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ROAD SAFETY AUDIT TANGERANG - MERAK TOLL ROAD

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ABSTRACT

Tangerang-Merak Toll Road is a toll road connecting Tangerang and Merak Port, which includes Cikupa Toll Road, East Balaraja, West Balaraja, Ciakande, Ciujung, East Serang, West Serang, East Cilegon, West Cilegon, and Merak. With the more congested, will make the risk of car accidents also increased. In an effort to improve of road safety, especially toll roads, a Road Safety Audit (AKJ) is needed. Aspects examined and observed include geometric, traffic management, pavements, street furnitures and complementary buildings. As a result, it is concluded that in geometric aspect, in general has been designed in accordance with the provisions, but nevertheless there are parts that still require improvement. This research will discussed the existing condition of Tangerang-Merak Toll Road based on direct observation. The aspects reviewed are geometric, pavement, street furnitures and road complementary buildings such as Signs, Markings and Median roads. In the end, accident-prone areas will be obtained on tangerang- merak toll road with a comparison analysis of direct observation data, and traffic accident data.

KEYWORDS *Toll Road, Street funitures, Accident Prone Areas, Road Safety Audit*

INTRODUCTION

Traffic violations are quite high, and the ownership of private vehicles is increasing day by day, which indirectly can trigger traffic accidents. Despite the experiences of developed countries in addressing road safety deficiencies, these practices are often not implemented in Indonesia because almost 92% of accidents are caused by human factors, 5% by vehicle factors, and 3% by road infrastructure and environment (Fuller, 2005; Mulyono et al., 2009). The interaction between humans and road surface conditions contributes to nearly 35% of road accidents (Treat et al., 1979), which then decreases to 24% (Austroads, 2002). Accidents in urban areas further categorize human error factors driven by limited visibility when driving, causing almost 30% of accidents (Austroads, 2002).

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In the past two years, traffic accidents in Indonesia, as assessed by the World Health Organization (WHO) in 2018, were considered the third largest killer, following coronary heart disease and tuberculosis/TB. The high number of traffic accidents urges the mobilization of all national components to collectively reduce accident rates in Indonesia (Zulhendra, 2015).

Indonesia has a vast land area, with extensive road infrastructure including the Trans-Java Toll Road. Toll roads are continuously constructed to alleviate congestion on arterial roads (Radiansyah et al., 2017). However, with the increasing inter-city activities among the population, congestion also occurs on toll roads, leading to accidents. According to BPS data for 2018, traffic accidents caused at least 27,910 fatalities throughout the year, with a total of 103,672 recorded traffic accidents. Additionally, the number of minor injuries this year increased by about 17 percent from 4492 in 2017 to 5237 victims this year. The notion that human error is more triggered by traffic system and road conditions at certain times that cannot be anticipated (hazard surprised) by road users, thus the installation of signs and markings is highly useful for early warning and anticipation (Duddu et al., 2019; Firgian et al., 2014; Idalin et al., 2018). For example, research at the University of Leeds in 1989 (Carsten, 1989) on accidents in urban areas further categorizes human error factors driven by limited visibility when driving, which accounts for almost 30% of the 45% of cases caused by human factors.

One easy and economical way to improve road safety is by installing road equipment facilities. If these facilities are installed according to their intended purpose and location, and their regulations are strictly enforced, this method will be highly effective and efficient. Of course, coordination between the Ministry of Public Works as the road manager (PERMEN PU no. 20 of 2010) and the Ministry of Transportation as the road equipment facility manager (PM 82 of 2018), and Toll Road Operator (Jasa Marga) as the operational and maintenance manager of roads, as well as the Police as law enforcers, is required in the procurement and operation of road equipment facilities, especially on toll roads. In this regard, coordination and integration among agencies (5 pillars in the National Road Safety Plan/RUNK) are essential. According to Vardaki, et al., 2018, safety is an integral part of all decisions and bureaucratic integration that affects roads and infrastructure systems.

