CONSTRUCTION
E-ISSN: 2785-8731
VOLUME 3, ISSUE 2, 2023, 183 – 189
DOI: https://doi.org/10.15282/construction.v3i2.9606

RESEARCH ARTICLE

Motorcyclists Preferred Lane Position on Federal Roads in Malaysia

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ABSTRACT - Motorcycle fatalities comprised of 60% of the total fatalities in Malaysia. Weaving between traffic and speeding are among the contributors to the high motorcycle fatalities and there is not much understanding of the. This study was conducted with the objective to determine the lane preference of motorcyclists within various road cross-section and speed of motorcyclists when using the lanes. The lane usage was recorded with video camera and video was playback to count the count of motorcyclists using their respective lane. As for speed of motorcyclists, spot speed measurement was conducted covertly to avoid affecting motorcyclists' behaviour. A total of 11 locations with different cross-section designs throughout the Malaysia was identified for observation. The empirical results show that more than 95% of the motorcyclists travelled on the non-exclusive motorcycle lane (NEML) when the NEML is presence at 2 lane single carriageway section. Meanwhile, paved shoulder about 2.2-2.3m wide was found to be used by majority of motorcyclists (75%). Apart from obtaining the lateral travel position of the motorcyclists, the spot speed data were also collected. The speed results revealed that motorcyclists travelled statistical significantly slower on NEML or Paved shoulder (PS) than on main travel lane. The findings of this study conclude that NEML and paved shoulder can affect motorcyclists to ride slower and thus enhance the safety of motorcyclists in term of speed exposure. In addition, the NEML and PS separate motorcyclists from other motorized vehicles which could reduce the risk of crashes of motorcyclists with another vehicle. Even though provision of NEML incurs high costs, however in long term, NEML would prove to be one of the most efficient allocation resources in reducing motorcycle crashes. However, further studies need to be carried out on the use of paved shoulder by motorcyclists.

ARTICLE HISTORY
Received : 03rd Aug. 2023
Revised : 04th Sept. 2023
Accepted : 19th Oct. 2023
Published : 21st Dec. 2023

KEYWORDS
Motorcycle behaviour
Motorcycle lane
Motorcycle infrastructure
Paved shoulder

1.0 INTRODUCTION

Motorcycles consist of high percentage in road traffic in developing countries [1]. Whereas, motorcycle is the predominant mode of transport in Malaysia. According to statistics from the Road Transport Department, the number of registered motorcycles has increased from 9,985,308 in 2011 to 14,891,585 in 2020 [2] which translate to compound annual growth rate of 4.08%. Preference to use motorcycle is higher at urban area as population density at urban area is higher than at rural area [3]. The high number of motorcycles on the road has also increased the rate of crashes involving motorcyclists. The latest road traffic accident and casualties for 2020 recorded a total of 3,118 motorcyclists that have lost their lives in traffic crashes while another 9,129 were injured [2]. The motorcyclists' fatality for the year 2020 was the lowest in 10 years, however this is affected by the Movement Control Order (MCO) that was implemented that restrict long distance vehicle travel and vehicle travel was allowed only for basic needs such as to buy groceries and necessities. Even though the frequency of motorcyclists' fatality was low, the percentage of motorcyclists' fatalities was 67% from the total fatality which is the highest in 10 years. Road crashes involving motorcycles occurred due to judgement error of speed and distance from the riders or other vehicles [4].**Error! Reference source not found.** It has been proven that the positioning of a motorcycle on the road affects traffic movement and leads to road casualties. Therefore, motorcyclist deaths have led to a quandary for the relevant authorities and many countermeasures being devised to mitigate the problem.

One countermeasure to reduce crashes among motorcyclists is using road engineering approach to separate the motorcycle from the main traffic stream by providing motorcycle lanes. Motorcycle lanes segregate motorcyclists from other vehicles and reduce the conflicts between them; therefore, reducing the number of crashes. In Malaysia, there are two types of motorcycle lane, namely exclusive motorcycle lanes (EML) and non-exclusive motorcycle lanes (NEML) [5]. Paved shoulder was also mentioned as part of engineering approach for the road safety programmes for motorcyclists [6]. It is worth to note that Malaysia is perhaps the first country in the world in introducing exclusive motorcycle lanes [7].[7] EML is separated from the other traffic through the use of a traffic barrier structure. Radin Sohadi, R. U., et.al. (2000) found that with the provision of EML, motorcycle crash was reduced by 39% [8]. Whereas NEML is separated by specifically-designed separator markers painted on the road surface. NEML separator marking is 750mm in width with

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two continuous lines at the edge and hatchings in the middle. A study by Poi, W. A., et. al. (2019) indicated that NEML help in reducing motorcycle crashes [9]. However, not all the roads in Malaysia are equipped with EML and NEML.

