Road Performance Analysis Using PCE MC Value 0.17 on Rungkut Madya Road

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Abstract

Passenger Car Equivalent (PCE) is a conversion factor from various types of vehicles into passenger car units (pc). The PCE value in the 2014 Indonesian Road Capacity Guidelines called PKJI 2014 has a long period with the present. The purpose of this study is to prove that there is a change in current traffic characteristics with the traffic characteristics described in the PKJI 2014. To prove this, the study was conducted by comparing road performance using the PCE MC value according to the PKJI 2014 with research that has been done previously with the results of PCE MC using the modified average headway time method showing 0.17 results. The location of this research was carried out on the Rungkut Madya road (2/2 UD), Surabaya City, East Java, Indonesia. The results obtained from this study are the use of PCE MC according to the PKJI 2014, resulting in a theoretical speed value close to the actual speed value compared to using modified PCE MC. So that the calculation of the performance of the Rungkut Madya road or other roads with similar characteristics does not require modification of the PCE MC value.

Keywords: passenger car equivalent (pce), urban road, vehicle volume

INTRODUCTION

Surabaya is the second largest city in Indonesia after Jakarta. The population of the metropolis reaches 2,874,314 people (calculation in 2020). Therefore, public facilities that aim to support the community’s needs continue to grow. Some examples include the center of business, trade, industry, and education. One road with a high density and activity is Rungkut Madya Road. The number of facilities on Rungkut Madya Road is one factor causing traffic jams. This is also supported by the existence of a university located on this road. Of course, this condition is one of the factors that makes the volume of vehicles around Rungkut Madya Road increase and have the potential to be jammed. In estimating traffic volume, it can be done in several ways, one of which is the calculation of traffic at peak hours (morning, afternoon, and evening) on weekdays [1].

Traffic behavior has also changed a lot compared to some of the provisions that apply in the PKJI 2014 [2]. Many factors, including the percentage of the number of motorcycles and the aggressiveness of motorcyclists, cause these changes. Traffic conditions on roads in Indonesia are heterogeneous, as can be seen from the number of fast-moving vehicles (such as motorbikes) and slow-moving vehicles (such as rickshaws) sharing the same road [3].

Vehicles have different equivalence numbers with passenger cars, commonly called passenger car equivalence (PCE)[4]. The PCE value for light vehicles is 1. The PCE number for each type of vehicle is broadly divided into two, namely at intersections and roads [5].

The average time headway method is used to calculate the PCE value. However, in the research conducted by Alfiansyah (2021) regarding the case study of Malang City Street Veterans, the PCE value for motorcycle calculation concluded that the average time headway method was not suitable for direct use. This is because in the field, the principle of measuring headway time is used when vehicles are traveling simultaneously, while the basic principle of this method is to estimate when a motorcycle moves sequentially in a similar path [3]. The Average Time Headway method needs to be modified so that the PCE MC calculation can reflect the actual conditions.

To determine the PCE value, SWEAROAD suggests three ways, each with a basic approach, namely based on the speed of traffic flow, based on capacity and time slot method. The first method tends to be more common, but requires data rates and traffic volume per composition of vehicles. The second method is used for roads in urban environments and requires traffic volume per composition of data. The third method is more suitable for use at intersections or inter-city roads, but traffic flows must follow high traffic discipline, namely walking in one lane. Together so that the time gap is evident [6].

Some researchers state that the passenger car equivalent (PCE) can be calculated using several methods such as: the homogenization coefficient, semiempirical method, walker method, multiple linear regression method, headway method, simulation method, and objective method. Calculation of traffic flow data is carried out hourly for a certain period; it can be seen the volume of traffic
The headway method is one way to determine the PCE value by recording the time between successive vehicles when they pass a predetermined point. This headway method is suitable for intersections or inter-city roads that flow through traffic the traffic follows high discipline, namely walking in one lane together so that the time between vehicles becomes apparent [9].

The headway method is the ratio of the average time between certain types of vehicles divided by the average time between passenger cars Recording of intermediate times with this method is calculated from the bumper the rear of the vehicle in front with the rear bumper of the vehicle following it [10]. Comparison of the capacity method, density method, and headway method to find the PCE value, it can be concluded that the headway method is the most appropriate method used to find the PCE value on expressways. The same research using the time gap method on the Rungkut Madya road.

