

EVALUATION OF SERVICE INFRASTRUCTURE INFORMATION PASTEUR TOLL GATE

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ABSTRACT: *The long queue that took place at the Pasteur toll gate caused inconvenience for users of the Pasteur toll gate. The length of the queue is one of the impact of the imbalance between service time and the number of vehicles. To overcome the queue length problem at Pasteur toll gate, it is necessary to evaluate the capacity and service time. In the evaluation process used queue simulation to obtain the optimum number of toll booth and the length of the queue space needed as a solution of the problems that occur. Solutions obtained from the results of further analysis laid the foundation in the geometric design of the Pasteur toll gate. the result is that the need of toll booth at Pasteur toll gate is 10 toll booth both for toll gate entrance and exit gate. For the projection result until 2027, it takes a substation of 14 toll booth on each gate.*

KEYWORDS: Simulation Queue, Number of Toll Booth, Toll Gate Geometry

INTRODUCTION

The unbalanced condition between the number of incoming and outgoing toll gates with service time led to long queues during peak hours at the Pasteur toll gate, thus causing inconvenience for users of the Pasteur toll gate. To improve the effectiveness and efficiency of the function of Pasteur toll gate, the need for a solution in the form of designing the improvement of service infrastructure at Pasteur toll gate in several variables such as the number of service toll booth.

LITERATURE

The theory used in this study refers to the results of research on "Level of Service Analysis of Toll Plazas on Freeway Main Lines". where in the research is trying to evaluate the performance of a toll gate with the main parameters of vehicle queue length by considering the volume parameters and capacity of the toll gate.

METHODOLOGY

The purpose of Pasteur toll gate evaluation is to find out the optimal number of toll booths required based on the number of vehicles crossing the Pasteur toll gate. The output of the queue simulation used to evaluate the Pasteur toll gate is the number of toll booth, the average length of the vehicle queue, the average time in the system which is a cumulative of the average time in the queue and the average service time as well as the length of the queue space. In the evaluation process there are several analysis steps that need to be done, the following explanation,

1. The first stage of evaluation is conducted to find out the output parameters of the simulation results of the existing condition, where the parameters of the number of toll booth which are the output parameters are used as input parameters with the service time parameters and the number of vehicles. The results of the analysis in the first stage is how long the average queue that occurs, how much time average in the system experienced by the vehicle, as well as how long the queue space needs. Previous studies (Lin & Su, 1994) on the queue simulation which is the main variable is the length of the queue, the following equations are used,

$$L = 0, \quad \text{if } \frac{V}{C} \leq 0,5 \quad (2.1)$$

$$L = 7\frac{V}{C} - 3,5 \quad \text{if } 0,5 \leq \frac{V}{C} \leq 0,93 \quad (2.2)$$

$$L = 3 \left[1 + 6,29 \left(\frac{V}{C} - 0,93 \right) \left(\frac{C \times 3600}{360} - 1 \right) \right] \left[1 + \left(14\frac{V}{C} - 13 \right)^2 t \right]$$

$$\text{if } \frac{V}{C} \geq 0,93 \quad (2.3)$$

In addition to the length of the queue, in this simulation we can obtain the maximum queue length data value to determine the Toll Plaza design, to obtain the maximum queue length value, the equation is used as follows

