EXTENT OF TRAFFIC SHOCKWAVE PROPAGATION INDUCED BY MIDBLOCK U-TURN FACILITIES

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To my beloved father, mother and family

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ABSTRACT

The aim of study is to determine the extent of traffic shockwave propagations induced by midblock U-turn facilities. Based on the hypothesis that shockwave would result from U-turning at midblock facility, 24 hour data were collected which is volume and speed at two sites in FT005 Skudai – Pontian highway, Malaysia. The two sites are denoted as site A and site B. The study of highway capacity is the most important part in the identification of road performance. Any change made at the roadway for example installing a midblock U-turn facilities would result in highway capacity loss.There are mainly three causes of capacity loss which are due to the road condition itself, due to ambient and due to the traffic operation. When capacity loss happen, it would lead to traffic shockwaves. Traffic shockwave is a motion of propagation of a change in density and flow.When shockwaves happen, it would lead to reduction of roadway level of service. Speed, fow and density for with and without midblock U-turn facility are estimated using Greenshields Model. All data was collected using Automatic Traffic Counters (ATC). Shockwave velocity propagation with and without midblock U-turn facility were estimated by determining and comparing the capacity and density of roadway. Direct empirical capacity estimation methods are use to estimate capacity of roadway. Results shows that there is significant shockwave velocity propagation happen on the exit of the U-turn midblock facility which is about -35.1 km/hr. While a minor shockwave happens at the approaching of the U-turn. This study concluded that midblock U-turn facilities will induce traffic shockwave that may lead to road accidents.

ABSTRAK

Tujuan kajian adalah untuk menentukan tahap gelombang kejutan trafik berlaku disebabkan oleh blok kemudahan pusingan-U. Berdasarkan pada hipotesis bahawa gelombang kejutan trafik akan berlaku disebabkan blok kemudahan pusingan-U, 24 jam data telah dikumpul iaitu isipadu dan kelajuan pada dua tapak di FT005 lebuhraya Skudai – Pontian, Malaysia. Tapak ditandakan sebagai tapak A dan tapak B. Kajian kapasiti lebuh raya adalah bahagian yang paling penting dalam pengenalpastian prestasi jalan raya. Sebarang perubahan yang dibuat di jalan, contohnya memasang satu blok kemudahan pusingan-U, akan mengakibatkan kehilangan kapasiti. Terdapat tiga punca kehilangan kapasiti iaitu disebabkan oleh keadaan jalan raya itu sendiri, persekitaran dan operasi trafik. Apabila kehilangan kapasiti berlaku, ia akan membawa kepada gelombang kejutan trafik. Gelombang kejutan trafik adalah perubahan dalam ketumpatan dan aliran. Apabila gelombang kejutan trafik berlaku, ia akan membawa kepada pengurangan tahap perkhidmatan jalan. Kelajuan, aliran, dan ketumpatan untuk dengan adanya kemudahan pusingan-U dan tanpanya dianggarkan menggunakan Model Greenshields. Semua data telah diambil menggunakan cerapan traffic automatik (ATC).

Halaju gelombang kejutan trafik dengan dan tanpa kemudahan pusingan-U dianggarkan dengan menentukan dan membandingkan kapasiti dan ketumpatan jalan. Empirikal langsung adalah kaedah penganggaran kapasiti yang digunakan untuk menganggar kapasiti jalan. Keputusan menunjukkan bahawa terdapat halaju gelombang kejutan trafik yang ketara berlaku pada laluan keluar kemudahan pusingan-U iaitu -35.1km/jam. Manakala, kelajuan gelombang kejutan trafik yang kecil berlaku di laluan menghampiri kemudahan pusingan-U. Kesimpulanya, blok kemudahan pusingan-U akan mendorong gelombang kejutan trafik yang membawa kepada kemalangan jalan raya.