Paved shoulder (PS) or an area with limited width parallel to the travel way is commonly designed to accommodate any breakdown and emergency vehicles as well as for lateral support for the base and surface courses [10]. For JKR's rural roads, the PS width varies as it is based on the road hierarchy and design and the width can be up to 3.0m [11]. Although PS is only for the use of emergency vehicles, a study by Hallmark, S. L., et. al. (2013). Found that provision of additional paved shoulder width and presence of paved shoulder reduces crash rate [12]. In another study by Kvasnes, S. et. al. (2021) has shown the odds of involving in a single motorcycle crash is lower for wider paved shoulder, although the result is not statistically significant [13].

Riding on the wrong side of the road is one of the factors that causes crashes [14]. However, in Malaysia, there is no law in regulating the motorcycle riding position on the roads. It is commonly observed that motorcyclists may travel on paved shoulder (PS), however PS is gazetted by law for the use of ambulance, fire engine etc or as a temporary stop area for vehicle breakdown. In terms of EML, a study which observed the naturalistic riding on the EML found that motorcycle riders felt safer to overtake another motorcycle whose position was closer to the left edge of the lane [15]. With the evolution of technology, the engine power of motorcycle has increased tremendously. It is reported that even with the presence of EML, the users of those superbike are reluctant to use EML. In term of PS, Bisht, L. S., & Tiwari, G. (2022) found that PS width of up to 1.5m have the safety benefit for all road user [16]. However, the safety of motorcyclists reduces on sections with more than 2m width, and the study also found that there were more rear end crashes sections with more than 1.5m PS than on sections without PS. In another study by, the result found that the frequency of head on crashes reduce by 0.303 by every unit increase in PS width [17]. Abdel-Aty, M., & Cai, Q. (2021) found that several variables positively increase the traffic safety and one of the variables is PS [18].

There is no guideline or procedure on the position of motorcyclists to ride on the travel lane. Motorcyclists would ride randomly on the road and weaving operation is common among some motorcyclists. Therefore, the aim of this study is to observe the lane position of motorcyclists on primary rural roads with different cross section designs and to compare the speed on PS or NEML and on main travel lanes. The findings contribute to the knowledge of how motorcyclists operate on the roads and provide an insight into the travel behaviour thereby formulating the most suitable countermeasures to improve the safety level as highlighted in Sustainable Development Growth (SDG) goal 3, target 3.6 to halve the number of global deaths and injuries from road traffic accidents by 2030 as desired by United Nations organizations [19.].

Therefore, this study is carried out with the objectives, to determine the motorcyclist's lane preference on different type of road cross sections and to compare the speed of motorcyclists on non-exclusive motorcycle lane or paved shoulder and on main travel lane

2.0 METHODOLOGY

This section highlights the methodology for this study which include the method for site selection, determination of motorcyclists' lane preferences and motorcyclists' speed on the preferred lanes.

2.1 Site selection

Site was selected randomly on the federal roads with various cross sections of different carriageway type such and cross sections. A total of 11 locations were selected for observations. **Table** 1.Table 1 lists the summary of 11 locations with their road characteristics, of which they were classified into seven (7) cross section types and lane usage proportions of similar cross section types is compared. The width of non-exclusive motorcycle lane (NEML) varied between 2.1 m to 3.4 m. The paved shoulder (PS) width varied from 1.3 m to 2.4 m, while some road sections only provided marginal strip (1m or less in width after the edge line). There were two locations Location 6 (L6) and Location 7 (L7) with paved shoulders with poor surface condition or paved shoulder with less than 1.4m width which discouraged motorcyclists from using the shoulder. The two locations (L6 and L7) were classified as cross section type with unfavourable PS. PS with favourable condition had a width of 1.9m or more, with a good surface condition. Data was collected during good weather condition and dry road surface as motorcyclists tend to avoid adverse weather conditions especially during rainy days.

