Performance and Service Evaluation of Cibubur Toll Gate (A Case Study of Cibubur 1 Toll Gate and Cibubur 2 Toll Gate)

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ABSTRACT

Toll road is a road devoted to two or more wheeled vehicles (car, bus, truck) and aims to shorten the distance and travel time from one place to another. Along with the increasing number of vehicles, the traffic volume on the Toll road also increases, which causes a long queue at the toll gate. Therefore, the performance evaluation of the toll gate is required to obtain the optimum number of toll gates to accommodate the volume of existing vehicles at this time and in the upcoming years. This final project evaluated the queues at the Cibubur 1 Toll Gate, Cibubur 2 Toll Gate, and Cibubur 2 Satellite Toll Gate on the Jagorawi toll road section because queues often occur at these toll gates, especially during rush hours. Data taken when conducting a survey were the vehicle arrival rate, the service time, and the vehicle queue length. The analysis carried out was the analysis of arrival rates, service time, traffic intensity, and queuing analysis. Queuing analysis was carried out using the First In First Out method as a queuing discipline and the Single Channel – Single Phase method for queuing structure. The evaluation results of the toll gate were known to be the vehicle arrival rate at the Cibubur 1 Toll Gate of 531 vehicles/hour/ gate; Cibubur 2 Toll Gate of 421 vehicles/hour/ gate; Cibubur 2 Satellite Toll Gate of 337 vehicles/hour/ gate. The number of required gates was 12 for Cibubur 1 toll gate, 6 for Cibubur 2 toll gate, and 5 for Cibubur 2 Satelite toll gate. From the predicting analysis results in 2024, the number of gates required for each gate was obtained, namely 15 gates (10 ATG Single and 5 ATG Multi) for Cibubur 1 toll gate; 7 gates (3 ATG Single and 4 ATG Multi) for Cibubur 2 toll gate; 6 gates (3 ATG Single and 3 ATG Multi) for Cibubur 2 Satelite toll gate.

INTRODUCTION

Along with the increasing number of vehicles, the traffic volume on the toll road has also increased. The increase in traffic volume on the toll road causes traffic congestion on the toll road. It often occurs at the toll gate due to the long queues of vehicles.

One of the traffic congestion that occurred was at the Cibubur toll gate. Cibubur Toll Gate is entry access from Cibubur City to the Jagorawi toll road and vice versa. This toll gate consists of Cibubur 1 toll gate (exit) and Cibubur 2 toll gate (entry). The traffic congestion that often occurs at this toll gate is during weekday morning and evening rush hours.

Therefore, the performance and service evaluation of the toll gate is required to obtain the optimum number of toll gates to accommodate the volume of existing vehicles at this time and in the upcoming years.

This study aims to evaluate the queues at the toll gate with the vehicle arrival rate and gate service rate. The analyzed toll gate is the Cibubur toll gate which consists of the Cibubur 1 toll gate and Cibubur 2 toll gate with an automatic toll gate (ATG) transaction system. In addition, this study aims to determine the current capacity and performance level of toll gate services and for the upcoming years in dealing with surges in toll road traffic.

A similar study that has been carried out is a study on the Capacity Analysis of the West Karawang Toll Gate by Winarsih (2013) [1]. The study results indicate that the toll gate has exceeded its capacity and is not in accordance with the Toll Road Minimum Service Standards [2]. In addition, it also shows that minimizing service time, adding toll gates, and implementing a tandem gate system can increase the toll gate capacity.

METHODOLOGY

The research location was Cibubur 1 Toll Gate and Cibubur 2 Toll Gate. This research was conducted by collecting primary and secondary data for later analysis. Primary data was taken through a survey conducted at each toll gate that will be analyzed. Data taken when conducting a survey were the vehicle arrival rate, the vehicle queue length, and the service time. The survey was

Table 1. Data Summary of Arrival Rate Survey at Cibubur Toll Gate 1 GTO Single (Gate 4, 6, 8, 10, and 12).