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LIST OF SYMBOLS/ ABBREVIATIONS

AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
ATC	Automatic Traffic Count
HCM	Highway Capacity Manual
HGV	Heavy Good Vehicle
hr	Hour
JKR	Jabatan Kerja Raya / Public Work Department
k	Density
k_c	Critical Density
k_j	Jam Density
km	Kilometer
p.c.u	Passenger Car Unit
Q	Capacity
q	Flow
q_{max}	Maximum Flow
R^2	Regression
SSD	Stopping Sight Distance

u	Speed
u_f	Free Flow Speed
u_c	Optimum Speed
veh	Vehicle

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Traffic congestion problem and excessive traffic delays that is happening all around the world on urban and suburban multilane highways may due to the ineffective installation of traffic signal control system. In recent years, there has been major interest in “access management” as a new reaction to this situation. Based on TRB (2003), access management refers to the design, implementation, and management of entry and exit points between roadways and adjacent properties. Access management calls for improvements in access control, spacing, and design to preserve the functional integrity of the road system (Koepke & Levinson, 1992). One of the access management strategies is to prohibit the left turn movements at unsignalized driveways and the deterred traffic will be forced to make a U-Turn.

The clear advantage of prohibiting right turns at midblock driveways is an immediate increase in safety by the reduction in crashes. A study in California, United States which is applying right-hand traffic stated that by simplifying driving tasks could significantly reduce the crash rate (Vargas & Gautam, 1989). Other than can reduce the number of conflict points between road users it also provide smoother, more reliable, and potentially higher travel speeds for arterial traffic.

As for Malaysia which has left-hand traffic, the approach is to prohibit the right turn movements by allowing the left turning movements only. This approach often coupled with provision of midblock U-turns in the downstream to accommodate the right turning traffic. This system is called the left turn U-turn (LTUT) system. The most common factors that influence the decision of this approach are the volume on the roadway and crash rates involving fatality at the site is high.

A quantitative assessment of traffic stream which is roadway capacity is based on the relationship of flow, speed and density. According to TRB (2000), the capacity of a facility is defined as the maximum hourly flow rate at which vehicles can reasonably be expected to traverse a point or section of a roadway under prevailing roadway, traffic and control conditions. By knowing the capacity of the roadway, we can do improvements to the roadway design and also traffic management.

Due to the midblock U-turn on downstream, it would create the phenomenon of backups and queuing on a highway due to a sudden reduction of the capacity of the highway which is known as a bottleneck condition. The sudden reduction in capacity could be due to a crash, reduction in the number of lanes, restricted bridge sizes, work zones, a signal turning red and so forth (Nicholas J. Garber & Hoel, 2009). Any change made on the roadway for example installing midblock U-turn facilities would result in highway capacity loss. Not only changes of roadway geometry is the only factor of highway capacity loss, the traffic conditions and also the ambient condition like dry and wet condition also contribute to highway capacity loss. When capacity loss happens, it would lead to traffic shockwaves.

Traffic Shockwave is a motion of propagation of a change in density and flow. Where traffic stream is moving at a speed in close proximity and lead vehicle driver step on the brake, if the follow up driver lose their nerves on sighting the brake lights, abrupt braking will trigger shockwaves (Johnnie Ben-Edigbe & Mashros, 2011). A driver is influenced mostly by motion of vehicles downstream of him or her. The shockwave speed is conventionally represented by the rate of change in volume and density (Lighthill & Whitham, 1955; Richards, 1956). When shockwaves happen, it would lead to reduction of roadway level of service.

1.2 Problem of Statement

Over the past few decades, there have begun considering the use of U-turn as an alternatives to direct left turn for the right-hand traffic and direct right turn for the left-hand traffic. The driving side depends on the country itself. Past studies have indicate that direct left turn maneuvers increase delay, conflicts, and crashes, and they reduce capacity and mobility in the major traffic stream and stated that the access management which providing a right turn followed by U-turns (RTUT) system gives many advantages like reducing the conflict points at the intersections.

