Estimated Travel Time on the Kelapa Gading – Pulo Gebang Toll Road Using the MKJI Method and Speed Choice Analysis

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Abstract

The increase and development of the DKI Jakarta area have implications for the increasing needs of the population so that the need for travel and high mobility will also increase in the form of increased activities for the movement of people and goods in one area or city. The DKI Jakarta Provincial Government has made efforts to build 6 Inner City Toll Roads in the DKI Jakarta Region to reduce congestion polemics which will be carried out in stages, namely Section A of the Development of the 9.3 km Kelapa Gading - Pulo Gebang Inner City Toll Road. Based on the MKJI analysis, the travel time was 6 minutes, and with the speed choice analysis, it was found that the travel time was around 7 minutes. Based on the evaluation of the performance analysis of the toll road section, the capacity of 6,624 pcu/hour was obtained with the level of service in category B for the Pulo Gebang direction and the level of service in category A for the Kelapa Gading direction with traffic flow calculations at peak-peak hours in the afternoon. From the results of the analysis, it was found that post-operational toll roads can reduce congestion on the existing road, namely Jalan Boulevard Barat Raya, Kelapa Gading with a 61% shift in vehicle volume so that the level of service changes from category C to category B.

Keywords
Travel Time Value, Road Capacity, Speed Choice and Toll Road.

1. Introduction

Jakarta is the center of the capital city which has a very high level of congestion. The congestion polemic in Jakarta is caused by the increasing vehicle population growth without any increase in road growth (Isradi et al. 2020). Congestion is the situation or condition of congestion or last stop cross which is caused by a lot of vehicles that exceed the capacity of the road (Prasetijo et al. 2011). Traffic jam problems seem to have already become a characteristic of big cities in developing countries, including Indonesia (Manganta et al. 2019). With the high mobility of travel needs, it will have an impact on the growth of motorized vehicles, by 4.4% in the period 2016-2020 (BPS Kota Bekasi 2021). Meanwhile, the growth of road length in the DKI Jakarta area only reaches 0.01% per year (Hadiwardoyo 2018), resulting in an increase in the vehicle population that is not commensurate with the growth of road construction, which causes the polemic issue of congestion in the DKI Jakarta area until 2021. The low level of public awareness in complying with traffic rules causes traffic conflicts and congestion (Prasetijo and Ahmad 2012).

The increase and development of the DKI Jakarta area have implications for the increasing needs of the population so that the need for travel and high mobility will also increase in the form of increased activities for the movement of people and goods in one area or city (Isradi et al. 2021). The DKI Jakarta Provincial Government, in collaboration with PT Jakarta Toll Development, took the initiative in the construction and operation of infrastructure in the form
of expressways in DKI Jakarta, namely 6 Sections of Inner City Toll Roads in the DKI Jakarta Region, namely Section A Development of the Kelapa Gading - Pulo Gebang Inner City Toll Road, along 9.3 km as a form of implementation of one of the additions to the road network. The purpose of the construction of 6 Inner City Toll Roads in the DKI Jakarta Region is to increase the level of service and provision of transportation services and be affordable by the community (Rifai et al. 2021). Success development is very influenced by the role of transportation as a center of life, economy, social culture, security, and politics (Isradi et al. 2020) and (Setiawan et al. 2021). The development of highway infrastructure or toll roads in a country can be used as a benchmark to determine the extent of the economic progress of a country, both macro and micro (Rifai 2015). This study aims to determine the value of travel time, a description of the condition of the segment, and the impact of congestion after the operation of the Inner City Toll Road in the DKI Jakarta Region Section A Kelapa Gading – Pulo Gebang.

2. Research Methods

2.1. Research Location

a. The place chosen in this study is the Kelapa Gading - Pulo Gebang Inner City Toll Road segment. This location is a Project of the Construction of 6 Inner City Toll Roads in the DKI Jakarta area see Figure 1, namely Section A Development of the Kelapa Gading – Pulo Gebang Inner Toll Road along 9,287 km with the type of freeway, namely 3 lanes 2 divided directions (MW 6/2D)

![Figure 1. Map Freeway Location](image1)

b. The existing research site selected in this research is Jl. Boulevard Barat Raya 0.493 km long. The specified existing road see Figure 2 is a road point for which road widening has not been carried out so that it becomes the part that intersects with the ramp of the freeway segment.

