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Study on Lane Capacities of Motorcycles Under Controlled Conditions

Ricardo D. SIGUA [a], Glenn Simon LATONERO [b], Sahid KAMID [c], Sherman AVENDAÑO [d]

[a] *Institute of Civil Engineering, University of the Philippines, Diliman, Quezon City, 1101, Philippines; E-mail: rdsigua@up.edu.ph*
[b, c, d] *National Center for Transportation Studies, University of the Philippines, Diliman, Quezon City, 1101, Philippines*
[b] *E-mail: gdlatonero@up.edu.ph*
[c] *E-mail: skamid@gmail.com*
[d] *E-mail: sherman_291620@yahoo.com*

Abstract: With cars or other 4-wheelers as the dominant mode in the country, roads are generally designed without due consideration of the need of the motorcycle(MC) riders. In 2011, however, the implementation of motorcycle lane was started in some major arterials in Metro Manila due to frequent road crashes involving motorcycles. Rather than being exclusive though, the lanes are shared by other motorized vehicles. It may be appropriate at this time to recognize the needs of the motorcycles and its inclusion in the design guidelines. The study will help in the development of motorcycle design guidelines for the following applications: design of exclusive MC lane at road sections and at intersections and for intersection traffic signal control setting.

Keywords: Motorcycle, lane capacity, passenger car unit, saturation flow rate

1. INTRODUCTION

The number of motorcycles (MC) in the Philippines has increased rapidly over the last years. It is growing at a much faster rate compared to the other modes of transportation as shown in Figure 1. Currently, more than 50% of registered motor vehicles are MCs (LTO, 2016). However, no study has been done yet on the design requirements for exclusive MC lanes in the Philippines.

On the provision of separate lane/s for motorcycles, the government has to recognize the role MC plays in the transportation system. Everyone wants a share of the limited road space; 'Roads are very congested; can't afford to allocate dedicated lane for MC'. Provision of separate lanes for MC is more of a safety, rather than a capacity issue. Based on past studies by Umar, et al. (1995) traffic flow of more than 15,000 vehicles per day with 20 to 30% motorcycle volume would bring the ''greatest benefit" of a separate lane

The objective of the study therefore is to help in the development of MC guidelines for the following applications: a) design of exclusive MC lane – at road sections and at intersections; and for intersection traffic signal control setting.

