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Road Lights Profiling Based on Road Lighting Setting-Up and Performances

J. Prasetijo[*1], M. A. Mohd Nar[1], Z. Mohd Jawi[2], Z. Ngadiron[1], M. E. Mahyeddin[1], M. Norrizan[1] and M. F. Abd Latif[1]

[1]Department of Transportation Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600 Panchor, Malaysia
[2]Malaysian Institute of Road Safety Research (MIROS), 43000 Kajang, Selangor, Malaysia

[*]*Corresponding author: joewono@uthm.edu.my*

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Abstract – *Roads and highways are the areas where road accidents commonly occurred, and the number increases during a certain period such as festive breaks. ASEAN NCAP is committed to ensuring the safety of vehicles in Southeast Asia by improving the rating systems and standards of a vehicle such as AEB and AHB. Additionally, efforts on the improvements of street/road lighting performances and facilities (profiling and design) would play an important role in safety along the road stretches since vehicle lighting are strongly correlated with visual effectiveness. Road lighting performance with low hence and low visual quality would contribute to accidents in certain road sections. Therefore, this study experimented with road lighting performance environments by using Luxmeter based on the Euro NCAP (2018) standard and guideline. A reference grid of road light measurement with a 1-meter interval was used to measure lighting performance on each distance interval. Two federal roads in Johor were picked as experiment sites, i.e. FT050 (Jalan Batu Pahat – Ayer Hitam – Kluang) and FT001 (Jalan Johor Bahru – Segamat). FT050 road is a two carriageway with a width average of 2.6 meters, 134-kilometer in length, and the lamp used most was a double arm lamp. FT001 is similar in width (2.6-meter), 992.6-kilometer in length, and used single-arm lamps. The study found that FT050's lighting performance decreasing at each interval grid while away from the lights at the range of 38 lux to 16 lux, however, FT001's result was decreasing at mid-interval and it increases when approaching mid between the lights at 23 lux – 15 lux – 19 lux. The following study concluded that using single arm lighting systems (by turns) resulting in higher lights (lux) performances and larger (lux) distributions (coverage) on roads. Therefore, the installments of single arm lighting system (by turns) would be considered for lights performance and efficiency concerning the drivers' visibility.*

Keywords: Lighting performance, road safety, lamp, LUX meter

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1.0 INTRODUCTION

Road accidents are now among the main causes of fatalities around the world. The World Health Organization (WHO) mentioned that in 2016, all kinds of accidents had claimed 4.9 million lives. More than a quarter (29 percent) of these deaths were due to road traffic mishaps, and it was apparent among the vulnerable road users (VRUs), i.e. pedestrians, bicyclists, and motorcyclists. Furthermore, road traffic accidents were the leading cause of death for children and young adults aged 5-29 years with risk factors of accidents are speeding; driving under the influence of alcohol and other psychoactive substances; ignoring the use of motorcycle helmets, seat-belts, and child restraints; distracted driving; unsafe road infrastructure; unsafe vehicles; inadequate post-crash care; and inadequate law enforcement of traffic laws (ASEAN NCAP, 2018).

Malaysia's road accidents rise alarmingly high, particularly during a certain period such as the festive breaks, with more than 6,000 fatalities per year (Jindal & Mukherji, 2005). Motorcyclists have been listed as the most vulnerable road user since the fatalities are beyond 50 percent of total deaths. Malaysian Institute of Road Safety Research (MIROS) had identified the Batu Pahat District in Johor as one of the districts with the highest number of traffic fatalities, with 554 cases recorded over three years between 2013 - 2016 (Prakash, 2019). The previous study has considered that road accessories would improve the safety of motorists including pedestrians and motorcyclists. Examples show typical road accessories mounted on the road include barricades, signs, speed bumps, and lamps, while lamps profile and type are vary depending on several factors such as location, and the commonly used types are double arm and single-arm lamp.

