Analysis of motorcycle unit (MCU) for motorcycle-dominated traffic with effective space approach (case study: Jalan Raya Lenteng Agung Barat dan Jalan Teuku Nyak Arief)

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Abstract. Number of vehicles especially motorcycle in Jakarta are increasing more than 9% per year. This condition can turn the traffic into motorcycle-dominated flow on several roads where the proportion of motorcycle is significantly higher than other vehicle. The purpose of this research is to analyze and determine the value of motorcycle unit (MCU) with effective space approach rather than using passenger car unit (PCU). This research tried to relate between vehicle speed and vehicle effective space, for each type of vehicle. This research was conducted on Jalan Raya Lenteng Agung Barat and Teuku Nyak Arief Street, South Jakarta, for four days from 07.00 am to 11.00 pm. The results of this study indicate that there is a very strong relationship between speed and effective space with the value of \( R^2 \) more than 0.9. MCU values for motorcycles is 1.0, for light vehicles is 2.04, and heavy vehicles is 2.64.

Keywords: motorcycle unit, MCU, PCU, effective space, speed

1. Introduction

Based on BPS DKI Jakarta in 2016, the number of motorcycles during 2011 to 2015 experienced the highest growth compare to other vehicles. The growth of motorcycle is up to 9.14% per year, while passenger car only 8.09% per year [3]. Due to significant portion of motorcycle in traffic e.g. in Jakarta, it is suggested that using motorcycle as a common unit rather than passenger car. Many methods have been established to estimate Passenger Car Unit (PCU), one of the methods is using effective space as vehicle will occupy the road during its flow. Effective space of vehicle (m²) is determine from effective width of running vehicle (m) times effective length of running vehicle (m). Minh et al (2010) [1] suggested that when deal with motorcycle-dominated traffic, use Motor Cycle Unit (MCU) as unit as follows:

\[
MCU_k = \frac{S_k(V_k)}{S_{mc}(V_k)}
\]

where:

- \( MCU_k \) = Motorcycle unit of vehicle type k
- \( V_k \) = The mean speed of vehicle type k (M/sec)
- \( S_{mc}(V_k), Sk(V_k) \) = Effective space of motorcycle and a vehicle type k at speed \( V_k \) (m²) respectively
This approach has been implemented in Vietnam with typical mixed traffic conditions are very common in most roads and highway. The purpose of this research is applying this approach in Jakarta which has common traffic conditions as Vietnam and compare the result. In this research, Jalan Teuku Nyak Arief and Jalan Raya Lenteng Agung Barat, South Jakarta were chosen.

2. Data Collections
Survey has been conducted to collect data in these two locations including road geometry, traffic volume, and speed. Road geometry data was obtained by measuring the length and width of the road using roller. Speed, volume, and effective space were analyze using video camera located at the pedestrian bridge above site location. Vehicle volume and speed has been collected during 7.00-11.00 AM for two days (Friday and Saturday) on these two locations. The result shown that motorcycle dominated the traffic for these two locations with average of 75% of traffic. The volume of peak hour is more than 7,000 vehicle per hour during 7.00 – 8.00 AM on Friday.

3. Results and Discussion
First location is at Jalan Teuku Nyak Arief. It has a two-lane road with 3 m width for each lane. The second location is at Jalan Raya Lenteng Agung Barat has three-lane roadway with 3 m width for each lane. For the purpose of this research, the observed lane is only lane 2 and 3. The observed length was measured 40 m, for each location.

3.1. Comparison analysis for speed with effective space of each vehicle

![Figure 1](image)

**Figure 1** The comparison between speed with effective space for motorcycles in two locations for four days

Figure 1 shows that location 1 and location 2 has slightly different result, this can be due to different road conditions (two and three lane) which can affect the value of the speed and effective space. But overall, the $R^2$ value is relatively the same. The curve shown that the higher the speed of motorcycle, the effective space is increase as well. This condition can be explained that during high speed the vehicle will using more space than lower speed and this is a common things and logic. The next two figures shown the same trend between speed and effective space for light and heavy vehicle. The different is only the trend of the curve.
Figure 2 The comparison between speed with effective space for light vehicles in two locations for four days

Figure 2 shows that the curve for light vehicle is slightly more vertical than previous one. This indicate that speed of light vehicle is more sensitive to effective space compare to motorcycle.

Figure 3 The comparison between speed with effective space for heavy vehicles in two locations for four days

Figure 3 shows that heavy vehicle has less average speed than other vehicles observed, and the curve is similar to light vehicle.

3.2. Recapitulation the value of $R^2$ in the relationship of speed and effective space

Table 1 Recapitulation the value of $R^2$ in the relationship of speed and effective space

| Location & Days | Motorcycle (MC) | Light Vehicles (LV) | Heavy Vehicles (HV) |
|----------------|-----------------|---------------------|---------------------|
| 1 (Friday)     | 0.9796          | 0.9882              | 0.9750              |
| 1 (Saturday)   | 0.9827          | 0.9882              | 0.9818              |
| 2 (Friday)     | 0.9731          | 0.7070              | 0.9710              |
| 2 (Saturday)   | 0.9886          | 0.9934              | 0.9908              |
Where the numbers one and two show the location of research:
1 = Jalan Teuku Nyak Arief, South Jakarta
2 = Jalan Raya Lenteng Agung Barat, South Jakarta

It can be seen from Table 1, the value of $R^2$ in the relationship of speed and effective space was slightly different. In this case, the next step is merging all data from both location and days for each category of vehicle. The result can be seen in next section.

