IDENTIFICATION OF HAZARDOUS ROAD LOCATION BASED ON DESIGN CONSISTENCY AND ACCIDENT PREDICTION MODEL FEDERAL ROAD IN JOHOR

ZAFFAN FARHANA BINTI ZAINAL

A thesis submitted in fulfilment of the requirement for the award of the Degree of Master of Civil Engineering

Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia

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This thesis is dedicated with a great love to my dear parents Mr. Zainal bin Ibrahim and Mrs. Zainon binti Zakaria, who always supported me. I also dedicate it to the light of my life; my family who always supported me till I finish Master’s Degree by Research. Finally, I will not forget my great friends for always being there for me especially Wan Zahidah binti Musa, Wan Mohamad Ikhwan Shafiq bin Wan Othman, Nurul Nadia binti Che Zakaria and Nur Muna binti Sallahudin. Their support is my strength until I finish my Master’s Degree by Research.
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ABSTRACT

Every year road accident in Malaysia is kept rising, especially road accidents occur in between a collision with passenger cars, other motorcycles and single-motorcycle accidents. In early 2016, Johor has been mentioned as the highest ranking hazardous road accident especially federal roads. However, the problem road accident on hazardous road still unsolved even though others research has been done. This study using a new method design consistency and the accident prediction model to decreasing road accidents from occurring at hazardous road locations. The purpose of this study was to determine the relationship of accidents between motorcycles and cars on select segments Federal route 050 (Jalan Kluang – Ayer Itam – Batu Pahat) and Federal route 023 (Jalan Muar – Tangkak). These studies were related a geometry elements of access point, median, shoulder width, lane width and continuous speed of motorcycle and cars to determine value design consistency model (IC) and threshold. The data collections were GPS DG-200 to collect continuous speed data, the geometry data collection during the site visit and police data. The models were developed based on the new method of speed profiles, analysis to determine the value of the index integrated design consistency model (IC) between motorcycles and cars. The result showed similarities the value of design consistency model with hazardous locations. Hence, the developed accident prediction model was related road design consistency models and accident rates to evaluate the impact of design consistency with road safety. Therefore, based on results and analysis, some discussions of geometric elements based on design consistency result and relationship with road accident occurs between motorcycles and cars at hazardous road locations and some of recommended are provided such as improve widen shoulder for inadequate shoulder, increase enforcement for illegal parking and others.
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$R^2$ - $R$ - squared
$R^2_{\text{adj}}$ - $R$ - squared adjusted
$V_{85}$ - Operating Speed Model/85th percentile speed
$\text{CCR}$ - Curvature Change Rate
$R$ - Radius of Curve
$\text{LW}$ - Lane Width
$\text{SW}$ - Shoulder Width
$\text{AADT}$ - Average Annual Daily Traffic
$L_C$ - Length of Curve
$L_T$ - Length of Tangent
$V_{85T}$ - Operating Speed Model of Tangent
$V_{85MC}$ - Operating Speed Model of Curve
$m$ - Metre
$\text{km/h}$ - Kilometre per Hour
$\text{ft}$ - Foot
$\text{mph}$ - Mile per Hour
$R_a$ - Relative Area Measure Consistency
$V_{\text{avg}}$ - Average Weighted (by length) Operating Speed along Highway
$A_{\text{CT}}$ - Normalized Bounded Area between the Speed Profiles Two Types of Vehicles
$\text{IC}$ - Integrated Consistency of a Highway Segment
$C$ - Design consistency quality
$m/\text{sec}$ - Meter per Second
$\text{km}$ - Kilometre
$E(Y)$ - Mean
$\text{var}(Y)$ - Variance
$\text{am}$ - Morning Time
pm - Evening Time
KM - Kilometre Post
$A_1$ - Speed of Vehicle
$L$ - Length Tangent/Curve
AP - Access Point
Q - Median
t - Tangent
c - Curve
C - Basic Consistency of a Highway Segment
$L$ - Entire Segment Length
$m^2/sec$ - Metre square per Second
$V_j$ - Operating Speed along the $j^{th}$ Geometric Element (tangent/curve)
n - Number of Geometric Elements along a Segment
$V_i$ - Operating Speed
Z - Road Accident Prediction
AIC - Akaike’s Information Criterion
BIC - Bayesian Information Criterion
$y$ - The Quality of the Fit between the Observed Values
$\sigma$ - Standard Deviation of Operating Speed
$e$ - Exponent
$\mu$ - The Expected or Mean Number of Counts (Road Accidents) per period
$\Sigma a_i$ - Sum of i Areas Bounded Between the Speed Profile and the Average Operating Speed
$\mu$ - The Predicted Value
$x_i$ - The Vector of The Explanatory or Independent Variables
$\beta$ - The Vector of Unknown Regression Parameters
$y_{ij}$ - Dependent Random Variables
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<tr>
<td>ACAD</td>
<td>AutoCAD Software</td>
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<tr>
<td>APW</td>
<td>Accident Point Weightage</td>
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<td>ASEAN</td>
<td>Association of Southeast Asian Nations</td>
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<td>DG-200</td>
<td>Global Positioning System DG-200</td>
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<td>FT 050</td>
<td>Federal Route 50</td>
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<td>FT 023</td>
<td>Federal Route 23</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>HPU</td>
<td>Highway Planning Unit</td>
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<tr>
<td>IPK</td>
<td>Johor Bharu Police Headquarters</td>
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<tr>
<td>JKR</td>
<td>Road Safety Department</td>
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<tr>
<td>JKR/PWD</td>
<td>Malaysian Public Works Department</td>
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<td>MIROS</td>
<td>Malaysian Institute of Road Safety Research</td>
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<td>OECD</td>
<td>The Organisation for Economic Co-operation and</td>
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<td></td>
<td>Development</td>
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<td>PDRM/RMP</td>
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CHAPTER 1