$$L_{max} = 7 + 1.7L, \quad \text{if } L \leq 10 \quad (2.4)$$

and

$$L_{max} = 11 + 1.3L, \quad \text{if } L > 10 \quad (2.5)$$

Explanation,

L = System queue length, vehicle

V = volume / number of vehicle (λ), vehicle/second

C = Capacity, vehicle/second

t = durasi, jam

$$T = \frac{1605 + 3250L}{C} \quad \text{if } L \leq 15 \quad (2.6)$$

$$T = \frac{8748 + 2776L}{C} \quad \text{if } L > 15 \quad (2.7)$$

$$C = \frac{60}{ST} \quad (2.8)$$

Explanation,

T = average time in system, second

L = average queue length, vehicle

C = Capacity of toll both, vehicle/hour

ST = service time, second

Vehicle arrival delay time can be calculated by equation,

$$d = 0,92T \quad (2.9)$$

$$d = \frac{2,060 + 2,980L}{C} \text{ if } L \leq 15 \quad (2.10)$$

$$d = \frac{8,244 + 2,570L}{C} \text{ if } L \geq 15 \quad (2.11)$$

Explanation,

d = delay time of arrival of vehicle, second

T = average time in system, second

L = average queue length, vehicle

C = Capacity of toll both, vehicle/hour

To calculate the required number of gates the equations are used,

$$N_i = \frac{F_i}{c_i \left(\frac{V}{C} \right)_i} \quad (2.12)$$

Explanation,

N = number of toll booth needed, unit

V = volume / number of vehicle (λ), vehicle/second

C = Capacity of toll both, vehicle/hour

F = Design of vehivle flow, vehicle/hour

2. After the first stage is finish, the next is verification of the simulation results with real conditions that occur at the toll gate associated with the queue length parameters and the average delay time in the system. The real conditions occurring at the toll booths are the number of vehicles per 15 minutes for one hour, as well as the time delay in the system from multiple vehicle samples over the course of an hour, as well as the average queue length that occurs within one hour, real condition data in the field taken at the same time both day and hour.

From the verification result to the next real condition compared with the simulation result on the queue length and time delay parameters in the system, if there is any difference then calibration is necessary. if there is no difference in the results of both, it can be concluded that the queue simulation is in accordance with real conditions at the toll gate pasteur. The calibration will produce a constant aka multiplied by the equation to calculate the queue length and time delay in the system.

3. After calibration, use the simulation that has been added to the calibration constant constants to analyze the next step is to evaluate the need for optimal number of toll booth on the Pasteur toll gate. Having obtained the output of the analysis of the number of toll booth, the length of the queue and the time delay in the system, compared with the minimum service standards for the queue length queue is in accordance with the minimum service standards of toll roads.

If the length of the queue does not meet the requirements of the minimum toll road service standards, it is necessary to evaluate the substation capacity, whether the service system composition is used in the substation, or improve the service system used in terms of the use of technology to increase the speed of transactions at toll booths.

RESULTS AND DISCUSSION

At the time of evaluating the toll gate of Pasteur both toll gate entrance and exit gate of toll. Input data used is the number of vehicles during peak hours and time average pelayananan at toll gate Pasteur. for the data of the number of vehicles used is the maximum number of vehicles during peak hours of data on the number of vehicles per hour from October to December 2017. For the number of vehicles obtained value of 2047 vehicles at the entrance gate tolls and 2557 vehicles at the exit gate, 10.52 seconds. Table 4.1 shows the results of the analysis on the Pasteur toll gate after the service system implemented e-toll on all toll booths. At the gate entrance of the average queue length of the line is 42 vehicles with an average time in the system of 366 seconds, while at the exit gate, the average queue length is 3 vehicles with the average time in the system for 50 seconds.

Table 4.1: Query Queue Length and Average Time Results in the System under the conditions after the e-toll System implementation

ENTRANCE GATE					
Number of Vehicle	Toll Booth Capacity	Number of Toll Booth	Actual v/c Ratio	Average Queue Length (L)	Average Time in System (T)
veh/hour	veh/hour	unit		veh.	sec.
2047	342	5	1,197	42	366
GERBANG KELUAR TOL PASTEUR					
Number of Vehicle	Toll Booth Capacity	Number of Toll Booth	Actual v/c Ratio	Average Queue Length (L)	Average Time in System (T)
veh/hour	veh/hour	unit		veh.	sec.
2557	342	8	0,935	3	50

After evaluating the Pasteur toll gate, the question arises as to whether the results of the analysis reflect the real conditions occurring at the Pasteur toll gate, given that certain conditions of congestion are still common. Therefore, it is necessary to verify the simulation result on real condition at Pasteur toll gate for the average queue length parameter as well as the average time in the system.