3.3. The relationship between speeds and effective spaces seen from the type of vehicle

Figure 4 shows the relationship between speed and effective space of motorcycles

![Figure 4](image)

Figure 4 The relationship between speed and effective space of motorcycles

Figure 4 shows the relationship between speed and effective space of the entire data of motorcycles in both locations for four days. These samples are taken for the analysis of relationship between speed and effective space are the speed and effective space at 08.00 am - 09.00 am. The equation that will be used to find the MCU value can be found as $Y = -0.3763x^2 + 14.071x - 34.728$ with the value of $R^2$ is 0.9717. It means that the relationship between speed and effective space of motorcycle has a very strong relationship.

Figure 5 shows the relationship between speed and effective space of the entire light vehicle. The samples taken for the analysis are

![Figure 5](image)

Figure 5 The relationship between speed and effective space of light vehicle

The next step is do the same with other light and heavy vehicle. Figure 5 shows the relationship between speed and effective space of the entire light vehicle. The samples taken for the analysis are
from 08.00 am - 09.00 am. It was found that the equation of this relationship is $Y = -0.6085x^2 + 27.182x - 74.065$ with the value of $R^2$ is 0.9473.

Figure 6 The relationship between speed and effective space of heavy vehicle

Figure 6 shows the relationship between speed and effective space of the entire for heavy vehicle. The equation is found as $Y = 0.0998x^2 + 25.426x - 91.617$ with the value of $R^2$ is 0.9707.

3.4. Recapitulation of relationship between speed and effective space

The relationship between speed and effective space for each vehicle type, as follows:

- For motorcycle: $S_{mc} = -0.3763(V_{MC})^2 + 14.071V_{MC} - 34.728$
- For light vehicle: $S_{lv} = -0.6085(V_{LV})^2 + 27.182V_{LV} - 74.065$
- For heavy vehicle: $S_{hv} = 0.0998(V_{HV})^2 + 25.426V_{HV} - 91.617$

where,

$S_{mc}, S_{lv}, S_{hv}$ = The effective space of motorcycle, light vehicle, heavy vehicle.

$V_{MC}, V_{LV}, V_{HV}$ = The average speed of motorcycle, light vehicle, heavy vehicle.

Table 2 The MCU value

| Location & days | Motorcycle (MC) | Light Vehicle (LV) | Heavy Vehicle (HV) |
|----------------|----------------|--------------------|--------------------|
|                | Speed (m/s)    | MCU                | Speed (m/s)        | MCU                | Speed (m/s) | MCU    |
| 1 (Friday)     | 11.48          | 1.00               | 11.44              | 2.04               | 10.74       | 2.64   |
| 1 (Saturday)   | 12.89          | 1.00               | 10.58              | 2.02               | 10.12       | 2.54   |
| 2 (Friday)     | 7.66           | 1.00               | 6.97               | 1.90               | 6.94        | 2.00   |
| 2 (Saturday)   | 7.35           | 1.00               | 6.62               | 1.89               | 6.71        | 1.95   |

From this table it can be found the different of average speed for each location is high. The average speed must represent average speed in urban area especially in Jakarta. According to Ministry of Transportation, average speed in Jakarta is about 10 to 20 km per hour which represent speed of LV 6.62 or 23.8 km per hour. It shown that the MCU for LV and HV is about 2.0.
Table 3 The MCU value from other research [1]

| Location & days | Motorcycle Speed (m/s) | MCU | Car Speed (m/s) | MCU | Mini Bus Speed (m/s) | MCU |
|----------------|------------------------|-----|----------------|-----|----------------------|-----|
| 1              | 4.59                   | 0.98| 9.35           | 2.20| 8.89                 | 3.45|
| 2              | 5.07                   | 1.00| 9.43           | 2.19| 9.27                 | 3.33|
| 3              | 3.98                   | 0.94| 7.42           | 2.54| 6.06                 | 4.52|

Table 3 shows the result of MCU in Vietnam using effective space method. The result shown that MCU value is more or less the same with this research. Moreover, higher number of MCU for car and mini bus can represent the driver behavior in Indonesia are different compare to Vietnam.

4. Conclusion
The value of $R^2$ shows the relationship between speed and effective space very high ($R^2$ value above 0.9) means that speed and effective space is highly connected. It can be shown that if the speed of vehicle is low, then effective space value is also low, and vice versa. This condition can be explained that the driver need more space for safety reason in higher speed. This safety space condition can be different depend on driver behavior.

The MCU value of motorcycle is 1.00, while the MCU value for light vehicles is 2.04, and MCU value for heavy vehicles is 2.64.

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