Evaluation Tol Gates Study in Karang Tengah of Toll road (Jakarta–Tangerang, West Java, Indonesia)

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Abstract: The increase of traffic volume on the Jakarta - Tangerang toll road from the beginning of operations to the present (1984 to 2015) has started to cause quite long queues, especially at the Gates of Karang Tengah Toll Gate, which indicates the start of the toll gate transaction capacity compared to Volume of transactions to be served. This is coupled with the operation of JORR segment W1 West and North W2, Ramp Alam Sutera and Ramp / Simpang Susun Km. 11 + 000. Survey data then processed and used in analyzing the capacity of toll gates is a queue component, including queue length and queue time. With the number of toll booths operated amounted to 32 (thirty two), each has different levels of service because there are substations that have been using the electronic system is toll no. 05, 06, 07, and 08 (line A) as well as toll booth no. 22, 23, 24 and 25 (line B). In addition, there are 4 (four) tandem-installed substations, (this is enabled if the arrival rate of vehicles in one lane is too dense).By taking a queue parameter, by inputting the service level data, the number of vehicles that can be serviced for each substation that operates is 302 vehicles / hour does not meet Minimum Service Standard of toll road <270 vehicle / hour per substation. And also can concluded effort to improve service of gate is by minimizing service time, adding toll booth and applying of electronic system.

Keywords: Queue, arrival rate, service time.

I.   INTRODUCTION

The toll road is a public highway and as a national road whose users are required to pay the toll. Steady traffic on the toll road is affected by service time provided by toll road operator on toll road users when picking up tickets at toll gate counters. The increase of traffic volume on the Jakarta - Tangerang toll road from the beginning of operations to the present (1984 to 2015) has started to cause quite long queues, especially at the Gates of Karang Tengah Toll Gate, which indicates the dense capacity of toll gate transactions to be served. This is coupled with the operation of JORR, Ramp Alam Sutera and Ramp / Simpang Susun Km. 11 + 000. The toll gate of Karang Tengah is a toll gate through which the toll gate is an access (entrance) of vehicles moving from West Jakarta to Tangerang / Banten and surrounding areas and is an exit (exit) access that moves otherwise.

Figure 1   Location Toll Gate Karang Tengah Km. 09+600

II. TOLL ROAD SYSTEM

Toll road transaction services, can be explained as follows:

1. Open sevice that is user of toll only do one transaction when entering toll gate

2. Closed sevice where toll user is obliged to conduct 2 (two) transactions where at the first gate entrance by taking ticket and transaction at exit toll gate in accordance with the road travesed.

Electronic sevice where toll users do not conduct ticketing or ticketing activities or payments at toll gates, but instead use transponder tools owned by vehicle and connect with customer accounts debited or usually toll charges sent it later to the registered owner by mail.

III.   PLANNING TOLL GATE

A. General Criteria:

Toll gate must be planned according to the following criteria:

a.   The roof construction and minimum height of the toll gate are constructed that it has free space on the traffic lane with a minimum height of 5.10 m.

b.   The width of the roof is minimum 13 m and the form of the listplank is made such that it allows the installation of traffic lights or lane indicator. The placement of the gate column must be such that it does not interfere with the free-collecting view of the toll collector towards the arrival of the vehicle and the need for adequate space for the employee of the gate in carrying out its duties at the toll gate.

c.   For toll gates with numbers of lanes over 10 lanes (9 toll islands) are required to be equipped with interconnecting tunnels between substations and to the gate office for the safety and security of toll collectors which also accommodate utilities.

d.   Placement of lights on the roof of the gate to be made and do not dazzle toll collectors to see the vehicles coming and do not interfere with the function of lane indicator.

B. Island toll (Toll Island):

The minimum island width of the toll is 2.10 m with a minimum length of 25 m for the direct lane and 33 m for the reversible lane. The tip of the toll island facing the direction of traffic comes with bull nose and 2 bumper blocks. One bumper block is placed at the end of the bull nose and the other one is placed in front of the toll booth. The bull nose length is 7 m and the bumper block height is 1.35 m above the road surface. The toll island margin is completed with a concrete curb (road frame) with a height of 0.25 m above the road surface.

C. Toll booth (toll booth):

The toll booths need to be planned in such a way to create comfortable and comfortable working conditions for toll collectors. For that toll booths should be equipped with temperature regulator, fresh air supply and communication equipment between substations and with gate or post office. The size of toll booth minimum width 1.25 m length 2.00 m and height of 2.5 m. The toll booth is a sliding door and placed on the rear of the substation, with a minimum width of 0.60 m.

D. Number of toll booth requirements:

To determine the number of lanes or number of planned toll booths, will be determined by 3 (three) factors:

1. Traffic volume

In planning the number of lanes (toll booths), the traffic volume to be approximate with is the volume of traffic during peak hours, in this case the traffic volume of the planning is used.