Tangerang, as one of the satellite areas of the capital Jakarta, has experienced very rapid growth in various sectors, particularly in terms of population, economic, and industrial growth. This is evidenced by the increasing investment value in the city of Tangerang and the ongoing improvement of infrastructure (Head of the Economy Division of Tangerang City Government, Muhammad Noor, 2011). The Tangerang-Merak Toll Road is a toll road that connects the city of Tangerang and the Port of Merak. This toll road passes through the city of Tangerang and the districts of Tangerang, Serang, and Cilegon. This toll road is also an extension of the Jakarta-Tangerang Toll Road. Kilometer 0 starts at Tomang, Jakarta, and ends at Kilometer 98 in Merak. The length of this toll road is 72 km. The toll road operator is PT Marga Mandalasakti (MMS). Based on PJR data, the number of accidents that occurred on the Tangerang-Merak Toll Road throughout 2018 was 913 cases, involving 386 victims, including 25 fatalities, 155 serious injuries, and 206 minor injuries. Meanwhile, in 2017, there were 911 cases with a total of 28 fatalities, 160 serious injuries, and 255 minor injuries. Roseily (2013) discussed the Tangerang-Merak toll road regarding the characteristics of traffic accidents on the Tangerang-Merak Toll Road section. The occurrence of accidents on the Tangerang-Merak Toll Road section every year shows a relatively high number of traffic safety incidents. This is shown in Table 1, which contains the number of accidents that occurred on the Tangerang - Merak Toll Road according to data from the operator, PT. Marga Mandala Sakti (MMS) in 2018.

Table 1. Number of Toll Road Accidents (Year 2018) Table Source: PT Marga Mandalasakti (MMS)

Road Name	Km	Total Accidents	Severity		
			MD	LB	LR
Balaraja Barat – Cikande	38.90 – 52.20106		6	20	57
Cikande – Ciujung	52.20 – 60.00135		19	42	81
Ciujung – Serang Timur	60.00 – 72.00123		2	37	72
Serang Timur – Serang Barat	72.00 – 77.6044		1	15	19
Serang Barat – Cilegon Timur	77.60 – 87.1045		2	11	17
Cilegon Timur – Cilegon Barat	87.10 – 94.8022		0	5	9
Cilegon Barat - Merak	94.80 – 98.1017		0	6	7

Therefore, it is necessary to conduct a road safety audit to reduce the potential for accidents on toll roads (Agus Taufik Mulyono, et al, 2016). The Safety Audit that will be applied is *Pro-Active* , which is more oriented to efforts to prevent or avoid (*to prevent*) accidents. But in fact, audit guidelines for toll roads themselves do not exist so that the guidelines used are for national roads that cannot all be applied to toll roads, and the standards and criteria for toll roads in Indonesia itself are still in the process of revision (Marwoto et al., 2003). Therefore, consistent steps and cooperation of related institutions are needed on an ongoing basis for significant improvement (Bagi & Kumar, 2012; Elvebakk, 2015; Sutandi & Santosa, 2013). According to Mulyono, et al., (2009), the audit results are calculated with risk value indicators handling the results of road safety audits show that some parts of road facilities are in the category of "hazard" or "very hazard".

RESEARCH METHOD

Research Stages

As a guide in the research process to ensure that the conducted research proceeds smoothly and systematically, it is necessary to create a research flowchart to serve as a guide in the implementation of the research. The research flowchart can be seen in Figure 1.