Based on research by Alfiansyah, it is said that PCE MC is calculated using the time headway ratio method between MC and LV. The time headway data was obtained from the survey results using a video camera and then the headway time was recorded in the LV-LV, LV-MC, MC-LV and MC-MC categories. Based on the results of recording the average time headway for LV-LV is 2.77 seconds, LV-MC is 2.13 seconds, MC-LV is 2.29 seconds and MC-MC is 1.52 seconds. So that the previously calculated PCE MC value of 0.54 is then applied to the calculation of road performance analysis based on the MKJI 1997 [3]. Then the performance of the road segment is compared with the performance of the road section which is calculated using the standard PCE MC that has been set, which is 0.25.

While the calculation of the PCE value Based on the results of research conducted by Primasari and Alfiansyah, the calculation of PCE using the average Headway time method in general is the ratio between Headway MC-MC time and LV-LV where the smaller the Time Headway MC-MC, the more small value of the resulting PCE MC and otherwise. Meanwhile, the smaller LV-LV time headway value, the greater the resulting PCE value and so on. The PCE MC value in the previous study was 0.17. Where this is caused by the dimension factor of 0.31. The dimension factor is needed because in actual conditions, one lane can be passed by more than one motorcycle [2].

**RESEARCH METHODS**

This research was conducted by comparing the performance of the road segment using the Passenger Car Equivalent for Motorcycle (PCE MC) value according to the PKJI 2014 with the modified PCE MC value of 0.17. Then the performance of the road segment is compared with actual conditions based on vehicle speed. The primary data needed in this research is traffic volume and local speed. The traffic volume survey was conducted on Mondays at 16.20-18.20 where this time is predicted to be the peak hour of traffic volume on weekdays. Local speed surveys were conducted at the same time as samples of light vehicles, heavy vehicles, and motorcycles.

The traffic volume survey was conducted on Monday at 16.20 - 18.20 at Rungkut Madya Road to obtain the rush hour volume in the afternoon, which was used as input for the actual road. Traffic volume logging is recorded every 5 minute intervals during the survey hour period using a traffic counter application. After that, the data is processed to get the values of Free Flow Speed, Capacity, Degree of Saturation, and Theoretical Speed based on PKJI 2014.

**A. Free Flow Rate (\(v_0\))**

The speed of a vehicle that is not affected by the presence of other vehicles, namely the speed at which the driver feels comfortable to move in geometric, environmental and traffic control conditions that exist on a
road segment without other traffic (km/h). \( V_B \) passenger car type is defined as the basic criteria for road segment performance. \( V_B \) values for heavy vehicle and motorcycle are set as reference only. \( V_B \) for passenger car is usually 10-15% higher than other vehicle types. \( V_B \) calculated using the equation:

\[
V_B = (V_{BD} + V_{BL}) \times FV_{HS} \times FV_{UK} \quad (1)
\]

Description:
\( V_B \) = free flow velocity for passenger car under field conditions (km/h), 
\( V_{BD} \) = basic free-flow velocity for passenger car, 
\( V_{BL} \) = speed adjustment value due to road width, 
\( FV_{HS} \) = adjustment factor for free flow due to side barriers on roads that have shoulders or roads equipped with curbs/pavements with the curb distance to the nearest obstacle, 
\( FV_{UK} \) = independent speed adjustment factor for city size.

B. Degree of Saturation (DS)

DS is the main measure used for determine the level of performance of the road segment. DS value shows the quality of traffic flow performance and varies from zero to one. Value that approaching zero indicates an unsaturated current, which is a quiet current condition where the presence of vehicles others do not affect other vehicles. Values close to 1 indicate current conditions at capacity conditions, medium current density with a certain current speed that can be maintained for at least an hour. Dcalculated using the equation:

\[
D = \frac{Q}{C} \quad (2)
\]

Description : 
\( D \) = degree of saturation, 
\( Q \) = traffic flow (pc/hour) 
\( C \) = capacity (pc/hour)

C. Capacity

Capacity is defined as the maximum current through a point in the road that can be maintained per unit hour under certain conditions. For two-lane two-way roads, the capacity is specified for two-flows (two-way combination), but for roads with multiple lanes the flow is separated per direction and the capacity is determined per lane. Capacity values have been observed through field data collection wherever possible. Capacity is expressed in Passenger Car Units (pc).