![Figure 2. Map Existing Road Location](image2)
2.2. **Data Collection**
Data collection is carried out after the preparation stage and is the first step in the process of implementing the evaluation and planning because at this stage a problem can be determined and various alternative sets to determine the solution to the problem to be taken (Dermawan et al. 2020). The data taken are primary data and secondary data which includes for this study, among others: vehicle volume, vehicle speed, road geometric, vehicle criteria, vehicle traffic data (Hartatik et al. 2020).

2.3. **Number of Samples**
Determination of the number of observation samples on the Kelapa Gading – Pulo Gebang toll road section was carried out before the main survey. This was done on Tuesday, December 7, 2021, by calculating the number of vehicle population at the observation point from secondary data for toll road exit gates. The calculated vehicles include light vehicles, medium-heavy vehicles, and large trucks. After determining the number of vehicle populations, the number of samples in each interval (Prasetijo et al. 2020).

2.4. **Speed Survey Design**
The local speed survey is a survey aimed at measuring the speed and travel time of passing vehicles at the observation point by using a speed measuring instrument (*Speed Gun*) and a time-measuring instrument (*Stopwatch*), in determining the local speed (Isradi et al. 2020). First, determine the location of the survey which is determined by dividing the segment by 3 (three) links see in Figure 3.

![Local Speed Location Map](image)

Figure 3. Local Speed Location Map

2.5. **Travel Time Analysis**
In determining the travel time, calculations were made based on the 1997 MKJI and the speed choice analysis method (Bina Marga 1997). Travel time estimation methods can be estimated by direct surveys in the field and can also be obtained from travel time modeling (Brilon and Wu 2001). The speed choice analysis method uses an instantaneous model estimation based on spot speed data which has been processed into 2 (two) forms of variable speed, namely: time average speed (TMS) and space average speed (SMS) (Bina Marga 2009).

2.6. **Analysis After Toll Road Operates**
In the post-operational analysis, the toll road operates by calculating the volume of traffic flow based on the afternoon rush hour, it is estimated that the volume of the existing road can be reduced by the volume of the toll road for the Kelapa Gading – Pulo Gebang direction so that the transition value of the volume of vehicles for each road segment is obtained, and evaluation of road performance which aims to determine the impact of congestion due to the construction of the toll road (Prasetijo et al. 2021).

2.7. **Speed Choice Analysis Method**
Speed Choice Analysis method is a method or method to determine the value of vehicle travel time in calculating travel time (Bina Marga 1997). The analysis of the value of travel time with this speed calculation is based on the technicality of driving a vehicle at a certain speed to minimize the total cost of the trip. The speed choice analysis method after getting the local speed, then calculating the estimated trip using the instantaneous model with the following calculation formula:

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\[ t(i,k) = \frac{2l_i}{v(ia,k) + v(ib,k)} \]

Where:

- \( l_i \) = Link length (km)
- \( v(ia,k) \) = Speed upstream of link \( i \) at time \( k \) (km/h)
- \( v(ib,k) \) = Speed downstream of link \( i \) at time \( k \) (km/h)
- \( t(i,k) \) = Travel time

3. Results and Analysis

3.1. Vehicle Traffic Volume

The volume of vehicle traffic on the toll road see Figure 4, the highest recapitulation was obtained on Tuesday for the direction of Kelapa Gading - Pulo Gebang so that the traffic data recapitulation was chosen in this study.

![Figure 4. Vehicle Volume Data](image)

Surveyor retrieval of vehicle traffic volume data based on traffic data at rush hour at the exit gate of the Kelapa Gading – Pulo Gebang toll road. Estimated traffic rush hour around 06:00-08:00, 11:00-13:00, 17:00-19:00. Secondary data collection of traffic during peak hours on toll roads for 3 days, namely on 7 December, 10 December, 12 December 2021 see Table 1.