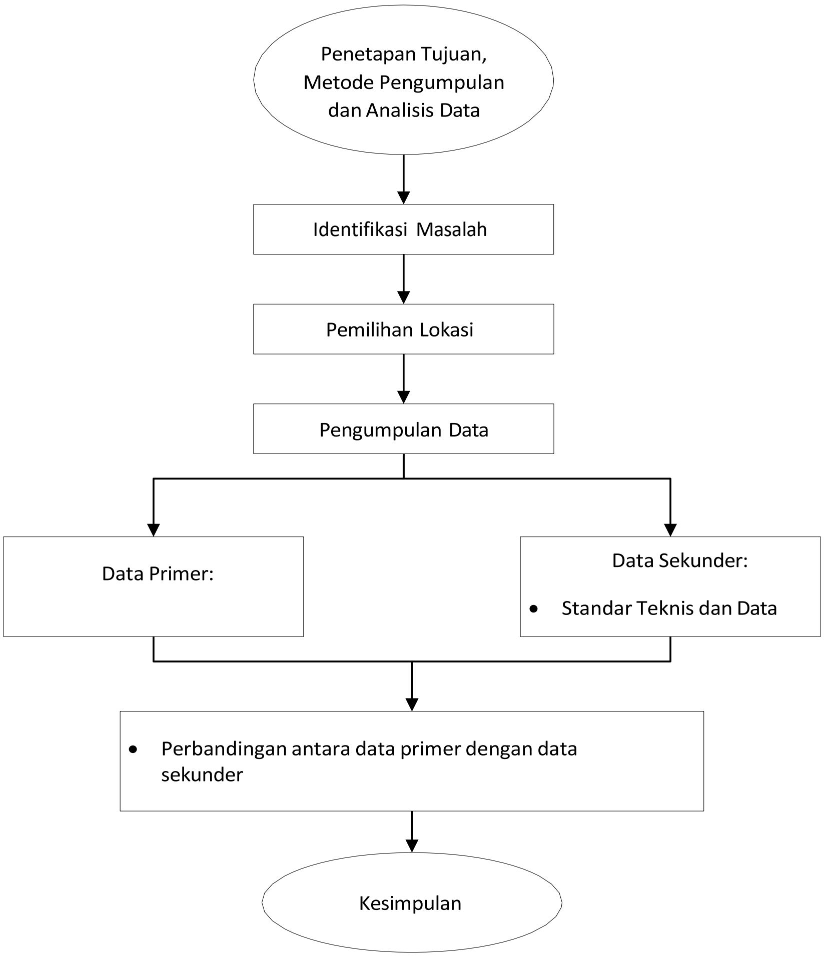

Figure 1. Stages of Research

Research Methodology

The methods used in this research consist of 4 important steps: (Rochaety et al., 2007)

1. Field survey method (observation) by directly observing and examining the condition of the road at specified locations, considering all aspects such as geometric, pavement, road supplementary buildings, and road equipment.
2. Equivalent Accident Number (EAN) method followed by the Upper Control Limit (UCL) - BKA (Upper Control Limit) method to identify accident-prone areas from traffic accident data.
3. Analyzing data from direct observations by comparing them with technical standards according to applicable regulations.
4. Analyzing traffic accident data obtained from the police / PT Marga Mandalasakti using the EAN method followed by UCL - BKA to determine accident-prone areas.

Data Collection

The collected data is divided into 2 parts, namely primary data and secondary data. Primary data consists of survey data obtained through field observations conducted at predetermined road segment locations. For field observations, data will be recorded using a GoPro camera with a minimum angle of 135° and reviewed from the video results, considering geometric aspects, pavement, road supplementary buildings, and road equipment.

RESULT AND DISCUSSION

To determine accident-prone areas, the EAN (*Equivalent Accident Number* / AEK) method is used (Sugiyanto & Fadli, 2016), which is a weighting of accident equivalent numbers referring to the cost of traffic accidents. AEK is calculated by adding up the incidence of accidents on each kilometer of road length and then multiplying by the weight value according to severity. The standard weight values used are Death (MD) = 12, Serious injury (LB) = 6, Minor injury (LR) = 3, vehicle damage (K) = 1, (Soemitro, 2005). Where is expressed in the formula:

$$Yan = 12MD+6LB+3LR+1K \quad \text{..........} \quad (1)$$

The determination of accident-prone locations is carried out based on the number of accidents per kilometer of road that has an AEK weight value exceeding a certain limit value. This limit value can be calculated, among others, using the Upper Control Limit (BKA) and Upper Control Limit (UCL) methods. The value of the Upper Control Limit (BKA) is determined using the following equation:

$$BKA = C + 3\sqrt{C} \quad \text{..........} \quad (2)$$

where C = Average EAN accident rate

The UCL (Upper Control Limit) value is determined using the following equation:

$$UCL = \lambda + \phi + \sqrt{(\lambda/m)} + (0.829/m) + [1/(2/m)] \quad \text{..........} \quad (3)$$

with: λ = Average EAN accident rate;
Ψ = Probability factor = 2.576 m = Number of segment accidents under review (AEK)

The *Upper Control Limit* (UCL) and Upper Control Limit (BKA) methods will be used to determine the location of traffic accident prone points. A road section or segment will be identified as a traffic accident prone point location if the number of accident equivalents is greater than the UCL value or BKA value.

Results of direct observation analysis

Table 2. Results of Direct Observation Analysis

KM. (via Merak – Tanggerang)	Road Conditions	Pavement Conditions	Sign
92.40 – 92.10	Turn right	The road is uneven and there are cracks	None
94.00 – 94.50	Turn left	The road is flat and smooth	Left bend warning
68.90 – 68.50	Turn left and uphill	The road is flat and smooth	Left bend warning
39.00 – 42.30	Turn left	Uneven and bumpy roads	minimum speed 40, maximum 80
41.50 – 42.00	Turn left	The road is flat and smooth	None
64.60 – 70.30	Goes Straight	Uneven and bumpy roads	None

From Table 2 can be seen several sections that have a lack of signs, namely on the road section Km. 92.40 – 92.10 in the direction of Merak - Tangerang, there is a bend to the right but there is no warning sign to turn right, so it will be prone to accidents. Likewise, from the direction of Tangerang - Merak at Km. 41.50-42.00 and Km. 64.60 - 70.30 there are no left cornering warning signs and speed limit warnings. Likewise, the road condition has changed to downhill or uphill but there are no notification signs on the section. This is not in accordance with Ministerial Regulation No. 13 of 2014. From table 2, it can also be seen that the sections with uneven and bumpy pavements but no warning signs so that it can be a *surprise hazard* factor for drivers.

