategori 4, di mana bentuk muka bumi dengan banyak dan tinggi, tinggi (10,0 m ke 30.0 m tinggi) dan halangan yang rapat seperti pusat bandar yang besar dan maju kompleks perindustrian. Oleh itu disimpulkan, topografi dan kekasaran muka bumi menjadi faktor penting yang menyumbang kepada kejadian angin kencang yang bahaya.

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LIST OF ABBREVIATIONS

ESRI	Environmental Systems Research Institute, Inc.
GIS	Geographical Information System
MOIST	Malaysian Ministry of Science, Technology and Innovation
JUPEM	Jabatan Ukur & Pemetaan Malaysia
GCS	Geographic Coordinate System
WGS 1984	World Geographical System 1984
MRSO	Malaysia Rectified Skew Orthomorphic

LIST OF SYMBOLS

%	Percent
^0C	Degree Celsius
mm	Millimetre
φ	Slope Factor
km/h	Kilometre per hour
m	Meter
H_o	Height
$L_{h\ c}$	Distance
A_c	Area

CHAPTER 1

INTRODUCTION

1.0 Introduction

In Malaysia, recently numbers of damage and injuries has been reported due to wind hazard in past few years had increase in Malaysia. The impact of incident, the level of awareness among the respective people especially wind hazard have a great deal of influence on building design and the design of the other kinds of civil engineering structure. There are very little emphasizes of design building structure such a roof and cladding to minimize wind-induced damage to building. Many whole structures or parts of structure that fail do so because inadequate thought was given to wind action at the design stage (C. Dyrbye and S.O. Hansen, 1997).

Generally, most of the possibility risk of wind hazard is based on recent wind-induced damage to buildings structure in Malaysia is due to the thunderstorm. Wind load and geographical regions have a great deal to be considering on building design and the design of the other kind of civil engineering structures. Several study had made by previous researches in Malaysia. From the study made there are several factors are founded to contribute damage to building component. It can be concluded most of the failures cause by lack of the consideration due to wind effect during stage.

Based on Malaysian Metrological Department, usually thunderstorms can occur throughout the year but are most likely to happen in the intermonsoon periods, namely April to May and October to November. Over the land, thunderstorms are more frequent at night.

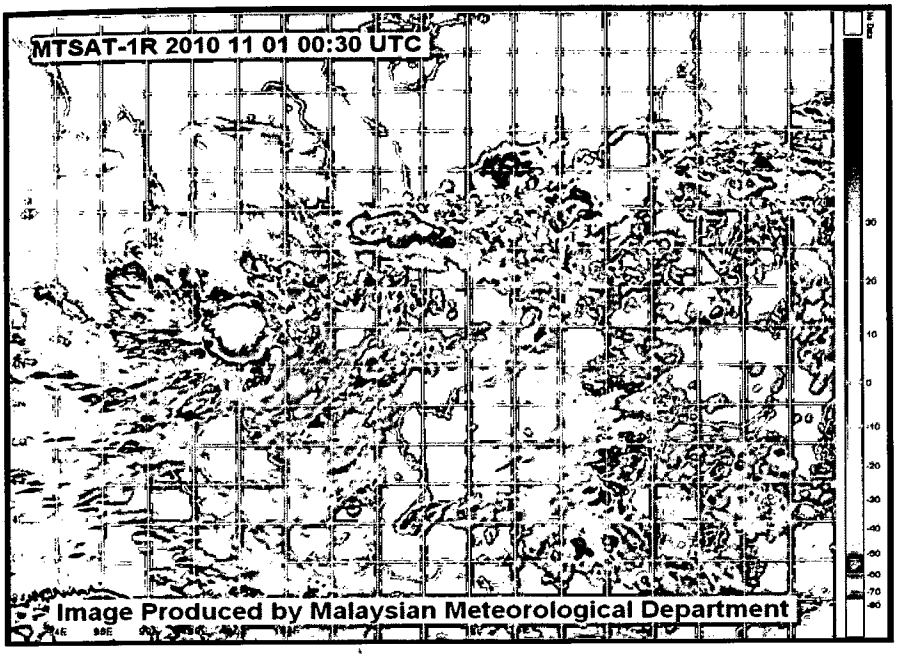

Figure 1.1 The Weather Map of Tropical Cyclones in the Northwest Pacific Ocean.