Table 1. Pulo Gebang Direction Traffic Data Recapitulation

<table>
<thead>
<tr>
<th>No.</th>
<th>Day</th>
<th>Light Vehicle</th>
<th>Medium Heavy Vehicle</th>
<th>Big Truck</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pcu/hour</td>
<td>pcu/hour</td>
<td>pcu/hour</td>
<td>pcu/hour</td>
</tr>
<tr>
<td>1</td>
<td>Tuesday</td>
<td>2077</td>
<td>25.2</td>
<td>6</td>
<td>2108.2</td>
</tr>
<tr>
<td>2</td>
<td>Friday</td>
<td>1973</td>
<td>33.6</td>
<td>8</td>
<td>2014.6</td>
</tr>
<tr>
<td>3</td>
<td>Sunday</td>
<td>980</td>
<td>12.6</td>
<td>18</td>
<td>1010.6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5030</td>
<td>71.4</td>
<td>32</td>
<td>5133.4</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>1676.7</td>
<td>23.8</td>
<td>10.7</td>
<td>1711.1</td>
</tr>
</tbody>
</table>

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3.2. Number of Vehicle Samples
From the calculation of secondary data in the direction of Pulo Gebang, it is found that the number of vehicles passing at intervals of 2 hours during the afternoon rush hour conditions on December 7 see Table 2, 2021, namely LV = 1,519 pcu/hour, MHV = 12.6 pcu/hour, LT = 2 pcu/hour, and the total vehicle becomes 1,533.6 s m p/hour.

<table>
<thead>
<tr>
<th>Period</th>
<th>Time Interval</th>
<th>Light Vehicle (LV)</th>
<th>Medium Heavy Vehicle (MHV)</th>
<th>Big Truck (BT)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afternoon Rush</td>
<td>17:00 - 19:00</td>
<td>1519</td>
<td>12.6</td>
<td>2</td>
<td>1533.6</td>
</tr>
<tr>
<td>Proportion</td>
<td></td>
<td>99%</td>
<td>1%</td>
<td>0%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

So that the proportion of vehicles is LV = 99%, MHV = 1%, and LT = 0%. Then determine the minimum number of vehicle samples at each interval using the krejcie table. Based on the krejcie table, the number of vehicle samples that can be taken for observation is 310 vehicles. For sample calculations every 5 minutes for 2 (two) hours is 310/24 = 12.92 vehicles, then rounded up to 13 vehicles at every 5-minute interval.

3.3. Toll Road Section Performance
The toll road section in the city of Kelapa Gading - Pulo Gebang is a toll road that has a type of 6 lanes 2 divided directions (MW 6/2D) with a segment length of 9,287 km, for the calculation of vehicle volume using the total number of vehicles on Tuesday during peak hours. busy afternoon in each direction at 17:00 – 19:00.

3.3.1. Road Capacity
The calculation for road capacity is based on the manual (Bina Marga 1997a). According to the MKJI manual, the capacity of a road is the sum of the maximum traffic flows that can be maintained under a certain condition. The unit is pcu/hour.

\[ C = Co \times FCw \times FCsp \]

Where have known the factors that relate to finding road capacity:

a. The type of road is 6 lanes 2 directions divided (MW 6/2D) so \( Co = 2300 \text{ pcu/hour/lane} \) so \( Co = 6900 \text{ pcu/hour total of 3 lanes} \)
b. Adjustment factor due to traffic lane width, FCw = 0.960
c. Adjustment factor due to direction separation (divided freeway), FCsp = 1.0

The result is that the road capacity is \( C = (6900 \times 0.960 \times 1.0) \) so that the result is \( C = 6.624 \text{ pcu/hour} \).