Table 1. Characteristics of the observed locations

No.	Location	Cross section type	NEML/PS width	Route no.
1.	Tmn Banang Jaya, Bt Pahat (L1)	2 lane per carriageway which include NEML	2.6 m (NEML)	F5
2.	Tmn. Merbau, Sg Petani (L2)		2.6 m (NEML)	F1
3.	Bukit Banang, Bt Pahat (L3)		3.4 m (NEML)	F5
4.	Bt 8 Lekir, Manjung (L4)	2L1C with PS	2.4 m (PS)	F5
5.	Taman Desa Kamila, A Setar (L5)		2.3 m (PS)	F1
6.	Taman Sri Molek Bt Pahat (L6)	2L1C with unfavorable PS	2.4 m (PS)	F5
7.	Kanchong Darat, Banting (L7)		1.3 m (PS)	F5

Table 1. (cont.)

No	Location	Cross section type	NEML/PS width	Route no.
8.	Kepala Batas, Kedah (L8)	4L2C with NEML	2.1 m (NEML)	F1
9.	Seri Iskandar (L9)	4L2C with PS	1.8 m (PS)	F5
10.	Pedas, Rembau (L10)	4L2C without PS&NEML	< 1 m (PS)	F1
11.	Jeram, K Selangor (L11)		< 1 m (PS)	F5

Legend:
NEML = Non-exclusive motorcycle lane
PS = Paved shoulder
2L1C = Two lanes single carriageway
2L2C = Two lanes dual carriageways
4L2C = Four lanes dual carriageways

2.2 Motorcyclists' preferred lanes

The data collection was conducted during peak (7:00-9:00am or 4:30-6:30pm) and off peak (10:00-12:00pm or 2:00-4:00pm) period for a total of four (4) hours by using camera recording. Data was collected during peak and off-peak period to represent the typical vehicle traffic on federal roads. The data were then retrieved in the office for motorcyclist's lane preferences. On 2L1C and 2L2C road section with NEML/PS, motorcyclists had the choice to ride on NEML/PS or Lane1 (slow lane or left lane on main travel lane). Meanwhile, on 4L2C road sections, motorcyclists had the choice to ride on NEML/PS or Lane1 (slow lane or left lane) or Lane2 (fast lane or right lane).

Motorcyclists' lane usage proportion was determined and confidence intervals for the proportions was calculated. Chi square was applied using SPSS to determine the difference in proportions and to carry out test of independence of the lane width towards the proportion of motorcyclists using the lane.

2.3 Motorcyclists' speed on preferred lanes

Spot speed data was collected during off-peak hour (9:00-10:00am) or (2:00-3:00pm). Speed data was collected by using laser gun. Spot speed data was measured covertly to not affecting the road user behaviour. The difference between speed on NEML or PS and main travel lane was compared by applying independent sample t-test using SPSS software.

3.0 RESULTS AND DISCUSSION

This section discusses the results of the observation. The results are divided into 2 subsections: lane preferences and speed analysis.

3.1 Lane Preference

Figur 1 shows the lane usage proportion for 2 Lanes per carriageway road sections (2L1C and 2L2C) with NEML at Location 1 (L1), Location 2 (L2) and Location 3 (L3). Motorcyclists have the option to use NEML or Lane1. A chi square test indicates that there is no significant difference in NEML usage proportion between L1, L2 and L3, X^2 (df=2, N = 2129) = 2.763, p=0.251. This indicates that even though the location was different, similar cross section of 2L1C with NEML had similar usage proportion by motorcyclists.

In term of proportion of NEML usage, it was found that the usage proportion at L1 was 96% (95% CI [93.9%, 97.5%]), L2 was 97% (95% CI [96.3%, 98.1%]) while L3 was 96% (95% CI [94.5%,98.1%]). Therefore at 5% significance level, the evidence shows that more than 93%, 96% and 94% used the NEML at L1, L2 and L3 respectively. Overall, at 5% significance level, evidence shows that more than 95% of motorcyclist use the NEML.