The extreme wind is been determine base on probabilistic method that maximum wind speed can occur in a specific return period. However, there are still many factors that can contribute to wind hazard. The surround affect such topography and roughness had been neglected by the danger. Eventually, it seems important to consider the effect of surrounding. Currently, there certain highlighted issues already to surrounding effect to the structure can contribute hazarding by wind. According to Choi (2009), the wind speed is zero at ground surface and it increase with height above the ground within the atmospheric boundary layers (ABL).

Refers to the pervious case occur in Malaysia, it can be shown that most of the damage occurs in northern region peninsular Malaysia. Based on that, the suitable study area is Perlis, Malaysia, is located at the northern point and

experiences wind storm and thunderstorm almost every year. Wind hazard has a very strong relation with the wind load and the different geographical regions. The suitable tools to analysis all the data provided Geographical Information System (GIS), which is among currently software growing use in developing countries should be manipulated properly. This system capable to record basic and detail information about wind directions, wind speeds, wind hazard, geographical region, and surface roughness topography in form of model. In the end of this study, to provide the current information data base that easy to access and manageable is necessary in our community.

1.1 Problem statement

The important of this study is the risk of wind hazard problems due to thunderstorm is a serious level and most widely spoken issues around Malaysia especially based on the recently incident. On March 25, 2012, almost 20 houses and one school damage by uplifting of the roof structure or roof sheeting due to the wind storm at Kangar, Perlis Based on the investigated the scene, reason given for these losses include; increased development in high risk areas, a lack of awareness of or failure to follow recommended construction practises and the introduction of new and unproven materials. Economic losses included repairing or replacing damaged buildings and their contents, while the loss of personal possessions and relocation during reconstruction are common outcomes of residential damage.

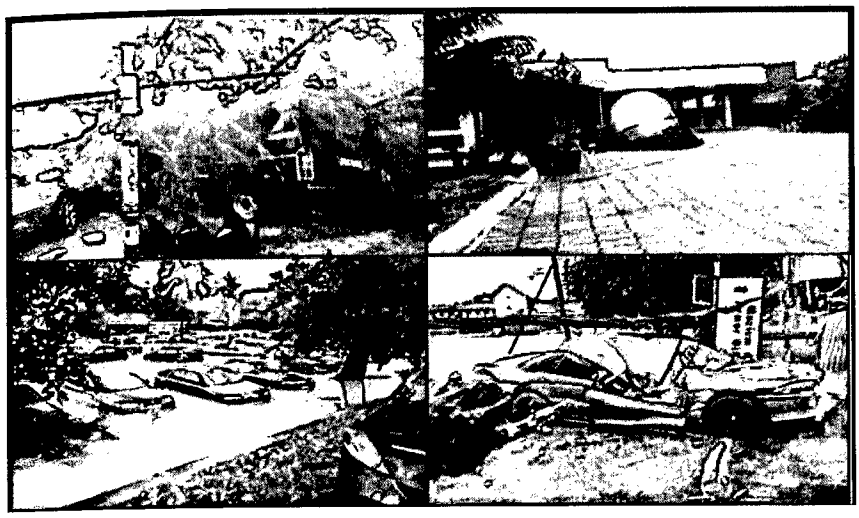

Figure 1.2 The Damage Due to Thunderstorm. (Berita Harian Online, 2011)

Since there are many damage occur for engineered and non-engineered build during the thunderstorm and mostly are located at remote area. The engineers are built the structure which doesn't have enough information and knowledge about considering wind load and geographical region on their design. In additional, lacking of the structure, complete, compact, and efficient system data management to store or restore data and information about windstorms that might be the reason failure on certain civil structure. Therefore, the initiatives to create the awareness among local expertise by providing the tools or information data that compile with data of wind speed, surface topography model and wind hazard area/region such as Geographical Information System (GIS).

