マレーシア地方道路の無信号T交差点での重傷事故と車両危険挙動の解析

Analysis of Fatal-Serious Accidents and Dangerous Vehicle Movements at Access Points on Malaysian Rural Roads

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

2014

Fajaruddin Bin Mustakim

ANALYSIS OF FATAL-SERIOUS ACCIDENTS AND DANGEROUS VEHICLE MOVEMENTS AT ACCESS POINTS ON MALAYSIAN RURAL ROADS

DISSERTATION

Submitted in partial satisfaction of the requirement for the degree of

DOCTOR OF ENGINEERING

By

FAJARUDDIN BIN MUSTAKIM

NAGOYA INSTITUTE OF TECHNOLOGY

DEPARTMENT OF SCIENTIFIC AND ENGINEERING SIMULATION, NAGOYA, JAPAN

2014

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

To my parents

Mustakim Bin Mohsin

and

Moltfiah Binti Masood

For the support, motivate, encourage and trust

To my beloved wife

Rosmah Binti Sarmin

For her patient and love

To my sons

Muhammad Fateh

Muhammad Abbas

Muhammad Muaz

For the cheerful and peaceful

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

HE
5614
.F37
2014
pa
7/5/10

ACKNOWLEDGEMENTS

This study was made possible mainly through the kind scholership provided by Department of Building and Construction Engineering, Faculty of Civil Environmental Engineering, Universiti Tun Hussein Onn Malaysia (UTHM) and Ministry of Higher Education of Malaysia.

My special heartfelt appreciating goes to Professor Dr. Motohiro Fujita for very close guiding me successfully through the study, as well as the production of this thesis. He was not just my supervisor but, also an intellectual mentor and guardian, who showed keen interest in both my academic progress and personal welfare. I owe a debt of gratitude, to Dr Wisinee Wisetjindawat and, for the advice and guidance.

Lastly, I wish to register my appreciation to my wife Rosmah Sarmin and the kids Fateh, Abbas and Muaz who give motivation and colorful life throughtout the PhD journey.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

ABSTRACT

Traffic accidents have been recognized as one of the major causes of human and economic losses in both developed and developing countries. In 2010, Malaysia recorded a total of 414,421 accidents, resulting in an average of 19 deaths from road accidents every single day. This research analyzed the factors relevant to fatal and serious accidents on rural federal roads in Malaysia. The objective was to identify the dangerous vehicle movements and factors posing significant risks for fatal-serious accidents at access points (non-signalized minor junctions) and to suggest countermeasures.

This research consists of seven Chapters. Firstly, Chapter 1 provides a discussion of accident trends and traffic studies in general. In Chapter 2, the scope was then narrowed down to focus on the accident black spot in order to identify the hazardous or black spot sections. Chapter 3 further examines the quantitative accident records and traffic characteristics for each of the selected sections. Next, Chapter 4 focuses on vehicle movements at non-signalized intersections. Chapter 5 provides the methodology and procedures adopted in the development of accident prediction models. Chapter 6 focuses on the development of gap acceptance model. Finally, Chapter 7 provides the development of serious conflict model.

This research carries out numerous surveys to observe various traffic movements, including right and left turns, from minor and major roads, in addition to many other characteristics, in order to construct accident analysis models. One of the findings is that right-turn motorcycles caused serious conflicts and right turn movement was considered

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

to be the most dangerous movement. Based on this finding, this research further examines the driver behavior of gap acceptance and serious conflicts using the proposed four gap patterns for a right-turn vehicle from minor to major roads at access points in Road Section 10 of the Federal Road 50 (Unchannelized intersection connected 2-lane minor and 4-lane major roads). In addition, further analysis is performed to identify the gap pattern and the factors relevant to serious conflicts. The results demonstrated that right-turning vehicles, especially motorcycles, apparently intended to start turning right in a very short gap and the approaching speed and the gap between a pair of vehicles from opposite directions in the mainstream were the critical factors causing serious conflicts to the right-turn vehicles. In addition, this research studies more on the other two non-signalized intersections located in Road Sections 2 (Channelized intersection connected 2-lane minor and 6-lane major roads) and 9 (Unchannelized intersection connected 2-lane minor and 4-lane major roads with a traffic signal in close proximity) of the Federal Road 50. The results found that the existence of channelization on the intersection encouraged the right-turn vehicle to accept a longer gap. Furthermore, the combined analysis of all the three un-signalized intersections (Road Sections 2, 9 and 10), reveals that angular serious conflict, nose-tail conflict, and if the second vehicle in the pair in the mainstream is a motorcycle or a passenger car, can significantly influence the right-turn vehicles to accept a short gap. On the other hand, a traffic light located in a relatively close distance to the access point, as well as channelization on the intersection can cause the right-turn vehicles to accept longer gaps.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