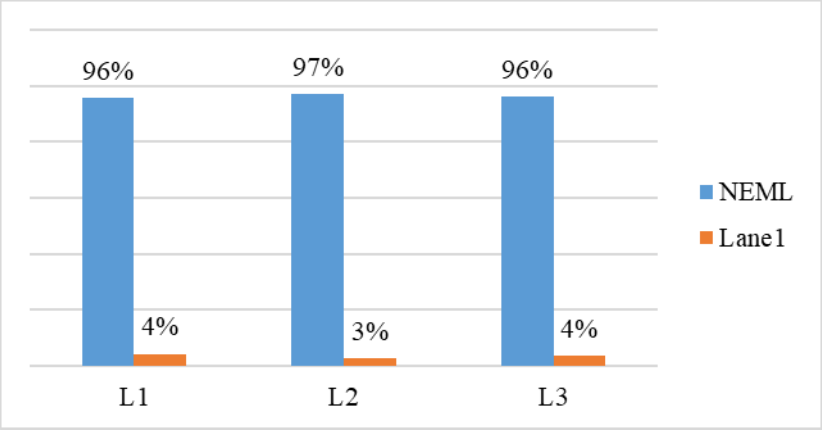

Figure 1. Lane usage proportion for 2 lane per direction which include NEML

Figure 2 shows the PS usage proportion for 2L1C road sections at Location 4 (L4), Location 5 (L5), Location 6 (L6) and Location 7 (L7). Motorcyclists have the option to use PS or Lane1. L4 and L5 have statistically significant higher proportion of PS usage as compared to L6 and L7. L4 have a PS usage proportion of 85% (95% CI [81.9%, 88.5%]) and L5 have a PS usage proportion of 73% (95% CI [70.7%, 76.1%]). This is because L4 and L5 have a wide paved shoulder ranging from 2.2-2.3m with good surface condition. Meanwhile, L6 have a poor PS surface condition while L7 have a narrow PS of 1.3m which were unfavourable by motorcyclists to travel on. As a result, L6 have a PS usage proportion of 49% (95% CI [45.5%,52.9%]) and L7 have a PS usage proportion of 54% (95% CI [49.9%,57.4%]). In summary, there is evidence at 5% significance level that on 2L1C with PS and width range of 2.2-2.3m with good surface condition, L4 and L5 have overall usage proportion of more than 74%. This translates to more than two third of motorcyclists that prefer to use PS with width of 2.2m or more with good surface condition on 2L1C road sections.

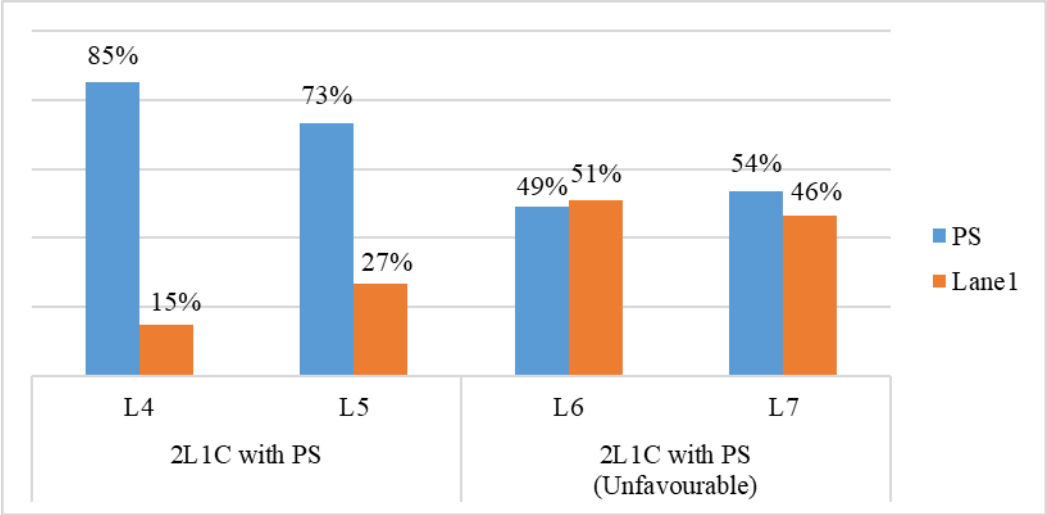

Figure 2. Lane usage rate for 2L1C road sections with PS

Additionally, the lane usage proportion was compared between narrow (1.3m width) and wide (2.3-2.4m width) PS and the usage proportion is shown in Figure 3. Chi square test was carried out and it was found that the PS usage is dependent on the width of the PS. X2 (df=1, N = 2170) = 120.442, p=5.06371E-28 (p<0.001), whereas PS usage rate was statistically significant more on wide PS than on narrow PS. Observation saw that there were 77% motorcyclists who used the wide PS as compared to 54% who used the narrow PS.