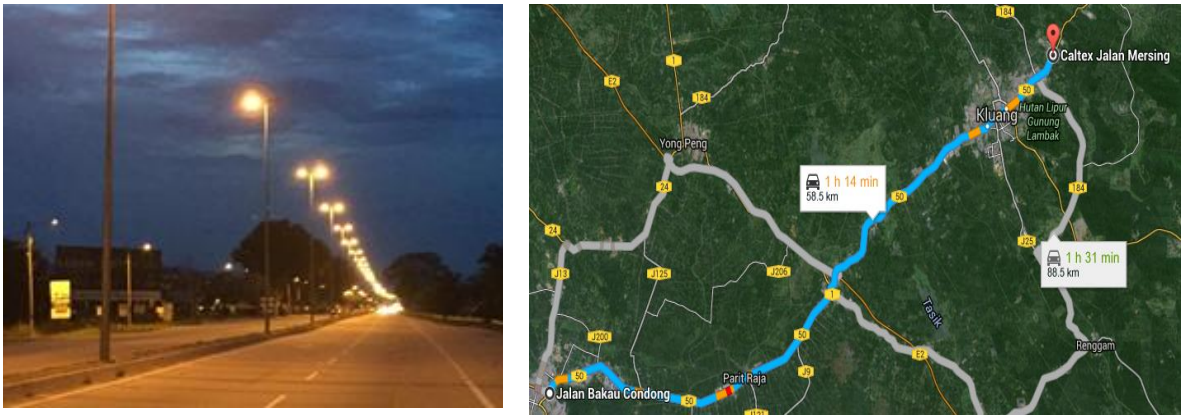
Lighting intensity, profile, and architecture influence the performance of road users. The minimum luminous intensity, road lighting performance is required, which provides possible implications for driving safety and Auto High Beam (AHB) requirements based on requirements for speed-stopping distance (SSD) (Prasetijo et al., 2018a; Prasetijo et al., 2020). Generally, the form of the road and conditions along the sections of the road are not the same, including the road lighting systems. The luminous intensity reflects the efficiency of the road lighting along the sections (Bullough et al., 2013; Bullough, 2014). Street lighting performances and efficiency are indicated by luminance (intensity). Therefore, the model and instrument of the light are an important part of road lights profiling. The previous study has shown that linear profiles of any vehicle and lights performance would be important (Prasetijo et al., 2018b). The light per square meter is estimated as lumens [lux]. Therefore, the objectives of the current project are to identify potential factors related to road lighting performances with regards to luminance [lux] criteria; and developing the road light intensities profiles based on the type of lamps, the interval between lamp and height of lamps with regards to vehicles travel-time and distances.

2.0 ROAD LOCATION – DATA COLLECTIONS

2.1 Federal Road FT050: Jalan Batu Pahat – Ayer Hitam – Kluang

The study considered two (2) Federal Roads in Johor; FT050 and FT001. The roads are known as the highest rate of accidents and fatalities. Federal Road FT050 has a length of 136 km equipped with double carriageways/two-way four lanes and average lane width of 2.6m, which connects Batu Pahat and Kluang. The road is found to be with high traffic volumes during the day and night. Generally, the road is installed with double arms lamps type with LED IP66

model at the height of pole as 12 meters. The average interval distance between the lamp poles is within 32 – 40 meters. Figure 1 shows the location of road FT050 and its topography (Google view).



(a) (b)

Figure 1: (a) Double arm lamps and (b) Location of data collections at Federal Road FT050

2.2 Federal Road FT001: Jalan Johor Bahru – Segamat

Federal Road FT001 is one of the main federal roads in Johor. The road is also considered as one of the roads with the highest accidents and fatalities in Malaysia, even though the numbers are not as high as FT050. The road connects Johor Bahru – Singapore causeway in the south to Segamat in the north. FT001 has a length of 231 km and two double carriageways/two-way four lanes with an average lane width of 2.6 meters. The average gap between the lamp poles is 38 – 40 meters. The lamps installed are the single-arm type with LED IP66 model at a height of 12 meters. The light poles' positions are in turns (criss-cross) along with the directions (two ways directions). Figure 2 shows the location of data collection at FT001, street light sketches, and the road topography.

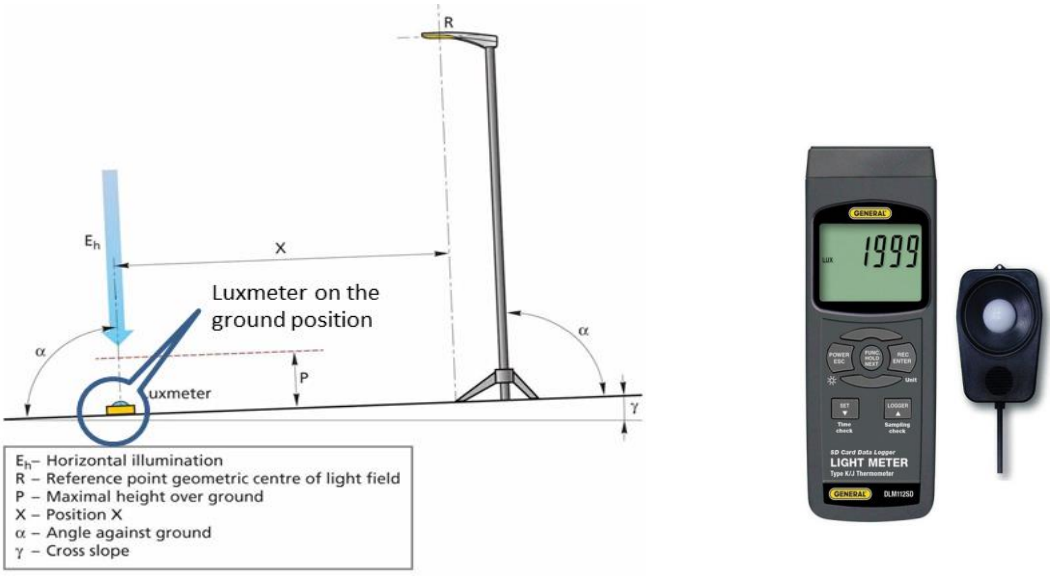
(a) (b)