TABLE OF CONTENTS

PAGE

ACKNOWLEDGEMENT.....I
ABSTRACT.....II
TABLE OF CONTENTS.....IV
LIST OF ILLUSTRATIONS.....VIII
LIST OF TABLES.....XII
NOTATION.....XII

CHAPTER 1: INTRODUCTION

1.1 Introduction.....1
1.2 Objective of the Study.....2
1.3 Scope of the Study.....3
1.4 Structure of the Thesis.....4

CHAPTER 2: REVIEW OF PREVIOUS STUDIES

2.1 Introduction.....7
2.2 Traffic Accident in Malaysia.....8
2.3 Problem Associated with Motorcycle.....10
2.3.1 Motorcycle Fatalities by Collision with Vehicle Type.....11
2.3.2 Motorcycle Fatalities by Occupancy.....12
2.4 Review of Previous Theoretical Studies.....12
2.4.1 Accident Prediction Model.....13
2.4.2 Traffic Conflict Studies.....15
2.4.3 Gap Acceptance Movement Model.....17
2.5 Collection and Compilation of Accident Data in Malaysia.....18
2.6 Accident Computer Program System.....20
2.7 Significance of Study.....22
2.8 Summary.....23

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

CHAPTER 3: ANALYSIS OF ACCIDENT CHRACTERISTIC

3.1 Introduction.....24

3.2 Rural Roadways Situation.....25

3.2.1 Road Accident Trends.....25

3.2.2 Transition of Traffic Volume in Main Sections.....26

3.2.3 Accident by Hours of The Day.....26

3.2.4 Accident by Type of Faults.....27

3.3 Black Spot Study.....29

3.3.1 Accident Point Weighting.....29

3.3.2 Accident Map.....30

3.3.3 Accident Frequency.....31

3.3.4 Fatal and Serious Injuries.....31

3.4 Survey and Data Analysis.....32

3.4.1 Study Area.....32

3.4.2 Outline of Survey.....33

3.4.3 Collection of Data on Vehicle Movement.....35

3.4.4 Collection of Data on Approaching Speed.....37

3.4.5 Accident Data for Analysis.....37

3.4.6 Basic Data Analysis.....37

3.4.7 Type of Vehicle Involved in Accident.....38

3.4.8 Type of First Collision.....39

3.4.9 Traffic Volume by Vehicle Type.....39

3.4.10 Variation in Traffic Volumes.....40

3.5 Development of Accident Prediction Model.....43

3.5.1 Modeling Procedure.....44

3.5.2 Significance of Regression Model.....45

3.5.3 Analysis Factor for Accident.....45

3.5.4 Dependent Variables.....47

3.5.5 Independent Variables.....47

3.5.6 Correlation Coefficient and Regression Analysis.....48

3.5.7 Comparison among Models.....48

3.5.8 The Number of Access Point (AP).....51

3.5.9 Road Median (MD) and Traffic Signal (TS).....51

3.5.10 Motorcycle Lift-Turn from Minor Road (McLTi).....51

3.5.11 Motorcycle Right-Turn from Minor Road (McRTi).....52

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

3.5.12 Comparison among Models.....53
3.6 Summary.....53

CHAPTER 4: ANALYSIS ON RIGHT-TURN VEHICLES CONSIDERING GAP ACCEPTANCE AND SERIOUS CONFLICT

4.1 Introduction.....55
4.2 Data Collection.....55
4.3 Vehicle Movement and Gap Definitions.....56
4.4 Types of Serious Conflicts.....58
4.5 Other Variables.....59
4.6 Basic Analysis on Gap Acceptance and Serious Conflict.....59
4.7 Estimation Method for Critical Gaps.....61
4.7.1 Raff's Method for Estimating Critical Gap.....61
4.7.2 The Method of Maximum Likelihood.....62
4.7.3 Basic Analysis of Critical Gaps.....63
4.8 Gap Acceptance Movement Model.....64
4.8.1 Development of Models.....65
4.9 Critical Gap Analysis for RTVs Considering Serious Conflicts.....68
4.10 Serious Conflict Models.....70
4.11 Summary.....73

CHAPTER 5: ANALYSIS ON RIGHT-TURNING VEHICLES CONSIDERING GAP ACCEPTANCE AND SERIOUS CONFLICT (ROAD SECTION 9 AND SECTION 2)

5.1 Introduction.....75
5.2 Data Collection.....75
5.3 Vehicle Movement and Gap Definitions.....76
5.4 Types of Serious Conflicts.....79
5.5 Other Variables.....81
5.6 Basic Analysis on Gap Acceptance and Serious Conflict.....81
5.7 Estimation Method for Critical Gaps.....83
5.7.1 Basic Analysis of Critical Gaps.....83
5.8 Gap Acceptance for Section 9.....86

