

PERPUSTAKAAN UMP



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EFFECT OF WIND LOADS ON THE BRIDGE AT NORTH-SOUTH  
EXPRESSWAY (KUALA LUMPUR TO TANGKAK)

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## ABSTRACT

In becoming a develop country, Malaysia government had built infrastructure including highway for easy commute. Hence of that, North-South Expressway was built from Kuala Lumpur to Tangkak. This expressway was built through variation of roughness of Land Use Land Cover (LULC), terrain and topography. From this situation will make cross wind phenomena occurred along the road. Consequently, road accident could be happen due to the phenomena of cross wind. Therefore, in this study terrain database along North-South Expressway was established and relationship between slope topographic factor and wind speed was derived. Furthermore, access possibilities of the accident prone-location due to wind speed induced were identified. The GIS technique was used to establish database of study area and analysis information of topographic effect. The database demonstrate the system analyze in spatial analysis to obtain spatial variation of slope along that area. Indirectly, this technique has enabled GIS database showing the system analysis for the effect of topographic variation in slope was established. In conclusion, the objectives prove successful in the relation between data information and slope topographic effect of that area. Therefore, the result for this study can be made as a guideline for road construction and improvement in safety of the road users.

## ABSTRAK

Dalam usaha menjadi sebuah Negara yang membangun, kerajaan Malaysia telah memperluaskan penggunaan infrastruktur termasuklah lebuhraya untuk kemudahan rakyat Malaysia. Oleh itu, Lebuhraya Utara Selatan telah dibina dari Kuala Lumpur ke Tangkak, Johor bagi memudahkan dan memendekkan masa perjalanan. Lebuhraya ini dibina melalui kawasan yang mempunyai topografi yang berbeza. Keadaan ini menyebabkan kejadian angin lintang di sepanjang lebuhraya. Kejadian angin lintang boleh mengakibatkan kemalangan jalan raya. Oleh itu, pangkalan data bagi bentuk muka bumi sepanjang lebuhraya dan hubungan antara factor kecerunan dan kelajuan angin telah dapat dihasilkan dalam kajian ini. Disamping itu, lokasi yang mempunyai kecenderungan tinggi berlakunya kemalangan disebabkan angin lintang telah dikenalpasti. Teknik GIS telah diaplikasikan untuk menghasilkan pangkalan data bentuk muka bumi dan maklumat analisis dari kajian kesan bentuk muka bumi di kawasan- kawasan yang terlibat. Sistem analisis yang ada pada pangkalan data membolehkan 'Spatial Analysis' untuk menghasilkan kecerunan sepanjang lebuhraya. Secara tidak langsung, analisis kesan bentuk muka bumi telah dihasilkan dengan aplikasi GIS. Kesimpulannya, objektif kajian telah tercapai dengan terhasilnya hubungan antara bentuk muka bumi dan kelajuan angin dan kesan perubahan bentuk muka bumi di kawasan yang terlibat. Oleh itu, hasil kajian ini boleh dijadikan sebagai garis panduan bagi pembinaan jalan raya dan meningkatkan taraf keselamatan pengguna jalan raya pada masa hadapan.

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## LIST OF SYMBOLS / SHORT FORMS

GIS	=	Geographical Information System
KM	=	Kilometer
PWD	=	Public Work of Department
PLUS	=	Projek Lebuhraya Utara Selatan
NSE	=	North-South Expressway
RMP	=	Royal Malaysia Police
COG	=	Centre of Gravity
JICA	=	Japan International Cooperation Agency
TEM	=	Topographic Effect Model
DEM	=	Digital Elevation Model
GPS	=	Global Positioning System
MS	=	Malaysia Standard
TM	=	Thematic Mapper
LULC	=	Land Use Land Cover
JUPEM	=	Jabatan Ukur dan Pemetaan Malaysia
$V_{ref}$	=	Basic wind speed at 10m height
$b$	=	Constant Value Depending in Terrain Category
$\alpha$	=	Constant Value Depending on Terrain Category
$z$	=	Height Above the Ground Surface
$z_{ref}$	=	Reference Height Taken as 10m Above The Ground Surface
$\Phi$	=	Slope
$H$	=	Height of Hill or Escarpment Relative to The Upwind Terrain
$L_h$	=	Distance upwind of crest to where the difference.

