

EFFECT OF VARIOUS TYPES OF TRAFFIC SIGNAL ON RED LIGHT
RUNNING

MELANI BINTI HASIM

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Engineering (Civil – Transportation and Highway)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

NOVEMBER 2009

To my beloved mother and father

ACKNOWLEDGEMENT

First and foremost, I would like to express my sincere thanks and appreciation to my supervisor, Assoc. Prof. Dr. Othman Che Puan, for all his kind patience, encouragement, guidance, critics and friendship. Without his continued support and interest, this thesis would not have been the same as presented here.

My fellow postgraduate students should also be recognized for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family members.

ABSTRACT

Traffic signal assigns the right-of-way to various conflicting traffic movements at an intersection. However, when a driver's approaches a signalized intersection at the onset of amber, he/she is forced to make decisions about whether to pass or stop during a very short time period. This can be a difficult decision when the vehicle is located within the dilemma zone. It may result in a rear-end crash due to a sudden stop or red-light violation due to insufficient time to stop safely. In the present study six intersections, two with countdown timer, two with no-countdown timer and two with vehicle actuated system were analyzed to study the effect of various traffic signal systems on red light violation. The data of off-peak hour traffic was collected to minimize the influence of congestion on driver's behavior by using video-recording technique. The data collected are those pertaining to the analysis of vehicles' approaching speed distance from the stop line, the decision made by driver (i.e. stop abruptly, accelerate through amber and run red light) at onset amber as well as the types of vehicles driven. The finding of the study indicates that relatively large proportion of drivers did not willing to stop at onset of amber signal. The study suggests that a vehicle-actuated traffic signal system has resulted a higher rate of red-light violation with 55.56 percent compared to the others types of signal system studied. However, more data are required to validate this finding.

ABSTRAK

Lampu isyarat menentukan hak jalan kepada pelbagai konflik pergerakan lalu lintas di persimpangan jalan. Akan tetapi, apabila pemandu menuju hampir ke persimpangan lampu isyarat pada masa kuning, mereka terpaksa membuat keputusan sama ada meneruskan perjalanan atau berhenti dalam jangka masa yang singkat. Ini merupakan keputusan yang sukar dibuat kerana pemandu berada dalam situasi dilemma. Ini akan mengakibatkan berlakunya pelanggaran/kemalangan disebabkan pemandu berhenti mendadak atau melanggar lampu merah kerana tempoh masa untuk berhenti dengan selamat tidak mencukupi. Kajian dijalankan pada enam persimpangan berlampu isyarat; dua sistem lampu isyarat dengan penunjuk tempoh, dua lampu isyarat tanpa penunjuk tempoh, dan dua lampu isyarat berdasarkan pengawalan penggerak kenderaan, dianalisa untuk mengkaji kesan pelbagai sistem lampu isyarat terhadap pelanggaran lampu merah. Cerapan data dilakukan pada masa aliran tidak tepu untuk mengurangkan kesan kesesakan lalulintas terhadap kelakuan pemandu dengan menggunakan teknik rakaman video. Data yang diceraap adalah berkaitan dengan had laju pemandu, jarak daripada garisan berhenti, keputusan yang dibuat oleh pemandu pada masa kuning (berhenti mendadak, melajukan kenderaan dan melanggar lampu merah) dan jenis kenderaan. Kajian telah mendapati bahawa sebahagian besar pemandu tidak berhenti pada masa kuning. Kajian juga menyatakan bahawa system lampu isyarat pengawalan penggerak kenderaan menunjukkan kadar yang tertinggi dalam kes melanggar lampu merah dengan mencatat 55.56 peratus berbanding dengan sistem lampu isyarat lain yang dikaji. Namun demikian, lebih banyak data diperlukan bagi mengesahkan hasil kajian ini.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF APPENDICES	xiii
	LIST OF ABBREVIATIONS	xiv
I	INTRODUCTION	1
	1.1 Background	1
	1.2 Research Problem	3
	1.3 Aim and Objective	4
	1.4 Scope and Limitation	4
II	LITERATURE REVIEW	5
	2.1 Introduction	5
	2.2 Traffic Signal System	6
	2.2.1 Fixed-time System	6
	2.2.2 Vehicle Actuated Signal System	8