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

5.9 Gap Acceptance Model for Section 2.....87
5.10 Critical Gap Analysis for RTVs.....88
5.11 Summary.....89

CHAPTER 6: ANALYSIS ON RIGHT-TURN VEHICLES CONSIDERING GAP ACCEPTANCE AND SERIOUS CONFLICT FOR COMBINED SECTION

6.1 Introduction.....91
6.2 Data Collection.....91
6.2.1 Data Reduction.....92
6.3 Vehicle Movement and Gap Definitions.....93
6.4 Type of Gap Acceptance Pattern Analysis.....94
6.5 Types of Serious Conflicts.....96
6.6 Basic Analysis on Gap Acceptance and Serious Conflict.....97
6.7 Basic Analysis of Critical Gap.....100
6.7.1 Analysis of Critical Gap using the Raff Method.....100
6.8 Gap Acceptance Model for Section 9 and 10.....103
6.9 Gap Acceptance Model for Section 2, 9 and 10.....104
6.10 Critical Gap Analysis for RTVs Considering Serious Conflicts.....107
6.11 Summary.....108

CHAPTER 7: DISCUSSION AND CONCLUSION

7.1 Accident Prediction Model.....110
7.2 Gap Acceptance Model.....111
7.3 Serious Conflict Model.....112
7.4 Summary.....113

REFERENCES.....115

APPENDIX A.....120

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF ILLUSTRATIONS

Figure	Title	Page
Figure 1.0	Research methodology flow	6
Figure 2.0	Total Motor Vehicles by Types	8
Figure 2.1	Number of vehicle accident in Malaysia (2000-2009)	9
Figure 2.2	Fatality distribution by mode of transport	9
Figure 2.3	Motorcycle accident by land use type (2005-2010)	11
Figure 2.4	Motorcycle fatalities by collision with vehicle type	12
Figure 2.5	Traffic safety and relationship between errors, standard behavior, traffic conflicts and accident	17
Figure 2.6	Malaysia Accident Data Collection	20
Figure 2.7	Data input and processing framework	22
Figure 3.1	Federal Route F050	24
Figure 3.2	Location of Federal Route 50 (Batu Pahat- Ayer Hitam)	25
Figure 3.3	Accidents and casualties on rural roadways	26
Figure 3.4	Transitions of traffic volume (2005-2010) in each section	26
Figure 3.5	Accidents by hour of the day (2006-2010)	27
Figure 3.6	Accident data by type of fault (2003-2007)	28
Figure 3.7	Right-turn conflict	28
Figure 3.7a	Accident at junction	28
Figure 3.8	Nose to tail conflict	28
Figure 3.8a	Nose to tail conflict	28
Figure 3.9	Accident Black Spot Map on F050	31
Figure 3.10	Accident Frequency at rural roadway over 5 year period (2006-2010)	32

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

Figure 3.11	Fatal and serious injuries for type of vehicle at rural roadway (2008:2010).....	33
Figure 3.12	Study section locations for model development.....	34
Figure 3.13	The traffic flow at a junction.....	36
Figure 3.14	Distribution of speed at section 10.....	38
Figure 3.15	The number of accidents by type at the study location (2006-2010) during the 12 hours.....	39
Figure 3.16	Type of vehicle involved in accidents over 5-year period (2005-2009).....	39
Figure 3.17	Total Numbers of Casualties By Type of First Collision (2006-2010).....	40
Figure 3.18	Traffic volume by vehicle type at 11 sections for 6-hour survey Period.....	41
Figure 3.19	The hourly variation in traffic volumes on a weekday.....	42
Figure 3.20	Temporal traffic fluctuation in traffic volume at section 5.....	44
Figure 3.21	Flowchart for the development accident models.....	45
Figure 3.22	Right-turn conflicts at road section 2.....	53
Figure 4.1	Type of gaps accepted or rejected by vehicle right-turn section 10 un-signalized T-junction.....	58
Figure 4.2	Type of gap frequency in section 10 T-Junction.....	59
Figure 4.3	Type of serious conflicts at an un-signalizedT-Junction.....	59
Figure 4.4	Two types of serious conflicts: angular and nose to tail.....	60
Figure 4.5	Frequency of accepted gap for RTV motorcycles with serious conflicts at the section 10 junction.....	61
Figure 4.6	The percentage by vehicle type for RTVs at section 10.....	62
Figure 4.7	Cumulative distributions of accepted or rejected gaps versus the gap at the junction in road section 10.....	64