No	*Time*	*I*	*II*	*III*	*IV*	*V*	*Total*
1	16.00-17.00	1504	0	0	0	0	1504
2	17.00-18.00	1578	0	0	0	0	1578
3	18.00-19.00	1434	0	0	0	0	1434
Total		4516	0	0	0	0	4516
Proportion (%)		100	0	0	0	0	100
Proportion (%)		89,16	7,44	2,71	0,58	0,11	100,00

Table 2. Data Summary of Arrival Rate Survey at Cibubur Toll Gate 1 GTO Multi (Gardo 2, 14 and 16).

No	*Time*	*I*	*II*	*III*	*IV*	*V*	*Total*
1	16.00-17.00	421	81	19	4	1	526
2	17.00-18.00	650	37	21	2	0	710
3	18.00-19.00	607	22	11	5	1	646
Total		1678	140	51	11	2	1882
Proportion (%)		89,16	7,44	2,71	0,58	0,11	100,00

Table 3. Cibubur 1 Toll Gate Traffic Volume Data in 2017.

Month	*Number of Vehicles*
January	1.066.817
February	949.501
March	1.052.800
April	979.161
May	984.457
June	909.833
July	1.020.386
August	1.009.615
September	990.826
October	1.035.516
November	998.249
December	1.028.882

conducted by calculating the number of vehicles and the service time of each gates during rush hours. Service time calculation was conducted when the vehicle moved towards the toll gate until the vehicle left the toll gate. Secondary data is supporting data taken through the toll road management agency, namely PT Jasa Marga. Secondary data taken was in the form of annual traffic volume and toll gate configuration. Analysis was carried out after obtaining the primary data. The analyzed vehicle arrival rate was the arrival rate with the original number of vehicles, namely the number of vehicles surveyed at the analyzed toll gate. Analysis of service time that has been obtained from the survey results was processed. Thus it could obtain a cumulative frequency graph of the analyzed toll gate. Furthermore, a traffic intensity analysis was carried out to determine whether the toll gate capacity can accommodate existing vehicles. Queuing analysis at toll gates was carried out according to the First In First Out (FIFO) queuing discipline [3]. Queuing analysis was carried out to see how long the queue was in terms of calculations, and could see the number of gates needed in the analysis results table.

RESULTS AND DISCUSSIONS

A. Arrival Rate Analysis

Calculation of the original volume arrival rate analysis at the Cibubur 1 toll gate. Recapitulation analysis of vehicle arrival rate survey results at the Cibubur 1 Toll Gate divided according to 2 types of toll gates, namely ATG Single (toll gate for class I vehicles with a maximum height of 2.1 meters) and ATG Multi (toll gate for class I, II, III, IV, and V). The analysis results can be seen in Table 1 and Table 2.

Formula :

$$\lambda = \frac{\sum x}{N}$$

$\sum x$ = The total number of vehicles per vehicle class

N = Time needed

Thus:

$\lambda = \frac{4516}{3} = 1505.3$ = 1506 vehicles/hour

It obtains the vehicle arrival rate for Cibubur 1 toll gate for 5 Single toll gates is 1506 vehicles/hour.

Formula :

$$\lambda = \frac{\sum x}{N}$$

$\sum x$ = The total number of vehicles per vehicle class

N = Time needed

Thus:

$\lambda = \frac{1882}{3} = 627.3$ = 628 vehicles/hour

It obtains the vehicle arrival rate for Cibubur 1 toll gate for 3 Multi toll gates is 628 vehicles/hour.

The vehicles proportion is class I = 96.81%; class II = 2.19%; class III = 0.8%; class IV = 0.17%; class V = 0.03%. Class 1 vehicles can enter the Multi and Single toll gates, so the distribution is 96.81% x 2134 (total survey results) = 2066 vehicles/hour. Based on the survey results, it was obtained that class 1 vehicles for the Single gate were 1506 vehicles/hour, (1506/2134) x 100% = 72.9%. Therefore, the proportion of class I vehicles that can enter each gate, namely ATG Multi = 27.1% and ATG Single = 72.9%.

To obtain the vehicle arrival rate in 2019 is carried out using the predicting method from previous years' data using the Minitab assistance application with the Time Series Decomposition method. The traffic volume data at

Table 4. Cibubur 1 Toll Gate Traffic Volume Data in 2018.

Month	*Number of Vehicles*
January	1.163.102
February	1.149.098
March	1.134.338
April	1.079.778
May	1.101.558
June	1.056.325
July	1.118.838
August	1.124.347
September	1.037.649
October	1.060.669
November	1.032.608
December	1.056.124

Table 5. Cibubur 1 Toll Gate Traffic Volume Data in 2019.

