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Cipularang toll road safety audit of traffic signs and road markings

Ni Luh Putu Shinta*, M.I. Dewi Linggasari, Hendy Limawan, Antonius

Department of Civil Engineering, Faculty of Engineering, Tarumanagara University

*niluhs@ft.untar.ac.id

Abstract The Cipularang Toll Road is built to shorten the distance and time travel for people from Jakarta to Bandung. The Toll Road has been used since 2005 and the number of vehicles going through it keeps growing every year. With the increased amount of vehicles passing through the Toll Road, the risk of accidents occurred also rises. Special aspect of concern must be given to traffic signs and road markings on the Cipularang Toll Road. This research is, conducted by data through the observation of traffic signs and road markings, and then it is compared with the regulations of road signs and markings according to the regulations of Ministry of the Transportation. The conclusion drawn is that the absence of traffic signs and road markings resulted in an increase of accidents.

1. Introduction

The increase in the number of motor vehicles due to the ease of owning a vehicle and has been caused of traffic accidents to increase both in terms of quantity and level of fatality. The number of motorized vehicles produced in the first 30th years of the 21st century is estimated to be much greater than the total of motorized vehicles throughout the 20th century. Furthermore, these vehicles are distributed much more in developing countries, meaning that accidents and fatalities are greater in low and middle-income countries.[1][2]

According to WHO, 2013, in the year 2010 at least 1.24 million accident victims have died and 20 to 50 million were injured. Casualties from traffic accidents became the fifth largest cause of death in 2013, and every hour in Indonesia there are 3-4 people who die due to traffic accidents, which is much more than the death rate due to war in Afghanistan, there are 1-2 people per hour. The government is very aware of this complicated challenge, because traffic accidents cause more deaths to the employed age groups (productive age). The number of motorized vehicles in Indonesia continues to increase rapidly; in 2014, there were 114,209,260 units of motorized vehicles and in 2016, the number increased to 129,281,079 units. The government has made a breakthrough by publishing the INPRES No. 4 of 2013 concerning the 2011-2020 Road Safety Action Decade which coincided with the declaration of the National Road Safety Plan (RUNK) declared in 2011. To reduce accident fatalities, the Indonesian government carried out a coordination pattern of inter-sectoral synergy that is coordinated by BAPENAS. The sectors are divided into 5 pillars of safety, namely: Pillar 1 Road Safety Management of BAPENAS institute, Pillar 2 Safe Roads by the Ministry of PUPR, Pillar 3 Safe Vehicles by the Ministry of Transportation, Pillar 4 Safe Behavior of Road Users by the Police Department of the Republic of Indonesia, Pillar 5 Handling of Victims of Post-Accident by the Ministry of Health. The



Ministry of Public Works, in this case, the Director General of Highways is responsible for provided safe road infrastructure and is obliged to make improvements to accident-prone locations.

While the Directorate General of Land Transportation is responsible for harmonizing signs and marking of road functions, one of the 9 activities carried out is the Road Safety Audit. The target is reducing accident fatalities , such as the target of the Second Pillar by the Ministry of Public Works, it requires hard , fast work and intense coordination for all involved organizations. Therefore, there is a considerably large amount of roads that must be audited, one of which one is an audit of road signs and markers. One of the factors that increasingly promotes road safety audits is that traffic safety is no longer just based on driver safety, but rather a traffic system error (including road infrastructure)[3]. Supported by a greater responsibility now , is on the road operators, namely the activities is planning and regulation of the traffic system that is capable of creating quantitative indicators, monitoring and evaluating road safety deficiencies. [4]

According to [5], the number of traffic signs on the Cipularang Toll Road is still lacking, especially warning and instruction signs that serve to direct and guide the flow of traffic, and the technical specifications for signs and markers are still lacking as well. Various types of signs and road markings on the Cipularang Toll Road meant to assist drivers in driving are laid out in accordance with the Republic of Indonesia Transportation Minister's Regulation Number PM 13 of 2014 concerning traffic signs and the Republic of Indonesia Transportation Minister's Regulation PM 34 Year 2014 concerning road markings. With the implementation of road safety audits , we are expected to be able to find out the effectiveness of road signs and markers as well as their suitability when compared to regulations set by the government and their influence as one of the causes of accidents . This is to achieve three aspects of road safety, namely forgiving Road Environment, self-explaining road, and self-regulation road [6]&[4] .