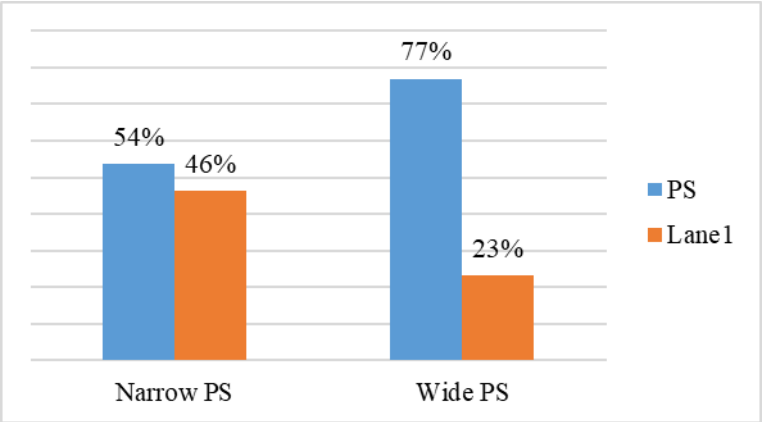

Figure 3. PS usage proportion on 2 lane per direction road sections

Figure 4 indicates the lane usage proportion for 4L2C road. For Location 8 (L8) and Location 9 (L9) motorcyclists have the option to ride on NEML/PS, Lane1 or Lane2. While at Location 10 (L10) and Location 11 (L11) motorcyclists have the option to ride on Lane1 or Lane2. At L8, the usage proportion of NEML was 58% (95% CI [54.5%,60.7%]). The separator marking at L8 was only one continuous line road marking similar to edge marking, which may affect the usage proportion. At 5% significant level, there is evidence that more than 54% of motorcyclists use the NEML which is more than half of motorcyclists, even though there is two more main travel lane with much wider width than NEML. At L9, there is PS with a width of 1.8m. The Usage proportion for PS or Lane1 was 38% and 39% which no statistically significant difference. It should be noted that lane usage proportion at L9 was affected as some motorcyclists used the main travel lanes to turn right at the traffic light about 200m downstream. Therefore, the observation shows significantly more proportion of motorcyclists used Lane2 (Right lane) as Lane2 is the right turn lane at the traffic light.

L10 and L11 was 4L2C road sections with less than 1m width paved shoulder. At L10, proportion of motorcyclists observed to use Lane1 was 86% (95% CI [83.2%,88.5%]). While at L11, proportion of motorcyclists observed to use Lane1 was 90% (95% CI [87.0%,93.0%]). This shows that at 4L2C without NEML or with narrow shoulder, motorcyclists tend to use Lane1. At 5% significance level, there is evidence that at 4L2C road sections without NEML or with narrow or no PS, more than 85% motorcyclists prefer to use Lane1.

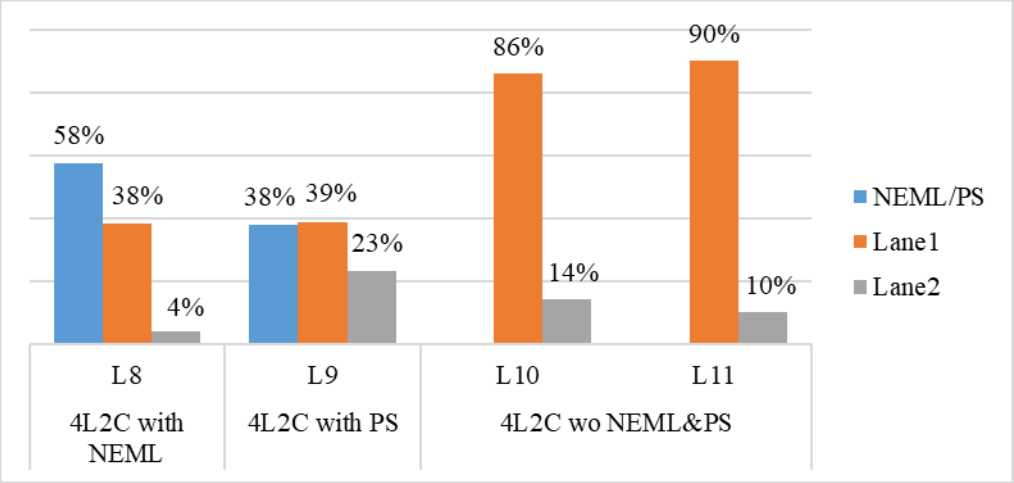

Figure 4. Lane usage proportion for 4L2C road sections

3.2 Motorcyclists' speed comparison speed between most preferred lanes

Speed comparison between motorcyclists riding on NEML and Lane1 was made at location with sufficient observation (more than 30 sample size for each lane at each location) using independent sample t-tests as shown in Table 2 and Table 3. It was found that speed of motorcyclists between NEML or PS and Lane1 was statistically significant. Specifically, the speed of motorcyclists on NEML was observed to be significantly lower (L8). This indicates that NEML or PS lane have the effect to reduce the speed of of motorcyclists hence improve the safety. The effect may be due to the narrower width of NEML and PS as speed of traffic will increase as the lane width increase [20].