## CHAPTER 1

### INTRODUCTION

#### 1.0 Introduction

Transport and communication is catalyst or rapid economic growth. Infrastructures facilitate adequate and efficient movement of resources between the central production and consumption. It also has played an important role in promoting the development of rural areas population to participate in this growth process. This rapid growth in various economic sectors has also established greater demand on distribution, capacity and efficiency transport and communication network in the country. For that purpose, Malaysia introduced North-South Expressway project (PLUS), cross the country from North to South.

North-South Expressway was officially established on 1994. The overall length of the expressway is over 823 km from Thai border to Singapore and starts from Bukit Kayu Hitam and ends in Johor Bahru. It connects all the major cities on the West Coast, the peninsular Malaysia. The purpose of this project is to improve the country's economic future, which create new cities as urban growth and development. Unfortunately, these infrastructures give a higher rate in road accident.

From road accident statistic year 2000 until year 2006, showed that the increase number of road accidents and death. In years 2000, the total of number of road accident is 250,429 cases and in year 2006 it is increase to 341,252 cases. The cases are increase about 26% in 6 years. For road death cases in year 2000 is 6035 cases and in year 2006 is 6287 cases. From the statistic, it showed that the number of accident increase year by year. (Royal Malaysia Police, 2011)

The increase of road accident is in link with the rapid growth in population, economic in development, industrialization and motorization encountered by the country. Beyond all of that reason, environment or weather factors such as wind can lead to increasing the road accidents. Moreover, a considerable portion of road accidents has adverse weather for example strong winds as a primary or a contributing cause of accidents. Vehicles in coastal regions or in a valley area sometimes deviate from their desired path because of the strong crosswind accelerated by the concentration of flow over the bridges or valleys. Continual compensation of the steering wheel against the crosswind causes stress for the driver, leading to an increase of accident risk. The incident was occur because of the cross wind along the expressway.

In understanding the source of road accidents, data needs to be studied and analyzed in a proper manner. In turn, data accuracy plays a vital role in making road accident data analysis. The aim of this study is to analysis cross-wind effect spatially over PLUS highway. GIS technique have used in this study.

## **1.2 Problem Statement**

Road accident cases are increasingly time by time. Almost accident cases occur due to weather condition such as strong wind. It is because the expressway in Malaysia is along coastal region, cross over variation of roughness or terrain and valley that exposed to strong cross wind. The accident can be controlled with the vehicle speed limit, to negotiate with cross wind condition.

## **1.3 Objectives of the Study**

The objectives of this study are:-

- I. To establish terrain database along North-South Expressway Southern Route (NSE)
- II. To identify relationship between slope factor and wind speed analysis.
- III. To identify and access possibility of the accident prone location due to wind speed induced.

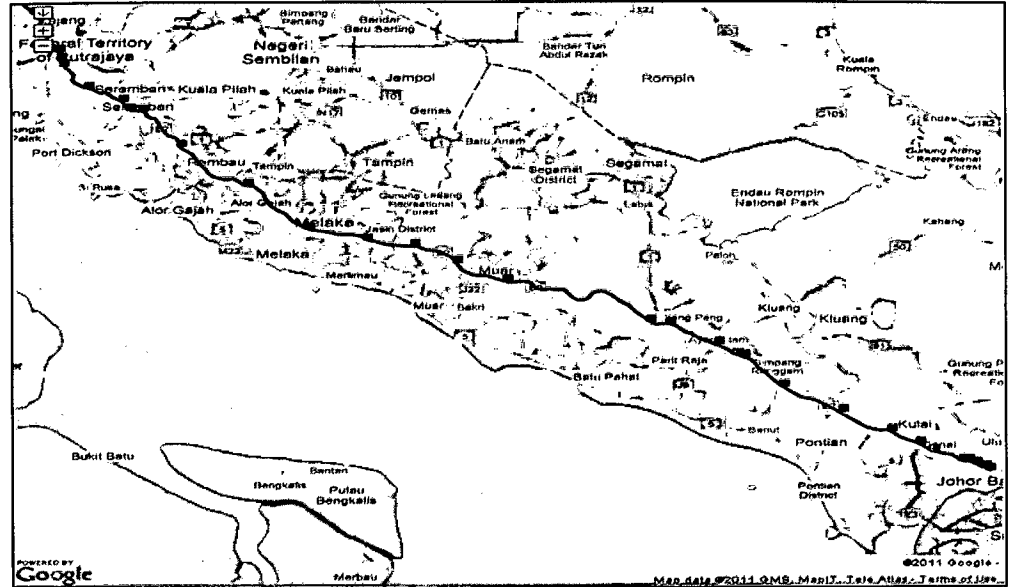
## **1.4 Scope and Limitation of Study**

