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Analysis of the effect of toll gate geometry designs on traffic accidents in toll gate on Tangerang-Merak toll road

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Abstract. According to the data of accidents occurred throughout the period from January 2014 to September 2018 on the Tangerang-Merak toll road, there were 3117 traffic accidents which were spread across 72.4 kilometers of the Tangerang-Merak toll road. From the total number of 3117 accidents, 214 traffic accidents or 7% have occurred centrally in 10 Toll Gate locations. The picture of this situation seems to require further in-depth evaluation on why the accident at the Toll Gate whose location is centrally located is quite high compared to the accidents occurred along the toll road section where the location is scattered, while the vehicle speed at the location of the Toll Gate should be already in low speed before stopping to make a toll payment transaction.

1. Introduction

According to data records obtained from PT Marga Mandalasakti / Astra Infra Toll Road Tangerang-Merak, within the period of January 2014 to September 2018 there have been 3117 traffic accidents along 72.4 kilometers of the Tangerang-Merak toll road segment in which 214 traffic accidents occur at 10 toll gates.

Traffic movement on the toll road as a freeway has its own interesting characteristics to be continuously observed considering that toll road conditions have different dynamics compared to non-toll roads.

Toll Road as a Freeway has two main areas as a traffic movement area:

- First, is the area of toll road entrance and exit which includes access roads for entering / exiting the toll road, toll gate area and interchanges.
- Second, is the main route area / main road of the toll road after the entrance / exit area which covers the area along the toll road which consists of ROW, shoulder of the outer lane, lane 1, lane 2, lane 3 etc, inner shoulder, and median of the toll road.

Traffic accidents on roads / toll roads can occur due to driver factors, vehicle factors, road factors and environmental factors (Pignataro (1973), while the location of accidents on toll roads can occur spreadly either in the first area, namely in the entrance and exit, or in the second area along the toll road.

Based on the aforementioned causal factors it is very interesting to observe the phenomenon of traffic accidents incidence, because on the crime scene (TKP) that occurs on the main area / main road of the toll road, the location of the traffic accident point can occur spread along both directions, so the distribution of accident location points that can be actualized as the number of fatality figures and accident numbers will be divided representing the entire length of the toll road. As for traffic accidents that occur in the Toll Gate area which is the toll road entrance / exit area, is a pure traffic accident and occurs in an accumulated manner at a crime scene and is centered on the entrance and exit areas in particular at the Toll Gate. Traffic accidents can also occur in interchanges and access roads to the Toll Gate which is usually a relatively short road length of at least 2 KM (Construction Standards and Building No.007 / BM / 2009, Freeway to Toll Roads Geometry, Department of Public Works Directorate General of Highways.



2. Design and Method

Referring to Government Regulation Number 43 of 1993, the Definition of Accidents is an unexpected and unintended incident involving vehicles with or without other road users, resulting in human casualties or property losses. Traffic accident victims can be in the form of death victims, major injuries and minor injuries.

The calculation to measure the accident rate on toll roads is usually always assumed that the traffic accidents occur spreadly throughout the length of the toll road, even though the toll road construction physically consists of two main areas, namely the toll gate area which is the entrance and exit, and the main road of toll roads. In fact the incidence of traffic accidents in the exit / exit area will have a greater accident rate and fatality rate compared to the accident rate and fatality rate that occurs in the main lane / main road, considering that the toll gate area is accumulated at a point which is always the same, while the incidence of accidents on the main lane / main road is spread throughout the entire length of the toll road.

This research intends to observe the way of managing and handling accidents and calculating the number of accidents and fatality rates that have been done so far. From the data of accidents that occurred throughout the period of January 2014 to September 2018 on the Tangerang-Merak toll road, there were 3117 traffic accidents which were spread across 72.4 kilometers of the Tangerang-Merak toll road. While of the total number of 3117 incidents of accidents, 214 traffic accidents or 7% have occurred centrally in locations that only consist of 10 Toll Gate locations. When observed from the composition of incident location between the accidents in the main lane and the toll gate where 214 incidents occurred in 10 points of distribution of the gate location, while 3117 incidents of accidents occurred spreadly throughout the length of 72.4 kilometers of toll roads, then this picture of situation seems to require further in-depth evaluation as to why the accident at the Toll Gate is quite high compared to the incidence of accidents along the toll road section, considering the condition of vehicle speed at the Toll Gate has been at a low speed before stopping to perform toll tariff payment transactions.