3.3.2. Free Flow Speed

\[ FV = FV_0 + FV_w \]

Where it is known that the factors related to finding the free-flow velocity are:

a. The type of road is 6 lanes 2 divided directions (MW 6/2D) so that the basic free-flow speed with light vehicles (LV), \( FV_0 = LV \) (91 km/hour)
b. The adjustment factor due to the width of the traffic lane with the width of the flat lane (3.25 m) is the result, \( FV_w = -1 \)

The result of the basic free flow velocity is \( FV = 91 + (-1) \) so that the result is \( FV = 90 \text{ km/hour} \).
3.3.3. Other Vehicle Base Free Flow Speed

\[ FV (MH, LB, LT) = FV (MHV, LB, LT)_0 + (FVw \times FV(MHV, LB, LT)_0/F_{vo} \]

Where it is known that the factors related to finding the free flow velocity are:

a. The road type is 6 lanes 2 divided directions (MW 6/2D) so that the basic free flow speed of other vehicles
b. \( FV_0 = MHV \ (71 \text{ km/h}), LB \ (93 \text{ km/h}), LT \ (66 \text{ km/h}) \)
c. The adjustment factor due to the width of the traffic lane with a flat lane width (3.25 m) results in \( FV_w = -1 \)

The results obtained for the other basic free-flow speed of vehicles are:

a. \( FV_{MHV} = 71 + (-1 \times 71)/91 \) so the result is \( FV = 70.21 \text{ km/hour} \).
b. \( FV_{LB} = 93 + (-1 \times 93)/91 \) so the result is \( FV = 91.97 \text{ km/hour} \).
c. \( FV_{LT} = 66 + (-1 \times 66)/91 \) so the result is \( FV = 65.27 \text{ km/hour} \).

3.3.4. Degree of Saturation

\[ DS = Q/C \]

The degree of saturation is obtained from the calculation of traffic flow divided by capacity. Where it is known that the traffic flow \( Q = 1533 \text{ pcu/hour} \) in the direction of Pulo Gebang and \( Q = 292 \text{ pcu/hour} \) in the direction of Kelapa Gading and the capacity of \( C = 6624 \text{ pcu/hour} \) to obtain:

\[ DS = 1533/6624 = 0.231 \text{ for Pulo Gebang direction, and} \]
\[ DS = 292/6624 = 0.044 \text{ for Kelapa Gading direction} \]

3.3.5. Speed

Actual speed calculation obtained based on DS = Q/C. The obtained DS = 0.231 for the direction of Pulo Gebang and 0.044 for the direction of Kelapa Gading.

a. Light Vehicle (LV) of 83.52 km/hour
b. Medium Heavy Vehicle (MHV) of 65.16 km/hour
c. Large Bus (LB) of 85.36 km/hour
d. Large Truck (LT) of 60.58 km/hour

3.3.6. Travel time

Calculation of travel time according to the sample from the main survey, namely light vehicles (LV), Calculation of travel time based on MKJI, namely:

\[ TT = L/V \]

The results obtained from the direction of Kelapa Gading to Pulo Gebang:
\[ TT = (9,287)/(83,52) \times 60 = 6.7 \text{ minutes and} \]

From Pulo Gebang to Kelapa Gading:
\[ TT = (9,287)/(88,80) \times 60 = 6.3 \text{ minutes} \]

3.3.7. Road Service Level

The level of service (Level of Service/LOS) states the level of traffic quality on the current road section. The level of service (Level Of Service/LOS) is based on the degree of saturation (DS) = 0.231 from the Kelapa Gading direction and (DS) = 0.044 from the Pulo Gebang direction. So that the Level Of Service is based on the standard LOS value according to MKJI:

a. The direction of Kelapa Gading to Pulo Gebang with DS = 0.231 obtained the category "LOS B" The flow is stable, but the operating speed is starting to be limited by traffic conditions, the driver has enough freedom to choose the speed "
b. The direction of Pulo Gebang towards Kelapa Gading with DS = 0.044 obtained the category "LOS A" with the characteristics of free flow conditions at high speed, the driver can choose the desired speed without
3.4. Travel Time Analysis
Travel time analysis using the speed choice analysis method is based on calculations with primary data from local speed (spot speed), so that from spot speed data, travel time can be calculated based on segment length or the number of links observed (Høyer 2000).