1.1. Problem Identification

The underlying problem is the number of accidents occurred in the Cipularang Toll Road, despite the fact that the Toll Road has been equipped by traffic signs and road markings to help the driver through the road. Road signs and markers must be able to provided clear information so that the driver can always be ready to anticipate various traffic situations while driving.

1.2. Scope of Problem

The problems discussed are limited to taking road inventory data only at km 96 to km 100 which is then compared to the regulation of the [7]concerning traffic signs and the regulation of the [8]concerning road markings and the [9] concerning road planning specifications.

1.3. Purpose of Research

Based on the background, the purpose of this study is to determine the effectiveness of signs and road markings on road conditions that are straight, downhill and uphill and to determine whether there is a significant differences between incorrect sign and marking placement with the accidents.

Traffic Signs

The regulation of the [7] concerning traffic signs states that traffic signs grouped based on their function, The images of traffic signs can be seen in Figure 1 below:

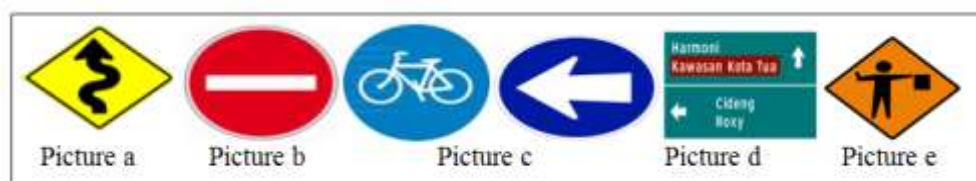


Figure 1. Traffic signs grouped based on the function

The Various types of traffic signs that are according to the group, namely warning signs, prohibitory sign, Mandatory sign, Non-Expressway sign and additional sign, are describe in figure 1; 1a, 1b, 1c, 1d, 1e, and 1f respectively.

The Warning signs, with a yellow base color, black borders, black symbols, letters, or numbers described on figure 1a. Warning signs are used to warn of possible hazards on the road or dangerous places on the road and inform about the nature of the hazard.

Then the Prohibitory signs; with white base color, red borders, black symbols, letters, or numbers, and red words illustrated on figure 1b. Prohibitory signs that are used to express actions that are prohibited to road users described on figure 1c. The signs with the following characteristics: blue base color, white borders, white coat, white letters and/or numbers; and white words namely The Mandatory signs, are used to declare orders that must be obeyed by road users, explained on figure 1d. And then Non-expressway signs on figure 1e: to provide information to road users. The trademark characteristics are: green base color, white border, white symbols, white letters and/or numbers. Also the last on figure 1f, the additional Signs, are those provide additional information for road users.

Road Markings

The regulation of the [8], concerning the road markings defines, a road marking is a sign on the road surface or above the road surface which includes equipment or that signs form longitudinal lines, transverse lines, oblique lines, and symbols which serves to direct the flow of traffic and limit the area of interest in traffic. The image of markings categorized into fig. 2, 2a, 2b, 2c, 2d, 2e, and 2f respectively :