The benefit of this research is to investigate and search for accident causes at Toll Gate locations and to bring the results of this study to a higher and more competent forum, in order to find the most optimal technical and operational solutions and recommendations to eliminate the occurrence of accidents at the Toll Gate, especially to the lowest level, to be utilized by toll road operators that are already operating, as well as in the design of future toll roads.

3. Discussion

This situation seems to require further in depth evaluation as to why the accident at the Toll Gate is quite high compared to the incidence of accidents along the toll road, while the vehicle speed conditions at the Gate are already at a low speed before stopping to make toll payment transactions.

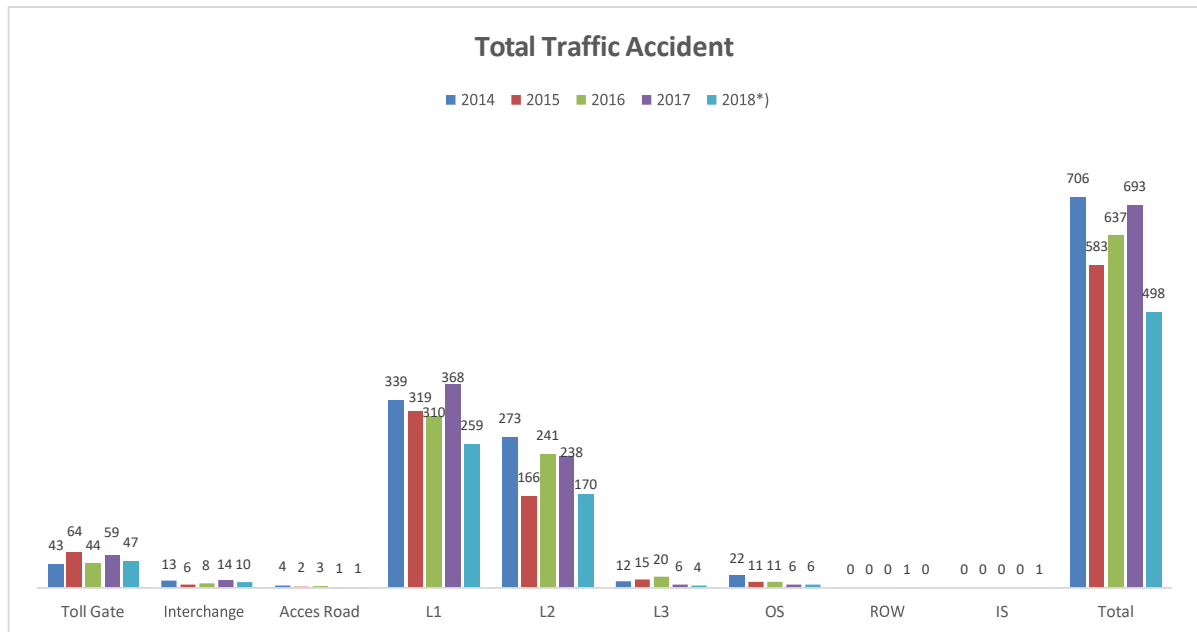


Figure 1. total traffic accident

Table 1. Total Traffic Accident and Percentage

	2014	2015	2016	2017	2018*)	Total
L1	339	319	310	368	259	1595
L2	273	166	241	238	170	1088
Toll Gate	43	64	44	59	47	257
L3	12	15	20	6	4	57
OS	22	11	11	6	6	56
Interchange	13	6	8	14	10	51
Access Road	4	2	3	1	1	11
ROW	0	0	0	1	0	1
IS	0	0	0	0	1	1
Total	706	583	637	693	498	3117
% on L1	48%	55%	49%	53%	52%	51%
% on L2	39%	28%	38%	34%	34%	35%
% on Toll Gate	6%	11%	7%	9%	9%	8%
% on L3	2%	3%	3%	1%	1%	2%
% on OS	3%	2%	2%	1%	1%	2%
% on Interchange	2%	1%	1%	2%	2%	2%
% on Access Road	1%	0%	0%	0%	0%	0%
% on ROW	0%	0%	0%	0%	0%	0%
% on IS	0%	0%	0%	0%	0%	0%

*based on data Jan-Sep 2018

- Based on the next table ranking, the traffic accidents rank on the Tangerang-Merak toll road is highest in number and percentage value in L1 location, where the second rank is at L2 location and the third highest rank is at the Toll Gate location.