Results of analysis with AEK method

Table 3. AEK Method Calculation Results

Road Name	Km	Total Accidents	Accident Equivalent Rate				UCL	BKA
			12xMD	6xLB	3xLR	TOTAL		
Cikupa – Balaraja Timur	31.40 – 36.10	79	24	90	87	201	293.6745744	316.8610379
Balaraja Timur – Balaraja Barat	36.10 – 38.90	86	36	108	102	246	296.3654561	316.8610379
Balaraja Barat - Cikande	38.90 – 52.20	106	72	120	171	363	302.4235254	316.8610379
Cikande – Ciujung	52.20 – 60.00	135	228	252	243	723	316.6018305	316.8610379

Ciujung – Serang Timur	60.00 – 72.00	123	24	222	216	462	306.8340753316.8610379
Serang Timur – Serang Barat	72.00 – 77.60	44	12	90	57	159	290.8999181316.8610379
Serang Barat – Cilegon Timur	77.60 – 87.10	45	24	66	51	141	289.6128112316.8610379
Cilegon Timur – Cilegon Barat	87.10 – 94.80	22	0	30	27	57	282.5633685316.8610379
Cilegon Barat - Merak	94.80 – 98.10	17	0	36	21	57	282.5633685316.8610379

From table 3 above, it can be seen that the road sections with the highest EAN values are Balaraja Barat - Cikande, Cikande - Ciujung, and Ciujung - Tanggerang Timur. Cikande - Ciujung has the highest accident fatalities with 19 fatalities, 42 serious injuries, and 81 minor injuries. The Equivalent Accident Number (EAN) is calculated as follows:

$AEK = 12\ x\ MD + 6\ x\ LB + 3\ x\ LR$
$AEK = (12 * 19) + (6 * 42) + (3 * 81) = 723$

The total calculated Equivalent Accident Number (m) on the Cikande - Ciujung section is 723. After calculating all EAN values, the next step is to find the average accident rate (λ), which is obtained by dividing the total EAN by the number of road sections. The average accident rate (λ) in 2018 is 2409 / 9 = 267.77. The calculation of the limit value is done to determine the accident vulnerability limit for each road section, where each road section has a different accident vulnerability limit. This calculation serves as a reference to determine the road sections included in accident-prone areas on the Tangerang-Merak toll road. An example calculation of the Upper Control Limit (UCL) value on the Cikande - Ciujung road section with the average accident rate (λ) = 267.77; probability factor value (Ψ) = 2.576, and total Equivalent Accident Number (m) = 723. The Upper Control Limit value for the Cikande - Ciujung road section is obtained as 316.6018305. The upper control limit value is obtained by inputting the average Equivalent Accident Number value for 2018, which is 267.77, into the equation, resulting in a BKA value of 316.8610379.

CONCLUSION

Based on the research conducted, there are several conclusions that can be drawn. 1.From the results of direct observation, the existing geometric condition is good but there are still some sections whose pavements have many patches and are bumpy, reducing driver comfort. For complementary buildings, it is quite good even though there is a lack of signs on some road sections, especially slight bend warning signs on the Tangerang-Merak toll road. 2.From the results of traffic accident data analysis, it can be concluded that traffic accident-prone locations obtained for 2018 are three road sections, namely West Balaraja - Cikande (Km36+100 - Km38+900), Cikande - Ciujung (Km38+900 - Km52+200), Ciujung - East Serang (Km52+200 – Km60+00). It shows that the three sections are black areas on the Tangerang-Merak toll road. 3. By comparing with direct observation, it can be seen that on the Tangerang – Merak road section there are several points where road signs are incomplete on cornering, uphill and downhill roads. 4.On the Cikande – Ciujung section Km39+00 to Km39+500, Km52+200 has uneven and bumpy pavement, and with bumpy pavement due to former patches (pathcing)

After this research is completed, the author would like to provide suggestions for further research, namely: 1. Carry out the initial survey more carefully so that all steps to anticipate errors in direct observation can be prevented. 2. Using a better camera for shooting road auxiliary buildings on toll roads to be able to cover at least 135o viewing angles with large camera memory so that all field data can be recorded.

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