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

Figure 5.1	Type of gaps accepted or rejected by vehicles turning right at the Road Section 9 non-signalized T-junction……..……..…..77
Figure 5.2	Types of gaps accepted or rejected by vehicles turning right at Road Section 2 non-signalized T-junction……..……...78
Figure 5.3	Types of gap frequencies in Road Section 9……..……78
Figure 5.4	Types of gap frequencies in Road Section 2……..……..79
Figure 5.5	Type of serious conflicts at a non-signalized T-Junction… ……..…80
Figure 5.6	Serious nose to tail conflicts at Road Section 9 non-signalized T-junction……80
Figure 5.7	Accepted gap frequency by vehicle type of RTV with serious conflicts at Road Section 9 junction……..……81
Figure 5.8	The percentage of RTVs by vehicle type at Road Section 9……..…82
Figure 5.9	Accepted gap frequency by vehicle type of RTV at section 2 junction……82
Figure 5.10	The proportions by vehicle type of RTV at Road Section 2.....……83
Figure 5.11	Cumulative distributions of accepted or rejected gaps versus gap at the junction in Road Section 9……84
Figure 5.12	Cumulative distributions of accepted or rejected gaps versus gap at the junction in Road Section 2……..……84
Figure 6.1	Type of gap frequency at Road Section 9 and 10 junctions… ……...93
Figure 6.2	Type of gap frequency at Road Section 2, 9 and 10 junctions.....……94
Figure 6.3	Type of gap pattern at the Road Section 2 junction……94
Figure 6.4	Type of gap pattern at the Road Section 9 junction……95
Figure 6.5	Type of gap pattern at the Road Section 10 junction……..……95
Figure 6.6	Type of serious conflicts at a non-signalized T-Junction. ……96
Figure 6.7	Accepted gap frequency by vehicle type of RTV with serious conflicts at Road Section 9 and 10 junctions ……..……97

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

Figure 6.8 Percentage of RTVs by vehicle type at the Road Section 9 and 10 junctions.....97

Figure 6.9 Accepted gap frequency by vehicle type of RTV with serious conflicts at Road Section 2, 9 and 10 junctions 98

Figure 6.10 Percentage of RTVs by vehicle type at the Road Section 2, 9 and 10 junctions.....98

Figure 6.11 Accepted gap frequency for right-turning motorcycles (single rider) involved in serious conflicts at Road Section 10 and 9 junctions.....99

Figure 6.12 Accepted gap frequency for right-turning motorcycles with a passenger involved in serious conflicts at Road Section 10 and 9 junctions.....100

Figure 6.13 Cumulative distributions of accepted or rejected gaps versus gap at the Road Section 10 and 9 junctions.....101

Figure 6.14 Cumulative distributions of accepted or rejected gaps versus gap at the Road Section 10, 9 and 9 junctions.....101

Figure 7.1 Gap pattern analysis for intersections in all sections.....113

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF TABLES

Figure	Title	Page
Table 2.1	Motorcycle fatalities by motorcycle occupancy	12
Table 3.1	Ranking accident point weighting on rural roadway over a 5 years period (2006- to 2010)	29
Table 3.2	Descriptions of each road section	35
Table 3.3	Traffic movements in and out from a minor and major road at Road Section 10	36
Table 3.4	Peak hour survey	42
Table 3.5	Descriptions of variables	46
Table 3.6	Correlation coefficient	49
Table 3.7	Result of accident factor estimation model	50
Table 4.1	Traffic movement at Road Section 10	56
Table 4.2	Description of variables for gap acceptance model	66
Table 4.3	Gap acceptance models for RTVs	67
Table 4.4	Comparison of the critical gaps	70
Table 4.5	Serious conflict models	71
Table 5.1	Traffic movement at the Road Section 9 intersection	76
Table 5.2	Traffic movement at the Road Section 9 intersection	76
Table 5.3	Description of variables for gap acceptance models	85
Table 5.4	Gap acceptance models for RTVs- Road Section 9	86
Table 5.5	Gap acceptance models for RTVs- Road Section 2	87
Table 5.6	Comparison of the critical gaps	89
Table 6.1	Traffic Movement at the Road Section 10	92
Table 6.2	Traffic Movement at the Road Section 9	92

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

Table 6.3 Traffic Movement at the Road Section 2.....92

Table 6.8 Gap acceptance models for RTVs (section 10 and 9).....102

Table 6.8 Gap acceptance models for RTVs (section 10, 9 and 2).....104

Table 6.9 Comparison of the critical gaps.....106

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

NOTATION

The basic structure of this study and designations of its sections are numbered separately in each chapter. For example, (5.5) designates the fifth equation of chapter 5; Figure 1.2 designates the second figure of chapter 1; and table 2.1 designates the first table of chapter 2.

The number and year of publication of the reference and equation are given in common parenthesis ( ).