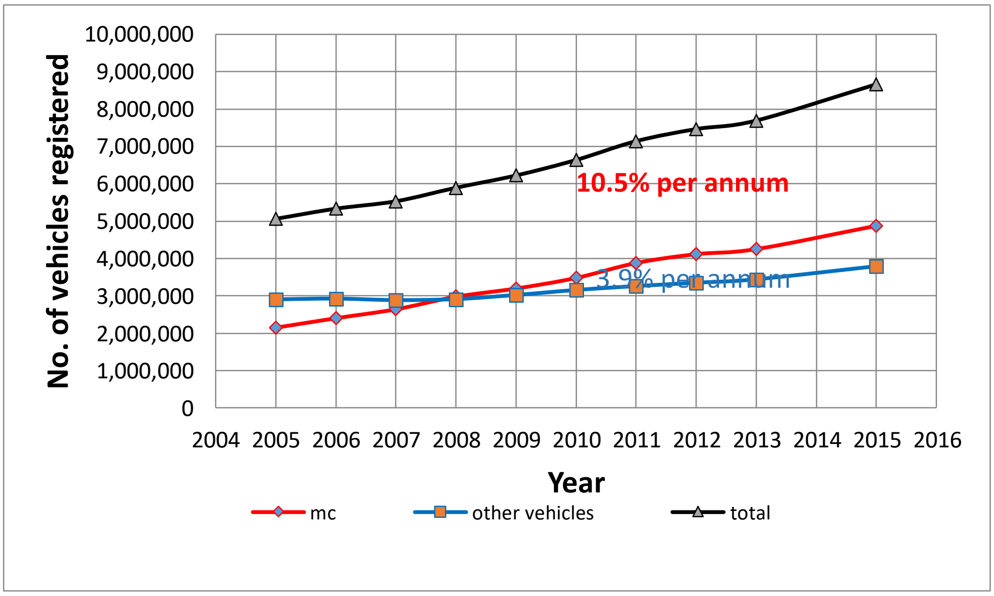


Figure 1. Number of vehicles Registered in the Philippines

2. LITERATURE REVIEW

The first exclusive motorcycle path in the world was said to be constructed along the Federal Highway Route 2 (F02) in the state of Selangor, Malaysia under the World Bank project during the early seventies Umar et al.(1995). Studies had shown that after the introduction of this 30km long (per direction) exclusive motorcycle path, the motorcycle road crashes per year was significantly reduced by 39%.

One of the most comprehensive studies on motorcycle lane was conducted by Hussain et al. in 2005. The findings of the study supported the general notion that segregation is the best engineering practice to save lives of vulnerable road users such as pedestrians, bicyclists and motorcyclists. In its continuous efforts to curb the key road safety problems in Malaysia, the government recognized this positive benefit and adopted a policy to provide motorcycle path along its new highways and the federal roads. The objective of the study was to establish the characteristics of the key components of a motorcycle-traffic system in Malaysia, i.e. the motorcycle/rider unit, motorcyclist space requirement, and motorcyclists riding manner along motorcycle paths of various lane widths. It highlights that the qualitative measures of motorcycle flow are similar to those used for vehicular flow, i.e. the freedom to choose desired speeds and to bypass others. Engineers were advised to avoid providing motorcycle paths of 1.7m wide or less unless the space is greatly constrained.

Cao and Sano (2012) presented a methodology to determine the motorcycle equivalent units (MEUs) in mixed traffic flow by considering the characteristics of moving vehicles, such as velocity and effective space. In addition, the effective space of each kind of vehicle was computed with consideration of the influences of velocity, physical size of the subject vehicle, and the surrounding motorcycles in the proposed methodology. Based on field data collected in Hanoi, Vietnam the results indicated that the MEU values of cars, buses, minibuses, and bicycles are 3.4, 10.5, 8.3 and 1.4, respectively. Moreover, the collection of the field data of vehicle flow and speed passing through road segments was conducted in three groups of divided roads with raised medians. The fundamental diagrams of vehicle speed-flow-density relationships, ranging from stable traffic flow to unstable conditions, were plotted and the values of capacity, maximum motorcycle flow, critical mean stream speed, and critical density of traffic flow were computed. Results indicated that the capacity values of urban roads with two, three, and four lanes per direction are 13,358, 21,725 and 24,335 (motorcycles per hour), respectively. The capacity, therefore, increases with the number of lanes of urban roads.

In Thailand, the idea of MC lane has been around for decades. In 2000, the Thai Cabinet approved pilot tests for four MC lane configurations: 1) a one-way lane on the shoulder of the Chiang Mai-Mae Rim Highway, having a 2.0m width and being marked out with a white 0.1m edge line; 2) a lane between a car lane and the road shoulder — two instances of this were set up in Phuket and Lampang provinces; 3) a semi-exclusive MC lane in Tak province where it is positioned on a strip along the left of the road shoulder, and marked out with intermittent barriers; and 4) an exclusive MC Lane, the trial for which has not yet been attempted. Despite the insufficient local data on this road feature, the Office of Transport and Traffic Policy and Planning (OTP) recommended guidelines for setting up MC lanes of varying capacities: For a lane with daily traffic up to 3,000 mc, the guidelines recommended a 2.0m lane for a one-way MC stream, to be positioned on a 3.0m wide road shoulder; for a daily traffic of 12,000 mc, the lane is to be exclusive for a one-way traverse and separated from other traffic lanes by green strips. Mama and Taneerananon (2006) sought to develop standardized configurations and widths for motorcycle lanes in Thailand. The optimum format for such a lane was determined from the simulation of data relating to road accidents, traffic volumes and vehicle speeds.