2. Service time at toll booth

The amount of service time is as follows:

o   Open toll collection system

• Incoming / outgoing entries: 6 seconds

o Toll collection system is closed

• Entrance: 4 seconds

• Outgoing entries: 10 seconds

o Service standard (number of allowed vehicle queues)

For the purposes of calculating the plan for the number of lanes (substations) of tolls at toll booths, the number of vehicle queues per lane (per substation) maximum is 3 (three) vehicles.

E. Tariff Toll Roads:

The toll rates imposed on toll road users correspond to vehicle type and vehicle mileage. Toll rates are determined by the following considerations (Government Regulation No. 15 of 2005 on Toll Roads): Based on the Decree of the Minister of Public Works No. 370 / KPTS / M / 2007 as below:

TABEL I: TYPE OF VEHICLES WHICH IS USED ON TOLL ROADS.

a	Type I	:	Private car, Jeep, Pick Up / Small Truck, Bus
b.	Type II	:	Truck with 2 axle
c	Type III	:	Truck with 3 axle.
d.	Type IV	:	Truck with 4. axle.
e	Type V	:	Truck with 5 axle.

IV. CHARACTERISTICS OF QUEUES

In the queuing system there are several characteristics that must be considered for service providers to serve customers who arrive, namely:

A. Arrival Rate (λ):

The arrival rate of customers is usually calculated through time between arrivals, ie the time between the arrival of two or more consecutive customers at a service facility.

Headway distribution of traffic arrivals, which may be evenly distributed (ie with a constant headway) or may follow a random arrival pattern (Poisson). Arbitrary arrival patterns can be described with statistical distributions and can be determined in two ways: arrival per unit time and time distribution between arrivals. All arrivals are depicted with a discontinuous and non-negative integer random variable (0, 1, 2, 3, 4, 5, etc.). For 10 minutes cars that queue at toll booths can be 3, 5, 8, etc.

The number of vehicles coming at one interval is independent of the other interval. The probability n arrival in time T is determined by the formula:

$$P(r,T) = \frac{e^{-\lambda T}}{r!}$$

Where :

λ = average arrival time unity T = time period

e = natural logarithmic number (e = 2.7182818)

r = number of arrivals in time T; (N = 0,1,2 ....)

P(r,T)= probability n arrival in time T

If the arrival follows the Poisson Distribution that it can be shown mathematically will be distributed according to the exponential distribution.

$P(s \leq t) = e^{-\lambda t}$, $0 \leq t \leq \infty$

Where :

P (s≤ t) = probability where time between arrival time unity

λ = average arrival time unity

t = average time in system (sec)

B. Service Level (μ):

The level of service is usually characterized by service time, ie the time it takes to serve the customer. Service time is the length of time since service is provided to the customer until the service facility is completed.

In addition to the level of service, it is also known that the Service Time (WP) can be defined as

WP = 1 / μ

Also known as ρ notation is defined as a comparison between

Arrival rate (λ) with the level of service (μ) with the requirement that the value should always be less than 1

ρ = λ / μ

If the value is ρ> 1, this means that the arrival rate is greater than the level of service. If this happens, then certainly there will be a queue that will always increase in length (infinity).

C. Mechanism and Number of Service Gateway:

The service mechanism consists of one or more series facilities. Each facility can have one or more parallel service gates. If the system has more than one service facility then the population will receive service in series that must pass the service circuit first, then can leave the system. If the system has more than one parallel service gate, then some populations can serve simultaneously.

A queuing model is called a single service, if the system has only one service gate and is called a dual service model if the system has a number of parallel service units each served by a set of services.

D. Queuing System:

The queuing structure can be classified by the number of gates or paths and the number of stages of service available. Single channel-single phase system means that in the queue system there is only one service provider and one type of service provided. While single-stage multi-phase single line queue system means that in the queue system there is more than one type of service provided, but in each service type there is only one service provider. One-way multi-channel single line queue system is one type of service in the queue system, but there is more than one service provider. Multiple-line multi-line queuing system (multi-channel multi-phase) is a queue system where there are more than one service type and there are more than one service provider in each service type. In this study will be discussed single-phase single gate (single channel-single phase) and single-stage multi-gate (multi-channel single phase).

V.   RESEARCH METHODS

A. Plant of Planning:

Data collection is done by visiting the agencies related to the problems that have been formulated. After the analysis, the results will be used to determine the level of the toll gate services. In addition, the results of the analysis can be used as a benchmark related to the planned upgrading of toll gate capacity in the future.

B. Data Collection:

Based on the source, the data obtained in the datav collection process is:

1. Primary data

Primary data is data obtained based on direct observation in the field by conducting field surveys. The survey was conducted at an outlet that operates at the Gates of Karang Tengah Toll Gate. The data taken during the survey are:

- Service time, when the vehicle stops in front of a counter for a transaction (when toll payment is in progress) until the vehicle moves out of the substation. The length of the queue is done by measuring the length of the queue that occurred shortly after the vehicle is right in front of the branch to make transactions.