Month	*Number of Vehicles*
January	1.229.825
February	1.212.422
March	1.196.699
April	1.142.911
May	1.170.348
June	1.126.386
July	1.187.635
August	1.167.773
September	1.139.703
October	1.189.341
November	1.143.239
December	1.172.856
Total	14.079.138

the Cibubur 1 toll gate in 2017 and 2018 can be seen in Table 3 and Table 4. The results of traffic volume predicting at the Cibubur 1 toll gate in 2017 and 2018 can be seen in Figure 1.

Based on the results of traffic volume predicting in Figure 1, the traffic volume in 2019 can be calculated as follows:

Monthly traffic volume = (960645 + 6998 x t-month) x index factor

Example of calculating traffic volume in January 2019, t = 25th month of 2017, i = 1.08298

Volume = (960645 + 6998 x 25) x 1.08298

= 1.229.825 vehicles

Cibubur 1 toll gate traffic volume data in 2019 can be seen in Table 5.

B. Servis Time Analysis

The calculation results of the service time analysis with the original number of vehicles at the analyzed toll gate are as follows:

1) Cibubur 1 Toll Gate Single Gate (5 Gates)

Based on the average value of service time at the Cibubur 1 toll gate, Table 6 is obtained, which explains the cumulative frequency of vehicle service time as Table 6. Based on Table 6, the cumulative percentage graph (%) and service time obtained with 5 gates obtained the average transaction time can be seen in Figure 2.

From Table 6 and Figure 2 above, the following data is obtained as follows:

Median = 8 seconds
Modus = 7 seconds
Average service time = 8.07 seconds
Cumulative percentage 50% = 8 seconds
Cumulative percentage 75% = 8 seconds

To determine the service time of automatic toll gates, it can be seen from the average service time value, the

Time Series Decomposition for TK

Method

Model type	Multiplicative Model
Data	TK
Length	24
NMissing	0

Fitted Trend Equation

Yt = 960645 + 6998×t

Seasonal Indices

Period	Index
1	1.08298
2	1.06112
3	1.04098
4	0.98818
5	1.00582
6	0.96225
7	1.00854
8	0.98582
9	0.95647
10	0.9923
11	0.9483
12	0.96725

Figure 1. Results of Traffic Volume Predicting at Cibubur 1 Toll Gate in 2017 and 2018.

cumulative percentage 50%, and the cumulative percentage 75%. Furthermore, comparing the three values with the median and mode values. Then, the value closest to the median and mode value was taken, which in this case was the service time with a cumulative percentage 50% and 75%, namely 8 seconds. If considering the maximum service time required at the Cibubur 1 ATG Single toll gate, thus it obtains:

λ = 2.996 vehicles/hour

N = 5 Gates (2, 3, 4, 5, and 6)

$$\frac{2996/5}{\mu} < 1$$

Obtained: μ = 599.12 vehicles/hour

Thus, the maximum service time required is

$599{,}12 = \frac{3600}{WP} \rightarrow WP = \frac{3600}{599{,}12}$

WP = 6,01 = 7 seconds/vehicle (max)

From the arrival rate λ = 2,996 vehicles/hour, it was obtained that the maximum service time at the Cibubur 1 ATG Single toll gate was 7 seconds/vehicle. While from the average service time data, the service time was 8 seconds/vehicle.

Meanwhile, according to the Minimum Service Standards (MSS) [2] of toll roads, service time on a closed system must be ≤ 7 seconds/vehicle (TRRA, 13 February 2019). Therefore, Cibubur 1 ATG Single toll gate does not meet the requirements because the average service time at each gate is 8 seconds/vehicle.

2) Cibubur 1 Toll Gate Multi Gate (3 Gates)

Based on the average service time of the Cibubur 1 toll gate can be seen in Table 7.

Based on Table 7, the cumulative percentage (%) and service time graphs obtained with 3 gates and obtained the average transaction time in Figure 3.

From Table 7 and Figure 3 above, the following data is obtained as follows:

Table 6. Vehicle Service Time at the Cibubur 1 Toll Gate Single Gate.