This study is limited to the following:

- a. Study area was along southern route North-South Expressway (PLUS), Kuala Lumpur to Tangkak stretch.
- b. Slope analysis over the study area was conducted using GIS technique.

## 1.5 Study Area

The research area or location is at southern route of expressway from Kuala Lumpur to Tangkak, Johor. This road through several states which are Selangor, Negeri Sembilan, Malacca and Johor. The length of this expressway is about 313 kilometre.



**Figure 1.1:** Location of study image

## 1.6 Significance of Study

At the end of this research, from the data that we have got and analyze from GIS software, we can formulate the mitigation for public people. The mitigation such as give warning and awareness to people about the current condition of winds at precise location of expressway and can decrease the accident cases. Besides that, we can help the involves parties that in charge in the expressway to put the warning signboard in the area that high possibility for accident to happen.

## 1.7 Thesis Layout

The contents of each chapter are introduction, literature review, methodology, result and analysis, conclusion and recommendation and references. In introduction will include background, problem statement and justification, objectives of the study, scope and limitation of study and study area. The literature review will review about wind speed and road accident analysis background, the definition, the materials, the methods and summary of literature review. In the methodology, it will show the method that has been used from start to end of this project run and method of using the GIS software. The next chapter is about the GIS wind speed and road accident analysis and result. The result will be presenting as slope database maps and discussion. In the conclusions and recommendation, it will be present the summary of conclusion and recommendation for the future. After conclusion there will be references or sources to run this research.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

In this literature review, there is a survey and discussion of the literature in a given area of the study. The purpose of literature review is written to highlight specific arguments and ideas in a field of study. By highlighting these arguments, it will show what has been studied in the field, also where the weaknesses, gaps, and areas needed in the studied. This literature review is described in detail about the one of the factor that induced to road accident.