3. METHODOLOGY

Actual field experiment involving 102 riders of motorcycles was conducted (Figure 2). Aerial video footages using drone were taken and throughputs at various lane widths were determined. Both free flow condition and starting from stop (saturation flow condition) were observed.

Figure 2. Actual field experiment using drone

The most common motorcycles used in the Philippines have engine displacements from 110 to 125 cc. The breakdown of engine displacements of motorcycles owned by those who participated in the experiment is shown in Figure 3. Motorcycle riders were instructed to behave as they would normally do when riding on ordinary streets.

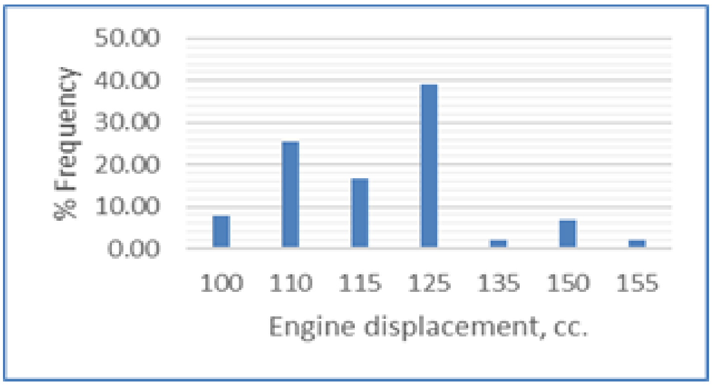


Figure 3. Breakdown of engine displacements of motorcycles

3.1 Survey Location

The survey was conducted inside the campus of the University of the Philippines in Diliman, Quezon City (Figure 4).

Figure 4. Survey locations located along University Avenue and Science Complex Oval

The stretch of the University Avenue was used as test track during weekend (Figure 5).

Figure 5 – Aerial footage of the straight section along University Avenue

The lane widths were varied from 1.5m to 3.0m. and were delineated by traffic cones as shown in Figure 6.

Figure 6. Varied lane widths (1.5m, 2.0m, 2.5m, 3.0m)

4. EXPERIMENT RESULTS

4.1 Number of motorcycles that can be stored at stopped condition

Figure 7 shows the average number of motorcycles that can be stored within a 12 meter long road section for various lane widths of 1.5, 2.0, 2.5, and 3.0m. The average number for each designated lane was determined by considering several randomly selected frames.