It should be noted that although the incidence of accidents that occurred at L1 and L2 locations (first and second rank) with total number of accidents of 3117, the crime scene (TKP) for both categories were spread into 72.4 kilometers long toll roads, while the accident occurred at the location of the Toll Gate with the total of 257 incidents, occurred centrally at the Toll Gates (in 10 toll gate locations).

- From the above observations and discussion, it seems clear that there are things that need to be studied in depth on why the incident of the Accident at the Toll Gate can occur along the observation period of 4 years 9 months between January 2014 and September 2018, with high enough numbers which leads to questions as to why the toll gate area which considered an operational site with low speed before stopping to perform toll tariff payment transactions is actually a **Blacksite** area.

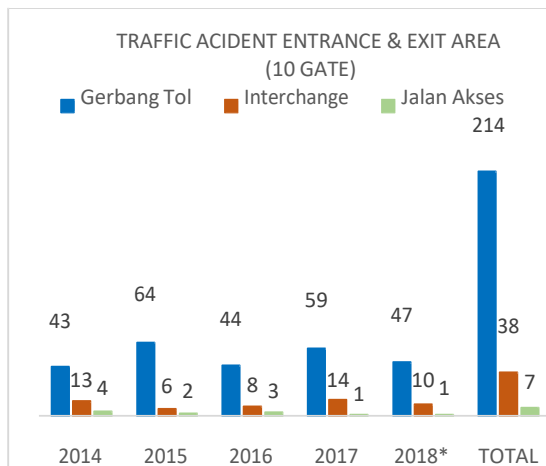


Figure 2. Traffic Accident Entrance & Exit Area (10 Gate)

Table 2. Rank and Number of Traffic Accident per Entrance/Exit

Gate	2014	2015	2016	2017	2018*	Total
Cikupa	21	24	8	22	14	89
Ciujung	6	13	13	14	10	56
BalBar	6	9	8	7	2	32
CilTim	4	5	4	6	7	26
SerTim	3	4	2	3	8	20
Merak	2	4	2	3	2	13
CilBar	1	4	1	2	2	10
SerBar	0	0	3	2	2	7
BalTim	0	1	3	0	0	4
Cikande	0	0	0	0	0	0

Table 3. Cause and Rank of Accident on Toll Gate

Cause	Qty
Anticipative	124
Brake Failure	89
Driver Fatigue	16
Overload	8
Mechanical	6
Flat Tire	4
Etc	3
Skid	2
Unsafe Distance (too close)	1
Undisciplined	1
Road Crossers	1
Law Officer's Vehicle	1
Stopped Vehicle	1
Total	257

- When examined in greater depth from the above table, it appears that from the location ratings of toll gates located along the Tangerang-Merak toll road, the most accidents occur at the Cikupa Toll Gate with a total occurrence over the period of January 2014 to in September 2018 with 89 incidents in the same location, this of course really needed more in-depth follow-up from various competent parties to find problems and solutions. Geographically the Cikupa Toll Gate is located at kilometer

31 + 00 of the Tangerang-Merak toll road which is a Gate with a "Barrier" configuration which functions as an On / Off Toll Gate which separates the operational area between the Tangerang-Tangerang Barat toll road (Jasa Marga) and West Tangerang-Merak Toll Road (Astra Marga Mandalasakti). Geometrically, the condition of the Toll Gate is well planned according to the applicable standards, but if we look at the data, the highest accident cause besides the brake failure are the same as most other toll gates, which is due to lack of anticipation, this is possible considering that drivers approaching Cikupa Toll Gate are in a state of condition of traveling far enough for 31 kilometers from Jakarta so the alert level are most likely not ready when entering the Cikupa Toll Gate with its barrier form and its location in the middle of the trip.

- However, these situations and conditions do not occur at the Merak Toll Gate which also has the form of a "Barrier" configuration which functions as an On / Off Toll Gate from the direction of Merak for the Tangerang-Merak toll road.
- There is a possibility that the level of traffic density in the area around the Toll Gate affects the number of accidents at the Toll Gate so that more in-depth study and research will be needed on this matter as well as geometric studies and other studies.
- Furthermore, the second rank for traffic accidents occurred at the Toll Gate is on the Tangerang-Merak toll road, followed subsequently by Ciujung Toll Gate with 56 events, the Balaraja Barat Toll Gate (Balbar) with 32 events, the Cilegon Timur Toll Gate (Ciltim) with 26 events.
- The aforementioned toll gates (Ciujung, Balbar, Ciltim) have similar forms and configurations, namely in the Toll Gate form whose position is at the end of a downhill road at the exit off ramp / entrance on ramp from an Interchange location with a form of a Trumpet. Significantly, the number of accidents occurrence has decreased according to the Toll Gate position where the traffic volume to the west direction is lower