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

CHAPTER 1

INTRODUCTION

1.1 Introduction

Approximately 1.3 million people die each year on the world`s roads and between 20 and 50 million people sustain non-fatal injuries. According to the World Health Organization (2009) in 2004, deaths due to road accidents was the ninth cause of deaths worldwide and in the year 2030 it is predicted to be the fifth leading cause of deaths worldwide. The Global Status Report (WHO 2009) on road safety carried out a broad survey road in 178 countries which revealed that road traffic injuries are on the most significant public health problems, especially for developing and undeveloped countries. Motorcyclists, pedestrians and cyclists appear to be most likely killed on the roads. More attention needs to be given to these road users in road safety program (WHO 2009).

Growth in urbanization and in the number of vehicles in many developing countries has led to the increase in traffic accidents on road networks which were never designed for the volumes and types of traffic which they are now required to carry. In addition, unplanned urban growth has led to incompatible land uses, which has resulted in high levels of pedestrian/vehicle conflict. The drift from rural areas to urban centre often results in large numbers of new urban residents who are unused to such high traffic levels.

As a result, there has often been a severe deterioration in driving conditions and a significant increase in hazards and competition between different classes of road users of the road system. In addition, the inherent dangers have often become worse by poor road maintenance, badly designed intersections and inadequate provision for pedestrians. All of these have contributed to serious road safety problems now commonly found in developing countries.

To many road projects could be the reason why road agencies responsible for the maintenance of the road network cannot keep pace with road construction. The result is that roads are often badly in need of maintenance, traffic signage is often inadequate, facilities for pedestrians are poor and guidance to drivers via channelization or other control measures is rarely available. These general deficiencies in the operational and control aspects of the road systems are worsened by the fact that drivers are rarely adequately trained and tested, traffic law enforcement is ineffective and driver behavior in respect of compliance with the road rules is frequently very poor. The net result of these inadequacies is the very high incidence of road accidents involving casualties and fatalities.

Gradual elimination of the most hazardous locations on the road networks and the adoption of safety conscious approaches to the design and planning of new road networks have contributed greatly towards improving traffic safety. Even though the eventual solutions may differ, the approaches and systematic methods used in industrialized countries to improve road safety are readily applicable to the developing world.

1.2 Objective of the Study

In light of the above, the main aim of this study is to identify the dangerous vehicle movements and factors which significantly contribute to road accidents causing serious injuries and fatalities at access points (non-signalized minor junctions) and to suggest countermeasures. To accomplish this, the following objectives were set:

1. To identify accident trends and severe accident spots (black spots) on the Malaysia rural Federal Road 50.
2. To collect data for all traffic volumes, movements (including right and left turnings, from minor and major roads, and by type of vehicles), approaching speeds, gaps (headway) and road geometry.

3. To identify the dangerous vehicle movements and factors posing significant risks for fatal-serious accidents at access points (non-signalized minor junctions) and to suggest countermeasures.
4. To carrying out an in-depth analysis of the behaviors on gap acceptance and serious conflict as the dangerous movements at access points (non-signalized T-junction) in order to clarify the factors causing fatal and serious accidents.
5. To identify gap pattern for right turning vehicles from minor road to major road at non-signalized junctions on Malaysia rural Federal Road 50.
6. To develop serious conflict models by using logistic regression in order to identify the critical gap patterns and factors relating to serious conflict at the non ~~no~~-signalized intersection.

1.3 Scope of Study

The scope of the project cover stretches from KM1- KM38 Batu Pahat –Ayer Hitam and investigates accident trends and identifies black spots. The accident record data used in the study was collected over a 10 years period from 2000 to 2010 from the District Police Traffic. The study also used an accident database on selected road sections from 2006 to 2010 for accident analysis. An appropriate statistical analytical tool was required to identify the hazardous location that caused the accidents, thus enabling the recommendation of improvements at selected sites to reduce the accident rate. The study developed an accident prediction model that included eleven sections of road: Section 2, 5, 8, 9, and 10 of the Batu Pahat area and Road Section 19, 20, 21, 22, 23 and 24 of the Parit Raja area. The study concentrated on Road Section 10, 9 and 2 of Batu Pahat area for the purpose of carrying out an in-depth analysis of the behaviors on gap acceptance and serious conflicts, as the dangerous vehicle movements at access points in order to clarify factors causing fatal and serious injury accidents. Furthermore, this study purposed four gap patterns for right turning vehicles from minor road to major road and established the fatal and serious conflict model by using the technique of logistic regression.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

1.4 Structure of the Thesis

The rest of the thesis is organized, as follows;

This research is presented in seven major chapters. The **first chapter**, we discuss the objective and scope of the study.

The **second chapter** presents a review of the literature on accidents on rural roads and problems causing accidents in undeveloped and developing countries. The chapter also includes a compilation of accident data in Malaysia and highlights the significance of the study.