1.2 Objective

Commercial building or residential houses located in the high risk area that were relatively unsheltered from the full force of the storm incurred the decent damage. The damage to these structures presented a unique opportunity to investigate the regions/areas and factors that extent of damage.

The objectives of this study are:-

1. To produce database of wind damage in Perlis state by using Geographical Information System (GIS).
2. To applying and produces information system for wind hazard and wind speed monitoring across Perlis state that can be managed efficiently and effectively.
3. To develop or establish the wind hazard map in Perlis, Malaysia

1.3 Scope of study

The scope of this study is to determine the ways to succeed the objectives. The following is the scope of this study was:-

1. The ArcGIS software as the preferred method to analyse the data and information obtained.
2. The GIS database system that completed with information that related with data of wind speed, surface topography model and wind hazard area/region etc.
3. The area of study is limited to certain area that has high numbers of maximum speeds and windstorms frequently occurred around Peninsular Malaysia.

1.4 Area of study

The area of study is limited to certain area that has high numbers of maximum speeds and windstorms frequently occurred every year. In generally, the locations that having windstorms problems are the location that consists of high maximum speed of wind, high residential density, financial and commercial districts and also urban parks around Perlis, Malaysia.

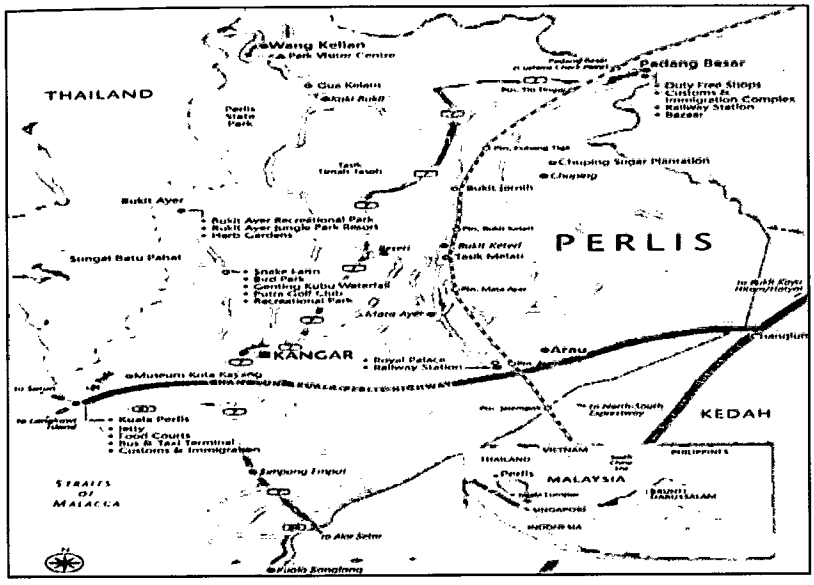

Figure 1.3 Map of Perlis State.

1.5 Thesis Layout

Briefly, Chapter I discuss the introduction of initial overall of the study. Firstly, the problems statement of the study, it is related with information management about wind hazard occurred at Perlis state in generally by using Geographical Information System (GIS). Further, the objective and aims of the study stated in the sub topic to determine the mission and vision during the research duration. Scope and the limitation of the study are discussed to make sure that this study can be completed within the prescribed time. Next is the expected result from the study to determine the product that will be produce in this study. In addition,

significant of the study explain about the benefits of analysis in futures to individual, community, and national level.