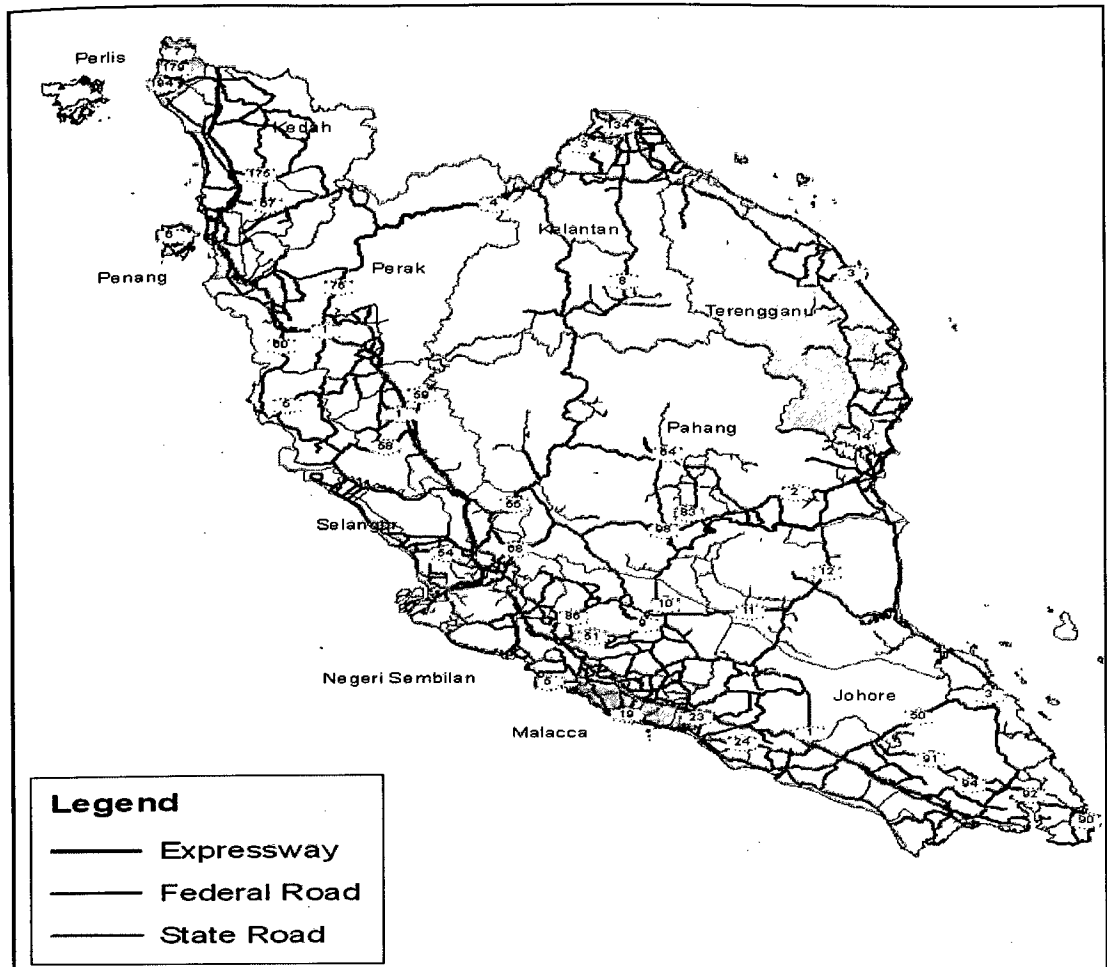
#### **2.2 Road in Malaysia**

Road is play an important role in transportation in development country as in Malaysia. Each road has its function according to its role either in the National Network, Regional Network, State Network or City Town Network. This can be

1

further divided into two functions that are mobility and accessibility and this function can be divided into rural and urban areas. The road can be categorized into three (3) roads, namely Highway, Federal Road and State Road (**Figure 2.1**). The length of all road in Malaysia is 82,144km include 61, 420 km state roads and municipality roads, 18,904 km Federal Roads and 1820 km Toll Highways. Most roads in Malaysia paved with flexible or rigid pavement. Construction of roads in Malaysia implemented mainly by the Federal Government and State Government. However, since the mid-1980s, construction of toll roads has been started by private companies, PLUS, whom then authorized by the government to charge tolls to road users. Federal roads are the major interurban roads joining the state capitals and roads leading to points to entry to and exit from the country. State roads generally comprises of the primary roads providing intra-state travel between the district administrative centers. They included urban collector roads under the municipalities and other minor roads within the villages and the rural inhabited areas under the District Offices (Public Works Department, PWD).





Source: Public Work Department of Malaysia (2005)

Figure 2.1: Major Road Network in Malaysia

### 2.3 North-South Expressway (Kuala Lumpur to Tangkak)

The research area or location is at southern route of expressway from Kuala Lumpur to Tangkak, Johor. This road through several states which are Selangor, Negeri Sembilan, Malacca and Johor. Generally, the topography along the proposed highway is hilly and slightly sloping. The highest contour is near the Ukay Perdana Interchange with 200-300 meters. The route through several major rivers and streams such as: -

- Sungai Merbau
- Sungai Long
- Sungai Sekamat
- Sungai Langat
- Sungai Sub
- Sungai Michu
- Sungai Gahal
- Sungai Kelang
- Sungai Ampang
- Sungai Pandang
- Sungai Kemesah
- Sungai Telok
- Sungai Seleak
- Sungai Batang Pusu.

The main land use along the project alignment is made up of vegetation and development (settlement). The majority of the affected forest areas are forest reserve which is Hulu Gombak Forest Reserve, Ampang Forest Reserve and Hulu Langat Forest Reserve. the land use of the development such as residential, industry and institutional that are directly involved with the proposed project is minimal.