INTRODUCTION

1.1 Background of research

In the middle of the ASEAN, Malaysia has the highest road accident risk (per 100,000 populations) and one of the developing countries that facing high road accident in Asia and more than 50% of the road accident fatalities involved motorcyclists. In additional, the West Coast Area of Malaysia is the highest motorcycle accidents due to the high number of registered motorcycles and population. From 1990 to 2008, an entire of motorcycle billion kilometres travelled in Malaysia therefore increased motorcycle also accidents increased as well (Manan et al., 2012). Recently, Malaysia economy is successful, the number of road users increased sharply in the last past years and the amount of traffic accidents that were recorded in Malaysia are rising about 300 00 accidents reported and 1% of fatal accidents for every year and traffic accident has been increasing over the last three decades with an average pace of 9.7% per annum (Mustafa, 2005). Generally, one million people are killed, three millions are disabled for life and thirty millions are severely injured in a road accident as stated by WHO for every year. If this trend continues road traffic accident is will be predicted to be the third important to contribute to the global burden of disease and injury by 2020 and its relevant issues in today’s society (WHO, 2004).

The large volumes of traffics on the road, accidents can occur by involving collision with passenger cars, collisions with other motorcycles and single-motorcycle accidents. The increase in motorization led to a consequent increase in the number of road traffic accidents (Sohadi, 2005). Based on provisional data by the Royal Malaysian Police, there were 6674 road deaths in 2014, and its decrease about
3.5% compared to 2013. But in 2013, motorcyclist rides represented 62% of all fatalities meanwhile car drivers and passengers represented 20% of fatalities (OECD, 2015) and motorcycles represent more than half the total vehicle population and it contribute more than 47% of the casualties based on deaths, serious and slight injuries in traffic accidents which recorded 48%, 47.4% and 47.7% for the year 2006, 2007 and 2008 (Yuen et al., 2014). Riding a motorcycle is 17 times more dangerous than driving a passenger car and also the motorcyclist will be in front of higher risk of injury or fatality because the level of exposure to injury is higher if compared to other vehicle such as a passenger car in accidents (Sohadi et al., 1995). The potential for exposure in a road accident is highest among the use of a motorcycle because it directly exposed and come in direct contact with the impacting vehicles or obstacle during a collision and resulting in severe injuries and fatal (Rahim et al., 2010). Based on previous studies, accidents occur where any car driver or motorcyclist was not injured, but the either passengers or the other vehicle around 97% of motorcyclist were injured or killed in these accidents compared with 50.5% of car drivers. It also stated that at higher speed motorcycles and car collision than car and car collisions motorcyclist involved were 95.4% likely to be injured while car drivers were 0.9% likely to be injured (Huang & Preston, 2004).