In Chapter II is Literature Review, the background and the definition of Geographical Information System (GIS) is discussed. Other that, the general analysis of wind hazard will be explained. The explanations of wind hazard analysis covered the components and subsystem about the general ideas of the system. The purpose is to state the important of GIS as a main tools in this study and application of GIS in other fields. In addition, definition of wind load and application on structures building will be explain this chapter. On the other hands, factor of wind hazard also stated in this chapter such as surface terrain roughness, wind speed, direction of wind and other.

Chapter II is Methodology; it is all about the methodology used along the study to identify problems until analysis data phase and conclusion with recommendation in detailed have been made, to make sure that the reader will be more understand the methodology of the study.

Chapter III is Analysis and Result, presentation of the result from data analysis of wind hazard maps and discussion.

Chapter IV is Conclusion and Recommendations as the final chapter and included the summary of the study before, during and after process study occurs. The conclusion stated at the end of this study to show that the effective and suitability of Geographical Information System (GIS) as the application in information management system for wind hazard according to the study.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Literature study is most the important thing to describe in detail on related subjects. According to Gavan, J, literature review refers to an extensive, exhaustive, and systematic examination of publications relevant to the stated research problem and also to acknowledge the strengths and weakness of the articles. Literature review is the first step to understand what the main concept and theory on this project. The fundamental our related subject also must be strong to achieve the objective. This project concern with aerodynamics characteristics and the detail descriptions will be described after this.

2.1 Geographical Information System (GIS)

GIS is the short form of "Geographic Information Systems" is one of many information technologies that have transformed the ways geographers conduct research and contribute to society. In the past two decades, these information technologies have been given the big impact and effects on research techniques specifies to geography, as well as in the general ways in which scientists and scholars communicate and collaborate (Kenneth E. Foote, 1995). A geographic information system is system designed to capture, store, manipulate, analyse, manage, and present all type of geographically referenced data (ESRI, 2011).

The definition quoted in William Huxhold's Introduction to Urban Geographic Information Systems (1991) mention that the purpose of a traditional GIS is foremost spatial analysis. As a result, the capabilities in GIS may have limited data and information capture and cartographic output. Capabilities of analyses typically support decisions making for specific projects and/or limited geographic areas. In GIS process, the map data-base characteristic (accuracy, continuity, completeness and etc.) are typically appropriate for small-scale map output.

In summary, Geographical Information Systems is an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyse, and display all form of geographically referenced information (Redlands, 1990).

In this study, the GIS will be used for identify or showing the data of wind hazard that include with data of wind speed, surface topography model and wind hazard area/region etc.

2.1.1 Application of Geographical Information (GIS) in Civil Engineering.

Civil engineering is about developing, planning and sustaining infrastructure. The profession cover many areas of interest and a broad range of expertise. As a result, civil engineers work with a voluminous amount of data from a variety of sources. Geographical Information System (GIS) technology provides the tools for creating, managing, analysing, and visualising the data associated with developing and managing infrastructure (Environmental Systems Research Institute, ESRI). GIS application allows the user to manage and share data and turn it into easily to access, maintains, store and understood reports and visualizations that can be analysed and communicated to others.

The application of Geographical Information System (GIS) in civil engineering speared widely. GIS provided the visualizing model and restored data, may improve management system such as in civil engineering, the application of GIS is use for more efficient :-

1. Planning and site location.
2. Environment Analysis.
3. Infrastructure design.
4. Data collection and as-built surveying
5. Operation and maintenance.

With all the demands on your time, using tools that streamline your business process and provide you with the best mapping and visualization make sense. GIS having an accurate, clear picture of the project helps the engineers make good decisions about to move forward.