Source: Google Earth

**Figure 2.2:** North-South Expressway

### 2.3.1 Road Accident

Road accident is one of the major problems in Malaysia. According to Malaysian Road Safety Council statistic, death caused by road accident have increased to 5891 people in year 2002, followed by 6286 death in 2003, 6223 (2004), 6188 (2005), 6287 (2006) and 6282 (2007) which amounted to 37157 death within just 6 years. Table 3.0 below showed the statistic of road accident along south-north expressway in 5 years. (**Table 2.1**)

**Table 2.1:** Statistics of Road Accidents for 5 Years.

<b>YEARS</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>Injury accidents</b>	<b>50,864</b>	<b>47,080</b>	<b>39,716</b>	<b>29,258</b>	<b>27,645</b>
<b>Minor accidents</b>	<b>37,415</b>	<b>33,413</b>	<b>25,928</b>	<b>15,596</b>	<b>13,979</b>
<b>Critical accidents</b>	<b>7,163</b>	<b>7,444</b>	<b>7,600</b>	<b>7,375</b>	<b>7,384</b>
<b>Deaths</b>	<b>8,286</b>	<b>6,223</b>	<b>6,188</b>	<b>6,287</b>	<b>6,282</b>

**Source:** Malaysia Road Safety Council (2009)

Statistic of the Royal Malaysia Police (RMP) shows the accidents continue to increase each year and during the festive season in year 2011 alone recorded a total of 1609 cases of an accident and it is the highest number of accidents recorded over last few years. While the overall number of accidents according to statistics of Royal Malaysia Police (RMP) shows the accidents continue to increase. At the 2010 a total of accident was recorded is 424,421 than 397,330 accident is year 2009.

In year 2006, it showed that the numbers of deaths from road accidents are 6,287 people. From this amount, 3,693 or 58.7% are from motorcyclists and pillion riders. Meanwhile in September 2007, the total numbers of death from road accidents is 4,646 and 2,476 or 53.3% are from the rider and pillion. The **Table 2.2** showed the different types of road accident.

**Table 2.2: Road Fatality Statistic**

<b>CATEGORIES</b>	<b>2006</b>	<b>Jan-Sept'06</b>	<b>Jan-Sept'07</b>
Driver/cars passenger	1215	920	1113
Rider / pillion riders	3693	2736	2476
pedestrian	595	438	482
Rider/ pillion rider bicycles	242	183	141
Driver/ bus passenger	39	26	64
Driver/ lorry attendant	229	174	145
Driver/van attendant	103	73	101
Driver/4-whee drive attendant	110	73	65
Others	61	48	59
<b>Totals</b>	<b>6287</b>	<b>4671</b>	<b>4646</b>

**Source:** Malaysia Road Safety Council (2007)

There are several factors that cause road accident. The main factor that contributes in increasing to road accident is because of the roadway environment that leads to uncontrolled the speed of transport (BAEK, Seungkirl et al 2005). This was accentuated by the fact that the capability or human failure has been identified as the cause of which has contributed more than 90 percent of the causes of road accident (Austroad 1989).

## 2.4 Wind

In meteorological aspect state that wind is air movement relative to the earth, driven by several different forces, especially pressure differences in the atmosphere, which are they produced by differential solar heating of different parts of the earth's surface, and forces generated by the rotation of the earth. Wind, with regard to road safety, can be divided into two categories. First, the gust of wind as the result of the movement of ambient air, and the second one is the blow of air generated by moving vehicles. Both types of wind can affect the stability and control of vehicles in motion. (Bjorn Olafson, 2008)

The natural wind blows in many directions, and when matched with the direction of traffic or vehicles on the road, it can be described in different terms, that are headwind, crosswind and tailwind. The different winds give a different impact to the vehicles. Usually, headwind and tailwind will not be a major safety issue. They only affect the performance of longitudinal vehicle speed, either by pushing back or pushing forward (Baker, 1988).

For crosswind, which blows from the sides, has a greater impact on vehicles especially those with high centre of gravity (COG) and large flat surface. These vehicles are highly prone to the effects of crosswind in terms of stability and control. The crosswind or side wind can cause vehicles such as buses, trucks transporting containers (semi-trailers and trailers), bonded pickups and vans to roll over (SWOF2007). From overview weather as a Road Safety Hazard in Malaysia, it is stated that, besides the aerodynamic and stability issues, wind also blows obstacles debris and sand onto the road and the presence of the precipitation with significant wind speed will make the situation more disorienting for drivers.