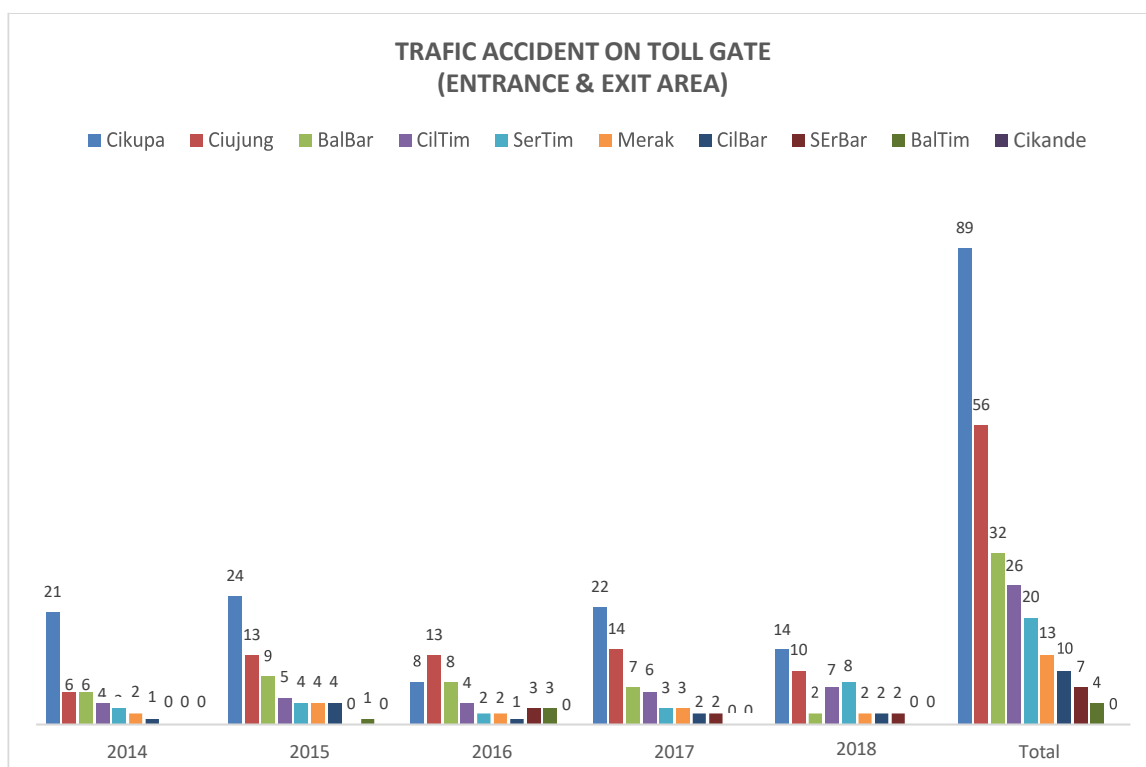


Figure 3. Traffic Accident On Toll Gate (Entrance & Exit Area)

Table 4. Type of Vehicle Involve in Accident on Toll Gate

Vehicle Type	Qty
Heavy Truck	121
Trailer Truck	41
Minibus	26
Small Truck	19
Box Van	13
Big Bus	12
Tank Truck	8
Pick Up	5
Sedan	4
Articulated Truck	3
Jeep	3
Unidentified Vehicle	1
Small Bus	1
Total	257

if we look at the majority of vehicle types involved in accidents at the Tangerang-Merak Toll Gate between January 2014 to September 2018, the highest rating is experienced and is dominated by the heavy truck type, which accounts to 121 accidents, whereas the second rank is dominated by trailer trucks. Both vehicle types have large dimension and carrying capacity so that the process of lowering speed or stopping will require a longer deceleration lane until the vehicle can stop completely.

4. Conclusion

According to the above analysis result, it can be concluded that there are quite massive number of accidents occurring on the toll road which were caused by vehicles lowering their speed in the process of braking to stopping to conduct toll payment transactions, indicating that there are something quite basic which must be evaluated, further researched and explored so we can obtain the most geometrical, aligned design, with optimal architecture that can ensure the safety of the toll road users as a whole when they are at the Toll Gate.

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