Figure 2: (a) Single-arm lamp position and (b) Location of data collections at Federal Road FT001

3.0 METHODOLOGY

3.1 Field of Experiments

The selection of sites and federal roads are located in Batu Pahat, Johor such as Federal Road FT050 (Batu Pahat – Ayer Hitam – Kluang) and FT001 (Johor Bahru – Ayer Hitam). The roads have different types of road lighting/street lights which were expected to have different light profiles. The profiles are based on the average rate of lux/lumens/illuminations performances. Measurement of illumination was done using a calibrated Luxmeter of SD-1128. The tool will be placed along the grid below the lamps. The length of transversal Y is about the width of a lane road. Luxmeter must be set on the ground at a right angle to the street as shown in Figure 3(a), and Figure 3(b) shows the Luxmeter of SD1128 used in this study. Luxmeter position was set based on the Euro NCAP (2018) guideline for the experiment.



(a) (b)

Figure 3: (a) Luxmeter position on the ground, and (b) SD-1128 Luxmeter

3.2 Reference Grid Light Measurements

The reference grid of road light measurements at Federal Road FT050 and FT001 are based on the Euro NCAP (2018) standard guideline for light intensities measurements. Points at the transversal position-y (m) are 1-meter interval while the longitudinal position-y (m) is in the average of 2.5-meter interval. The y-interval would be based on the actual lengths of the interval between lamps (distance) as shown in Figure 4.

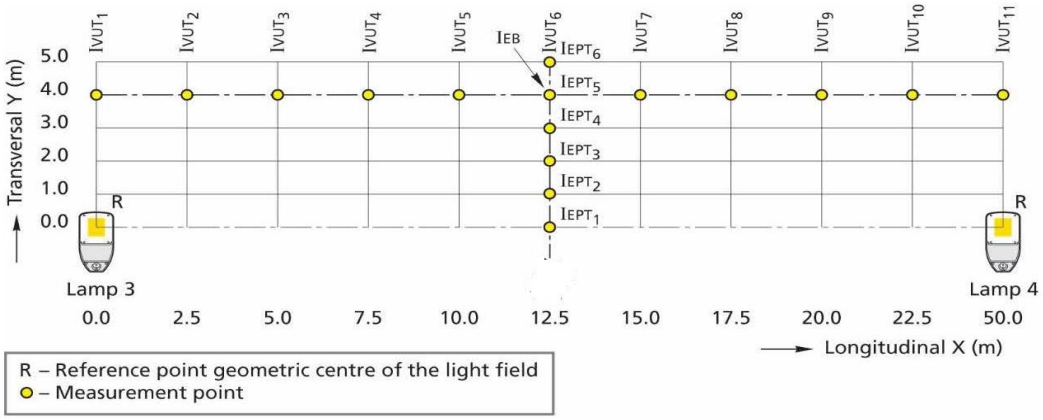


Figure 4: Reference grid of the road light measurement

4.0 RESULTS

4.1 Federal Road FT050 (Jalan Batu Pahat – Ayer Hitam – Kluang)

Federal Road FT050 used a double arms lamp with a distance (interval between lamps) average of 33 meters, as can be seen in Figure 5. Lux measurements were conducted on half of the distances (between lamps) with the assumption that the lamps will have the same performance since the model was similar (LED IP66).