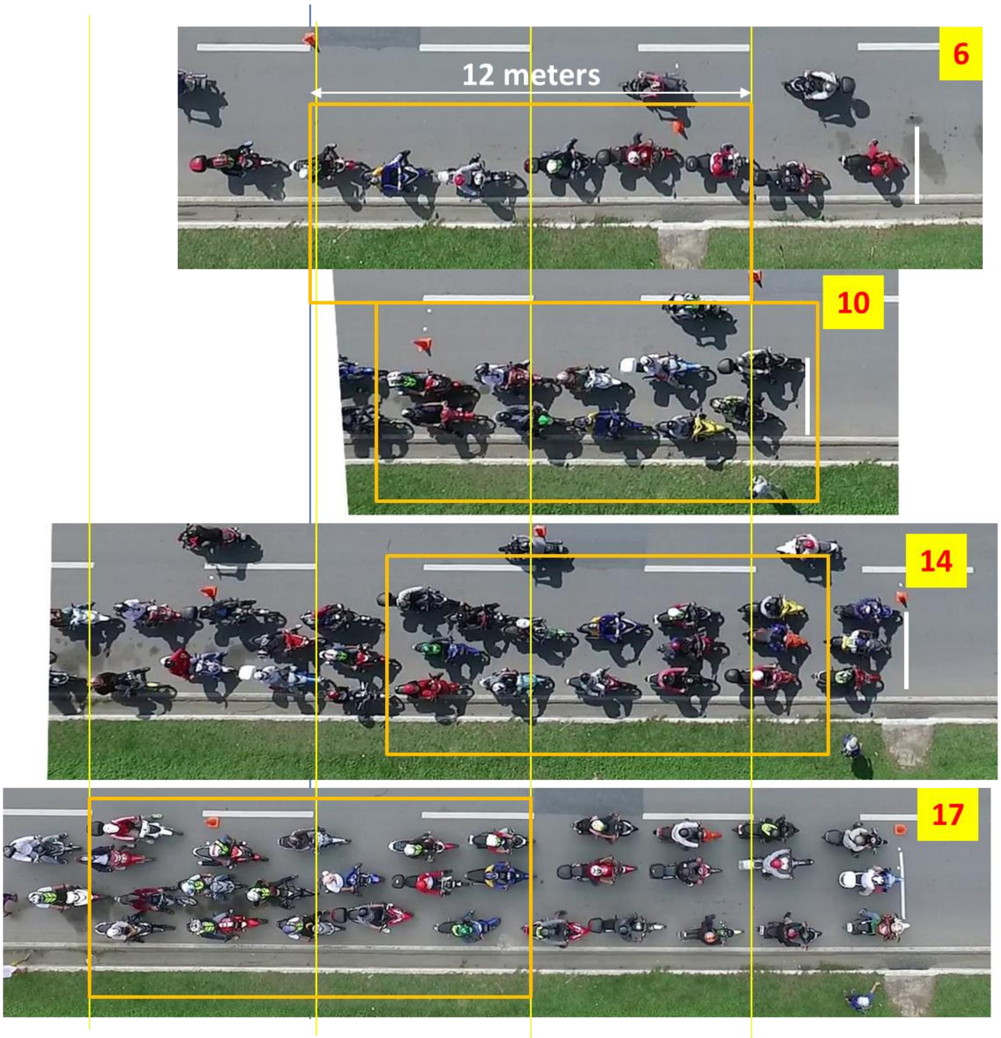


Figure 7. Average number of motorcycles that can be stored within 12m long road section (stopped condition)

The plot in Figure 8 shows the relationship of the number of motorcycles which can be stored in a 12 meter road section with varying lane widths.

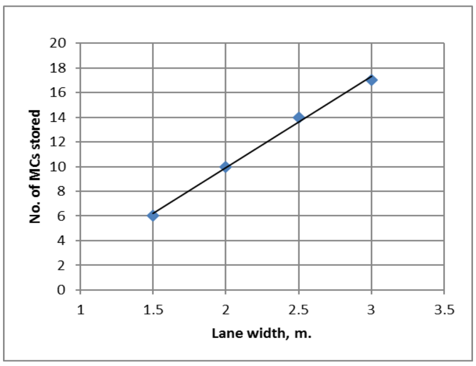


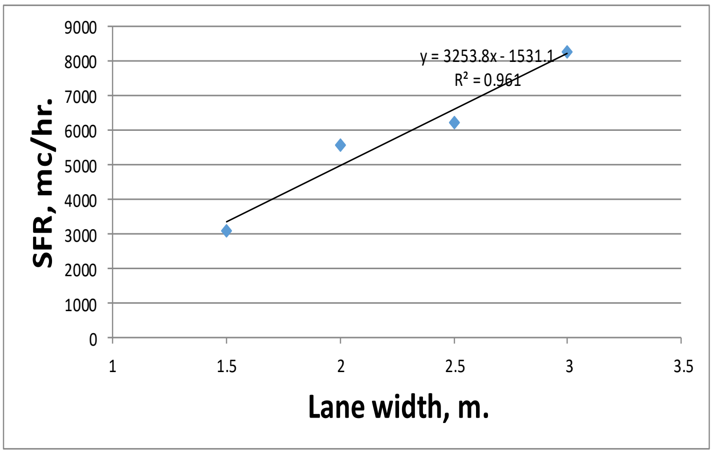
Figure 8. Average number of motorcycles that can be stored within 12m long road section (stopped condition)

4.2 Saturation flow rates

Used in traffic signal timing design, saturation flow rate (SFR) is the maximum flow rate that could be achieved when traffic starts from stop condition once given the green signal. During the experiment, motorcycle riders were asked to fall in line behind a stop line (Figure 9). The flow rate was then observed when the riders were given the 'GO' signal. Maximum flow rate may be observed during the first 3 to 4 10-sec. intervals. The average of these 3 to 4 intervals is taken as the saturation flow rate. Saturation flow rates for various lane widths were observed.