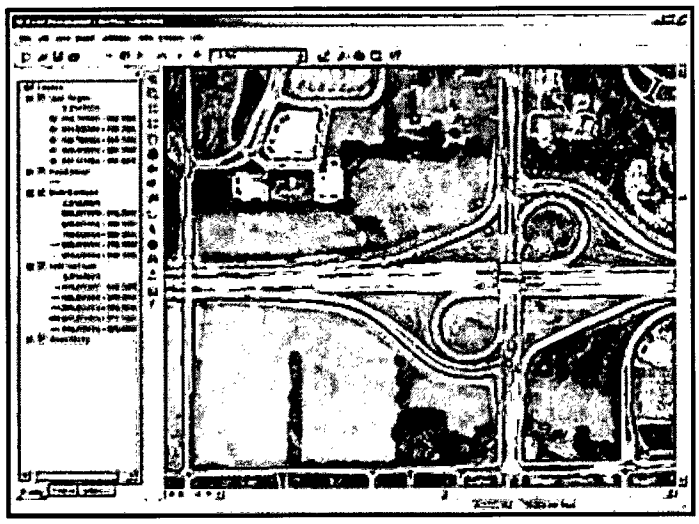

Figure 2.1 The Example of GIS Application in Road Maintainer and Controller. (Environmental Systems Research Institute, ESRI, 2011)

2.2 Wind

Windstorm pose a variety of problems in Malaysia particularly in residential area and commercial building, causing concerns for building owners, insurers, and engineers alike. The thunderstorms are the largest single causes of economic and insured losses due to natural disasters, well ahead of floods. The thunderstorm events reported that mot the damage occurs in northern region on peninsular Malaysia. For example, On 13, 2010, the damage accoutred at Malacca Night Market due to thunderstorm and causes the flying object from canopies had hit and 3 patrons of night markets.

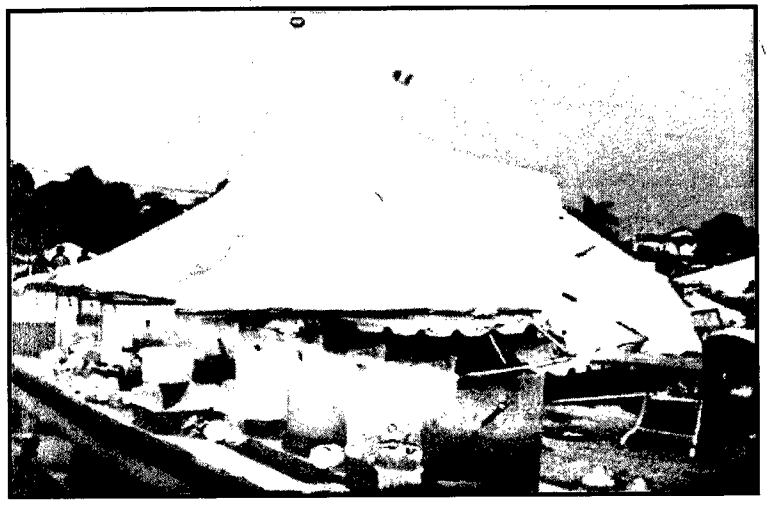

Figure 2.2 Canopy collapse at Malacca Night Market. (Berita Harian Online, 13 August 2010)

In naturally, wind is term used for air in motion and is usually applied to the natural horizontal motion of the atmosphere (B. S Taranath, 2005). Although one cannot see the wind, it is a common observation that its flow is quite complex and turbulent in nature. In Malaysia, the late northeast monsoon is characterized by persistent of moderate to strong north-easterly winds. February and March are the weakening months of the northeast monsoon. In 2011, Malaysian Meteorological Department Ministry of Science reported that the weather is normally fair to moderate dry (relatively hot and windy) and occasionally accompanied by strong

north-easterly wind of 20 to 40 km/h could reaches up of wind strength. This dry condition is due to strong north-easterly wind cross equatorial flow from northeast to southwest at the equator. In addition, the late northeast monsoon is characterized by persistent of moderate to strong north-easterly winds.