WP	*Frequency*	*Cumulative Frequency*	*Percentage*	*Cumulative Percentage*
6	91	91	3.073	3.073
7	1206	1297	40.729	43.803
8	984	2281	33.232	77.035
9	391	2672	13.205	90.240
10	121	2793	4.086	94.326
11	55	2848	1.857	96.184
12	33	2881	1.114	97.298
13	27	2908	0.912	98.210
14	14	2922	0.473	98.683
15	7	2929	0.236	98.919
16	2	2931	0.068	98.987
17	7	2938	0.236	99.223
18	6	2944	0.203	99.426
19	1	2945	0.034	99.460
20	4	2949	0.135	99.595
21	1	2950	0.034	99.629
22	2	2952	0.068	99.696
23	2	2954	0.068	99.764
24	0	2954	0.000	99.764
25	3	2957	0.101	99.865
26	1	2958	0.034	99.899
27	1	2959	0.034	99.932
28	0	2959	0.000	99.932
29	0	2959	0.000	99.932
30	1	2960	0.034	99.966
31	0	2960	0.000	99.966
32	0	2960	0.000	99.966
33	1	2961	0.034	100.000
Total	2961		100.000	

Median = 9 seconds
Modus = 8 seconds
Average service time = 12.54 seconds
Cumulative percentage 50% = 9 seconds
Cumulative percentage 75% = 15 seconds

To determine the service time of automatic toll gates, it can be seen from the average service time value, the cumulative percentage 50%, and the cumulative percentage 75%. Furthermore, comparing the three values with the median and mode values. Then, the value closest to the median and mode value was taken, which in this case was the service time with a cumulative percentage 50%, namely 9 seconds.

If considering the maximum service time required at the Cibubur 1 ATG Multi toll gate, thus it obtains:

λ = 1248 vehicles/hour

N = 3 Gates (1, 7, and 8)

$$\frac{1248/3}{\mu} < 1$$

Obtained: μ = 416.3 vehicles/hour

Thus, the maximum service time required is

$416{,}3 = \frac{3600}{WP} \rightarrow WP = \frac{3600}{416{,}3}$

WP = 8,65 = 9 seconds/vehicle (max)

From the arrival rate λ = 1248 vehicles/hour, it was obtained that the maximum service time at the Cibubur 1 ATG Multi toll gate was 9 seconds/vehicle. While from the average service time data, the service time was 9 seconds/vehicle.

Meanwhile, according to the Minimum Service Standards (MSS) [2] of toll roads, service time on a closed system must be ≤ 7 seconds/vehicle (TRRA, 13 February 2019). Therefore, Cibubur 1 AGT Single toll gate does not meet the requirements because the average service time at each gate = 9 seconds/vehicle.

C. Traffic Intensity Analysis

Traffic Intensity (ρ) is the ratio of Arrival Rate (λ) and Service Rate (μ), which has a condition that this value must always be less than 1.

The calculation results of the original volume traffic intensity analysis at the analyzed Cibubur 1 toll gate are as follows:

1) Automatic Toll Gate Single (5 Gates)

WP = 8 seconds
λ = 2996 vehicles/hour
N = 5 gates (4, 6, 8, 10, and 12)

$$\mu = \frac{1}{WP}$$

$$\mu = \frac{3600}{8} = 450$$

$$\rho = \frac{\lambda/N}{\mu} < 1$$

$$\rho = \frac{2996/5}{450} = 1{,}331 > 1$$

With $\rho > 1$, means that the traffic intensity that occurs cannot accommodate the existing vehicles.

2) Automatic Toll Gate Multi (3 Gates)

WP = 9 seconds
λ = 1248 vehicles/hour
N = 3 gates (2, 14, and 16)

$$\mu = \frac{1}{WP}$$

$$\mu = \frac{3600}{9} = 400$$

$$\rho = \frac{\lambda/N}{\mu} < 1$$

Table 7. Vehicle Service Time at the Cibubur 1 Toll Gate Single Gate.