2.3	Red Light Running	10
2.3.1	Factor Contribute Red Light Running	11
2.3.1.1	Intersections Characteristic	11
2.3.1.2	Human Factors	15
2.3.1.3	Vehicle Characteristics	18
2.3.1.4	Weather	18
2.4	Dilemma Zone	19
2.4.1	Driver's Dilemma	21
2.4.2	Factors Influencing Driver's Decision	22
2.4.3	Dilemma and Option Zone	23
2.5	Yellow Signal Timing	27
2.5.1	Driver's Response to Yellow Indication	28
2.5.2	Impact of Yellow Duration	29
2.6	Summary	31
III	METHODOLOGY	32
3.1	Introduction	32
3.2	Evaluation Parameters	34
3.3	Speed Data Collection	34
3.3.1	Stopwatch Method	37
3.3.2	Radar Meter Method	38
3.3.3	Pneumatic Road Tube Method	39
3.4	Case Study Site Location	41
3.5	Data Collection Method	44
3.5.1	Data Reduction	45
3.5.2	Chi Square (χ^2) Test	45
3.5.3	Sample Size	46
3.6	Equipment	47
3.7	Summary	49
IV	RESULT AND DISCUSSION	49
4.1	Introduction	49
4.2	Data Analysis	49

4.2.1	Sample Data Analysis	51
4.3	Evaluation of Existing Installed System	55
4.3.1	Yellow Interval	55
4.3.2	Operation Speed	56
4.4	Effect of Dilemma Zones on Red Light Running	56
4.4.1	Dilemma and Option Zones	57
4.4.2	Red-Light Running Rate	60
4.5	Effect of Various Type Traffic Signal System on Red-Light Running	61
4.6	Performance of Traffic Signal System Installed	64
V	CONCLUSION	66
5.1	Introduction	66
5.2	Findings	66
5.3	Problem Faced During Study	68
5.4	Recommendation for Future Research	68
5.5	Conclusion	69
	REFERENCES	70
	Appendices A - F	77 - 120

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Red Light Entries	30
3.1	General characteristic of the intersections studied	41
4.1	Weighted average based on traffic composition	51
4.2	Number of vehicles observed	52
4.3	General characteristics of the intersection studied	55
4.4	Descriptive statistic of operation speed	56
4.5	Stopping distance, X_o and clearing distance, X_c at each intersection	59
4.6	Frequency of DZ conflicts at each intersection	62
4.7	Tabulation of χ^2 comparisons between sites	64

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Traffic signal with countdown system	7
2.2	Vehicle approaching signalized intersection at the onset of yellow	10
2.3	Probability of stopping as a function of travel time and control type	13
2.4	Illustration of Dilemma Zone	20
2.5	Dilemma Zone	21
2.6	Formation of a Dilemma Zone	23
2.7	Formation of an Option Zone	25
3.1	Simplified methodology for this study	33
3.2	Stopwatch spot speed study layout	37
3.3	Radar Meter	38
3.4	Example Radar Meter spot speed study layout	39
3.5	Pneumatic Road Tubes	40
3.6	Road tubes and recorder	40
3.7	Site of data collection and case study (Site 1)	42
3.8	Site of data collection and case study (Site 2)	42
3.9	Site of data collection and case study (Site 3)	42

3.10	Site of data collection and case study (Site 4)	43
3.11	Site of data collection and case study (Site 5)	43
3.12	Site of data collection and case study (Site 6)	43
3.13	Illustration of setting up field reference points and digital camera	44
3.14	Equipment used during data collection	49
4.1	Vehicle composition at an onset amber period	50
4.2	The percentage driver's decision at an onset amber	51
4.3	Persimpangan Seri Melaka Road (Site 1)	53
4.4	Johor Jaya Road (Site 2)	53
4.5	Tebrau Road (Site 3)	53
4.6	Tun Aminah Road – Dato' Sulaiman (Site 4)	54
4.7	Gelang Patah Road (Site 5)	54
4.8	Pendidikan Road, Taman Universiti (Site 6)	54
4.9	Critical Distance (X_C) and Stopping Distance (X_0) at Site 3	58
4.10	Critical Distance (X_C) and Stopping Distance (X_0) at Site 1	58
4.11	Critical Distance (X_C) and Stopping Distance (X_0) at Site 4	58
4.12	Critical Distance (X_C) and Stopping Distance (X_0) at Site 5	59
4.13	Critical Distance (X_C) and Stopping Distance (X_0) at Site 6	59
4.14	Critical Distance (X_C) and Stopping Distance (X_0) at Site 2	59
4.15	Frequency of DZ conflicts based on types of traffic signal installed	61

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Data Collection in Persimpangan Seri Melaka Road (Site 1)	77
B	Data Collection in Johor Jaya Road (Site 2)	83
C	Data Collection in Tebrau Road (Site 3)	89
D	Data Collection in Tun Aminah Road – Dato’ Sulaiman (Site 4)	103
E	Data Collection in Gelang Patah Road (Site 5)	111
F	Data Collection in Pendidikan Road, Taman Universiti (Site 6)	116