- The arrival rate is done by calculating the number of vehicles coming in every minute.

- Number of gates is operated.

2. Secondary Data

Data obtained from records that already exist. The data is obtained from PT. Jasa Marga (Persero) Tbk. Branch as a toll road manager of Jakarta-Tangerang.

VI.   RESULTS AND DISCUSSION

A. Service Time Analysis per Toll Truck:

The required service time for each toll operated which can be explained in the following as:

1. Toll gate no. 05, 06, and 07 (line A) and substation no. 22, 23, and 24 (line B) applying electronic system (e-toll and e-pass) at substation no. Have service time (WP) <10 seconds.

2. Toll gate no. 08 (line A) and no. 25 (line B) implements ineffective electronic system, because at the substation the service time > 10 seconds vehicle driving.

3. The queuing intensity of vehicles on electronic substations is smaller (between 4 to 6 vehicles per substation) than the queue of vehicles in manual system substation (queue> 6 vehicles per shelter).

4. Intensity of vehicle arrival at satellite shelter (shelter 11 to 17 (line A) and shelter 27 to 36 (line B)) is smaller because the shelter is functioned for class II vehicles up to class V.

B. Conclusions:

The conclusions of the research results in this final project are as follows:

1. Based on data / samples conducted on Monday to Sunday December 7, 2015 to December 13, 2015 at 07.00 - 10.00 wib, found the volume of vehicles on the toll gate of Karang Tengah is:

a. The average arrival rate of vehicles on Monday December 7, 2015 is 2,684 vehicles per 15 minutes with 84 arrivals arrivals per substation.

b. The average arrival rate of vehicles on Tuesday, December 8, 2015 is 2,643 vehicles per 15 minutes with 83 arrivals arrivals per substation.

c. The average arrival rate of vehicles on Wednesday December 9, 2015 is 1,540 vehicles per 15 minutes with the arrival of 49 vehicles per substation.

d. The average arrival rate of vehicles on Thursday, December 10, 2015 is 2,814 vehicles per 15 minutes with 88 arrivals arriving per substation.

e. The average arrival rate of vehicles on Friday, December 11, 2015, is 2,654 vehicles per 15 minutes with 83 arrivals arriving at the substation.

f. The average arrival rate of vehicles on Saturday 12 December 2015 is 2,606 vehicles per 15 minutes with the arrival of 82 vehicles per substation.

g. The average arrival rate of vehicles on Sunday 13 December 2015 is 1,900 vehicles per 15 minutes with the arrival of 60 vehicles per substation.

h. Based on the data obtained that the average maximum vehicle arrival rate occurs on Thursday December 10, 2015 with the maximum average service time at the gate of the toll of Karang Tengah is 12.424 seconds. The toll road operators prepare a policy to anticipate the traffic density of vehicles that will pass through the toll gate of Karang Tengah.

2. It can be concluded that toll substations that implementelectronic system (e-toll card) in toll booth no. 05, 06, 07, and 08 (line A) as well as toll booth no. 22, 23, 24 and 25 (line B) are more efficient and effective due to service time (WP) <10 seconds of vehicles with vehicle arrivals per gate> 102 vehicles per 15 minutes.

3. As for toll booth no. 15, 16, and 17 (line A) and substation no. 27, 28, 29, 30, 31, 32, 33, 34, 35, and 36 (line B) have service time (WP)> 11 seconds per vehicle and based on observations in the field, the toll is widely traversed by large loaded vehicles (Group II to class V) so that the queue of vehicles through the toll booth is not too long between 4 to 6 vehicles.

4. With the arrival rate of 302 vehicles / hour per substation and with service time of 12.424 seconds average, the toll gate of Karang Tengah does not meet the Minimum Service Standard requirements (SPM) Toll Road with number per substation> 270 vehicles / hour per substation with 10 seconds service .

5. Based on the calculation of service time above, the need for handling or solution, so the priority to determine the solution needs to be reduced service time so there is no long queue.

6. In an effort to minimize the value of $\bar{n}$, $(\bar{q},)$ $(\bar{d},)$ $\bar{w}$, it can be inferred the priority order of policy determination, that is:

• The first priority is the policy of minimizing service time as small as possible in accordance with Minimum Service Standard (SPM) Toll Road, which is a maximum of 6 seconds per vehicle.

• The second priority is the policy to increase / increase the capacity of existing toll gates.

• Implementation of electronic payment system using e-toll card.

VII.   CONCLUSIONS

1. The toll service is still 2 times the standard of service required Minimum Service Standards (SPM) Toll Road that has been determined by the Ministry of Public Works.

2. Appliances that implement electronic systems (e-toll cards) are more effective than manual toll system substations.

3. The arrival rate of vehicles per substation has exceeded the minimum service standard requirements (SPM) Toll Road with the number per substation> 270 vehicles / hour per substation with 10 second service.

ACKNOWLEDGMENT

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