Verification aims to prove that the analysis performed shows the same results on the real conditions that occur. Analysis of the capacity of Pasteur toll gate is done by using queuing simulation developed by Lin and Su Year 1994 where the object of research conducted is toll gate located in Taiwan. Differences object of research is feared to have different characteristics as well, so it needs a verification whether correct simulation queue used to give the same results with the real conditions that occur at the toll gate Pasteur.

In this verification stage the data used are the primary data obtained from the results of the survey on Friday, February 2, 2018 at 08:00 to 09:00 pm on the exit gate, adapain data obtained is the number of vehicles every 15 minutes, average and average time in the system. Table 4.2 shows the results of the queue simulation on the day, date and time, obtained the value that the average queue length is 2.23 vehicles and the average time in the system is 25.90.

Table 4.2: Result of Queue Length Calculation and Average Time in System for Verification

Number of Vehicle	Toll Booth Capacity	Number of Toll Booth	Actual v/c Ratio	Average Queue Length (L)	Average Time in System (T)
veh/hour	veh/hour	unit		veh.	sec.
2242	342	8	0,819	2,23	25,90

Table 4.3 is a comparison of the results of the analysis with a queue simulation with real conditions at the exit gate of Pasteur toll. Once verified there is a difference, for the average queue length value there is a difference of 0.54 so that if the obtained value of the average queue length of the simulation results need to multiply the constant with a value of 0.24 so that between the simulation results the same as the conditions at the Pasteur toll gate, meanwhile the average time in the system needs to be multiplied by a constant with a value of 0.53 because there is a difference of 13.72 seconds. The constants will then be used during the analysis using queue simulation at the Pasteur toll gate.

Tabel 4.3: Results of Verification of Queue Simulation on Real Conditions at Pasteur Toll Gate Exit.

Parameter	Queue Simulation Results	Real Condition	Difference	Konstanta
1	2	3	4	5
Average Queue Length (L) (veh.)	2,23	2,77	0,54	0,24
Average Time in System (sec.)	25.90	39,62	13,72	0,53

The data of the number of vehicles owned is the sample data of the number of vehicles from June to December, so there is data that is not known in the preceding months, for the ignorance is necessary to predict the data by generating existing data so close to the real data. The monte carlo method is the frequently used data generating method, while the Generator or the tool for generating data in this research uses excel software help. Input data to generate data by monte carlo method is the mean value, standard deviation and distribution type. In this study the parameters to be generated is the value of the number of vehicles per hour from June to December. Generate data on the number of vehicles performed on the analysis table to calculate the need for the number of toll booth as in Table 4.4, so it will automatically perform calculations for other parameters such as average queue length, average time in the system, maximum queue length and queue space length on the toll plaza.

Table 4.4: Example of Requirements Calculation Results Gardu Number, After done Generating Data on the Number of Vehicles

Number of Vehicle	Average of Service Time	Toll Booth Capacity	Design Service Flow (F)	Estimation (V/C) ratio	Number of Toll Booth	Actual (V/C) ratio
1	2	3	4	5	6	7
1774						
1580	10,52	342	1580	0,800	5,77	0,800
495	10,52	342	495	0,800	1,81	0,800

Average Queue Length (L) (veh.)	Average Time in System (T) (sec.)	Maksimum Average Queue Length (L) (veh.)	Toll Plaza Queue Length (meters)
8	9	10	11
2	25	11	110
2	25	11	110

After the next value of substation count value calculate the mean value and standard deviation of the number of substations both at the entrance gate or toll gate exit, the mean and standard deviation of each gate can be seen in Table 3.5, the data of the substation number is then made frequency graph based the mean and standard values devised by Table 4.5.

Table 4.5: Mean and Standard Deviation Value of Generate Data Number of Vehicles at each Pasteur Toll Gate

Gate	Mean	Standard Deviation
Entrence	4,92	2,53
Leave	4,81	2,49

When finished creating the next frequency table for the frequency graph, it will get the graph form as in Figure 4.1. for toll entrance gates and Figure 4.2 for toll exit gates. From the graph then will be searched how many substations will be used for designing of Pasteur toll gate, based on trust level.