The basic equation for determining capacity according to the 2014 PKJI is as follows:

\[
C = C_0 \times F_{CL} \times F_{SA} \times F_{HD} \times F_{UK} \quad (3)
\]

Description : 
\( C \) = capacity (pc/hour) 
\( C_0 \) = base capacity, pc/hour

\( F_{CL} \) = capacity adjustment factor related to the width of the lane or traffic lane 
\( F_{SA} \) = the capacity adjustment factor regarding direction separation, only on undivided roads 
\( F_{HD} \) = capacity adjustment factor related to shoulder or berreb roads 
\( F_{UK} \) = capacity adjustment factor related to city size

D. The relationship between the degree of saturation (DS) with the degree of travel speed (VT)

A qualitative measure of the road performance can be measured from the speed of the vehicle where the driver is completely free to determine the speed he wants. Therefore, speed is one of the parameters in designing a road. While the degree of saturation (DS) is one of the indicators traffic performance, where the traffic volume (V) that occurs is compared to the road capacity or capacity (C). To determine the relationship between speed and degree of saturation obtained from survey data collected and then evaluated and analyzed with an emphasis on the theoretical basis of traffic flow through the relationship between speed and volume (degree of saturation). The relationship between theoretical speed, free flow speed, and degree of saturation can be seen in Figure 3.

Figure 3. Relationship Graph VT with DS (Source: PKJI 2014 (2014))

RESULTS AND DISCUSSIONS

A. Research sites

The location used in this study is on Rungkut Madya Road, Surabaya, and East Java, Indonesia. Rungkut Madya Road is an urban road with type 2 lane 2 direction without separators (2/2 UD). The survey was carried out in both direction at 16.20-18.20.

B. Traffic Flow Characteristics

The results of the traffic flow survey on Rungkut Madya Road are depicted in the Table 1 and Figure 4.

Table 1. Total Vehicle Volume with PCE MC Based on PKJI 2014
After getting research data from the results of the survey that has been carried out, the data results are processed with modified PCE MC. Data can be seen in Table 2 and Figure 5.

### Table 2. Total Vehicle Volume with Modified PCE MC

<table>
<thead>
<tr>
<th>Time</th>
<th>West to East (pc/hour)</th>
<th>East to West (pc/hour)</th>
<th>TOTAL (pc/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.20-17.20</td>
<td>1085.1</td>
<td>1264.1</td>
<td>2349.2</td>
</tr>
<tr>
<td>16.25-17.25</td>
<td>1104.7</td>
<td>1246.4</td>
<td>2351.1</td>
</tr>
<tr>
<td>16.30-17.30</td>
<td>1124.45</td>
<td>1238.45</td>
<td>2362.9</td>
</tr>
<tr>
<td>16.35-17.35</td>
<td>1113.15</td>
<td>1233.9</td>
<td>2347.05</td>
</tr>
<tr>
<td>16.40-17.40</td>
<td>1105.1</td>
<td>1212.4</td>
<td>2317.5</td>
</tr>
<tr>
<td>16.45-17.45</td>
<td>1087</td>
<td>1168.45</td>
<td>2255.45</td>
</tr>
<tr>
<td>16.50-17.50</td>
<td>1058.6</td>
<td>1135.75</td>
<td>2194.35</td>
</tr>
<tr>
<td>16.55-17.55</td>
<td>1039.3</td>
<td>1129.35</td>
<td>2168.65</td>
</tr>
<tr>
<td>17.00-18.00</td>
<td>1042.9</td>
<td>1097.65</td>
<td>2140.55</td>
</tr>
<tr>
<td>17.05-18.05</td>
<td>1037.1</td>
<td>1073.05</td>
<td>2110.15</td>
</tr>
<tr>
<td>17.10-18.10</td>
<td>1042.8</td>
<td>1061.7</td>
<td>2049.5</td>
</tr>
<tr>
<td>17.15-18.15</td>
<td>1037.35</td>
<td>1046.45</td>
<td>2033.8</td>
</tr>
<tr>
<td>17.20-18.20</td>
<td>1033.1</td>
<td>1025.45</td>
<td>2058.55</td>
</tr>
</tbody>
</table>