Figure 9. Saturation flow rates estimation

Figure 10 shows a very good correlation of saturation flow rate and lane width.



Lane Width, m.	SFR, mc/hr/lane.
1.5	3086
2.0	5554
2.5	6240
3.0	8280

Figure 10. Saturation flow rates and lane widths

A study by Nguyen (2016) gave a value of 11,352 MC/hr for a 3.5m lane width. Similarly, Hien (2007) gave a value of 11,241 MC/hr. If extrapolation is made for a 3.5m lane, Figure 10 above would result to a value of 11,389 MC/hr.

4.3 Flow relationships

In traffic flow theory, the three main variables used to describe traffic flow are volume (or flow rate), speed, and density. Figure 11 shows the scatter plot of the observed vehicular (4-wheeler) flow relationships at South Luzon Expressway (inner lane), (Sigua, 2008).

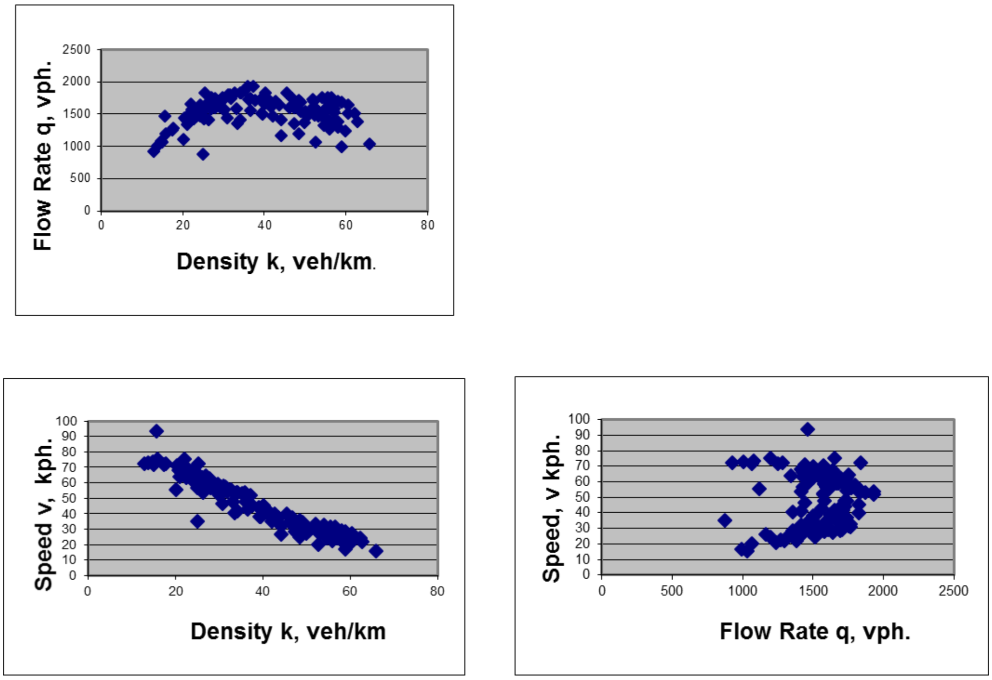


Figure 11. Scatter plot of observed vehicular (4-wheeler) flow relationships
(South Luzon Expressway, inner lane)

Typically, Greenshield's model as shown in Figure 12 would fit such scatter plots. The maximum flow or capacity may be calculated analytically.