3.4.1 Time Average Speed Analysis (Ū TMS)
The calculation of the average vehicle time means speed (TMS) is the total speed at the time interval divided by the number of samples studied. To be able to analyze the average speed of time as follows:

\[ \text{TMS} = \frac{\sum \text{speed}}{\text{total sample}} \]

Examples of calculating time mean speed can be seen in Table 4.

**Tabel 4. Calculation Example TMS**

<table>
<thead>
<tr>
<th>No.</th>
<th>Time Interval</th>
<th>Transportation type</th>
<th>TMS Upstream Link 1</th>
<th>TMS Upstream Link 2</th>
<th>TMS Upstream Link 3</th>
<th>TMS Downstream Link 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17:00 - 17:05</td>
<td>LV</td>
<td>70.69</td>
<td>66.54</td>
<td>74.31</td>
<td>68</td>
</tr>
<tr>
<td>2</td>
<td>17:05 - 17:10</td>
<td>LV</td>
<td>78.46</td>
<td>78.38</td>
<td>75.62</td>
<td>64.77</td>
</tr>
<tr>
<td>3</td>
<td>17:10 - 17:15</td>
<td>LV</td>
<td>76.62</td>
<td>78.92</td>
<td>72.15</td>
<td>66.85</td>
</tr>
<tr>
<td>4</td>
<td>17:15 - 17:20</td>
<td>LV</td>
<td>77.85</td>
<td>78.31</td>
<td>74.92</td>
<td>65.15</td>
</tr>
<tr>
<td>5</td>
<td>17:20 - 17:25</td>
<td>LV</td>
<td>77.54</td>
<td>77.54</td>
<td>76.77</td>
<td>63</td>
</tr>
</tbody>
</table>

3.4.2 Space Average Speed Analysis (Ū SMS)
The average space speed is carried out for all links on the researched road segment. The calculation of the average pace mean speed (SMS) of vehicles is as follows:

\[ \text{SMS} = \frac{1}{\sum \text{speed}} \]

Examples of calculating pace mean speed can be seen in Table 5.

**Tabel 5. Example Calculation Table SMS**

<table>
<thead>
<tr>
<th>No.</th>
<th>Time Interval</th>
<th>Transportation type</th>
<th>SMS Upstream Link 1</th>
<th>SMS Upstream Link 2</th>
<th>SMS Upstream Link 3</th>
<th>SMS Downstream Link 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17:00 - 17:05</td>
<td>LV</td>
<td>69.83</td>
<td>65.6</td>
<td>73.09</td>
<td>67.45</td>
</tr>
<tr>
<td>2</td>
<td>17:05 - 17:10</td>
<td>LV</td>
<td>77.5</td>
<td>76.67</td>
<td>74.07</td>
<td>63.67</td>
</tr>
<tr>
<td>3</td>
<td>17:10 - 17:15</td>
<td>LV</td>
<td>75.68</td>
<td>78.29</td>
<td>71.5</td>
<td>66.22</td>
</tr>
<tr>
<td>4</td>
<td>17:15 - 17:20</td>
<td>LV</td>
<td>76.88</td>
<td>76.47</td>
<td>73.45</td>
<td>63.97</td>
</tr>
<tr>
<td>5</td>
<td>17:20 - 17:25</td>
<td>LV</td>
<td>76.28</td>
<td>76.47</td>
<td>75.84</td>
<td>62.23</td>
</tr>
</tbody>
</table>

3.4.3 Travel Time Analysis with Instantaneous Model
Estimated travel time for vehicles on the Kelapa Gading - Pulo Gebang toll road segment on observations using the instantaneous model method based on spot speed data that has been processed into 2 (two) forms of variable speed, namely:
1. Average speed time (TMS)
2. Space average speed (SMS)

The calculation of the estimated travel time of the vehicle is based on the calculation of the average time speed ($\bar{U}_{TMS}$) in the first 5-minute interval at 17:00 – 17:05 WIB as follows:

1. **Upstream Link 1** = 70.69 km/hour
2. **Upstream Link 2** = 66.54 km/hour
3. **Upstream Link 3** = 74.31 km/hour
4. **Downstream Link 3** = 68.00 km/hour

The travel time of each link is calculated as the link length divided by the local average speed on the upstream and downstream links as follows:

$$t(i,k) = \frac{2l_k}{\bar{v}(l_k,i) + \bar{v}(i,g)}$$

1. Travel time on link 1 = $\frac{(2 \times 3)}{(70.69 + 66.54)} \times 60 = 2.62$ minutes
2. Travel time on link 2 = $\frac{(2 \times 3)}{(66.54 + 74.31)} \times 60 = 2.56$ minutes
3. Travel time on link 3 = $\frac{(2 \times 3)}{(74.31 + 68.00)} \times 60 = 2.53$ minutes

Based on the calculation of the estimated travel time with variable speed, the average time to cross the road which is observed in the first 5-minute interval at 17:00 – 19:00 WIB from the upstream link point 1 to downstream link 3 is $2.62 + 2.56 + 2.53 = 7.71$ minutes

The calculation of the estimated travel time of the vehicle is based on the calculation of the space average speed ($\bar{U}_{SMS}$) in the first 5 minutes interval at 17:00 – 17:05 WIB as follows:

1. **Upstream Link 1** = 69.83 km/hour
2. **Upstream Link 2** = 65.60 km/hour
3. **Upstream Link 3** = 73.09 km/hour
4. **Downstream Link 3** = 67.45 km/hour

The travel time of each link is calculated as the link length divided by the local average speed on the upstream and downstream links as follows:

1. Travel time on link 1 = $\frac{(2 \times 3)}{(69.83 + 65.60)} \times 60 = 2.66$ minutes
2. Travel time on link 2 = $\frac{(2 \times 3)}{(65.60 + 73.09)} \times 60 = 2.60$ minutes
3. Travel time on link 3 = $\frac{(2 \times 3)}{(73.09 + 67.45)} \times 60 = 2.56$ minutes

Based on the results of the calculation of the estimated travel time with the variable speed of the average space to cross the road which is observed in the first 5 minutes interval at 17:00 – 19:00 WIB from the upstream link point 1 to downstream link 3 is $2.62 + 2.56 + 2.53 = 7.78$ minutes.

### 3.5. Traffic Impact Analysis After Toll Road Operations
#### 3.5.1 Existing Road Vehicle Volume

The volume of vehicles on the existing road on Tuesday, 7 December 2021, at the peak hour in the afternoon, can be seen in Table 6, as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>Time Interval</th>
<th>Motorcycle (MC)</th>
<th>Light Vehicle (LV)</th>
<th>Heavy Vehicle (HV)</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pcu/hour</td>
<td>pcu/hour</td>
<td>pcu/hour</td>
<td>pcu/hour</td>
</tr>
</tbody>
</table>

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The highest traffic flow was found in the direction of the Kelapa Gading mall on Tuesday, December 7, 2021, so the calculation was carried out based on the traffic flow at the peak of the afternoon in the direction of the Kelapa Gading Mall. In table 6, it can be seen that the average traffic volume towards Mall Kelapa Gading during the afternoon rush hour is $MC = 195 \text{ pcu/hour}$, $LV = 1075 \text{ pcu/hour}$, $HV = 19 \text{ pcu/hour}$. So the total flow during the afternoon rush hour towards Mall Kelapa Gading $Q = 1289 \text{ pcu/hour}$.

### 3.5.2 Road Capacity

The calculation for road capacity is based on the 1997 MKJI manual. According to the MKJI manual, the capacity of a road is the sum of the maximum traffic flows that can be maintained under certain conditions. The unit is pcu/hour. The formula for calculating road capacity is as follows:

$$C = Co \times FCw \times FCsp \times FCsf \times FCcs$$

Where have known the factors that relate to finding road capacity:

a. The type of road is 4 lanes 2 directions divided (MW 4/2D) $Co = 1650 \text{ pcu/hour/lane}$ so $Co = 3300 \text{ pcu/hour total}$ of 2 lanes

b. Adjustment factor due to traffic lane width , $FCw = 0.92$

c. Adjustment factor due to direction separation (divided urban roads) , $FCsp = 1.0$

d. Adjustment factor of side resistance with kereb, $FCsf = 0.86$

e. City size adjustment factor $FCcs = 0.86$

The result is that the road capacity is $C = (3300 \times 0.92 \times 1.0 \times 0.86 \times 1.0)$ so that the result is $C = 2610 \text{ pcu/hour}$.