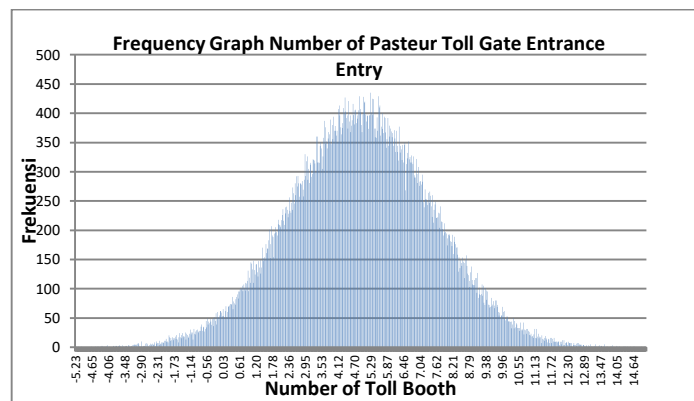


Figure 4.1 Frequency Graph Number of Pasteur Toll Gate Entrance Entry

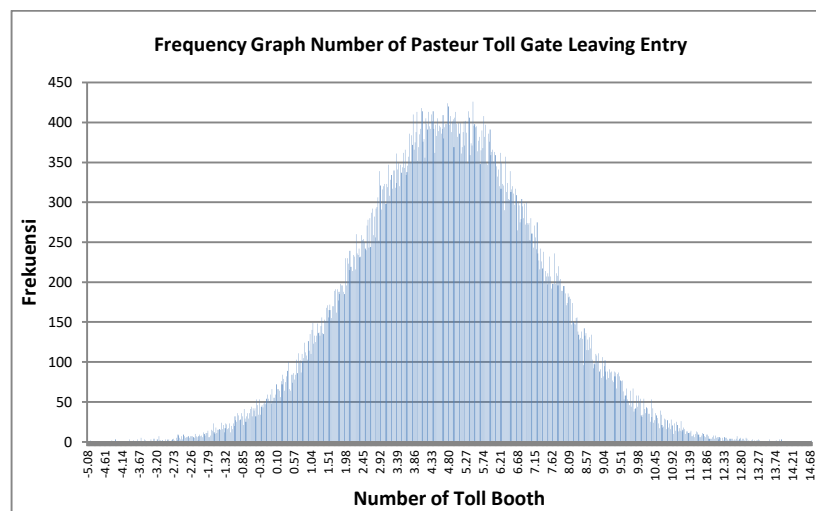


Figure 4.2 Frequency Graph Number of Pasteur Toll Gate Leaving Entry

Speaking of statistical data the number of substations will certainly talk about the distribution of data, the distribution of data presented is a normal distribution because based on a random value when generating data, and the next is the characteristic of a data with normal distribution is from the form of the resulting graph will form a bell upside down with a peak that divides both sides with the same extent.

Speaking of the level of confidence, the data with normal distribution is a probability value. Figure 4.3. is a normal distribution of distributed data distribution with a 95% confidence level, meaning that the level of trust is the area of a normal distribution graph or it can also be obtained from a graph of the distribution of a probability value or probability of an event. To simplify the current there is a normal distribution table that can be used to determine the probability of an event aided by equations for a standard normal distribution such as the following equation

$$z = \frac{x - \bar{x}}{\sigma}$$

Explanation :