Table 2. Motorcyclists' speed comparison between at NEML and Lane1

	NEML		Lane1		
Location	Mean (km/h)	SD (km/h)	Mean (km/h)	SD (km/h)	p-value
L8	57.1	9.8	73.9	12.8	< 0.01

Table 3. Motorcyclists' speed comparison between at Shoulder and Lane1

	Shoulder		Lane1		
Location	Mean (km/h)	SD (km/h)	Mean (km/h)	SD (km/h)	p-value
L5	61.5	11.4	68.1	12.3	< 0.01
L6	48.2	8.6	60.9	12.0	< 0.01
L7	55.3	12.3	68.9	11.9	< 0.01
L9	55.5	9.9	69.2	11.1	< 0.01

4.0 CONCLUSIONS AND RECOMMENDATIONS

Federal roads have various cross section designs such as single or dual carriageways roads or roads with various paved shoulder width and availability of motorcycle lane. This study observed the motorcyclists' lane preferences with respect to different road cross sections. The empirical results show that more than 95% of the motorcyclists travelled on the non-exclusive motorcycle lane (NEML) when the NEML is presence at two lane single carriageway section (2L1C). Meanwhile, paved shoulder width of about 2.2-2.3m wide was found to be used by majority of motorcyclists (75%). In addition, the analysis has shown that PS shoulder width affected the PS usage whereas significantly more motorcyclists use wide PS (2.3-2.4m width) as compared to narrow PS (1.3m width). Meanwhile, for 4L2C road sections, it was found that more than 85% of motorcyclists prefer to use Lane1.

Speed behaviour of motorcyclists was also measured using spot speed method. It was found that speed of motorcyclists on non-exclusive motorcycle lane (NEML) or paved shoulder (PS) were statistical significantly slower as compared to

speed of motorcyclists on the main travel lane. This indicated that NEML or PS could influence motorcyclists to ride slower which is a positive factor for road safety in term of speed exposure. In addition, the NEML and PS separate motorcyclists from other motorized vehicles which could reduce the risk of motorcyclists with other vehicle. Therefore, the provision of NEML could provide positive effects to the safety of motorcyclists. Even though provision of NEML incurs high costs, however in long term, NEML would prove to be one of the most efficient allocation resources in reducing motorcycle crashes. Even though there were evidence motorcyclists ride slower on PS and NEML and majority of motorcyclists tend to use the facilities, it is recommended to carry out further studies on the safety of the use of PS and NEML by motorcyclists.

There is little information about the riding behaviour of motorcyclist on Malaysia roads. The findings of this study provide some insights into the motorcyclists' riding patterns with respects to different type of cross sections. These findings can be used as a reference guide in new road planning as well as the budget allocation for infrastructure upgrading work. All in all, the aim of this work is to enhance the safety of motorcyclists on the roads which can ultimately reduce the fatalities in Malaysia.

5.0 AUTHOR CONTRIBUTIONS

Syed Tajul Malik Syed Tajul Arif: Conceptualization, Methodology, Software, Data curation, Writing- Original draft preparation, Visualization, Investigation, Software, Validation, Writing- Reviewing and Editing.

Ho Jen Sim: Writing- Reviewing and Editing.

Mohd Shafie Nemmang: Data curation, Writing- Original draft preparation, Software, Validation.

Nor Aznirahani Mhd Yunin: Writing- Reviewing and Editing.

Alvin Poi Wai Hoong: Supervision

6.0 FUNDING

The support provided by Malaysian Institute of Road Safety Research (MIROS) in the form of a research grant for this study is highly appreciated.

7.0 DATA AVAILABILITY STATEMENT

The data used to support the findings of this study are not included with the submission.

8.0 ACKNOWLEDGEMENT

The authors would like to thank the Malaysian Institute of Road Safety Research for providing the research grant and to all researchers, assistant research officers, and research assistants at Road Safety Engineering and Environment Research Centre (REER).

9.0 CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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