LIST OF ABBREVIATIONS

AASTHO	American Association of State Highway and Transportation Officials American
DZ	Dilemma Zone
CDS	Crashworthiness Data System
CD	Compact Disk
FHWA	Federal Highway Administration
GHM	Gazis, Herman and Maradudin
ITE	Institute of Transportation Engineer
JKR	Jabatan Kerja Raya
km/h	Kilometer per hour
m	Metre
m/s	Metre per second
NHTSA	National Highway Traffic Safety Administration
PRT	Perception Reaction Time
RRL	Run Red Light
s	Second
UFOV	Useful Field Of View
X ₀	Stopping Distance
X _C	Critical Distance
χ^2	Chi Square

CHAPTER I

INTRODUCTION

1.4 Background

Traffic signals are intended to promote safe and efficient traffic flow at busy intersections. However, the level of safety achieved is largely dependent on drivers' compliance with the signals. Research shows that many drivers routinely violate red signals, placing themselves and other road users at risk for serious collisions. A study conducted during several months at five busy intersection approaches in Fairfax City, Virginia, found that violation rates averaged 3 per intersection per hour (Retting et al., 1999). During peak travel times, red light running was more frequent.

Crashes resulting from red light running are a frequent occurrence. A nationwide study of 9,951 vehicles involved in fatal crashes at traffic signals in 1999 and 2000 estimated that 20 percent of the vehicles failed to obey the signals (Brittany et al., 2004). In 2005, more than 800 people were killed and an estimated 165,000 were injured in crashes that involved red light running (Insurance Institute for Highway Safety, 2006). About half of the deaths in these crashes were pedestrians and occupants in other vehicles who were hit by the red light runners.

Red-light running is a complex problem. There is no simple or single reason to explain why drivers run red lights. There is a tendency to cite driver error—either intentional or unintentional disregard of the traffic signal. Some drivers indecently enter an intersection after onset of a red signal; other commit intentional acts of red-light running. Because drivers cannot predict the onset of a yellow signal, the likelihood that a driver will stop is related to speed and distance from the intersection when the signal changes. This is called dilemma zone, where some drivers are going too fast when the signal changes to yellow to either enter prior to the onset of red or abruptly stop (Milazzo *et. al.*, 2001). There is also evidence that drivers may be induced into running red lights because of improper signal design or operation. These elements make red-light running difficult to predict and a difficult problem to solve. However, many drivers who run the red lights are provided adequate opportunity to stop safely but choose instead to proceed through a red signal: these drivers related to deliberate red light runners.

There is a wide range of potential countermeasures to the red-light-running problem. These solutions are generally divided into two broad categories: engineering countermeasures and enforcement countermeasures. Enforcement countermeasures are intended to encourage drivers to adhere to the traffic laws through the threat of citation and possible fine. In contrast, engineering countermeasures (which include any modification, extension, or adjustment to an existing traffic control device) are intended to reduce the chances of a driver being in a position where he or she must decide whether or not to run the red indication. Studies by Retting *et. al.* (2002), have shown that countermeasures in both categories are effective in reducing the frequency of red-light-running. However, most of the research conducted to date has focused on the effectiveness of enforcement; little is known about the effectiveness of many engineering countermeasures.

1.5 Research Problem

This study is concerned with the factors that influencing of red light runners at various types of signalized intersection. Signalized intersections are generally the most heavily traveled intersection types and are therefore a major element of the highway fatality especially at an onset of amber.

Traffic engineers rely heavily on traffic signals to control and separate conflicting traffic movements at busy intersections. Safe signal operation requires a high degree of voluntary driver compliance, and many drivers do not comply with red lights (Porter *et. al.*, 2000). Although traffic lights are installed to regulate and minimize the conflicts among vehicles, the risk of collision is still exist among the intersecting vehicles, affecting as well other road users, including pedestrians and bicyclists. When a vehicles approaches an intersection, whether the driver stops before the stop-line or not depends on the vehicles approach speed and distance from the intersection. Other factors of engineering design parameters for signalized intersections such as vehicle volume, change interval, amber time, cycle length, total phases, number of approach legs, are also deemed to affect runners behaviors. This report describes the result of a study carried out to evaluate those factors in influencing red light runners at intersection.

1.6 Aim and Objective

The aim of this study is to evaluate the effect of various types of traffic signal systems on red light running at onset of amber period. Satisfying of the following objective helps achieve this aim:

- i. To collect driver's decision on onset of amber period.
- ii. To determine the effect of traffic signal system studied on red light running.

1.4 Scope and Limitation

The study focuses on the effect of traffic signal system on red light running at signalized intersection. Potential factors that could affect the vehicles speed such as the lanes gradient will not be taken into consideration. Therefore, in order to obtain a more accurate data on the vehicles speed, the gradient value should be equivalent to zero. The factors of engineering design parameters for signalized intersections such as vehicle volume, change interval, amber time, cycle length, total phases, number of approach legs, are considered to affect runners behaviors. Other factors such as gender and age are not considered because the data are difficult to observe. Other than that, number of vehicles caught in dilemma zone is also taking into account for the analysis.