z = Random variable of normal distribution

x = The value of an event

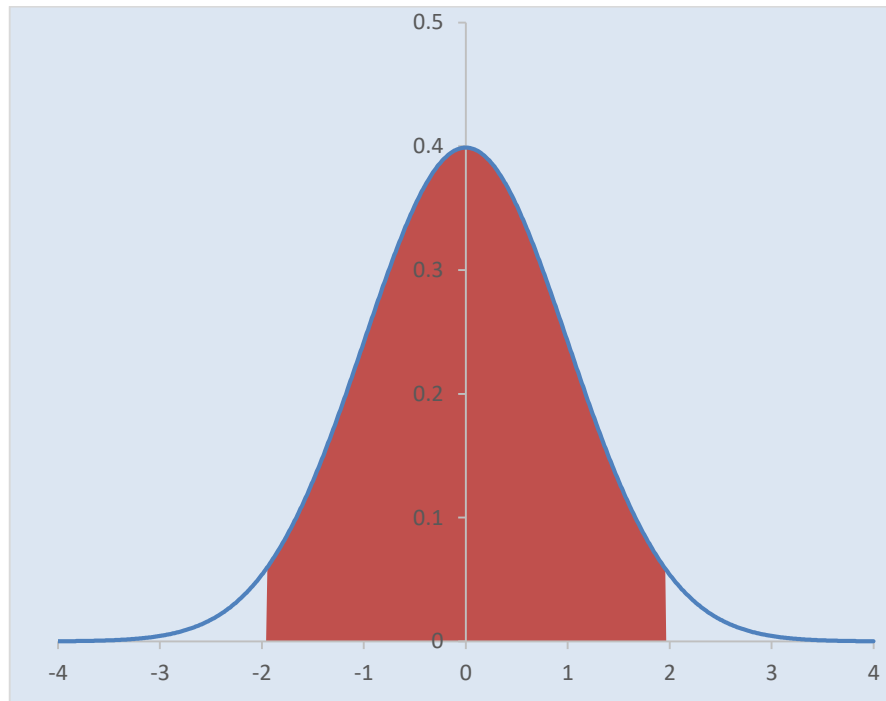
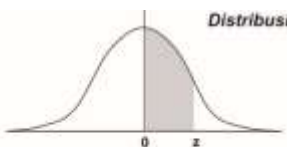
\bar{x} = Mean σ = Standard Deviation

Figure 4.3 Normal Distribution Chart

To determine how many substations will be used then the first time how much the level of confidence to be selected, in this study will use a confidence level of 95%. First of all how much the value of z with a confidence level of 95%, then used the help of normal distribution table 0 - z as in Table 4.6. 95% confidence level is the area under the normal distribution chart of 95%, but to find the area of 95% in the distribution table is by dividing the desired two area means if half of 95% is 47.5%, from the distribution table obtained z value with laus area 47,5% is 1,96.

Table 4.6 Normal Distribution Table from 0 to z


z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767

After the value of z is obtained then use the standard normal distribution equation to find out how much the value of x, the value of x to be searched is the value of the substation with probability or opportunity of 95%, the following explanation of the process of calculation:

Entrance Gate :

$$z = \frac{x - \bar{x}}{\sigma}$$

$$x = (z \times \sigma) + \bar{x}$$

$$x = (1,96 \times 2,93) + 4,93$$

$$x = 9,90 \sim 10 \text{ toll booth}$$

Leaving Gate :

$$z = \frac{x - \bar{x}}{\sigma}$$

$$x = (z \times \sigma) + \bar{x}$$

$$x = (1,96 \times 2,49) + 4,81$$

$$x = 9,69 \sim 10 \text{ toll booth}$$

From the calculation of the number of substations to be used for the design of the geometry of the toll gate obtained the value of the required substation as many as 10 substations and 10 substations for exit toll gate in 2017. In this study will be designed gate for 10 years to 2027 until, get the value then it is necessary to obtain the value of how much the value of vehicle growth at the toll gate Pasteur. To obtain the required growth rate, we use the comparison method or the average of the data in Table 4.7, so that the value of growth rate is 2.82% for toll entrance gate and 2.92% for exit gate.