Accidents occur of a combination between 4 elements; the driver, the road, the vehicle and the environment. Faulty vehicles, uneven roads, careless/reckless driving, speeding, drunk driving, inadequate sleep, alcohol and many more are the causes of road accident and also because the road condition itself. The accident can be occurs when lack of design consistency on the road which most drivers make fewer errors in the surrounding area of geometric characteristics especially in hazardous road location. Design consistency is the relationship between the geometric characteristics of a highway and the conditions that the driver expects when drive. When the design is consistent with the driver expects, the highway is also consistent and the worse the consistency, the more likely it is that drivers will be anxious and an accident will happen (Castro et al., 2008). The point design consistency in establishing, operating speed (85\text{th} percentile operating speed) is to know the relationship between the operating speed and the factor of geometric design on the two lane highways. The criteria to evaluate design consistency are based on operating speed evaluation of the 85th percentile speed of vehicles, and obtained by using operating speed prediction models (Gibreel et al., 1999). Some researchers
have extended the concept by using continuous speed profiles through the normalized area bounded of speed to determine the speed difference along a road segment and determining a consistency value for the entire road segment (Hassan, 2004; Polus & Mattar-Habib, 2004; Mattar-Habib et al., 2008).

Motorcyclist and car drivers tend to have a higher fatality per distance travelled; therefore this study develops the potential relationship between design consistency which is represented by continuous speed profiles and the occurrence of motorcycles and car accident that results in the identification of the potential locations of accidents along the selected Johor Federal roads. By estimating the 85th operating speed along the road, it produces continuous speed profiles of motorcycles and cars. By using the Poisson model as an accident prediction model to predict accident based on geometry characteristics and integrated design consistency (IC). The models are the relationship between design consistencies and expected number of accidents along the road over the years. The findings in the identification of hazardous location for motorcycles and cars are becoming the effective countermeasures to reduce accident frequency and severity of motorcyclist and drivers, in term of road design and traffic behaviour.

1.2 Problem statement

Road traffic becomes more complicated to control due to the continuous increase of traffic on the road, therefore the number of road accidents increases based on this problem. According to the Malaysian Institute of Road Safety Research, in year 2015, there were 26,301,952 registered vehicles and the statistics of road accidents are reported an increase for the time of 2014 (476,196 cases) until 2015 (489,606 cases). On the other hand, the number of injuries in road accident reported showed a decrease from 13,030 (2014) to 11,552 (2015), but the number of death in road accident was reported 6,674 cases in 2014 and 6,706 cases in 2015 (MIROS, 2017).

Alongside road accident increase nowadays, an unresolved issue is about road accident at hazardous location are causing distress to road users. The hazardous road locations are usually based on accident data and as well the increase in the number of vehicles. On the other hand, the accident data information may not explain as the factors that cause an accident occur at that location. Therefore, the actual road environments problems of road location are considered essential as a road safety
indicator in to overcome the accident occur on that road again (Razelan et al., 2014). Road hazard can be physical defects in the highway, such as potholes, intersection, including driveways, curves or bends in the road, the position or movement of other road users, lack of appropriate road markings, improperly graded curves and uneven shoulders, changes in weather and road conditions. Previous study acknowledged, identification of hazardous road location has a higher expected number of accidents compared with other similar location, as a result of local risk factors present at the location or hazardous road location means the process of plotting accident locations on the road maps as a black spot. For example, the accidents that occur based on adverse road design should have a greater influence than impaired driving (Hussien & Eissa, 2016). Poor road design, maintenance, or defects can cause roadway accidents and can be termed of hazards on the road. For example, Federal Route 85 at Simpang Pulai – Kuala Berang highway, Highland roads is exposed to hazard when drivers tend to speed or at night the visibility is reduced. Cameron Highlands from Simpang Pulai in 2010, a bus lost control on the road leading to hit a divider and killing most 26 people. This indicates that there is no clear warning signboard in that area and have a high risk for accidents (Susan, 2014).