Somehow, there are also arguments have been raised by some opponents of median modification projects, that the increase number of U-turning vehicles may result in safety and operational problems on multilane highways. Presently, there is a lack of information especially on the extant of traffic shockwave propagation induced by highway midblock U-turn facilities based on empirical research for Malaysia multilane highway condition.

1.3 Aim and Objectives

The aim of this study is to determine the extent of traffic shock wave propagations induced by highway midblock U-Turn facilities, and the objectives of this are:

i. Estimate flow and density for road section.
ii. Estimate and compare traffic flow for road section with and without midblock U-turn facility.
iii. Estimate and compare density for road section with and without midblock U-turn facility.
iv. Determine shockwave speed for road section.

1.4 Scope of Study

This study is focused on the determining the shockwave propagations of highway midblock U-turn facilities at FT005, Skudai – Pontian highway as shown in Figure 1.1. In achieving the capacity and shockwaves associated with midblock U-turn, the method covered in this study are direct empirical methods which are directed at estimation of capacity values at a specific site with traffic observations from site. The study relied on fundamental diagrams of traffic stream where flow is a function of speed multiply by density. The data collection is taken 24 hours per day for 3 weeks.

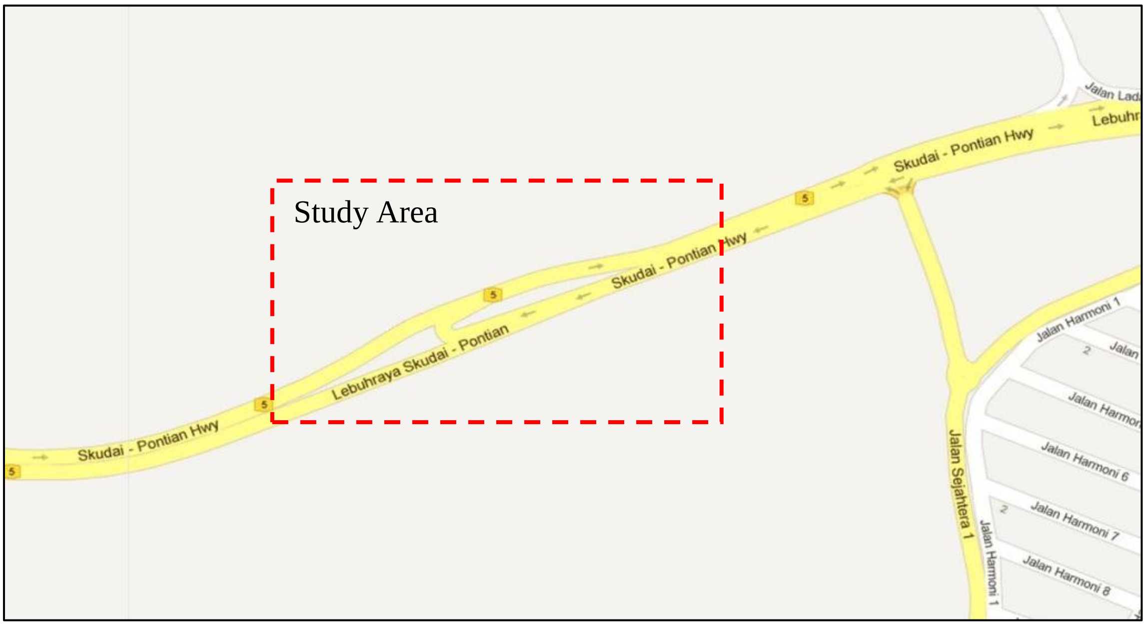

Figure 1.1: Midblock U-turn facilities at FT005

(Source: http://maps.goole.com)

1.5 Significance of Study

The shockwave propagation at any point along a road has a major implication in traffic flow analysis, modelling, traffic engineering design and also traffic management. Shockwaves would affect the level of service of the roadway. Data obtained from this study can be used as a reference for future traffic improvements and developments on the site location. It also can be used as a basis for traffic design and timing of traffic signals if need to implement for the future. By all the improvements, it helps to ease traffic flow and to decrease the travel time therefore minimizing the travel cost.

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