Cipali Toll Road Safety Audit

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Abstract. The toll road is freeways to accelerate and shortening of travel time, this is due to the existing arterial road which is decrease congested, especially in weekends. Increasing density of the traffict, the car accidents occure on toll roads has increased also. One of causes of vehicle accidents on toll roads is by the lack of marking, sign, complementary buildings and poor pavement condition. This study would be discused the existing conditions of the Purbaleunyi Toll Road based on direct observation of complementary buildings ,signs and marking and also in terms of pavement on toll roads. The observation data would be compared with the results of accident data from the Bina Marga that can help us to find out black area and grey area on the toll road in driver safety in terms of complementary buildings, marking , signs and pavement on toll roads .

1. Introduction

In 2015, totally of 47 toll road development projects are part of the National Strategic Project by President of Republic Indonesia for the period 2015-2019 began to be implemented. Even the Presidential Regulation , number 3 of 2016 is issued so that the implementation of the National Strategic Project can be accelerated. In view of the Republic of Indonesia Law Number 38 of 2004 concerning roads, article 44 paragraph 3 states that toll roads have to specifications and level of services more than arterial public roads. For the example there are no intersections, fully controlled exits or entrances (access) , and high plan speed.

Concerns have arisen when road construction continues but the road safety system is still not optimal in the implementation [1]. Accidents occurred throughout 2016, more than 26,000 people died and 143,000 suffered minor or severe injuries. In March 2010 the UN General Assembly declared the Decade of Action (DoA) for Road Safety 2011 - 2020 which purpose to control and decrease the fatality rate of past accident victims. Cross globally by increasing activities carried out on a national, regional and global scale[2,3].

Total accidents occur of Cipali toll road in 2016, are 811 times. In accordance the long-term strategy prepared by the Government of Indonesia in the Road General National Safety Plan (RGNSP)[2]. It is necessary to implement road safety using a cost-efficiency approach through curative and preventive measures in order to deal with victims, prevention injury, and prevention of accidents [4,5]. This study solicits to solve road safety problems that occur on roads in Indonesia, especially toll roads because services provided by toll roads should be higher than public roads. In preventing accidents, it is necessary to know which areas have high potential for accidents so that they can be handled according to the characteristics of each road [5-7].

The aims to determine the existing geometric and pavement condition, road complementary buildings , signs and markings are in accordance with the technical standards that have been applied, so as to obtain accident-prone areas of direct observation. Then the results of direct observation are compared with traffic accident as secondary data . The results of the analysis of accident-prone areas from direct survey were to find out whether the accident-prone areas obtained from the data.

Road Safety Audit

Road Safety Audit is a form and module of formal testing of an existing road section or a road/traffic project in which an independent and qualified team reports on potential collisions on the project[7,10-14]. Road safety audits are one way to prevent accidents for the already operating roads or newly ones. Road safety audits on new roads need to be carried out on all process, starting from the design, form of roads, guidance and operations. Road safety audits were initially developed for new roads, but are increasingly being used to check and improve existing road safety.[10,11,29]

Design Speed

Design Speed (DS), on the road segment the speed is chosen as the basis of road geometric planning that allows vehicles to move safely and comfortably in sunny weather conditions, design traffic volume, and meaningless road side effects [15,19]. The DS for each road function can be determined from Table 1The DS for each road function can be determined from Table 1.

Tabel .1 Design Speed Source : Bina Marga, 2004

Class	Function	Design Speed	
		Pimary	Secondary
I	Primary arteries	80 - 100	-
II	Primary Collector	80 - 100	60 - 70
IIIA	Secondary Arteries	80 - 100	60 - 70
IIIB	Secondary Colector	80	50
IIIC	Secondary Local	60	40

Road Alignment

Road alignment is a major factor in determining the level of safety and efficiency in meeting traffic needs. The alignment is influenced by topography, traffic characteristics and road functions.[15,19]

Road Markings

A sign that is on the surface of the road that includes equipment or signs that form longitudinal lines, transverse lines, oblique lines and other symbols that serve to direct the traffic flow and the limit area of interest of traffic.[16]

Traffic signs

Road Signs are the main tool in managing, warning and directing the traffic. An effective signs must fulfill the following[17]:

1. Meet the needs
2. Attract attention and get respect for road users.
3. Give a message that is simple and easy to understand.
4. Provide enough time for road users to respond.

Road Median

In high traffic flows, it is often necessary to have a median to separate traffic flows in opposite directions. So the median is a path that is located in the middle of the road to divide the road in each direction [17,19].

Broadly speaking, the median functions as:

1. Provide a neutral area that is wide enough where the driver can still control his vehicle in times of emergency.
2. Provide sufficient distance to limit / reduce glare against headlights from vehicles in the opposite direction.
3. Adding a sense of grandeur, comfort and beauty to every driver.
4. Secure side freedoms from each direction of traffic flow.