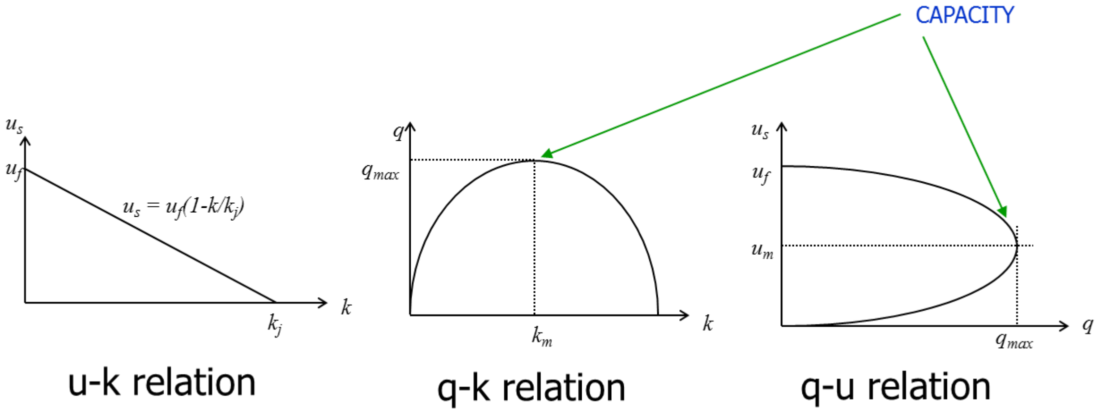


Figure 12. q-u-k relation

The three variables are related by the equation:

Flow rate = speed x density
or

$q = u_s \times k$

4.4 Motorcycle flow relationships for various lane widths.

Figure 13 shows the inverse relationships of speed and density for various lane widths. A linear model(Greenshield's) may be found to be appropriate.

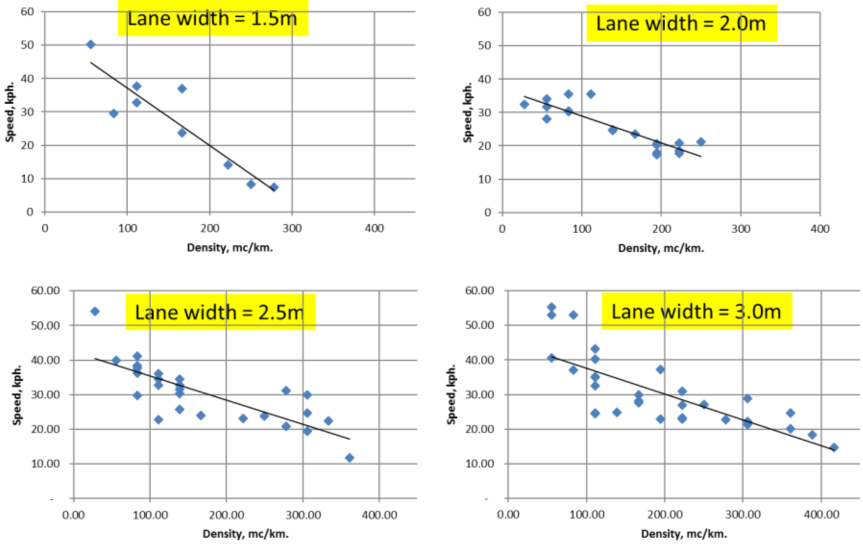


Figure 13. Speed and density relationships for various lane widths

4.5 Motorcycle lane capacity

The speed – density relation for a 3.0 meter lane width is selected as an example for capacity estimation. The flow rate – density relation is also plotted in Figure 14.