After calculating, both using the PKJI 2014 PCE value, which is 0.25 and the modified PCE value of 0.17, it was found that the peak of the vehicle occurred at 16.30-17.30 so the vehicle volume data used for the calculation is at that time. Traffic volume using PCE MC in accordance with the PKJI 2014 is 2362.9 pc/hour. While the traffic volume uses a PCE MC value of 0.17 which is 1953.14 pc/hour.

The composition of vehicles at peak hours can be seen in Table 3.

### Table 3. Composition of Vehicles at Peak Hours

<table>
<thead>
<tr>
<th>Peak Time</th>
<th>Motorcycle</th>
<th>Car</th>
<th>Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.30 – 17.30</td>
<td>392</td>
<td>87</td>
<td>7</td>
</tr>
</tbody>
</table>

### C. Road Performance

Road performance that is taken into account in this study is the value of Degree of Saturation (DS) and Theoretical Speed ($V_T$). The performance of the road is calculated based on the PKJI 2014 using motorcycle modified PCE MC value of 0.17. Furthermore, compared to...
the road performance that calculated with the PCE MC according PKJI 2014, which value is 0.25. The results of the calculation of the road performance can be seen in Tables 4 – 7.

### Table 4. Calculation of Free Flow Speed

<table>
<thead>
<tr>
<th>VBD</th>
<th>VBL</th>
<th>FV_BHS</th>
<th>FV_BUK</th>
<th>VB</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>6.2</td>
<td>0.95</td>
<td>1</td>
<td>45.79</td>
</tr>
</tbody>
</table>

### Table 5. Calculation of Capacity

<table>
<thead>
<tr>
<th>C0</th>
<th>FC_LJ</th>
<th>FC_PA</th>
<th>FC_HS</th>
<th>FC_UK</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>2900</td>
<td>1.3</td>
<td>0.98</td>
<td>0.89</td>
<td>1</td>
<td>3288.194</td>
</tr>
</tbody>
</table>

### Table 6a. Calculation of Road Traffic Performance

<table>
<thead>
<tr>
<th>Current (smp/hour)</th>
<th>C (pc/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKJI 2014</td>
<td>2362.9</td>
</tr>
<tr>
<td>Emp corrected</td>
<td>1953.14</td>
</tr>
<tr>
<td></td>
<td>3288.194</td>
</tr>
</tbody>
</table>

### Table 6b. Calculation of Road Traffic Performance

<table>
<thead>
<tr>
<th>DS</th>
<th>FV (km/h)</th>
<th>VT (k/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKJI 2014</td>
<td>0.71</td>
<td>PKJI 2014</td>
</tr>
<tr>
<td>Modified PCE MC</td>
<td>0.59</td>
<td>Modified PCE MC</td>
</tr>
</tbody>
</table>

### Table 7. Relationship between Actual Velocity and Theoretical Velocity

<table>
<thead>
<tr>
<th>Actual Speed</th>
<th>Theoretical Speed (km/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PKJI 2014</td>
</tr>
<tr>
<td>35</td>
<td>36</td>
</tr>
</tbody>
</table>

From the table above, it can be seen that the use of motorcycle PCE in accordance with the 2014 PKJI on Rungkut Madya Road is more precise or can be said to be close to the actual speed compared to the theoretical speed in the research results.

## CONCLUSION

Based on the results of the calculation of road performance using the 2014 PKJI, it can be concluded that the use of PCE MC value of 0.25 produces a theoretical speed value that is close to the actual speed value compared to using a PCE MC value of 0.17. So that the calculation of the performance of the Rungkut Madya road section or other roads that have similar characteristics does not require modification of the PCE MC value.

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## REFERENCES


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