Road Pavement
Subgrade is generally not able to withstand the weight of vehicles on it, so need a construction that can withstand and distribute the traffic load it receives. The road pavement technology continues to develop , now its common to used flexible pavement with asphalt concrete construction. With this mixture we get a mixture that is dense and high stability. The traffics loads of flexible pavement structure, were distributed to the subgrade in stages in each layers [29]. [18] The traffic load is distributed from the surface layer to the layers below it. The layer thickness below as the good quality pavement exspress by CBR value, the result is the pressure from the vehicle load is received by the subgrade becomes decrease.

2. Research Methodology

2.1 Data Collection Methods
The survey method with field observations was carried out at a predetermined location. Primary data obtained through direct observation, in this study is a survey on locations that are determined in various aspects, namely geometric straight, turn left and right turn, pavement, signs , markings and complementary buildings at the Cipali toll road.

2.2 *Data Analysis Method* Field observation methods
For field observations, a comparison is made between the existing conditions of the Cipali toll road in terms of geometric, hardening and road complementary structures against technical standards.

The equivalent accident number (EAN) method
Areas of traffic accident prone, are areas that have a high number of traffic accidents, high risk and accidents on a road section (Warpani, 1999). The technique for ranking accident sites can be done with the accident rate approach and quality control statistics, or weighting based on accident values [24].
One method for calculating accident numbers is to use the EAN (Equivalent Accident Number) method [24,27,28] which is the weighting of accident equivalent numbers referring to the cost of traffic accidents.
EAN is calculated by adding up the number of accidents at each kilometer of the road length then multiplied by the weight value according to the severity. The standard weight values used are People Died (PD) = 12, Severe injuries (SI) = 3, Suffered Minor (SM) = 3 [26].
EAN formula:

$$EAN = 12\ PD + 3\ SI + 3\ SM$$

The determination of accident-prone locations is based on the accident rate per kilometer of the road that has a weighted EAN value exceeding a certain limit value. This limit value can be calculated among others by using the Upper Control Limit (UCL_{index}) and Upper Control Limit (UCL) methods.[26,27].The Upper Control Limit (UCL_{index}) value is determined using the following equation:

$UCL_{index} = C + 3\sqrt{C}$ Information:

C = Average number of EAN accidents
The UCL (Upper Control Limit) value is determined using the following equation: UCL = $\lambda + \psi \times \sqrt{}$

$([(\lambda/m) + ((0.829)/m) + (1/2 \times m)]$

Information:
λ = Average number of EAN accidents Ψ = probability factor = 2.576
m = Review of road accident rates (EAN)

3. Analysis and Discussion

3.1 Data collection

Data on transportation aspects surveyed in the field are how the pavement conditions of the Cipali toll road and also the condition of signs, road markings, and geometric. This survey uses a gopro camera to get video results, which will then be examined and noticed.

Table 2. Road Characteristics

KM	Road Conditions	Pavement Condition	Signs	Markings
75.4 – 93.0	Straight	The road is level and smooth	none	Longitudinal Markings
85.2 – 86.0	Straight	Unevenand bumpy	Rest Area	Longitudinal Markings
			The minimum speed limit is 60 Km / Hour & the maximum speed limit is 100 Km / Hour	
104.6 – 105.0	Bend Right and Clim	Road is flat and smooth	Warning bend to the right	Longitudinal Markings
132.0 - 136.6	Straight	Road uneven and bumpy	The minimum speed limit is 60 Km / Hour & the maximum speed limit is 100 Km / Hour	Longitudinal Markings
			No Stopping	

Based on Minister Regulation No. 13 of 2004 article 39, paragraph 2, before reaching the part of road where there is a warning signs of dangers, warning signs must be installed at least 80 meters for roads with design speeds of 60km / hour to 80km / hour and at least 100 meters for roads at speed planned 60km / hour to 100km / hour. The absence of signs in several road sections is a form of violation of Ministerial Regulation No. 13 of 2004.

Accident Equivalent Number (EAN) value

The value of the accident equivalent number is according on the weighting value of Jasa Marga, the severity of accident victims PD: SI: SM = 12: 3: 3.
Examples of EAN calculations on the Cipali Toll Road can be seen in table 3, accident data on the Cipali toll road in 2017.