In **Chapter three**, the main characteristics of accident and traffic studies at non-signalized intersections on Malaysian rural Federal roads are identified. This is done in five steps. First, the subject is put into perspective through a discussion of accident trends and traffic studies in general. The scope is then narrowed down to focus on accident black spot studies to identify the hazardous or black spot sections. The third step focus on quantitative accident records and the traffic characteristics of each selected section. The next step focuses on vehicle movements at non-signalized intersections. Finally the methodology and procedures adopted for the development of accident prediction models are presented and the different developed models are discussed. In this chapter, we analyze the accident factors relevant to fatal and serious accidents and investigate the accident point weighting using a correlation coefficient and regression technique.

Chapter four, analyzes the factors affecting to fatal and serious traffic accidents on the Malaysia rural Federal Road 50, with respect to access points and various vehicle movements. Base on the result of the previous chapter, we carried out an in-depth analysis of dangerous vehicle movements, gap acceptances and serious conflicts with ~~of~~ right-turning vehicles (including motorcycles and passenger cars) from minor roads, to ascertain their importance contributing to fatal and serious accidents. This chapter also presents the methodology and procedures adopted for developing a ~~of~~

gap acceptance movement model and established the serious conflict models for section 10 intersection.

Chapter five concentrates on the two non-signalized access points located in sections 2 and 9 of the Batu Pahat area. The development of gap acceptance models and the analysis of right-turning vehicles for these sections were similar to that for section 10–in chapter four except the fatal and serious conflict model. Four gap patterns were proposed at access point (non-signalized minor junctions) in Road Section 9. Meanwhile five gap pattern were introduced at access point in Road Section 2.

Chapter six, deal with three access point in Road Sections, namely (2, 9 and 10). Several gap acceptance models have been developed involving two types of combined Section – the first combination is Road Section 10 and 9; and, the second combination is Road Section 2, 9 and 10. The gap pattern analysis has been carried out for each Road Section.

Finally, **chapter seven** presents the main findings of this study and the recommendations for further research. The methodology applied to achieve the objectives of this study is shown in the flow chart in Figure 1.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