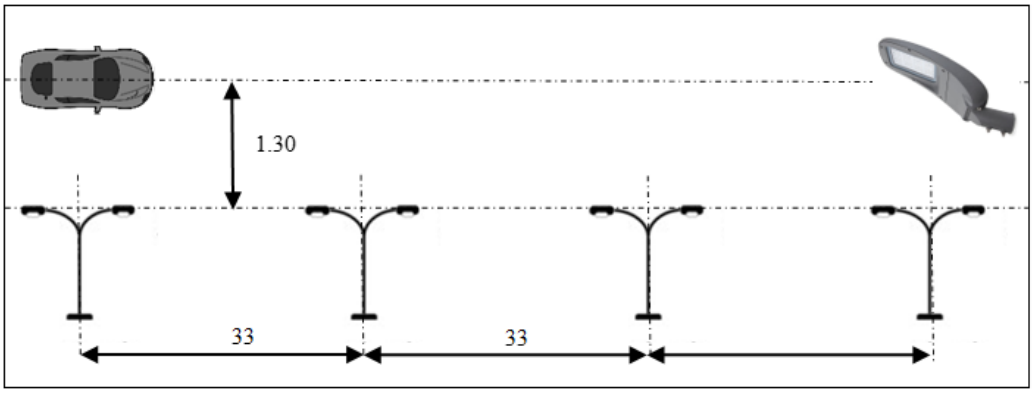


Figure 5: Distance between lamp poles at Federal Road FT050 with LED IP66 lamp

Results on the light linear profiles at FT050 show that the average between each interval which given the average total distance of the lamp post is16.5m. The decrease of lux intensities is in the average of 38 lux to 16.5 lux at every interval (Figure 6).

4.2 Federal Road FT001 (Jalan Johor Bahru – Segamat)

Similar standard measurements to the FT050, Federal Road FT001 with the single-arm lamp at the average distance of 38 meters between each lamp. Figure 7 shows the distance between lamp posts. The measurements were done at half of the range (between poles) as 18.5 meters with the LED IP66 model. The road lamps are arranged by turns along the two direction roads as it is explained in Figure 2(a), which are expected that would cover lights for both ways of the road.

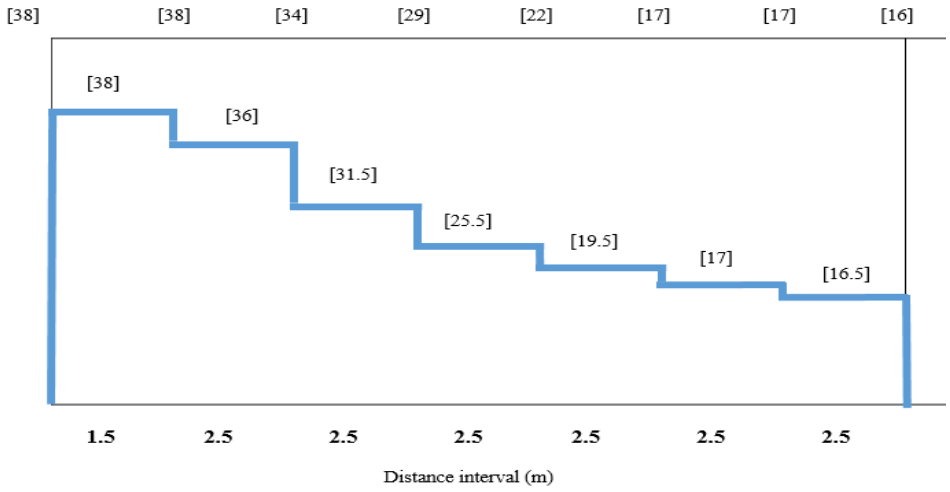


Figure 6: Light linear profiles at Federal Road FT050 in half range (16.5 meters)

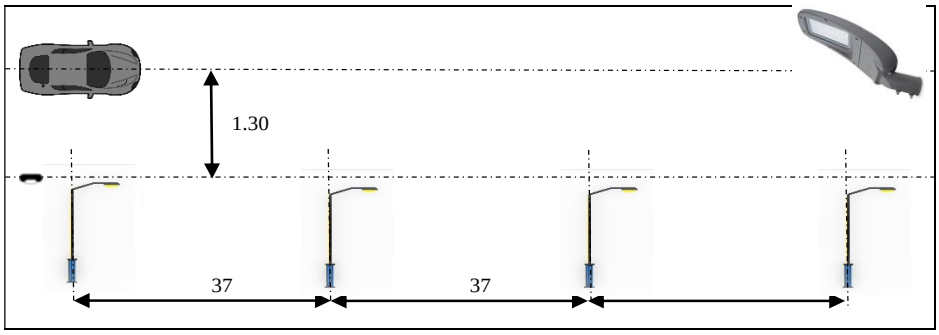


Figure 7: Distance between lamp poles at Federal Road FT001 (half distance 18.5 meters)

The following results on the light linear profiles at FT001 show the average between each interval which given the average total distance (half) of the lamp post, 18.5 meters. The decrease of lux meter was recorded from 23 lux to 15 lux. Furthermore, it increases 16 lux - 18.5 lux. The result is shown in the following Figure 8.

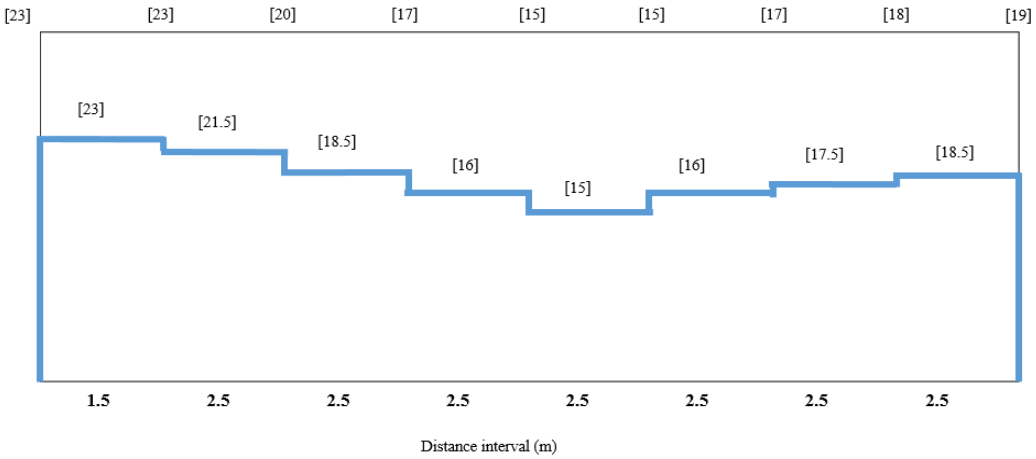


Figure 8: Light linear profiles at Federal Road FT001

5.0 DISCUSSION

5.1 Factors Relating to the Road Lighting Performances

Dimming profiles represent road lighting performances, road environment, and designs. Therefore, road lighting quality and design performances would contribute to the effectiveness of operating road lighting systems. Road lighting performances are required for the minimum luminous intensity which gives potential implications for driving safety and AHB requirements based on speed-stopping distance (SSD) requirements. Therefore, several potential factors are involved in the light system performances such as; type of lamp, distances/intervals between lamps, and the height of the lamp. The study found that factors might contribute to the street light performances such as the type of lamp used and the lamp arms arrangements, which are different hence, the difference result of lighting intensity performances. The linear profiles model involving the factors will be discussed further in the coming experiments.

Federal road FT050 has a double arm lamp that gives out more intensities/lux while Federal Road FT001 is with a single-arm lamp. Figure 9(a) shows an example of a double arm lamp used at FT050 and Figure 9(b) shows an example of a single-arm lamp used at FT001. The height of the poles is 12 meters. Results from Figure 6 and Figure 8 show that the intensity levels are different which produces different visual effects. This might produce lights covered along the road sections with regards to the AHB and SSD distances. The findings are important on the decisions for the minimum requirements of the AHB and street lights/road lamps performances and intensities.

5.2 Road Lighting Intensities Profiles

The current study has chosen two federal roads in Johor; FT050 and FT001. Both are considered as the highest roads with accidents and fatalities. The study along the Federal Road FT050 found that the average light intensities/lux level is in the range of 38 lux – 16.5 lux. The profiles are decreasing from 38 lux to 16.5 lux in the range of 16 meters (half interval between the arms). The typical linear profiles of intensities can be seen in Figure 7. Federal Road FT001 has performed different patterns of intensities due type of lamps and arms arrangements. It shows that the intensities decrease from 23 lux to 15 lux (at the range of ¼ distances/between interval arms) and increase to 18.5 lux. The investigation found that the performances due to the arrangements of lamps are irregular/in turns.

(a) (b)

Figure 9: (a) Double arm lamp, and (b) Single arm lamp

6.0 CONCLUSION

The different types of the lamp at the federal roads will give out different light performances and intensities. Federal Road FT050, with a double arm lamp, gives out a consistent decrease of intensities while Federal Road FT010, with a single-arm lamp, produces different patterns of intensities/lux. Pre-study found the street lighting performances are based on the type of lights/lamps, the height of poles, and distance between lights. The study has found that an effective lux range change is within the range of 1–meter intervals in y-direction with lux range of 1 – 6 lux, and the average for double light arms installation in a range of 1 – 3 lux for single light arms. Double arm systems give higher lights intensities and coverage than single systems. However, the rate of changes is found higher as within the range of 1 – 6 lux in 1-meter, while the single lights system has the rate of 1 – 3 lux changes in the 1-meter interval (consistency).

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