EXTENT OF ROAD LIGHTING IMPACT ON THE QUALITY OF ROADWAY SERVICE

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To my beloved mommy and daddy

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ABSTRACT

The quality of road surface and its facility will relate to performance evaluation, which relies on measures of performance quality, often stated in quality of roadway service (QRS). One of the facilities that available in highway outside the carriageway is road furniture, including road lighting. The availability of road lighting in highway helps driver at night time driving. Road lighting be expected can make road can be functioned in night time as well as drive in daytime. This study will compare QRS of two scenarios – day light condition and road light condition – in dry weather. QRS can be estimated by comparing 85^{th} and 15^{th} percentiles of cumulative speed distribution. Roadway capacity during daylight is estimated approximately 2096 pcu/hr/ln, while during road lighting the roadway capacity is 2154 pcu/hr/ln. The 15^{th} percentile speed during day light is 61 km/hr, decreasing to 59 km/hr during road lighting condition. The 85^{th} percentile speed during day light and road lighting are 88 km/hr and 85 km/hr respectively. Statistical test result shown that the difference of 85^{th} and 15^{th} percentile speed during day light and road lighting condition was statistically not significant. Optimum speed during daylight is 46.17 km/hr, while during road lighting is decrease to 44.42 km/hr. Since speed is a distributed parameter, a variance within 32.67 km/hr to 59.67 km/hr for the speed can be neglected and QRS assumed not affected. It shows that QRS under proper standard lighting system is not affected significantly compare to the daylight condition.

ABSTRAK

Kualiti permukaan jalan dan kemudahan yang berkaitan dengan penilaian prestasi, bergantung kepada prestasi kualiti yang diukur, yang dinyatakan dalam kualiti perkhidmatan jalan (QRS). Salah satu kemudahan yang disediakan di luar laluan lebuh raya adalah perabot jalan, termasuk lampu jalan. Penggunaan lampu jalan di lebuh raya membantu pemandu di waktu malam. Lampu jalan dijangkakan boleh membuat jalan berfungsi pada waktu malam serta pemanduan di siang hari. Kajian ini akan membandingkan QRS bagi dua senario – keadaan siang dan keadaan malam pada cuaca kering. QRS boleh dianggarkan dengan membandingkan 85 dan 15 persentil agihan laju kumulatif. Kapasiti jalan raya pada waktu siang hari dianggarkan kira-kira 2096 pcu/hr/ln, manakala semasa malam hari kapasiti jalan 2154 pcu/hr/ln. Kelajuan 15 persentil semasa siang hari adalah 61 km/hr, berkurangan kepada 59 km/hr dalam keadaan malam hari. Kelajuan 85 persentil semasa siang hari dan malam hari, masing-masing adalah 88 km/hr dan 85 km/hr. Keputusan ujian statistik menunjukkan bahawa perbezaan kelajuan 85 dan 15 persentil semasa siang hari dan keadaan malam hari adalah tidak signifikan secara statistik. Kelajuan optimum pada waktu siang hari adalah 46,17 km/hr, manakala semasa malam hari menurun kepada 44,42 km/hr. Oleh kerana kelajuan adalah parameter teragih, varians untuk kelajuan dalam lingkungan 32,67 km/hr hingga 59,67 km/hr boleh diabaikan dan QRS dianggap tidak terjejas. Ini menunjukkan bahawa QRS pada malam hari di bawah sistem lampu piawaian yang betul tidak terjejas dengan ketara berbanding dengan keadaan siang hari.

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LIST OF SYMBOLS AND ABBREVIATIONS

a	Deceleration rate
AASHTO	American Association State Highway Transportation Officials
ADT	Average Daily Traffic (veh)
ATC	Automatic Traffic Count
B.S	British Standards
cd	Candela
CI	Confidence Interval
d	Distance travelled (km)
FFS	Free-Flow Speed (km/h)
ft	Foot
h	hour
H_1	Alternative hypothesis
HCM	Highway Capacity Manual
HGV	Heavy Goods Vehicle
H_o	Null hypothesis
JKR	Jabatan Kerja Raya
k	Density (veh/km)
k_c	Critical density (veh/km)

k_j	Jam density (veh/km)
km	Kilometer
lm	Lumen
LOS	Level of Service
lx	Lux
m	Meter
mi	Mile
M.S	Malaysian Standards
n	Number of observed vehicles
PCE	Passenger Car Equivalent
p.c.u	Passenger Car Unit
PHF	Peak-Hour Factor
PI	Prediction Interval
q	Flow (veh/h)
q_m	Maximum flow (veh/h)
SE	Standard Error
t_i	Time for vehicle *i* to traverse d (h)
t_{p-r}	Perception-Reaction Time (sec)
TRRL	Transport and Road Research Laboratory
u	Speed (km/h)
u_f	Free-flow speed (km/h)
u_o	Optimum speed (km/h)

$\overline{u_s}$	Space mean speed (km/h)
$\overline{u_T}$	Time mean speed (km/h)
UTM	Universiti Teknologi Malaysia
V_d	Design speed (km/h)
veh	Vehicle
x	Length of road (km)

CHAPTER 1

INTRODUCTION

1.1 Introduction

Highway is the important aspect in life because it supports people movement to do their daily activity. It is also the important aspect in economic growth in a country. Economic growth can be directly related to the highways such as transportation of goods from factory to be distributed, people activity to go to work, or even family trip to recreational place.