### 3.5.3 Degree of Saturation

The calculation of the degree of saturation based on the 1997 MKJI is as follows:

$$DS = Q/C$$

The degree of saturation is obtained from the calculation of traffic flow divided by capacity. Where it is known that the traffic flow $Q = 1289 \text{ pcu/hour}$ and the capacity $C = 2610 \text{ pcu/hour}$ so we get: $DS = 1274/2610 = 0.49$ for the direction of Kelapa Gading Mall

### 3.5.4 Road Service Level

The level of service (Level of Service / LOS) states the level of traffic quality on the current road section. The level of service (Level Of Service / LOS) is based on the degree of saturation (DS) = 0.49. So that the Level of Service is based on the standard LOS value according to MKJI: The direction of Kelapa Gading Mall with DS = 0.49 got the "LOS C" category with stable current characteristics, but the speed and motion of the vehicle are controlled, the driver is limited in choosing the speed "

### 3.5.5 Performance Analysis After Toll Road Operations

Estimated traffic volume based on the afternoon rush hour on Tuesday 7 December 2021, it is estimated that the volume of existing roads that can be reduced by the volume of the toll road for the Kelapa Gading – Pulo Gebang direction can be seen in Table 9 as follows:
Table 9. Percentage of Volume Change of Existing Road Vehicles

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>TIME INTERVAL</th>
<th>Traffic Flow</th>
<th>Percentage redirected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre Operation</td>
<td>Toll road</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vehicle/hour</td>
<td>vehicle/hour</td>
</tr>
<tr>
<td>Afternoon Rush</td>
<td>17:00 - 18:00</td>
<td>2103</td>
<td>818</td>
</tr>
<tr>
<td>Hour</td>
<td>18:00 - 19:00</td>
<td>1639</td>
<td>710</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3742</td>
<td>1528</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>1871</td>
<td>764</td>
</tr>
</tbody>
</table>

After calculating the degree of saturation with the volume that has been changed according to the reduction in the volume of vehicles entering the toll road, the results can be seen in Table 10 and Table 11 as follows:

Table 10. Recapitulation of Vehicle Traffic Data in the direction of Kelapa Gading Mall after Toll Operations

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>TIME INTERVAL</th>
<th>MOTORCYCLE</th>
<th>LIGHT VEHICLE</th>
<th>HEAVY VEHICLE</th>
<th>VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>vehicle/hour</td>
<td>vehicle/hour</td>
<td>vehicle/hour</td>
<td>vehicle/hour</td>
</tr>
<tr>
<td>Afternoon Rush</td>
<td>17:00 - 18:00</td>
<td>876</td>
<td>401</td>
<td>8</td>
<td>1285</td>
</tr>
<tr>
<td>Hour</td>
<td>18:00 - 19:00</td>
<td>685</td>
<td>230</td>
<td>14</td>
<td>929</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1561</td>
<td>631</td>
<td>21</td>
<td>2214</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>781</td>
<td>316</td>
<td>11</td>
<td>1107</td>
</tr>
</tbody>
</table>

Table 11. Recapitulation of Traffic Data for Middle School in the direction of Mall Kelapa Gading after Toll Operations