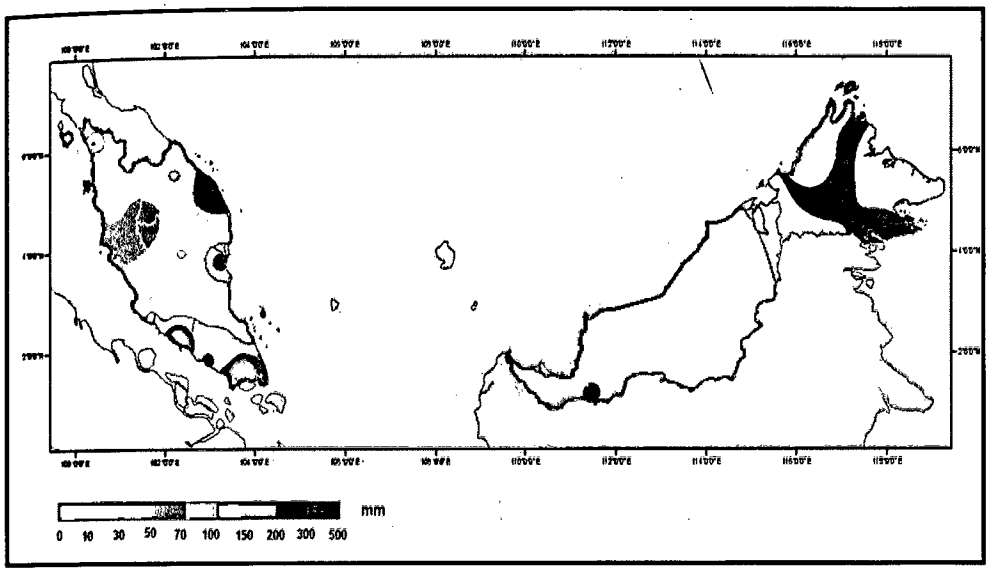

Figure 2.3 The Map of Actual Weekly Accumulated Rainfall (mm). (Malaysian Meteorological Department Ministry of Science, March 2011)

In general, the actual weather for 2011 showed that more rain was observed over central to northern part of Peninsula included Perlis which was ranging in between 100 to 333 mm. We can conclude, that Perlis have high probability for thunderstorm form and will cause wind hazard.

Wind load contribute a major influence on building design and the other civil structure. Many whole structure or part structure that fail, do so because inadequate thought was given to wind action at the design stage in process to construct structure. The flow of wind, unlike that of other fluids, is not steady and fluctuates in a random fashion (B.S. Taranath, 2005).

The flow of wind is complex because may flow situation arise from the interaction of wind with structure. However, in wind engineering, simplifications are

made to arrive at the design wind loads by distinguishing the following characteristics:

1. Variation of wind velocity effect form different high or terrain condition.
2. Wind climate.
3. The roughness length, z_o.
4. Rate of development.

2.2.1 Variation of Wind Velocity Effect from Different High / Terrain Condition.

The roughness of terrain exerts a major influence on the wind. The mean wind velocity is reduced by the roughness of the ground, but at the same time the wind becomes turbulent and more difficult to describe. Mean wind velocity increases with the height above the ground. The different of terrain of environment effects can be categorized according to their associated roughness length. On 2011, Siti Hajar stated that it is a known factor that roughness of certain terrain will retard the wind near to the ground. This is due to the frictional force created by the roughness of the terrain.

Usually, the terrain can only be described in a very coarse way by introducing different categories. There are then identified by the so-called roughness length, zo. . On 1996, C. Dyrbye and S. O. Hansen stated the terrain surrounding the structure in question characterizes the roughness, possible changes, such as the erection or demolition of nearby building, which may take place during the lifetime of the structure, may affect wind loads.

The speed effect is different, start from the ground up to certain height where the retarding forces are diminished totally. At this stage, the height called the gradient height the wind speed is unaffected by the ground as depicted.