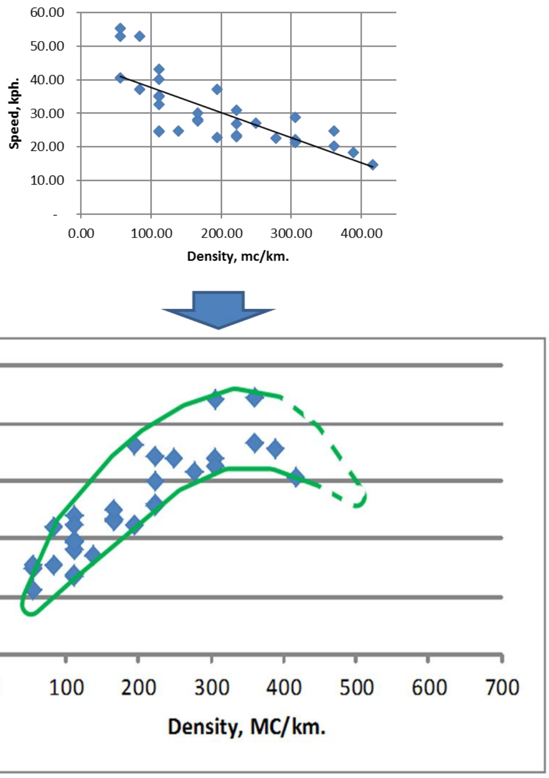


Figure 14. Capacity estimation

Although the plot is lacking some points at high density values, it may be surmised that the capacity can be estimated at around 9000 MC/hr. This flow would occur at a density, k of 350MC/km and Speed, u of 25kph.

4.6 Passenger Car Unit of Motorcycles

On roads where the dominant mode is the 4-wheeler vehicles, vehicles other than cars are converted to passenger car equivalent, herein called passenger car unit (PCU). PCU values are typically used for highway capacity analysis. It is noted however that, in some countries or cities where the dominant mode of transport is the motorcycle, traffic planners and engineers find it more convenient to use motorcycle unit (MCU) instead of the PCU. In this case, vehicles other than motorcycles are converted to motorcycle equivalent.

For the estimation of PCU of motorcycles using the data gathered in the survey, the case of lane width of 3.0m is used. For cars, the minimum accepted or safe headway is about 2 sec. (SWOV, 2012). This translates to 1 car every 2 seconds. Based on observed flow rates of motorcycles in 2 sec. during the experiment, an average of 4.1 motorcycles were counted. The PCU of motorcycle is therefore estimated as 0.24, i.e. 1.0/4.1. This provides a new value of motorcycle PCU which is about half of what is currently being used in capacity analysis (0.50 PCU). The result could help to reduce the green time requirement at a signalized intersection. A study by Huynh Duc Nguyen in Vietnam resulted to a PCU of 0.19 for a 3.5m lane based on a 5.35 MCU value of a car, i.e. 1.0/5.35.

5. CONCLUSIONS

The paper presented the methodology for the determination of the values of various parameters which are vital for the design of facilities for motorcycles. Although conducted under controlled conditions, the range of values obtained from the experiment compared well with values obtained from other ASEAN countries, in particular, Vietnam and Malaysia.

6. ACKNOWLEDGMENT

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REFERENCES

APEC, Motorcycle and scooter safety compendium of best practices, 2011.

Cao, N., Sano, K., Estimating capacity and motorcycle equivalent units on urban roads in Hanoi, Vietnam, Journal of Transportation Engineering, vol. 138 Issue 6, June 2012

Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.

Hussain H, Radin Umar, Ahmad Farhan, Dadang,Key Components of a motorcycle-traffic stream – A study along the motorcycle path in Malaysia, IATSS RESEARCH Vol.29 No.1, 2005.

Land Transportation Office (LTO), Motor Vehicle Registration, 2016.

Mama, S., Taneerananon, P., Effective motorcycle lane configuration: A case study of Southern Thailand, ENGINEERING JOURNAL Volume 20 Issue 3, 2006.

Nguyen, H., Saturation flow rate analysis at signalized intersections for mixed traffic conditions in motorcycle dependent cities, International Symposium on Enhancing Highway Performance, Transportation Research Procedia, Volume 15, 2016, pp. 694–708.

Nguyen, H. and F. Montgomery, Different models of saturation flow in traffic dominated by motorcycles. Journal of the Eastern Asia Society for Transportation Studies, 2007, pp. 2381-2395.

Radin Umar R.S., Murray G. Mackay, Brian L. Hills. Preliminary analysis of exclusive motorcycle lane along the Federal Highway F02, Shah Alam, Malaysia. “IATSS RESEARCH” 19 (2). (1995).

Sigua, R.G., Fundamentals of traffic engineering, University of the Philippines Press, 2008.

SWOV, Fact Sheet, Headway times and road safety, The Hague, Netherlands, December 2012.