WP	*Frequency*	*Cumulative Frequency*	*Percentage*	*Cumulative Percentage*
7	223	223	16.54	16.54
8	428	651	31.75	48.29
9	143	794	10.61	58.90
10	74	868	5.49	64.39
11	34	902	2.52	66.91
12	69	971	5.12	72.03
13	31	1002	2.30	74.33
14	7	1009	0.52	74.85
15	23	1032	1.71	76.56
16	37	1069	2.74	79.30
17	8	1077	0.59	79.90
18	10	1087	0.74	80.64
19	7	1094	0.52	81.16
20	61	1155	4.53	85.68
21	14	1169	1.04	86.72
22	14	1183	1.04	87.76
23	13	1196	0.96	88.72
24	50	1246	3.71	92.43
25	8	1254	0.59	93.03
26	7	1261	0.52	93.55
27	8	1269	0.59	94.14
28	19	1288	1.41	95.55
29	4	1292	0.30	95.85
30	4	1296	0.30	96.14
31	3	1299	0.22	96.36
32	18	1317	1.34	97.70
36	9	1326	0.67	98.37
38	1	1327	0.07	98.44
40	3	1330	0.22	98.66
42	1	1331	0.07	98.74
44	9	1340	0.67	99.41
48	2	1342	0.15	99.55
56	1	1343	0.07	99.63
60	1	1344	0.07	99.70
64	1	1345	0.07	99.78
80	2	1347	0.15	99.93
88	1	1348	0.07	100.00
Total	1348		100.00	

$$\rho = \frac{1248/3}{400} = 1{,}040 > 1$$

With ρ > 1, means that the traffic intensity that occurs cannot accommodate the existing vehicles.

D. FIFO Queue Analysis

The calculation results of the original volume queue analysis at the Cibubur 1 toll gate are as follows:

With a class I vehicle length = 5.8 m; class II = 8.7 m; class III = 12.1 m; class IV = 21 m; class V = m.

1) ATG Single (5 gates)

Using WP = 8 seconds/vehicle

Given:

λ = 2996 vehicle/hour

μ = 450

N = 5 gates (4, 6, 8, 10, and 12)

$$n = \frac{\lambda/N}{\mu - (\lambda/N)} = \frac{\rho}{(1-\rho)}$$

$$n = \frac{2996/5}{450-(2996/5)} = -4{,}01 \text{ vehicles}$$

$$q = \frac{(\lambda/N)^2}{\mu(\mu - (\lambda/N))} = \frac{\rho^2}{(1-\rho)}$$

$$q = \frac{(2996/5)^2}{450(450-(2996/5))} = -5{,}349 \text{ vehicles}$$

$$d = \frac{1}{\mu - (\lambda/N)} \text{x } 3600$$

$$d = \frac{1}{450 - (2996/5)} \text{x } 3600 = -24{,}141 \text{ seconds}$$

$$w = \frac{(\lambda/N)}{\mu(\mu - (\lambda/N))} = d - \frac{1}{\mu}$$

$$w = \frac{(2996/5)}{450(450 - (2996/5))} \text{x } 3600 = -32{,}141 \text{seconds}$$

At WP 8 seconds/vehicle, a queue analysis was conducted using various gates to see the number of gates needed. The queue calculation results using WP 8 seconds with the condition of the toll gate being fully operational (5 gates were open so that 5 queue lanes occur) can be seen in detail in Table 8.

From Table 8, the – (minus) value indicates the arrival rate is greater than the service level, so the queues that occur are infinite. Therefore, it is necessary to add 2 gates to accommodate the volume of existing vehicles.

2) ATG Multi (3 gates)

Using WP = 9 seconds/vehicle

Given:

λ = 1248 vehicles/hour

μ = 400

N = 3 gates (2, 14, and 16)

$$n = \frac{\lambda/N}{\mu - (\lambda/N)} = \frac{\rho}{(1-\rho)}$$

$$n = \frac{1248/3}{400-(1248/3)} = -26 \text{ vehicles}$$

Table 8. Queue Calculation of the Cibubur 1 Toll Gate ATG Single

Number of Gate (N)	*WP*	*FIFO Queue*					
		n (vech)	n (meter)	q (vech)	q (meter)	d (sec)	w (sec)
5	8	-5	-29	-6	-34.8	-25	-33
6	8	-11	-63.8	-12	-69.6	-74	-82
7	8	20	116	19	110.2	164	156