Road lighting is an important infrastructure facility. Initially, lighting was to enable pedestrians to move about in cities at night without being attacked. Currently road lighting installed because of its ability to reduce night time accident and driver comfort (Holmes; 1997). Moreover, road lighting has function to illuminate adequately the road surface and objects on the road and its surrounding areas to be visible enough to ensure that the driving task is performed successfully (Aleksanteri E. *et al.*, 2008). From engineer's point of view, primary object of road lighting is to improve the safety of roads at night by providing good visibility conditions for all road users.

A good highway makes it possible for user to ride safely and comfortably at the design speed. The quality of road surface and its facility will relates to performance evaluation, which traffic engineers can rate operating characteristics of individual section of roadway and facilities as a whole in relative terms. Evaluation relies on measures performance quality, often stated in level of service. The Highway

Capacity Manual (HCM) defines highway level of service as a qualitative measure describing operational conditions within a traffic steam, as perceived by motorist (Transportation Research Board; 2000). Level of service (LOS) divide into six levels, which range from A to F, separated by different value of measurement which is traffic density, volume-to-capacity (v/c) ratio, and average speed. However, the level of which these level of service are according to motorists' perception in USA. In Malaysia, quality of service can be measured from speed – volume relationship. In essence, by comparing 85^{th} and 15^{th} percentiles of cumulative speed distribution of roadway under day light and road lighting condition, the quality of roadway service can be estimated.

Greenshield (1934) method can be used to determine the optimum speed and free-flow speed as the parameter to describe quality of roadway service. Traffic condition and roadway condition have a strong influence on vehicles' speed. One of the most significant factors of road condition is visibility for the road user. Road light has important part in night time to provide visibility.

1.2 Statement of the Problem

Activity of the people is not restricted only in daytime, but people still doing their activity in night time. Night time driving can be a particularly problem. The US Department of Transportation (USDOT) and The National Highway Transportation Safety Administration (NHTSA) both report show that 27% of total crashes occur under dark condition, 45% of fatalities occur under dark condition (NTHSA; 2003). Those problems occur relates to good visibility for road user which can influence driver's behaviour. Previous study found no change in average speed when road lighting was introduced, while other show contrary (Anais M. *et al.*, 2010).

Most of previous study of road lighting usually related to traffic safety and accident prevention. Only limited study has been made to investigate effect of road lighting to the quality of roadway service (QRS). QRS should be considered under

road lighting condition to compare with the control QRS when it is under daylight condition.

In a low traffic volume situation, driver's selection of speed usually influenced by factor such as the road geometry, lighting and weather condition, (Othman C.P., 2004). The availability of road lighting in highway helps driver at night time driving. Although vehicles have their own headlight, but road lighting still needed. Road lighting provides visibility, helps driver to get enough visual information throughout driving. Road lighting be expected can make road can be functioned in night time as well as drive in daytime. Because of that, study will mitigate the impact of road lighting on the QRS.

1.3 Aim and Objective of the Study

The aim of the study is to determine the extent of road lighting impact on the quality of roadway service.

The objectives of this study are:

a) To determine the 85^{th} and 15^{th} percentile speed distribution for roadway with and without road lighting.
b) To compare the outcomes from the two scenarios.
c) To determine speed / flow plot points from estimated flow / density functions.
d) To compare the outcomes from speed / flow graphs from the two scenarios.

1.4 Scope

Scope of the study will be focused to determine QRS of the section of Skudai-Pontian Highway. QRS of highway section will be in two different conditions, day light during day time and road lighting during night time, to know

the impact of road lighting. The study will provide traffic data including volume and speed for that section of highway during 3 weeks continuously. Roadway type and geometry, and other important information in study location shall be collected.

Section of highway for this study is started from interchange of Jalan University and Skudai-Pontian highway and ended in Jalan Pontian Lama exit ramp. This segment of road is 1.7 km length with no sharp curve.

Figure 1.1: Site Map

Site location should be based on criteria so that the data is not affected by other factor. The criteria for site for this study are:

- roadway should be in level terrain, not hilly terrain
- roadway should not influenced by attractions and intersection

1.5 Significant of the Study

Result of this study will provide models of traffic pattern during daylight and road lighting condition. Models will be use to verify whether road lighting has impact on QRS, provided the road lighting are operated based on design standard and road surface is free from surface defect.

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