Table 3. Cipali Toll Road Accident Data Source: PT Lintas Marga Sedaya

Name of Road Section	Km	Total Accident	Severity		
			People Died	Severe Injuries	Suffered Minor
Cikampek - Cikopo	67.10 - 78.00	79	17	41	55
Cikopo – Kalijati	78.10 - 98.00	152	38	102	132
Kalijati – Subang	98.10 - 110.00	177	42	91	151
Subang - Cikedung	110.10 - 138.00	267	73	181	223
Cikedung - Kertajati	138.10 - 159.00	69	11	28	51
Kertajati - Sumberjaya	159.10 - 175.00	44	9	18	31
Sumberjaya - Palimanan	175.10 - 188.00	45	7	21	33

Subang - Cikedung with fatalities 73 people died, 181 severe injuries and 223 with suffered minor. The equivalent number value is calculated as follows:
EAN= 12xPD + 3xSI + 3xSM
EAN = (12 * 73) + (3 * 181) + (3 * 223) = 2088

The number of EAN (m) in the Subang - Cipapan segment is 2088. After all the EAN values have been calculated, the next step is to find the average accident value (λ) obtained from the total EAN value divided by the number of road segments. The average value of accidents (λ) in 2017 is 834. Calculation of boundary values is performed to determine the extent of accident vulnerability level for each section of the road, where each section of the road has a different level of accident vulnerability. This calculation is a reference to determine the road segments that are included in accident-prone areas on the Cipali toll road. Example of calculating the value of UCL (Upper Control Limit) on the road section of Subang - Cikedung with average accident rate (λ) = 834; the value of the probability factor (Ψ) = 2.576, and the number of accident equivalent numbers (m) = 2436. Obtained the upper control limit value of the Subang - Cikpapan road segment = 917.2359167. The upper control limit value is obtained by entering the average value of the equivalent accident number in 2017 of 883.7143 to Equation 3 and obtained the value of BKA = 870.2904905.

The results of the analysis of UCL and UCL_{index} values using the calculation example above for 7 road segments in 2017 are described in Table 4.

4. Discussion

1. From the field observation results,in actual conditions there are many shortages of signs and poor pavement codition on the Cipali Toll Road. It can be seen that the pavement conditions are completely uneven and bumpy at Km. 85.20 - Km. 86.00 and Km. 132.00 - Km. 136. 60. Also there are no warning signs to warn drivers that there are no uphill signs at Km. 104.60 - Km. 105.00, and the section on the Cipali Toll Road that does not have signs are the Cikopo way towards Palimanan.
2. From the results of the analysis of traffic accident data, it can be concluded the location of traffic accident prone obtained for 2017 , there are three roads section namely the Cikopo - Kalijati segment (Km. 78.10 - Km. 98.10) with UCL =895.991593 > UCL_{index} = 870.2905, Kalijati - Subang (Km. 98.10 - Km. 110.00) with UCL =897.8889362 > UCL_{index}= 870.2905, and Subang

- Cikedung (Km. 110.00 - Km. 138.00) UCL917.2359167 = >UCL_{index} = 870.2905. That shows the three sections are accident-prone areas on the Cipali toll road.

Table 4. Value of Equivalent Accident Numbers, Upper Control Limit and Control Limits

Name Of Road Section	Km	Equivalent Accident Numbers			UCL	UCL_{index}
		12 x PD	3 x (SI + SM)	Total		
Cikampek - Cikopo	67.10 - 78.00	204	288	492	874.4275367	870.2905
Cikopo - Kalijati	78.10 - 98.00	***456***	***702***	***1158***	895.991593	870.2905
Kalijati - Subang	98.10 -110.00	***504***	***726***	***1230***	897.8889362	870.2905
Subang - Cikedung	110.10-138.00	***876***	***1212***	***2088***	917.2359167	870.2905
Cikedung-Kertajati	138.10 -159.00	132	237	369	869.0278048	870.2905
Kertajati-Sumberjaya	159.10 -175.00	108	147	255	863.15289	870.2905
Sumberjaya-Palimanan	175.10 -188.00	84	162	246	862.6386122	870.2905

5. Conclusions and Suggestions

The conclusions of the results of the analysis in this study are:

1. From the results of direct observation, the existing geometric conditions, complementary buildings, are good enough. However, there is a lacks of signs and bumpy roads in the area on some Cipali toll roads, but it does not affect the comfort of the driver for road users, according to the interview at the time of the dissemination.
2. From field observation, it can be concluded that there are several Cipali Toll road sections which have no signs at all at Km. 75.40 - Km. 76.20, Km. 80.00 - Km. 80.80, Km. 91.20 - Km. 93.00.
3. From observation, it can also be concluded that in the Km.132.00 - Km.136.60 sections there are still many road conditions with uneven and smooth pavement.
4. From the results of the analysis of traffic accident data, it can be concluded that the traffic accident prone sections obtained for 2017 are the Cikopo - Kalijati segments (Km. 78.10 - Km. 98.10), Kalijati - Subang (Km. 98.10 - Km. 110.00), and Subang - Cikedung (Km. 110.00 - Km. 138.00). That shows that the three sections are accident-prone areas on the Cipali toll road.

Suggestions

1. When driving a vehicle for direct observation it is better to control a constant speed.
2. When using the camera it is better to know the memory capacity to record and have a good enough quality to record complementary building images.

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