Table 9. Queue Calculation of the Cibubur 1 Toll Gate Multi

Number of Gate (N)	*WP*	*FIFO Queue*					
		n (vech)	n (meter)	q (vech)	q (meter)	d (detik)	w (detik)
3	9	-26	-164	-27	-170	-224	-233
4	9	4	26	3	19	41	32
5	9	2	13	2	13	24	15

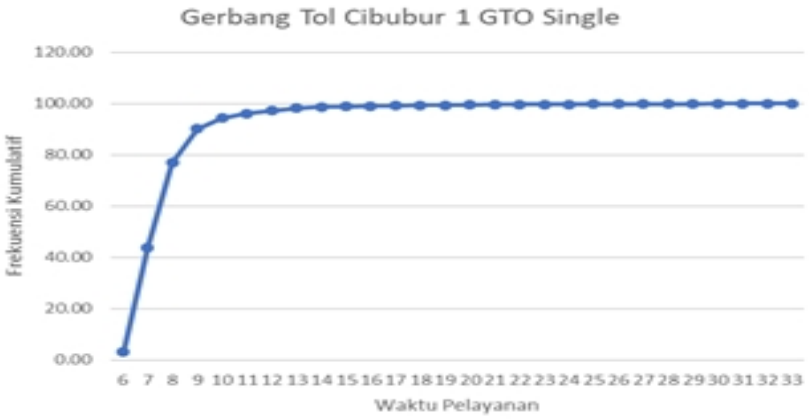

Figure 2. Graph of Cumulative Percentage (%) and Service Time of Cibubur 1 Toll Gate Single Gate.

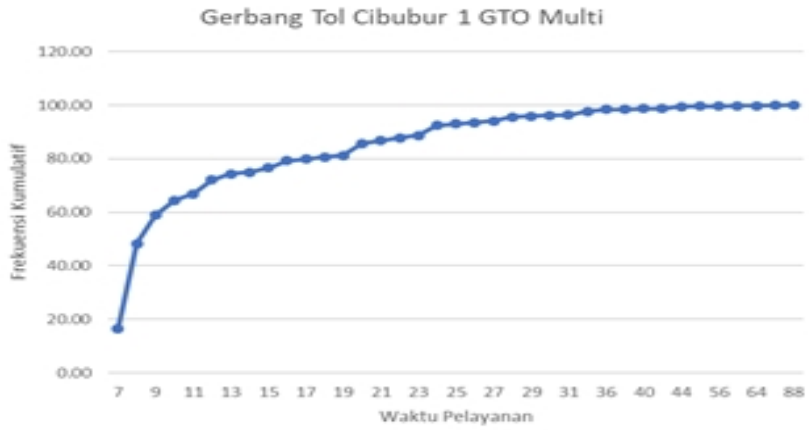

Figure 3. Graph of Cumulative Percentage (%) and Service Time of Cibubur 1 Toll Gate Multi Gate.

$$q = \frac{(\lambda/N)^2}{\mu(\mu - (\lambda/N))} = \frac{\rho^2}{(1-\rho)}$$

$q = \frac{(1248/3)^2}{400(400-(1248/3))} =$ -27 vehicles

$$d = \frac{1}{\mu - (\lambda/N)} \text{x } 3600$$

$d = \frac{1}{400 - (1248/3)} \text{x } 3600 = -224$ seconds

$$w = \frac{(\lambda/N)}{\mu(\mu - (\lambda/N))} = d - \frac{1}{\mu}$$

$w = \frac{(1248/3)}{400(400-(1248/3))} \text{x } 3600 = -233$ seconds

At WP 9 seconds/vehicle, a queue analysis was conducted using various gates to see the number of gates needed. The queue calculation results using WP 9 seconds with the condition of the toll gate being fully operational (3 gates were open so that 3 queue lines occur) in detail can be seen in Table 9.

From Table 9, the – (minus) value indicates the arrival rate is greater than the service level, so the queues that occur are infinite. Therefore, it is necessary to add 1 gate to accommodate the volume of existing vehicles.