To overcome the problem road accident at the hazardous road location in Malaysia, this study using design consistency and accident prediction model to overcome this problem.

1.3 Aim and objectives

The aim of the research was to identify location with high risk by using a new method; design consistency and accident prediction model to decrease problems in identifying the hazardous road locations at Johor Federal roads.

The objective of the research is based on this;

i. To determine speed characteristics of each type of vehicle (motorcycles and cars) based on a road geometric design at FT 050 and FT 023.

ii. To determine the value of the index the integrated road design consistency (IC) of motorcycles and cars at FT 050 and FT 023.

iii. To develop an accident prediction model of potential road accident locations with, relating to accident and road design consistency at FT 050 and FT 023.
1.4 Scope of research

The scopes of this study are included; determined the location by using ranking by accident point system based on weighted adopted by the Highway Planning Unit (HPU) and ranking top highest accident based on police data. Federal Route 50 (FT 050) and Federal Route 23 (FT 023) are being studied and the selected road segments per 5km at Johor Federal roads.

By using Global Positioning System DG-200, speed data are collected through along a selected segment. The vehicle data studied is cars and motorcycles. Other data are collected from authorities; Malaysia Royal Police Department data (PDRM), Public Works Department (JKR) data and Highway Planning Unit and field study for geometry data.

The limitation of information about accident based on the road segments FT 050 and FT 023 are fatal, serious injury and slight injury. The geometric elements used access points, shoulder width, lane width, medians and lengths of road (tangent and curve).

1.5 Significance of research

A road hazard can be terminated any source of danger or near the road that could lead to accidents. For example the vehicles are merging into your lane or slippery road surface after rain. Thus, several past studies in Malaysia have conducted about the trend and factors that cause road accident, especially hazardous road locations of Johor Federal roads by using various accident analysis techniques. Some techniques have been used are black spot identification method, Empirical Bayesian Approach, Artificial Neural Networks and Genetic Algorithm Models and others. In this study, by using a new accident analysis method based on design consistency and accident prediction model in term of improving to reduce the causes of the accident at hazardous road locations. Furthermore, no further research that based on the new techniques on speed profile analysis by developed from 85th percentile speed on a rural highway in Malaysia to estimate design consistency along the road and developed accident prediction models by related the relationship between design consistency and accident probability in term of road safety. Therefore, new methods
are being studied to reduce accident statistics on existing hazardous road locations on the Federal Road.

1.6 Thesis structure

The thesis structure consists of five chapters. Chapter one represents introduction. This chapter explains the backgrounds of study to understand road accident information that occur in Malaysia, especially motorcycles and cars, and the problem, why hazardous road location can cause road accidents frequent, aim and objective, scope of the study, significant of study and the structure of the thesis.

Chapter two describes a common literature review on the meaning of the hazard, road accident, characteristic of road accidents, GPS technology and parameter developed accident prediction model. It provides information about theories, model and techniques used in this research. Chapter three explains the methodology applied for analysis. It explains the methodology to develop the models relating design consistency with safety and includes the detail how the research was conducted, the information of data and processing analysis of data.

Chapter four are details about result, analysis and discussions. This chapter represents the results obtained from the research and shows the validation and modelling results and analysis with a detailed discussion. Chapter 5 described the final conclusion about these findings and gives some recommendation based on research and future. Lastly, the references and appendix using in this study are included at the end of this thesis.
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