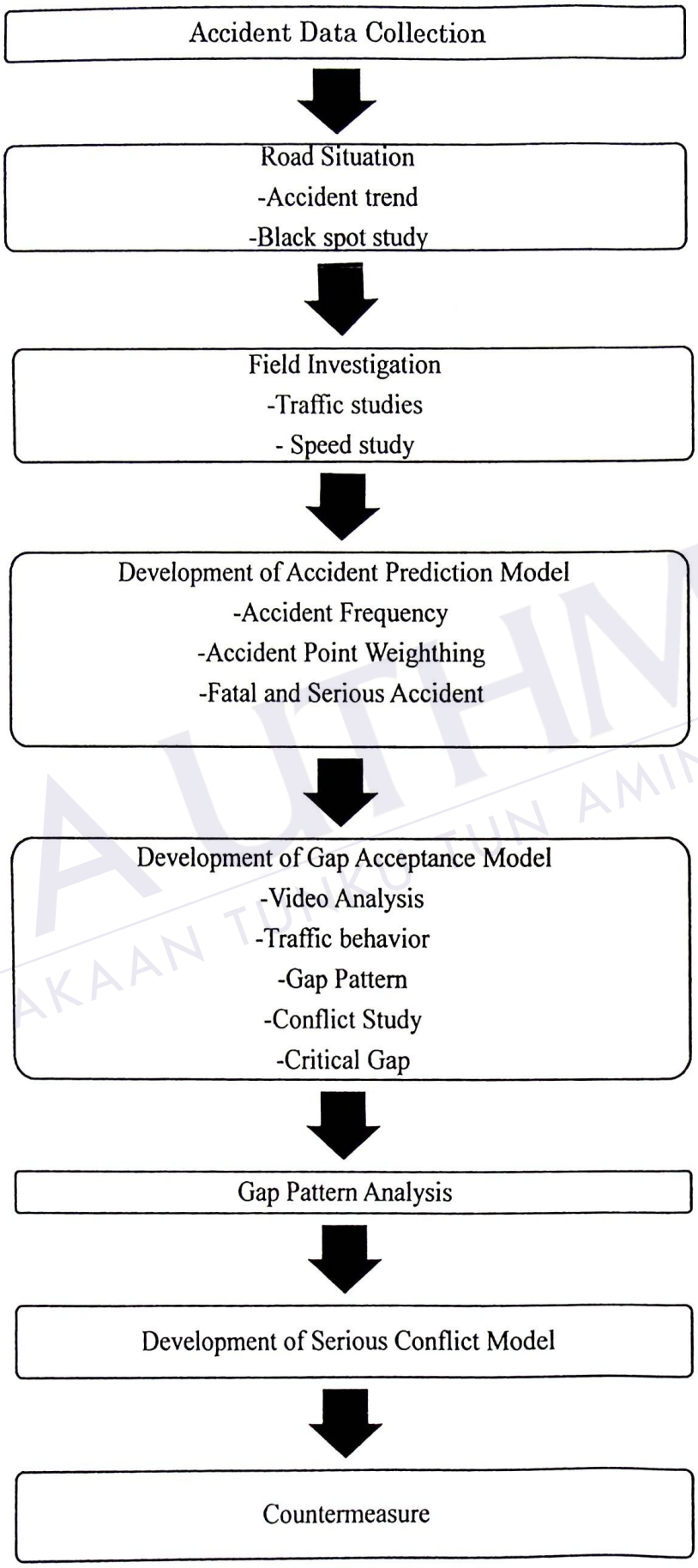

Figure 1: Research methodology flow

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

CHAPTER 2

REVIEW OF PREVIOUS STUDIES

2.1 Introduction

As the road networks in developing countries are at an early stage of development, engineers in those settings have the opportunity to draw upon the experience of developed countries where road networks have already passed through similar stages (although less rapidly than is being currently experienced in developing countries). The adoption of proven strategies from industrialized countries (such as accident black spot elimination and safety conscious design and planning of road networks) offers unparalleled opportunities to make significant and lasting improvements to road safety. Many developing countries continue to repeat mistakes made by numerous industrialized countries, such as still permitting linear development with direct access from frontage properties along major roads, even though this is known to lead to road safety problems.

One factor that all industrialized countries have found to be of crucial importance in their effort to improve road safety is the availability of accurate and comprehensive accident data, so that the problems can be properly defined and suitable remedial measures can be devised. Consequently, before developing countries can emulate industrialized countries, it is essential that comprehensive accident data systems be established.

In order to maximize the impact of engineering on safety problems, it is necessary to apply measures at various stages throughout the development of road networks. By incorporating good design principles from the start, it is possible to avoid many problems simply by planning and designing new roads in a safety conscious manner. Even where this has not been done, it may still be possible (although more expensive) to improve existing roads by the subsequent introduction of safety or

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

References

1) *Global status report on road safety: time for action.* Geneva, World Health Organization, 2009.

2) Ross Silcock Partnership (1991);"Towards Safer Road in Developing Countries", A guide for Planner and Engineers, TRRL, First Edition.

3) Radin Umar, R. S., Chai, W.L, Hussain, H. and Law, T.H.: Modeling of Traffic Accidents Along Major Trunk Roads in Malaysia, *Journal-Institution of Engineers, Malaysia*, Vol.62, No.3, 2001.

4) Harnen, S., Wong, S.V., Radin Umar R.S. and Wan Hashim, W.I.: Motorcycle Crash Prediction Model for Non-Signalized Intersections, *IATSS Research*, Vol. 27, No.2, pp. 58-65, 2003.

5) Donaldson, A.E., Cook, L.J., Hutchings, C.B. and Dean, J.M.: Crossing county line: The Impact of Crash Location and Driver's Residence on Motor Vehicle Crash Fatality, *Accident Analysis and Prevention,* Vol. 38, pp. 723-727, 2006.

6) Hadi, M.A., Aruldhas, J., Chow, L.F. and Wattleworth, J.A.: Estimating Safety Effects of Cross-Section Design for Various Highway Types Using Negative Binomial Regression, *Transportation Research Record 1500,* pp. 169–177, 1995.

7) Karlatis, M.G. and Golias, I.: Effects of road geometry and traffic volumes on rural roadway accident rates, *Accident Analysis and Prevention 34,* pp. 357-365, 2002.

8) Ye, X., Pendyala, R. M, Washington, S.P., Konduri, K. and Oh, J.: A simultaneous equations model of crash frequency by collision type for rural intersections, *Safety Science,* Vol. 47, pp. 443-452, 2009.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

9) Haleem, K. and Abdel-Aty, M: Examining traffic crash injury severity at unsignalized intersections. *Journal of Safety Research,* Vol. 41, pp. 347-357, 2010.

10) Kim, D.G. and Washington, S.: The significance of endogeneity problems in crash models: An examination of left-turn lanes in intersection crash models, *Accident Analysis and Prevention,* Vol. 38, pp. 1094-1100, 2006.

11) Wedagama, D.M.P and Dissanayake, D.: The Influence of Accident Related Factors on Road Fatalities Considering Bali Province in Indonesia as a Case Study, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 8, pp. 1905-1917, 2010.

12) Hagiwara, T., Kagaya, S., Hirasawa, M., Imoto, T. and Takemoto, A.: Estimation of Various Factors on Number of Fatal and Injured Accident in Japan using Past 25 years, *Journal of the Eastern Asia Society for Transportation Studies*, Vol . 8, pp. 1974-1985, 2010.