CONCLUSIONS AND SUGGESTIONS

A. Conclusions

1) The queue length that occurred at the analyzed toll gate in 2019 are as follows:

a) At the Cibubur 1 toll gate, the queue length that occurred with the queue analysis results where the existing toll gates, namely 3 ATG Multi and 5 ATG

Single, became 4 ATG Multi and 8 ATG Single using the average service time, namely as follows:

a. Automatic Toll Gate Single for class I:

n (the number of vehicles in the system) = 5 vehicles = 36.5 meter; q (the number of vehicles in the queue) = 5 vehicles = 36.5 meter.

b. Automatic Toll Gate Multi for class I, II, III, IV, and V:

n (the number of vehicles in the system) = 4 vehicles = 32 meter; q (the number of vehicles in the queue) = 3 vehicles = 24 meter.

b) At the Cibubur 2 toll gate, the queue length that occurred with the queue analysis results where the existing toll gates, namely 3 ATG Multi and 2 ATG Single, became 3 ATG Multi and 3 ATG Single using the average service time, namely as follows:

a. Automatic Toll Gate Single class I:

n (the number of vehicles in the system) = 3 vehicles = 21.9 meter; q (the number of vehicles in the queue) = 2 vehicle = 14.6 meter.

b. Automatic Toll Gate Multi for class I, II, III, IV, and V:

n (the number of vehicles in the system) = 8 vehicles = 63 meter; q (the number of vehicles in the queue) = 7 vehicles = 55 meter.

c) At the Cibubur 2 Satelite toll gate, the queue length that occurred with the queue analysis results where the existing toll gates, namely 2 ATG Multi and 2 ATG Single, became 2 ATG Multi and 3 ATG Single using the average service time, namely as follows:

a. Automatic Toll Gate Single for class I:

n (the number of vehicles in the system) = 2 vehicles = 14.6 meter; q (the number of vehicles in the queue) = 2 vehicles = 14.6 meter.

b. Automatic Toll Gate Multi for class I, II, III, IV, and V:

n (the number of vehicles in the system) = 7 vehicles = 55 meter; q (the number of vehicles in the queue) = 6 vehicles = 47 meter.

3) Based on the results of the arrival rate analysis, it was known that the arrival rate was 531 vehicles/hour/gate at the Cibubur 1 toll gate; 421 vehicles/hour/gate at the Cibubur 2 toll gate; 337 vehicles/hour/gate at the Cibubur 2 Satellite toll gate. The arrival rate of the Cibubur 2 and Cibubur 2 Satellite toll gates has met the Minimum Service Standards (SMM) [2]. In contrast, the arrival rate of the Cibubur 1 toll gates has not met the Minimum Service Standards (SMM) [2], where the condition is that the arrival rate is <450 vehicles/hour/gate.

4) With the number of existing arrival rates, thus the number of gates that need to be opened for each toll gate, namely for the Cibubur 1 toll gate = 12 gates (4 ATG Multi and 8 ATG Single); for the Cibubur 2 toll gate = 6 gates (3 ATG Multi and 3 ATG Single); for the Cibubur 2 Satelite toll gate = 5 gates (2 ATG Multi and 3 ATG Single).

5) With the number of arrival rates that have been predicted, the number of gates that need to be opened for each toll gate is obtained as follows:

a) In 2024, namely for the Cibubur 1 toll gate = 15 gates (5 ATG Multi and 10 ATG Single); for Cibubur 2 toll gate = 7 gates (3 ATG Single and 4 ATG Multi); for Cibubur 2 Satellite toll gate = 6 gates (3 ATG Single and 3 ATG Multi).

b) In 2029, namely for the Cibubur 1 toll gate = 19 gates (6 ATG Multi and 13 ATG Single); for Cibubur 2 toll gate = 9 gates (5 ATG Multi and 4 ATG Single); for Cibubur 2 Satellite toll gate = 8 gates (4 ATG Single and 4 ATG Multi).

B. Suggestions

To achieve a smooth traffic flow at the toll gate, there are several things that managers can do to achieve a good vehicle traffic flow situation. Things that can be done are as follows:

a) Socialization to toll road users related to awareness of e-toll balance so that it is sufficient before entering the toll road.
b) Improve or update the system at each type of gates to shorten the transaction time
c) Simplify doing a top-up and buying e-toll cards.
d) Implementation of an automatic toll machine system, namely, there are several toll road machines in one lane, which have begun to be implemented on the Jakarta toll road.
e) Services should be calculated for each class of a vehicle and the queue length analysis is calculated based on the length of service and the number of vehicles according to the class

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