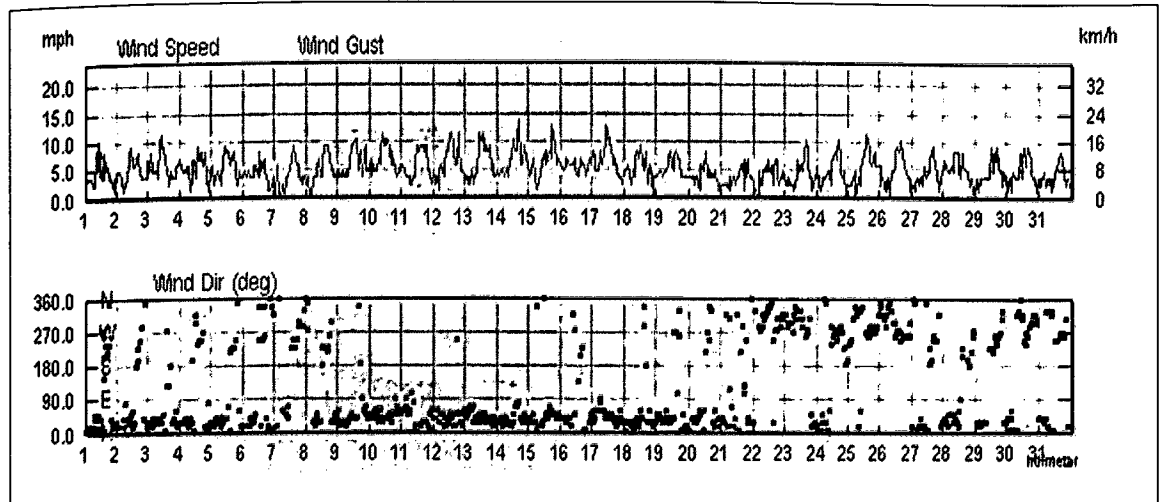
The (Skuli Thordarson, Bjorn Olafson) said that adverse weather such as strong wind, snow and ice can be one of the factor that contribute in increasing road

accident. In future climate, wind will probably appear as a more serious and frequent threat to road traffic than in present climate.

#### 2.4.1 Wind Speed

Wind speed is the speed of wind, the movement of air or other gases in an atmosphere. Wind speed also can be defined as the rate of flow of the wind undisturbed by obstacles. It can be measured in meters per second or knots. Calm is reported when the wind speed is less than 0.5 meters per second or less than one knot. The climate of Malaysia is driven by its equatorial position, extensive coastlines on tropical seas and monsoonal winds. The monsoon wind is the prevailing wind trend in Malaysia that blows in the range between 10 to 30 knots (18 to 55km/h).

A strong wind speed will cause an accident to occur. This statement has not been denied by PLUS and JICA in which they have recognized some locations along the north-south highway as cross wind areas at Kilometer 2441-244.6, 213.0-213.5, 211.2-211.9, 200.4-200.8 and 196.6-197.0(PLUS). From the analysis, the location is potential to be exposed to the strong gale, especially during north-east monsoon (January-March). The strongest wind speed has been recorded is 13.5m/s that is measured at the height of 5 meters. The **Figure 2.3** showed one of analysis wind speed data at one of location in North-South Expressway that is Malacca (**Figure 2.3**).



Source: Wunderground, Malacca (2011)

Figure 2.3: Wind Speed

Wind induced accidents. From the research, it is said that wind effect causing extremely hazardous condition on the road. The higher wind gust can be as high as 2.5 times of 15m/s higher than the mean wind speed that catching drivers off-guard, despite variable message signs indicating the wind speed on the site. It is well known that vehicle characteristic is important regarding stability during windy conditions. Once an accident has happened, the chances that recorded mean wind speed is 10m/s or more, are double for high –sided vehicles such as trucks and trailer, than for passenger cars. (Ljubljana, 2008).

Wind speed is affected by a factors and situations, operating on varying scales including:-

- a) **Pressure gradient** is a term to describe the difference in air pressure between two points in the atmosphere or on the surface of the earth. It is vital to wind