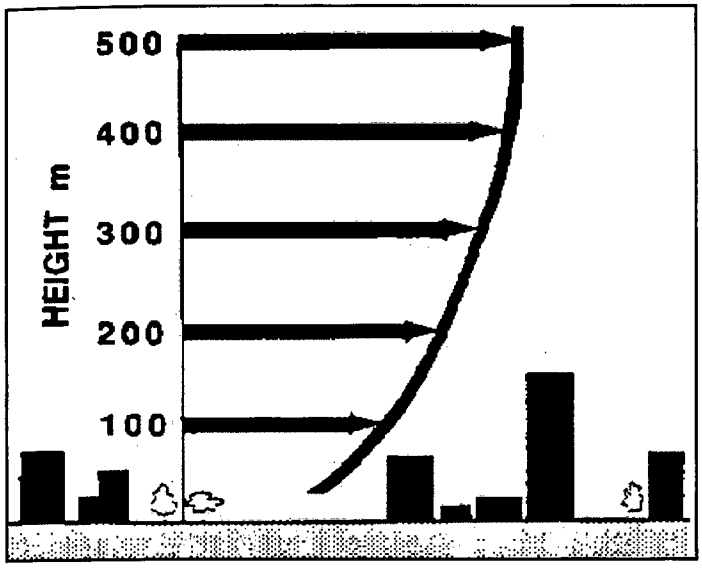

Figure 2.4 Variation of Wind Speed with Height (Templin, 1970)

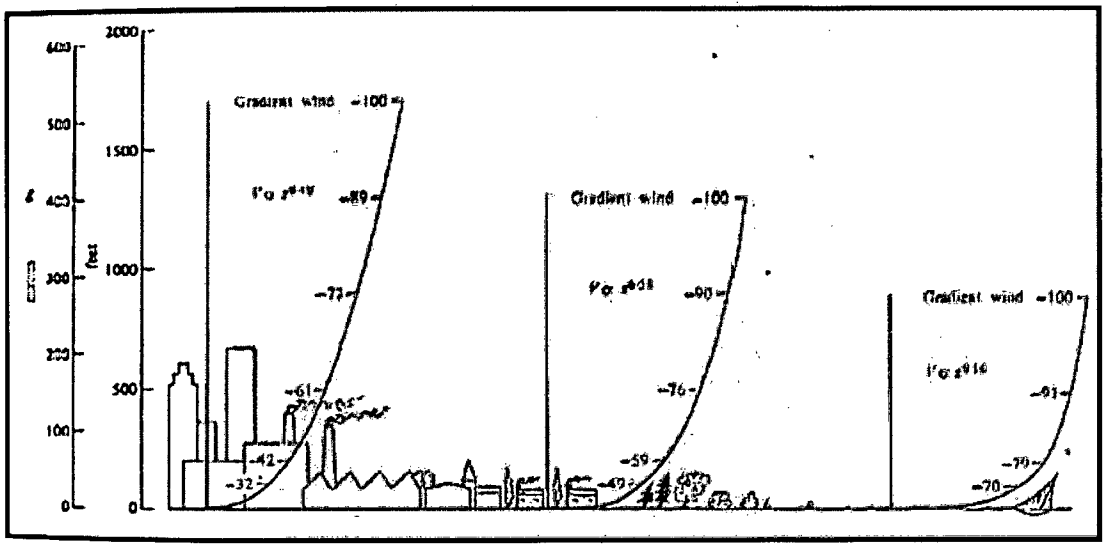

Figure 2.5 Profile of Mean Speed Over Different Level of Terrain Roughness. (Houghton & Carruthers, 1976)

Generally, the city centre terrain in Malaysia especially in Kangar, Perlis usually reaches gradient wind speed at 500 m while woodland or suburban and open country reaches gradient wind speed at height 400 m and 270 m respectively. As mention before that, the rougher of terrain is, the more retards the wind 15 within the ABL. As the result, the wind speed at 100 m in the city centre is less than half of open country.