Table 4.7 Number of Annual Traffic of Pasteur Toll Gate

Year	Gate		% Growth	
	Entrance	Leaving	Entrance	Leaving
2007	9.213.327	8.879.058		
2008	9.483.859	9.194.800	2,936	3,556
2009	10.063.122	9.814.217	6,108	6,737
2010	10.274.700	10.461.543	2,103	6,596
2011	10.785.722	11.021.815	4,974	5,356
2012	11.262.056	11.754.025	4,416	6,643
2013	11.503.885	12.285.625	2,147	4,523
2014	11.166.302	12.019.511	-2,935	-2,166
2015		11.764.047	2,821	-2,125
2016		11.900.752		1,162
2017		11.777.510		-1,036

Having obtained the level of growth, then the data is used to predict the number of substations toll pasteur next ten years using the following equation:

$$P_n = P_o(1 + i)^n$$

Explanation:

P_o = The number of initial toll booth

P_n = Number of toll booth year-n

n = Number of year

i = Growth Rate (%)

Table 4.8 is the result of the calculation of the number of substations 10 years to be precisely in 2027. Obtained the need for the number of substations at the Pasteur toll gate in 2027 is as much as 14 for both toll gate entrance and exit gate.

Table 4.8 The Need of Number of Toll Booth in Year 2027.

Gate Location	Number of Toll Booth	
	2017	2027
Entrance Gate	10	14
Leaving Gate	10	14

DISCUSSION

From result of analysis that it is known that requirement of toll gate number is 10 gate good for gate entrance and exit of toll. but the clan service party as the toll road manager only provides 7 toll gate entrance at the toll gate relocation. see these differences need to find what the cause of these differences, whether of the analysis of demand calculations toll booths or from differences in the level of trust that is used in the design needs of the toll gate

Implication to Research and Practice

The performance of toll gate is strongly influenced by factors such as gate capacity, arrival patterns and vehicle movement. but the need for a research related to the impact of geometry shapes or the placement of toll booths against parameters that affect the performance of the toll gate.

CONCLUSION

1. Based on the evaluation result by simulation of queue to capacity and service of toll gate of Pasteur at initial condition that is at the time still use service system, obtained result that value v / c ratio at toll gate of Pasteur > 1 added with high average queue length, at the entrance gate of the average queue toll of 5617 vehicles while at the exit gate -37.35 vehicles.
2. Looking at the evaluation result at point 1, it is necessary to verify the queuing simulation used, whether the simulation result actually shows the same result with real condition in Pasteur toll gate. From the verification result it turns out there is a difference to the average queue length and the average time in the system, there is a difference of 0.54 vehicles on the average queue length or approximately 0.24 times from the queue simulation results, while the average time in the system there is difference of 13.72 seconds or 0.53 times the simulation results. The value of time or the multiplier constants is calibrated to the simulation result for the queue length and time parameter in the system.
3. The need for substation at toll gate pasteur with 95% confidence level in 2017 is 10 substations both for toll gate entrance and exit gate, while for year 2027, need of

substation to 14 substation at each gate taking into account growth rate for toll gate entrance of 2.82% and toll exit gate of 2.92%.

4. To design the geometry of the Pasteur toll gate, toll plaza is obtained the required queue space is 110 meters with a taper along the 195 meters plus a slowing path with a plan speed of 60 km / h, the length of the 70 meter slowing path with a 45 meter taper, while the acceleration path with a plan speed of 60 km / h for the acceleration path length is 120 meters and taper 45 meters. For the placement of substations at the toll gates of 14 substations are made into two lines, each line consisting of 7 substations. Each row consists of 5 lanes for Class 1 vehicles with a maximum vehicle height of 2.3 meters and two lanes for Class II vehicles up to Class V.
5. Location of Pasteur toll gate will be relocated to 5 + 000 kilometers with consideration of area and availability of land for Pasteur toll gate.
6. Pasteur toll gate implementation method is divided into 3 zones, where zone 1 becomes the main settlement priority so that traffic flow in Pasteur toll road is not disturbed for long enough time.

FUTURE RESEARCH

1. Regarding the data verification stage of queue simulation result against real condition that happened at Pasteur toll gate, need to get more primary data as material of verification, so for calibration process give result of multiplier constants which really close to real condition at toll gate of Pasteur.
2. On February 1, 2018, the PT. Jasa Marga (Persero) Tbk. The Purbaleunyi Toll Branch relocates to the toll entrance gate to a location adjacent to the ramp site of the Baros toll exit gate, so it needs to be analyzed as well as the previous toll gate entrance.

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