13) Patwary, M.A.H., Fujiwara, A. and Zhang, J.: A Joint Model of Injury Severity and Collision Type for Examining Influential Factors of Traffic Accidents Occurring at Intersection of National Highways in Japan, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 8, pp. 1838-1853, 2010.

14) Tuan, V.A. and Shimizu, T.: An analysis of the interactions between vehicle groups at intersections under mixed traffic flow conditions, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 8, 2009.

15) Jenjiwattanakul, T. and Sano K: Effect of waiting time on the gap acceptance behavior of U-turning vehicle at midblock median openings, *Journal of the Eastern Asia Society for Transportation Studies,* Vol. 9, pp. 1601-1613, 2011.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

16) Devarasetty, P.D., Zhang, Y. and Fitzpatrick, K.: Differentiating between Left-Turn Gap and Lag Acceptance at Unsignalized Intersections as a Function of the Site Characteristics, *Journal of Transportation Engineering ©ASCE,* Vol.138, No.5, May, *2012.*

17) Hamed, M.M., Easa, S.M. and Batayneh, R.R.: Disaggregate Gap-Acceptance Model For Unsignalized T-Intersections, *Journal of Transportation Engineering ©ASCE,* Vol.123, No.1, January/February, 1997.

18) Gattis J.L, Sonny T.Low, Gap Acceptance at Typical Stop-Controlled Intersections. *Journal of Transportation Engineering ©ASCE Vol.125, No.3, May/Jun, 1999.*

19) Pollatschek, M.A., Polus, A. and Livneh, M.: A Decision Model for Gap Acceptance and Capacity at Intersections, *Transportation Research Part B,* Vol.36, pp. 649-663, 2002.

20) Mahmassani, H. and Sheffi, Y.: Using Gap Sequences To Estimate Gap Acceptance Functions, *Transp. Res. Part B,15(3), pp. 143-148,1981.*

21) Douglas, W.H., Mason, J.M. and Brydia, R.E.: Design policies for sight distance at stop-controlled intersections based on gap acceptance, *Transportation Research Part A,* Vol. 33, pp. 199-216, 1999.

22) Madanat, S.M., Cassidy, M.J. and Wang, M.H.: Probabilistic Delay Model at Stop-Controlled Intersection, *Journal of Transportation Engineering ©ASCE,* Vol.120, No.1, Jan/Feb, 1994.

23) Raff, M.S. and Hart, J.W.: *A* Volume Warrant for Stop Signs. Eno Foundation for Highway Traffic Control, Saugatuck, Connecticut, 1950.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

24) Jabatan Kerja Raya (JKR), Arahan teknik jalan no. 11/87: *A guide on Geometric Design of Road, Ministry of Work Malaysia, Kuala Lumpur,* 1987.

25) Transportation Research Board: *Highway capacity Manual 2000,* Special Report 209, Washington, 2000.

26) Glauz, W.D., Bauer, K.M. and Migletz, D.J (1985): Expected Traffic Conflict Rates and Road Accident in Developing Countries. *TRL Report 247, pp29.*

27) Malaterre. G. and Muhlrad , N. (1980): Conflicts and Accidents as Tools for a Safety Diagnosis, Proceeding of 2nd *Internatonal Traffic Conflict Tecqnique Workshop, TRRL Supplementary Report 557, pp43-63.*

28) Perkins, S.R and Harris, J.I. (1968): Traffic Conflict Characteristics – Accident Potential at Intersections. Highway Research Record 225, HRB, *National Research Council, Washington D.C., pp35-43*

29) J.F. Silva, A comparative study of road traffic accidents in West Malaysia, Annals of the Royal College of Surgeons of England 60 (1978).

30) Troutbeck, R.J: Estimating the Critical Gap from Traffic Movements`, *Physical Infrastructure Center Research Report* 92-5(1992).

31) Miller, A. J., Pretty, R. L., 1968. Overtaking on two-lane rural roads. Proc. Aust. Rd. Res. Board 4(1), 582±591

32) Miller, A. J., 1972. Nine estimators for gap-acceptance parameters. In: Newell, G. (Ed.), Proceedings of the International Symposium on the Theory of Traffic Flow and Transportation. Berkeley, California June, 1971. Elsevier Amsterdam.

33) Hair, J. F., Anderson, R.E., Tatham, R.L., and Black, W. (1995). Multivariate data analyses with readings, 4th Ed., Prentice-Hall, Englewood Cliffs, N.J.

PTTA UTHM PERPUSTAKAAN TUNKU TUN AMINAH

34) Hauer, E.: Identification of sites with promise, Transportation Research Record, 30, 54-60 (1996).

35) The Bureau of transport and Regional Economic of Australia BTRE (2001) Logistics in Australia: A Preliminary Analysis. Bureau of Transport and Regional Economics, Canberra.

PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH