THE EFFECTIVENESS OF ADVANCED STOP LINE (ASL) FOR MOTORCYCLES AT SIGNALISED INTERSECTION IN KUALA LUMPUR

Norfaizah Mohamad Khaidir
Malaysian Institute of Road Safety Research (MIROS)
Lot 125-135, Jalan TKS 1, Taman Kajang Sentral, 43000 Kajang, Selangor, Malaysia
Email: norfaizah@miros.gov.my

Nusayba Megat Johari
Malaysian Institute of Road Safety Research (MIROS)
Lot 125-135, Jalan TKS 1, Taman Kajang Sentral, 43000 Kajang, Selangor, Malaysia
Email: nusayba@miros.gov.my

Nurulhuda Jamaluddin
Malaysian Institute of Road Safety Research (MIROS)
Lot 125-135, Jalan TKS 1, Taman Kajang Sentral, 43000 Kajang, Selangor, Malaysia
Email: nurulhuda@miros.gov.my

Azzuhana Roslan
Malaysian Institute of Road Safety Research (MIROS)
Lot 125-135, Jalan TKS 1, Taman Kajang Sentral, 43000 Kajang, Selangor, Malaysia
Email: azzuhana@miros.gov.my

ABSTRACT

The motorcycle is one of the most economical and viable options for affordable transport in most developing countries. Malaysia suffers from the onslaught of motorcycle crashes, contributing to more than 60 percent of road deaths yearly. While various countermeasures such as helmet laws and physical segregation of motorcyclists from other vehicles have been implemented, high conflict area such as the intersections remains an issue. The provision of a dedicated space for motorcyclists at intersections in the form of advance stop line (ASL) is not something new; providing targeted vehicles a head start when the traffic signal changes from red to green. Kuala Lumpur recently adopted the use of ASL, and a total of 16 hour data collection on its utilization, misuse, as well as red-light violations were conducted at four signalised intersections with ASL. Only 57 percent of motorcyclists were observed to utilise the ASL provided during the red phase accounting for an occupancy rate of 5-55% of the ASL, indicating under-utilisation. Non-compliancy with the ASL can be attributed to the high misuse of the ASL by other vehicles. Additionally, the occurrence of red-light-running behaviour contributes to lower volume of motorcyclist stopping during the red phase affecting the occurpancy rate of the ASL.

Keywords: Advanced stop line, motorcycle safety, signalised intersection.

INTRODUCTION

The motorcycle is considered as the most affordable and viable option of transportation in low- and middle-income countries in South East Asia (Industry Research Department, 2015; Law, Hamid, & Goh, 2015; Leong & Sadullah, 2007). Malaysia recorded approximately 46.5% motorcycle registration each year with an average increment rate of 5.6% per year (Ministry of Transport Malaysia, 2017). The increment in motorcycle ownership has also led to the increment in motorcycle fatalities due to the road crashes. Malaysia suffers from the onslaught of motorcycle crashes, which contributes to more than 60% of road deaths yearly. In the year 2018, out of 6,284 road fatalities, 65.9% were motorcyclists and pillion riders (Royal Malaysia Police (RMP), 2018). Various methods covering a myriad of target approach is required to tackle the problem at hand, and this includes provision of a separate area for motorcyclists. One good example is the motorcycle lane, both segregated and non-segregated lanes provided as a form of longitudinal separation. However, few countermeasures exist for high conflict area such as at the intersections. Motorcycle exposure rate have been recorded to be high at signalized intersections, even in countries where motorcycle population is low (Haque, Hoong & Huang, 2008).

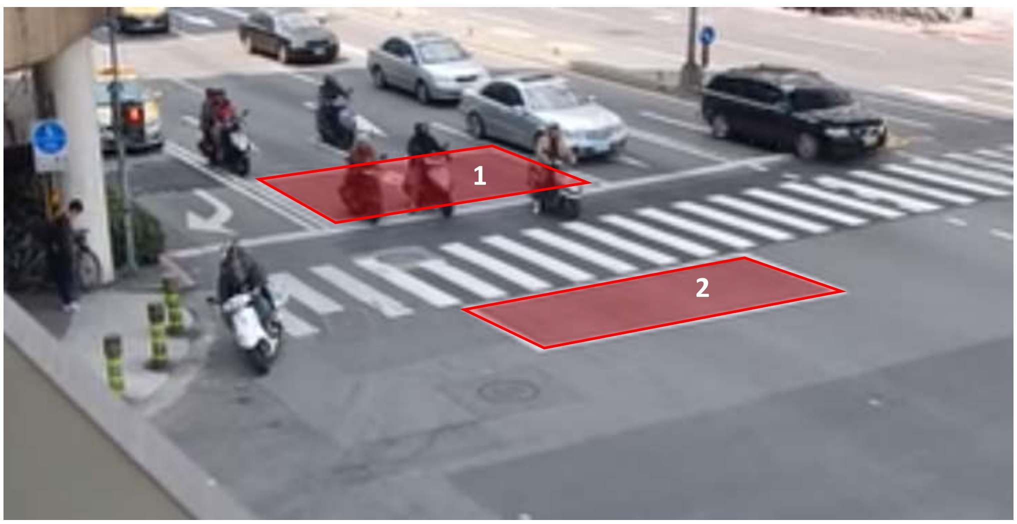
The provision of a dedicated area or space for vulnerable road users at signalized intersections is not something new. Europe has widely implemented advanced stop lines (ASL) to increase bicyclist safety. An ASL, also known as advanced stop box or bicyclist box, are road markings at signalised intersections which positions certain vulnerable road users such as bicyclists or motorcyclists in front of queueing vehicles, allowing for a head-start when the traffic signal changes from red to green. In the United Kingdom (UK), ASL was used since the mid-eighties to enhance bicyclists' safety at intersections (Atkins, 2006). The Atkins report also summarised reviews on prior research conducted on ASL, which revealed that the use of ASL gave positive effects to reduce vehicle encroachment towards vulnerable road users (Atkins, 2006; Newman, 2000). The presence of ASL was seen to help provide buffer towards pedestrian crossings at signalised intersections thus giving better protection towards crossing pedestrians (Allen, Bygrave, & Harper, 2005; Organisation for Economic Co-operation and Development (OECD), 1998). A similar finding was also obtained in a study conducted in Portland where less than 30% of drivers were recorded to encroach into a designated bike box after the installation of ASL for cyclists (Dill, Monsere, & McNeil, 2012). In the last decade, the ASL was introduced for motorcycle use. A test track trial was conducted in United Kingdom in 2011 where motorcyclists were permitted to use the ASL and no actual conflicts were recorded during the trial (Ball, Hopkin, Webster, & Anjum, 2011). Barcelona and Madrid in Spain also recorded the implementation of ASL for motorcyclists to reduce the risk of motorcyclist weaving through traffic to reach the head of the queue at signalized intersection (Organisation for Economic Cooperation and Development, 2015).

Hypothetically, by providing motorcyclists with a dedicated space at intersections as shown in Figure 1, the conspicuity of these road users are improved. Positioning motorcyclists in front of vehicle drivers, the direct field of vision decreases the risk of motorcyclists appear unexpectedly from "nowhere" when the traffic starts. The ASL meant to segregate motorcyclists from other motorised users is dependent on it being occupied during a red-time signal. ASL was implemented in Indonesia since 2010 and was called as Red Motorcycle Box (Mulyadi & Amelia, 2013). After the implementations, several studies have been carried out to evaluate the effectiveness of the ASL. A study related to the effect of the size of ASL and the length of red time operation by Mulyadi (2017) revealed that there is no significance difference of occupancy rate towards dimension of ASL area and red time operations. However, the study found that a combination of smaller ASL area and faster red time operation yield highest occupancy rate of just under 50%. In another study by Mulyadi (2017b), motorcycle occupancy of the ASL was between 33% to 68% but the implementation of ASL, in general, has increased the traffic flow at the studied intersection while the stop line violations reduced by 90%. In recent study, the ASL in Indonesia has also resulted in increasing the traffic flow and travel speed by 5% and 6% respectively (Nicholas & Mulyadi, 2018).

The ASL was also implemented in Taiwan since 1985 (Everington, 2018). There are two types of motorcycle box in Taiwan with specific functions as shown in Figure 2. The motorcycle box located behind the pedestrian crossing (numbered 1 in Figure 2) is for the motorcycles that wish to proceed straight through the intersection. The motorcycle box placed in front of the pedestrian crossing (numbered 2 in Figure 2) is for the motorcycles that intends to make a left turn and thus apprропiately named as a left-turn box. Instead of making a direct left turn (Taiwan adopts the left-hand right-side driving), left-turn-intended motorcylists are required to proceed to the number 2 motorcycle box cross the intersection when the traffic signals from that approach turns green. However, there was very limited information was found on the effectiveness of ASL in Taiwan.

Figure 1: The example of an ASL for motorcycle at one of the signalised intersection in Kuala Lumpur

Figure 2: Motorcycle box and left-turn box in Taiwan (Source: https://youtu.be/g4i47vTsVR8)



Within the past decade, Malaysia has dedicated various efforts on improving motorcycle safety such as providing additional kilometers of motorcycle lanes, improving helmet standards, and implementing various community based countermeasures at improving motorcycle safety. Agencies such as local municipalties have adopted improvement of safety for vulnerable road users such as motorcyclists by including related safety improvements in the city planning. As such, the ASL for motorcyclist are observed at some intersections in the metropolitan city of Kuala Lumpur. While various studies have discussed on the positive effects of the ASL for bicyclists, little known evidence exists on the effectiveness of similar applications for motorcyclist especially in developing countries like Malaysia, where the motorists' behaviours and traffic patterns are unique. Therefore, the purpose of this study is to shed light into the effective use of ASLs in Malaysia before the measures can be promoted at other locations. This research set forth to answer a research question on whether all road users sharing the road understand the ASL markings and behave as intended.

METHODOLOGY

This section is divided into data collection, onsite survey and analysis.

Data Collection

At the beginning of this study, the implementation of ASL in Malaysia is new. Kuala Lumpur City Hall has pioneered the usage of ASL at some of the intersection under its jurisdiction. Therefore, this study was only conducted at the selected intersection around Kuala Lumpur city. Recently the ASL was also observed in Ipoh city. However, limited or no study was published on the ASL usage in Malaysia. In providing a preliminary view on the implementation of ASL in Malaysia, this paper explores the compliance, misuse, and red-light running rate (RLR) at signalised intersection provided with ASL. Compliance defines as the number of motorcycles using the ASL during the red light phase while non-compliance refers to the number of motorcycles that do not utilise the ASL when remaining at the intersection during the red light phase. Misuse is the utilisation of ASL by other types of vehicle (i.e., passenger car, lorries or buses). In addition, the RLR occurs when the front wheels of a vehicle cross the ASL after the traffic signal changes to the red phase and the vehicle proceeds through the intersection while the signal was red.

Four (4) signalised intersections are reviewed in this study; three (3) four-legged intersection and one (1) three-legged intersection as shown in Figure 3. The selected intersections are within close vicinity to one another (200m - 450m), in the Kuala Lumpur city centre where the population is high and daily traffic congestion is an issue.

Figure 3: Location of the selected signalised intersection for study area

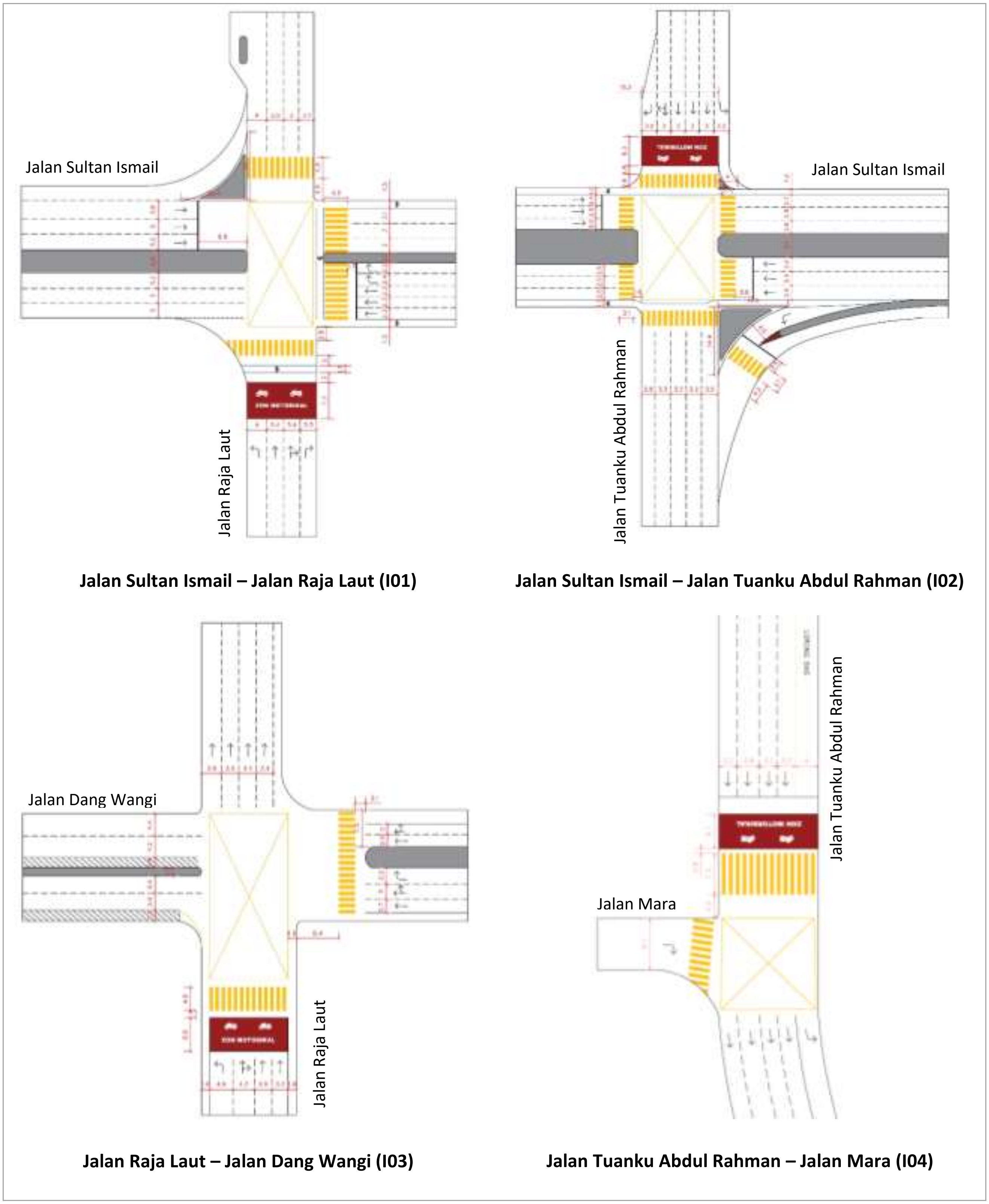
ASLs for motorcycle reviewed in this study have different dimension depending on the size of the intersection. Therefore, the capacity of the ASL also differs between location, as indicated in Table 1. The traffic signal system operates on an actuated system[1]. The study uses the average red time obtained from the phase timing. For all locations, ASL was only provided at only one (1) of the intersection leg as shown in Figure 4.

Table 1: Details of the selected intersection with ASL

Locations	ID	Intersection Type	ASL Dimension [Width x Length] (m)	Average Red Time (sec)	
				Off Peak	Peak
Intersection Jalan Sultan Ismail – Jalan Raja Laut	I01	4-legged with 3-way stopped controlled	7.3 m x 14.1 m = 102.9 m	130	151
Intersection Jalan Sultan Ismail – Jalan Tuanku Abdul Rahman	I02	4-legged with 3-way stopped controlled	6.3 m x 16.1 m = 101.4 m	117	116
Intersection Jalan Raja Laut – Jalan Dang Wangi	I03	4-legged with 2-way stopped-controlled	6.6 m x 15.5 m = 102.3 m	73	75
Intersection Jalan Tuanku Abdul Rahman – Jalan Mara	I04	3-legged with 2-way stopped controlled	6.1 m x 17.4 m = 106.1 m	84	86

[1] Actuated signals vary the amount of time (green or red) allocated to each phase based on traffic demand (Rodegerdts et al., 2004)

Figure 4: Sketch of the study location



Jalan Sultan Ismail – Jalan Raja Laut (I01)

Jalan Sultan Ismail – Jalan Tuanku Abdul Rahman (I02)

Jalan Raja Laut – Jalan Dang Wangi (I03)

Jalan Tuanku Abdul Rahman – Jalan Mara (I04)

Procedure

Data collection are categorised into four categories; geometric data of the intersection, traffic signal operation data (red phase timing), traffic operation data (volume), and traffic behaviour (compliance, non-compliance, misuse, and red light violation). The sample population were the vehicles entering and crossing the intersection from the ASL installed leg. The sample size is the number of observations in red phase obtained from four hours of data collection at each intersection using a video recording.

The data on intersection geometry and traffic signal operation was collected manually on site. Geometric parameters for intersection consist of the number of lanes, lane width, ASL dimension, as well as traffic direction. The red phase signal timing and the type of traffic signal system were part of the traffic signal operation data. The apparatus used for the onsite measurement and traffic signal operation were measuring wheel, measuring tape and stopwatch.

Traffic operation and behaviour data were extracted from the video recording captured on site. Unobtrusive video cameras were used to record traffic approaching and entering the intersection with a clear view of the signal indication and the stop line. Cameras were placed discreetly to ensure that drivers were not aware that the intersection was under video monitoring. Time period for intersection recording was for two (2) consecutive hours of morning peak (7.00 am – 9. 00 am) and two (2) hours of off-peak (10.00 am – 11.00 am and 12.00 pm – 1.00 pm) during fine weather on weekdays (Tuesday, Wednesday or Thursday). Traffic volume data were continuously recorded for each hour of data collection. However, traffic behaviour data was calculated during red phase only.

Statistical Analysis

The performance of the ASL was evaluated by the occupancy rate during red light phase where high occupancy rate may indicate the effectiveness of ASL provided and vice versa. Since the study on ASL in Malaysia is still new and limited, the assessment of occupancy rate was adopted from the study conducted by Mulyadi (2017a) as shown in Table 2.

Table 2: Assessment of occupancy rate by motorcycle to the ASL capacity

Occupancy Rate by Motorcycle to the ASL Capacity (%)	Assessment
>80%	Good
50% - 80%	Marginal
<50%	Poor

The occupancy rate is defined as the percentage of the number of motorcycles occupying the ASL during the red-light phase to the ASL capacity and can be translated into Equation 1. ASL capacity is defined as ASL area (width × length) divided by the required area for one motorcycle waiting during the red phase. In Malaysia, 95% of the registered motorcycles are small- to medium-sized with engines sizes of 150 cubic centimetres and below (Manan, Sim, Malik, Ghani, & Várhelyi, 2016). The dimension of a typical motorcycle is about 0.8 m in width, and 2.0 m in length, and this dimension was used in this study to estimate the ASL capacity.

Occupancy Rate by Motorcycle to the ASL Capacity =

$$\frac{\text{Average number of motorcycles that occupied the ASL}}{\text{ASL capacity}} \times 100\% \quad \text{............ Equation 1}$$

The ASL performance was also measured by the misuse rate of the ASL by other vehicles where the average number of misuse to average traffic volume for one-hour at each location. Compliance and misuse data were tabulated into a box-plot for comparison in pictogram forms.In addition, this paper highlights the RLR rate at the study location. RLR rate was measured from the average number of RLR to the average traffic volume by vehicle types for a one-hour duration. The RLR rate provides an overview of the safety issue at the selected study location.

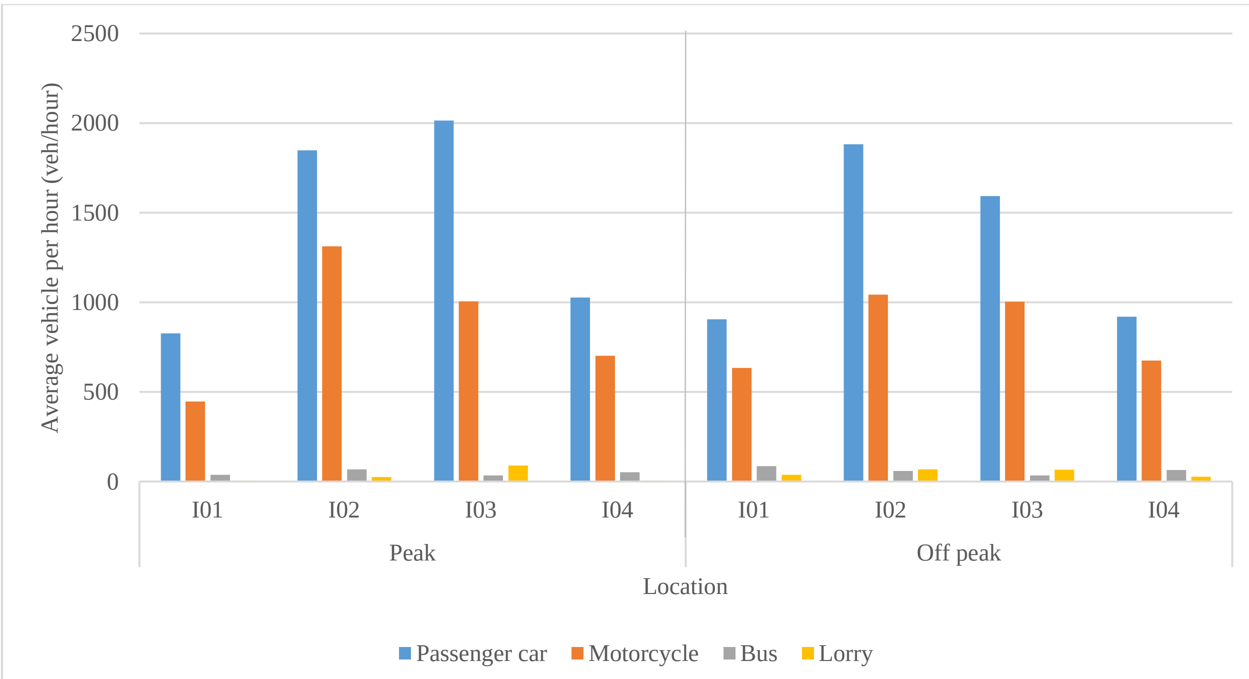
RESULTS AND DISCUSSION

A total of 16-hours data collection was conducted in this study i.e., four (4) hours at each selected signalised intersection. Results obtained was inclusive of traffic composition, ASL compliance, ASL occupancy, ASL misuse, and RLR rate.

Traffic Composition

The traffic volume study provides insight into the traffic composition at the study location. Figure 5 shows the average vehicle volume per hour based on vehicle type and location during peak and off-peak period. At all locations, passenger car type vehicles inclusive of car, van, MPV, SUV, and FWD dominates the traffic by 54% to 64%. The motorcycle is second highest group of vehicles with a percentage of 32% to 40%. The highest traffic volume observed was at location I02 (Intersection Jalan Sultan Ismail – Jalan Tuanku Abdul Rahman) with average traffic of 3,253 vehicles and 3,053 vehicles during peak and off-peak period respectively. The highest number of motorcycles can also be observed at the same location. On average, traffic volume was slightly higher during peak period (51%) compare to off-peak period (49%).

Figure 5: Average vehicle volume per hour based on vehicle type and location



ASL Compliance

Compliance, misuse, and RLR for a total of 494 red phase were observed over the duration of 16-hours of data collection. The traffic signal at the location was operated based on an actuated system. The signal phase shows slight difference during peak and off-peak period. The red phase for 3-way stopped controlled intersection (location I01 and I02) is longer than 2-way stopped controlled intersection (location I03 and I04) as indicated in Table 2. Table 3 summarises the frequency, minimum, maximum, mean, and standard deviation of the number of motorcycle compliance to ASL during the red signal phase.

Table 3: Descriptive analysis of motorcycle compliance to ASL

Statistic	Compliance (Inside ASL)	Non-compliance	
		In front of ASL	Behind ASL
Number of observations	3982	2473	512
Minimum	0	0	0
Maximum	39	52	46
Mean	8	5	1
Standard deviation	9	6	3

A total of 6,967 motorcycles was observed to stop at the intersection during the red phase. Out of that, 57% of motorcycles were found to have utilised the provided ASL while another 43% were recorded to stop either in front (35%) or behind (7%) the ASL. The percentage of motorcycle stopping in front of ASL is higher than those stopping behind the ASL. During data collection, it was observed that motorcycle stopping in front of ASL occupy the space provided for pedestrian crossing.

ASL Occupancy Rate

Compliance data were analysed by location to evaluate the ASL occupancy where the occupancy rate is calculated by percentage of ASL area occupied by motocycles during a single red phase. Table 4 summarises the occupancy rate by location.

Table 4: ASL occupancy rate by location

Locations	ASL area (m^2)	Motorcycle area (m^2) [0.8m x 2.0m]	ASL capacity (motorcycle)	Average number of motorcycle / red phase (motorcycle)	Occupancy rate (%)
I01	102.9	1.6	64	9	14
I02	101.4	1.6	63	21	33
I03	102.3	1.6	64	3	5
I04	106.1	1.6	66	4	6

Based on the assessment of occupancy rate suggested by Mulyadi (2017a), it was clear that all study location indicates poor ASL utilisation. The highest occupancy rate of 33% can only be observed at location I02 (Intersection Jalan Sultan Ismail – Jalan Tuanku Abdul Rahman) and this may be contributed by the high volume of motorcycle at the location.

ASL Misuse

Since ASL use pavement markings to separate the motorcycle from other vehicles at signalised intersection, the tendency of misuse of ASL is high during the red phase. Observation at the study locations found that a total of 448 vehicles including large vehicles such as buses and lorries, stopping in the ASL during the 494 of observed red phase (Table 5).

Table 5: Frequency, minimum and maximum number of misuse by vehicle types

	Passenger car	Bus	Lorry
Number of observations	429	14	5
Minimum	0	0	0
Maximum	7	1	4

Passenger car was recorded as the highest, making up more than 95% of all vehicles misusing the ASL. The maximum of 7 passenger cars was found to occupy the ASL during a single red phase, thus reducing the area available for motorcycle, impacting the number of ASL compliance by motorcyclist. A study in Oregon depicted that the misuse of bike boxes by other vehicles showed related diminishing frequency of use by bicyclist (Hunter, 2000). Misuse data was further plotted by location during peak and off-peak period as shown in Figure 6. The data indicates that higher misuse behaviour was observed during the peak period (62%) as compared to the off-peak period (38%).

Figure 6: Number of misuse vehicle based on vehicle type and location

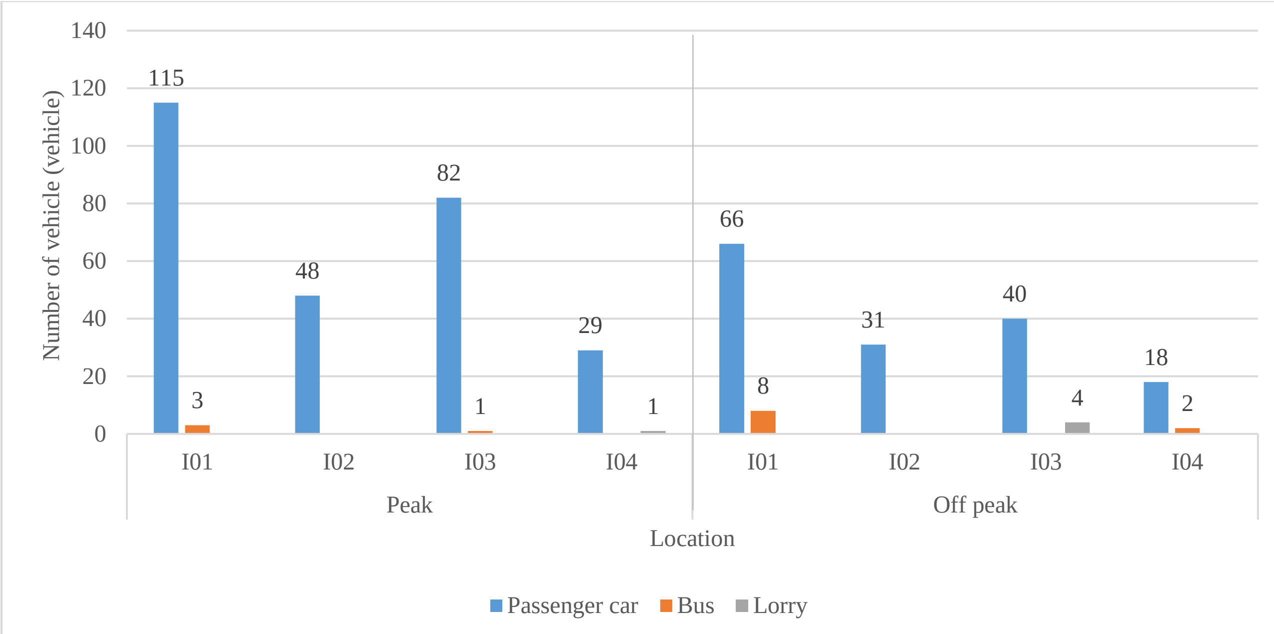
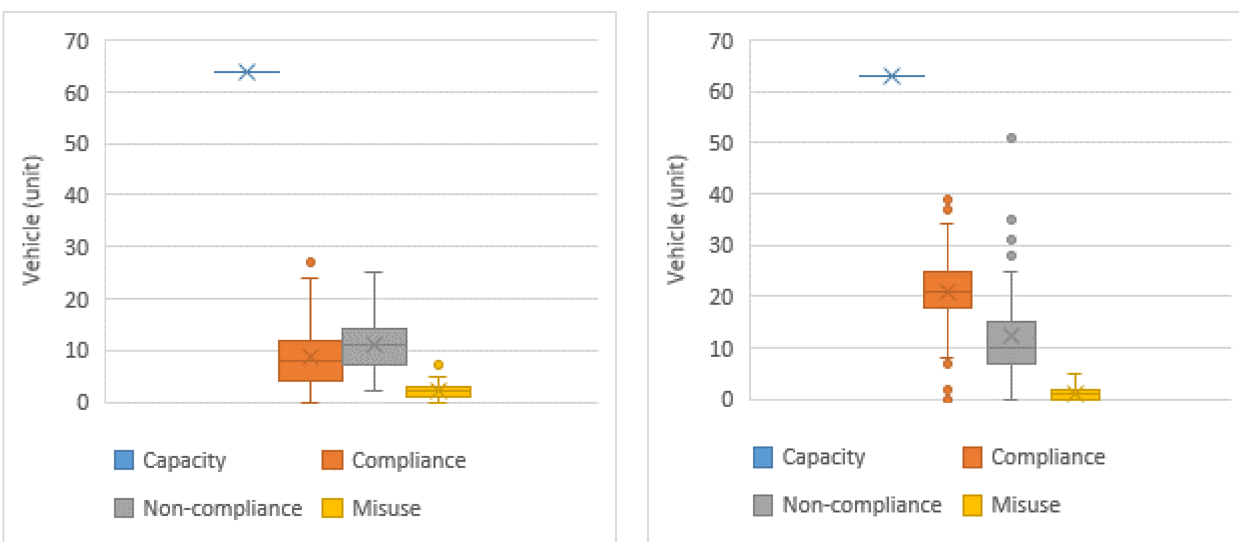
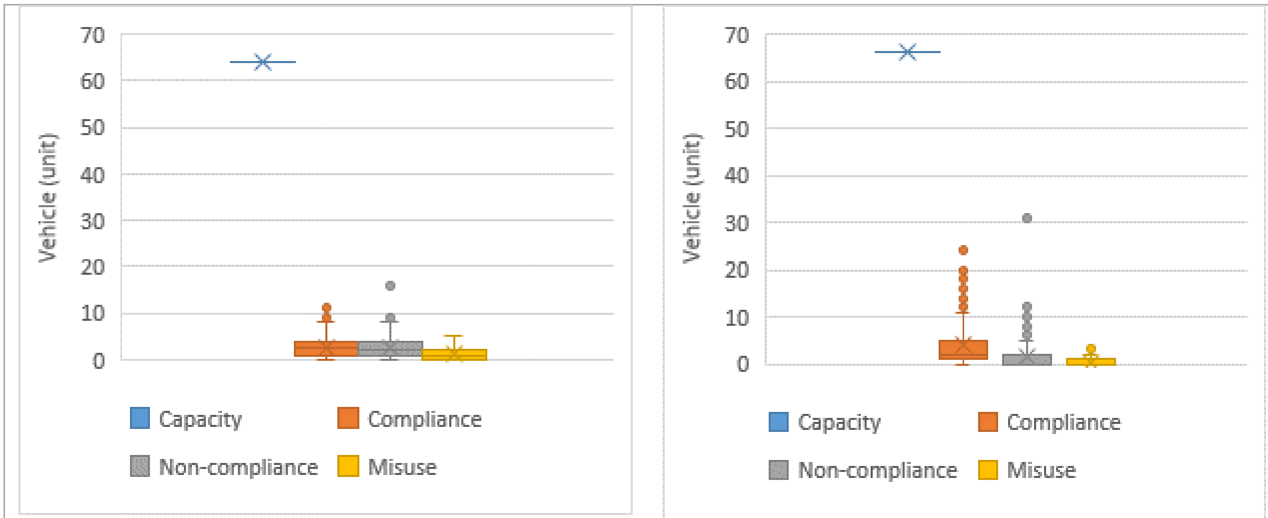


Figure 7 summarises the compliance, non-compliance, misuse, and capacity of ASL by location. It is evident that at all locations, compliance of ASL among motorcyclist is low and is reflected in the occupancy of ASL. ASL compliance was observed to be higher than non-compliance at two (2) locations; I02 and I04. The number of motorcycles stopping during red phase at intersection I03 and I04 was recorded to be low (less than 200 motorcycle per hour) although the volume of motorcycle was high (more than 800 motorcycle per hour) at both locations. Therefore, further analysis is required to study the rate of RLR at the study locations. It is anticipated that there is a correlation between motorcyclist stopping volume and RLR behaviour.

Figure 7: Box-plot of ASL capacity, compliancy and misuse



Location I01 Location I02



Location I03 Location I04

RLR Behaviour

Figure 8 shows the number of RLR, and Figure 9 indicates the RLR rate by vehicle type and study location. RLR rate was calculated from the average number of RLR per hour divided by average number of vehicles per hour. From the analysis conducted, the number of RLR is high among motorcycle with average percentage within 70% to 81%. This is followed by passenger car (47% - 53%), bus (3%) and lorry (1%). However, it was recorded that the RLR rate among bus and lorry is high at location I01 and I04 (8% and 8.3% respectively) during peak period and at location I03 (25%) during off-peak period. As predicted earlier, the RLR rate among motorcyclist is higher at location I03 and I04, affecting the occupancy rate of the ASL provided at both of the locations.

Figure 8: Number of RLR based on vehicle types and location

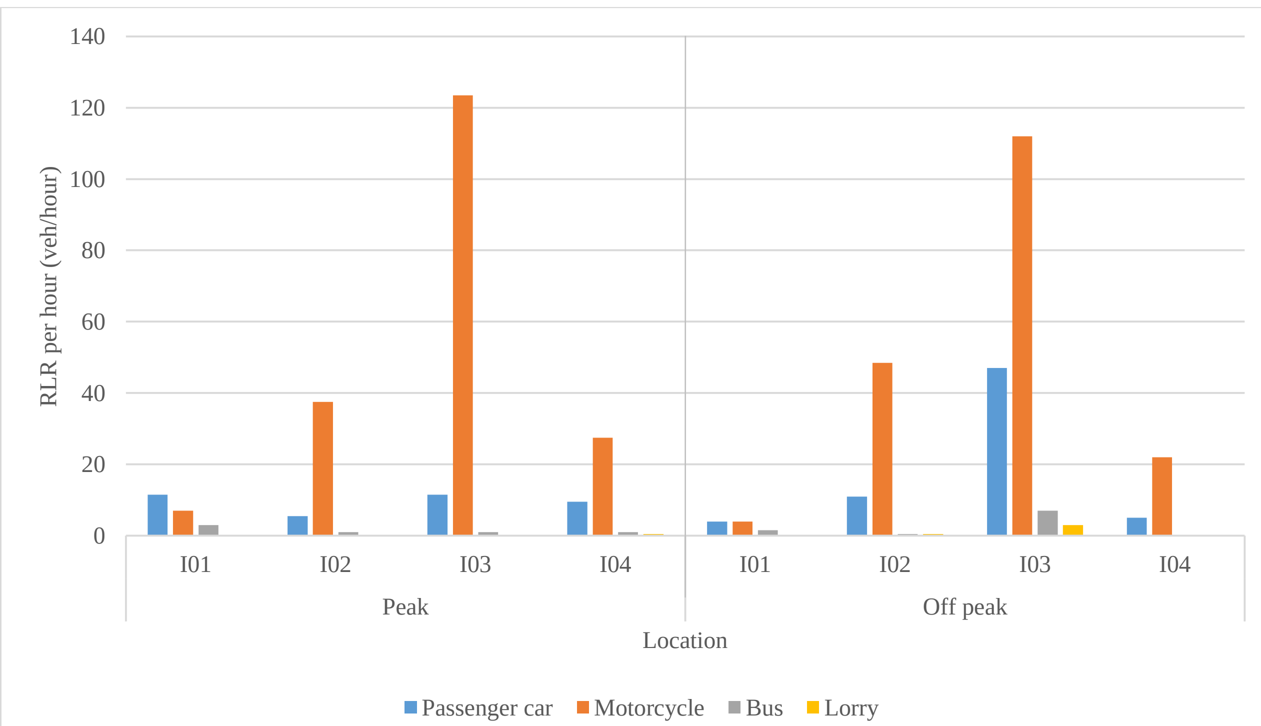
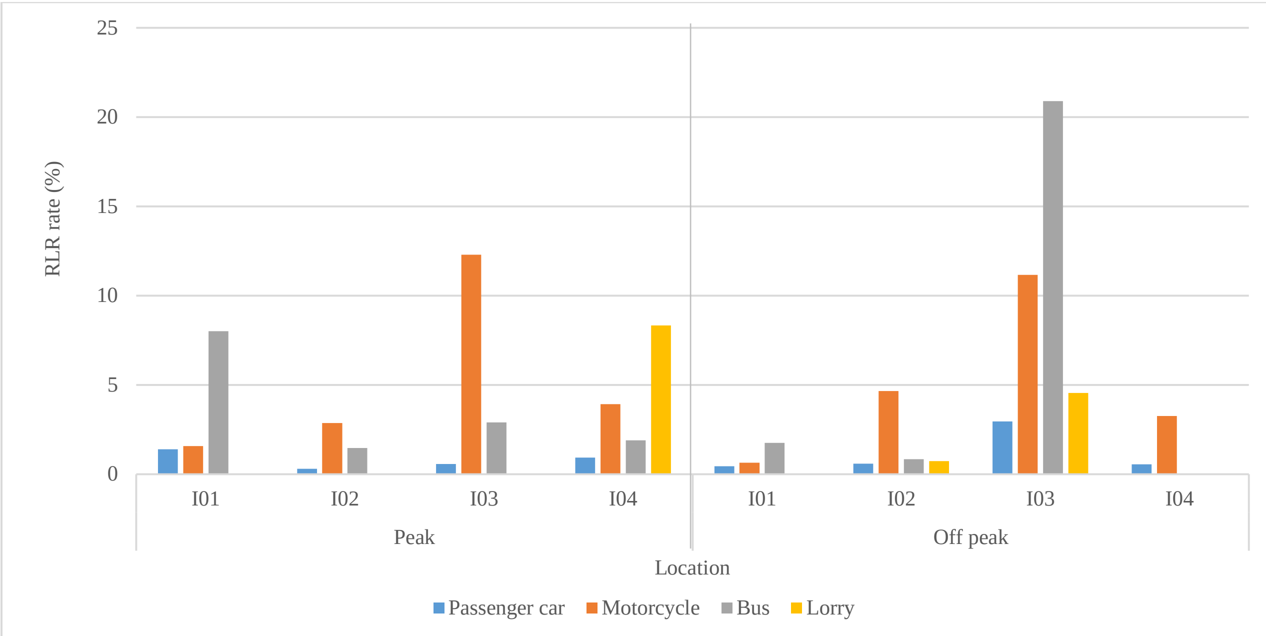


Figure 9: RLR rate based on vehicle types and location



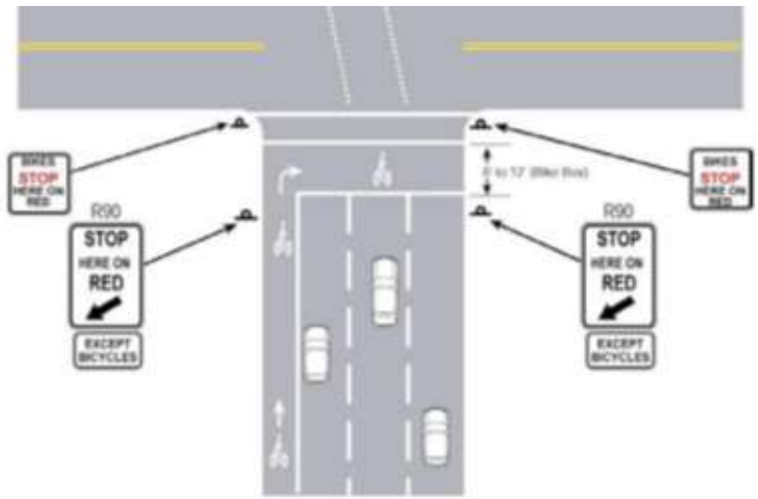
CONCLUSION

The increase in motorcycle ownership in Malaysia is one of the contributions to the increase in the number of road fatalities involving motorcyclist and pillion rider. The measures for providing ASL at signalised intersection was aimed to segregate the motorcycle from other vehicles at intersections while increasing motorcyclist visibility and safety. However, the success of the countermeasure depends upon the utilisation of the facility by motorcyclists. This paper address the current condition of ASL implementation in Malaysia. Based on data collection and analysis conducted, the conclusions to the implementation of ASL in this study are:

i. The compliance of ASL among motorcyclist obtained in this study are 57% while 35% were found to stop in front of the ASL and another 7% preferred to stop behind the ASL and between other road users.
ii. The occupancy rate of ASL was low at all study location where the maximum occupancy observed was only 33% i.e. at location I02. At other locations, the occupancy rate was below 15%.
iii. The low occupancy may be attributed by the misuse of ASL by other vehicles. During this study, maximum of 7 passenger cars were found occupying the ASL during a single red phase, thus reducing the area available for motorcycle inside the ASL.
iv. Observations also found that low volume of motorcycle stop at the signalised intersection during the red phase and this was contributed by the RLR behaviour among motorcyclist.

The low compliance and high misused rate for ASL maybe contributed by less understanding of the ASL marking. Since the marking is new to Malaysian users, it was suggested that the implementation of ASL should be coupled with provision of additional road sign for the road user informing the location where motorcycle and other motorised vehicle should stop as advised by Institute of Transportation Engineers (2003) and illustrated in Figure 10. In addition, the effectiveness if ASL can be improved if enforcement activity is increased at the intersection.

Figure 10: Suggested signage at ASL for bicycle



LIMITATION

This study was conducted after the local council implemented the ASL as well as with limited locations of countermeasures implemented. Further study can be conducted by including other control sites and observing stopping behaviors of drivers and riders in regards to the existing stop line. Collaboration with the local municipality may enable a before and after analysis of future sites of ASL implementation for further analysis.

ACKNOWLEDGEMENT

The authors would like to express their sincerest appreciation to the Director-General of the Malaysian Institute of Road Safety Research (MIROS), Siti Zaharah Ishak, Ph.D., for providing research grant and full support in completing this study. Deepest gratitude goes to the Acting-Director of Road Engineering and Environmental Research Centre, Muhammad Marizwan Abdul Manan, Ph.D., who has assisted in this study. Authors also would like to express the gratitude to research assistant's team; Mohd Saifullah Mohd Sohi, Azzemi Aziz, Suriani Bajuri and Saidatul Amanina Ariffin for their help and contribution towards the completion of this project.

REFERENCES

Allen, D., Bygrave, S., & Harper, H. (2005). *Behaviour at cycle advanced stop lines*. *TRL Limited*. Retrieved from http://trid.trb.org/view.aspx?id=840991

Atkins. (2006). *Advanced stop line variations research study*. *Transport for London (TfL)*. Retrieved from http://content.tfl.gov.uk/ASL-Findings-Report-October-011106.pdf

Ball, S. D., Hopkin, J., Webster, D., & Anjum, O. (2011). *PPR562: A track trial research study on allowing motorcycles use of Advanced Stop Lines.*

Dill, J., Monsere, C. M., & McNeil, N. (2012). Evaluation of bike boxes at signalized intersections. *Accident Analysis and Prevention*, *44*(1), 126–134. https://doi.org/10.1016/j.aap.2010.10.030

Everington, K. (2018). Removal of left turn boxes for scooters led to 40% fewer accidents in Taoyuan. *Taiwan News*, pp. 1–6. Retrieved from https://www.taiwannews.com.tw/en/news/3396951

Haque, M. M., Hoong, C.C., & Huang, H. (2009). Examining exposure of motorcycles at signalized intersection. *Transportation Research Record 2048(1): 60-65.*

Hunter, W.W. (2000). Evaluation of innovative bike-box application in Eugene, Oregon. *Transportation Research Record 1705(1):99-106.*

Institute of Transportation Engineers. (2003). *Innovative bicycle treatments*. City of San Francisco: Alta Planning & Design.

Manan, M. M. A., Sim, H. J., Malik, S. T. A. S. T., Ghani, M. R., & Várhelyi, A. (2016). *Motorcyclists' speed behavior and its contributory factors on Malaysian roads (In Press)*. Kuala Lumpur.

Ministry of Transport Malaysia. Retrieved from http://www.mot.gov.my/en/lands/road-transport/registration%20of%20vehicles

Mulyadi, A. M. (2017a). Influence of dimension box differences and time differences during operations of red box for motorcycles at signalized intersection. In *The 3rd International Conference on Construction and Building Engineering (ICONBUILD)*. https://doi.org/10.1063/1.5011560

Mulyadi, A. M. (2017b). Motorcycle red box evaluation at signalized intersections in Bogor : Traffic flow , occupancy rate and stop line violation. In *Regional Conference in Civil Engineering (RCCE)*. Surabaya, Indonesia.

Mulyadi, A. M., & Amelia, S. (2013). Influence of red motorcycle box to the traffic conflict and traffic flow at the Ahmad Yani-Laswi signalized intersection. *In 16th International Conference Road Safety on Four Continents. Beijing, China*, (May).

Newman A. (2002). The marking of advanced cycle lanes and advanced stop boxes at signalized intersection. City Streets Unit, Christchurch City Council, Christchurch, New Zealand.

Nicholas, M., & Mulyadi, A. M. (2018). Influence of the Red Box for motorcycle to the travel speed and traffic flow at the Margonda-Juanda signalized intersection. In *XXVth World Road Congress: Roads and mobility creating new value from transport* (pp. 11–12).

Organisation for Economic Co-operation and Development (OECD). (1998). *Safety of Vulnerable Road Users*. *Organisation for Economic Co-operation and Development (OECD)*.

Organisation for Economic Cooperation and Development (OECD). (2015). *Improving safety for motorcycle, scooter and moped riders*. Paris. https://doi.org/10.1787/9789282107942-en

Royal Malaysian Police. (2018), Statistical Report Road Accident, Bukit Aman, Kuala Lumpur: Traffic Branch.