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>TIME INTERVAL</th>
<th>MOTORCYCLE</th>
<th>LIGHT VEHICLE</th>
<th>HEAVY VEHICLE</th>
<th>VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pcu/hour</td>
<td>pcu/hour</td>
<td>pcu/hour</td>
<td>pcu/hour</td>
</tr>
<tr>
<td>Afternoon Rush</td>
<td>17:00 - 18:00</td>
<td>219</td>
<td>401</td>
<td>8</td>
<td>628</td>
</tr>
<tr>
<td>Hour</td>
<td>18:00 - 19:00</td>
<td>171</td>
<td>230</td>
<td>17</td>
<td>418</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>390</td>
<td>631</td>
<td>25</td>
<td>1046</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>195</td>
<td>316</td>
<td>13</td>
<td>523</td>
</tr>
</tbody>
</table>

The results of the analysis in table Q = 523 pcu/hour after access to the toll road section. So that road users who aim to Bekasi City can directly access the toll road without having to pass through the Kelapa Gading urban road. The results obtained degrees of saturation of:

\[ DS = \frac{523}{2610} = 0.20 \]

So the Level Of Service based on the standard LOS value according to MKJI: Mall Kelapa Gading direction with DS = 0.20 the category "LOS B" is obtained with stable flow characteristics, but the operating speed is starting to be limited by traffic conditions, the driver has enough freedom to choose the speed.”

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3.6. Road Performance Estimation

\[ P_n = P_o + (1 + i)^n \]

Where:
- \( P_o \) = Total volume of the original vehicle
- \( i \) = growth rate (rate of interest)
- \( n \) = Amount of time (in years)
- \( P_n \) = Total volume of vehicles at the end of year \( n \)

The calculation of the estimated 5-year projected road performance uses a traffic growth rate that can be projected until 2035, namely \( (i) = 4.8\% \) (KemenPUPR 2017). Estimated road performance estimates can be seen in Table 12.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Direction</th>
<th>Capacity Traffic Flow Estimate</th>
<th>Degree of Saturation</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pcu/hour</td>
<td>pcu/hour</td>
<td></td>
</tr>
<tr>
<td>Freeway</td>
<td>Kelapa Gading - Pulo Gebang</td>
<td>6,624</td>
<td>1.533</td>
<td>0.23</td>
</tr>
<tr>
<td>Urban Street</td>
<td>Kelapa Gading - Pulo Gebang</td>
<td>2,610</td>
<td>1.049</td>
<td>0.40</td>
</tr>
</tbody>
</table>

4. Conclusion

1. Based on the results of this study, the travel time on the toll road towards Kelapa Gading using the MKJI method was 6.7 minutes and the direction of Pulo Gebang was 6.3 minutes, while using speed choice analysis it was 7.17 minutes based on the average speed of time, and 7.25 minutes based on space average velocity.
2. The capacity of inner-city toll roads based on the analysis results is obtained at 6,624 pcu/hour, with a vehicle volume of 1528 vehicles/hour based on the afternoon peak rush hour on December 7, 2021, and the level of service on toll roads is located in the LOS B category.
3. The impact after the operation of the Kelapa Gading - Pulo Gebang inner-city toll road section can reduce congestion on the existing road, namely Jalan Boulevard Barat Raya Kelapa Gading with a transition percentage of 61% to reduce traffic volume on existing roads and road service levels on existing roads. from category C to category B.

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Biography


Arief Cahya Purnomo, born in Cirebon, 15 November 1997. He will achieve a Bachelor's degree in Civil Engineering at Mercu Buana University in 2022.

Muhammad Isradi, born in Kandangan on 18 August 1972. He is the secretary of the Civil Engineering department at Mercu Buana University. He earned a degree in Civil Engineering from Universitas Muhammadiyah Malang in 1998 with the thesis entitled “One Way Flat Plate Planning at Queen Plaza Madison. Hey then obtained a Master's degree in Civil Engineering, Transportation Concentration from Brawijaya University in 2001 with a thesis entitled “Family Movement Awakening Model in Sawojajar Housing Area, Malang”. He also teaches several subjects such as Pavement Planning, Geometric Road Planning, Transportation Planning, and Environmental Engineering.

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Dr.-Ing. Joewono Prasetjo, born in Pontianak, 18 October 1969. He graduated with an Engineer degree in Civil Engineering at Tanjungpura University, Pontianak, Indonesia in 1993. He then obtained a Master of Science degree
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