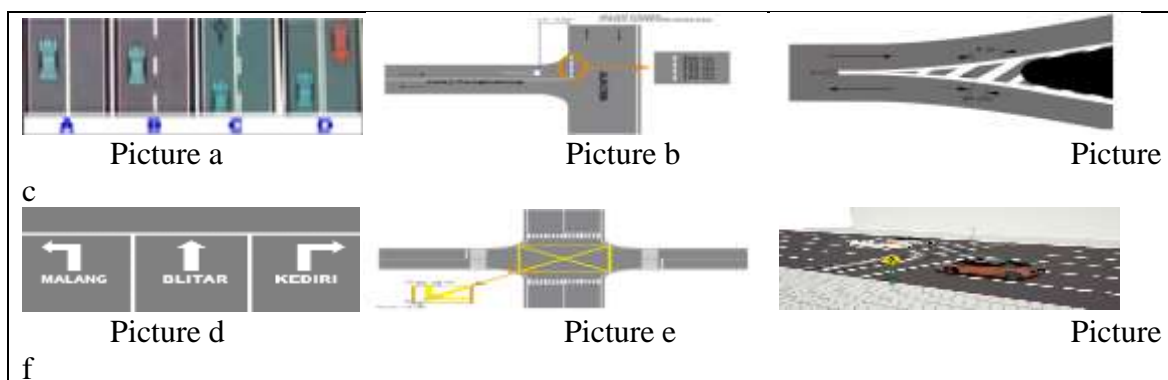


Figure 2. Traffic Markings grouped based on the function and line symbols

The Longitudinal markings, markings that are parallel to the road axis, are describe on figure 2a, then the Transverse markings, are road markings perpendicular to the axis of the road explained on figure 2b. Characteristic of the Oblique markings, are road markings that form a solid line that aren't included in the category of longitudinal markings or transverse markings illustrated on figure 2c. Also Refer to figure 2d, the Symbol markings, are road markings in the form of arrows, images, triangles, or writings that are used to repeat the purpose of traffic signs or to notify road users that can't be stated by traffic signs. And the Yellow box markings, are yellow rectangular road markings which function to prohibit vehicles from stopping in aspecified area according on figure 2e. Then the Last Other markings comprise of, a road crossing marking, no parking or stopping area marking, bike lane markings, markings of special bus lanes, motorcycle lane marking, tourism location entrance markings, alert markings, evacuation lane markings, school safe zone markings, also warning signs of intersections between rails and roads, are following figure 2f.

Uphill and downhill road conditions or vertical alignment is the intersection between the vertical plane and the axis of the road[10]. Vertical alignment design greatly affects the volume of earthwork that will be carried out.

Left and right curves on the road(Horizontal Alignment) are a line projection of the road axis perpendicular to the flat plane of the map. Road traces are commonly called road situations, generally showing the direction of the road in question. Horizontal alignment consists of tangent lines connected with curved lines [10]. Curves consists of 3 general forms, namely: full circle, full arc-shaped Curves , spiral-circle-spiral (SCS) which are Curves consisting of 1 circle curvature and 2 spiral curves , and spiral-spiral (SS) which are Curves consisting of two spiral curves.

2. Research Methodology

2.1. Method of Collecting Data

The method used for the data collection of this study is to conduct direct observation in the field (Road Inventory) using Go Pro video cameras and visual observations along the Km 96 to Km 100 section of the Cipularang Toll Road. The distribution and collection of factual data about road signs and markings in the Cipularang toll road is completed by signs and markings road inventories to obtain road characteristic data. Data of road characteristics in Cipularang Toll Road are collected by taking data every 50m length section , from Km 96 to Km 100. From the data on road characteristics we can find out the geometric conditions of the road at that location and the road signs and markings that are will be present. Then from the data obtained from the road characteristics, is created by a table form to make it easier to read the data .

2.2. Data Analysis Method

Comparisons of actual traffic signs and road markings on field observations (road inventory), done along the Km 96 to Km 100 of the Cipularang Toll Road. The form of characteristic data which is the comprehensiveness of road markings and traffic signs as well as the road geometry variations have to accordance with the technical specifications of the Ministry of Public Works and the Ministry of Transportation.

3. Analysis and Discussion

The results of data collection of road characteristics are in the table form to make it easier to see signs and markings at each location. That can be seen in table below , there is many location which in actual conditions has a lack of signs on towards Jakarta which is not in accordance the Ministerial Regulation No. 13 of 2004, namely the absence of warning signs to warn the driver that road conditions are no longer flat but inclined downward.

Table 1. The Results of Data collection of road Inventory Observation

Road to Bandung				
KM	Road Condition		Sign	Marking
96.00	96.05	Straight	Minimum Speed Limit 60 km/hour and Maximum Speed Limit 80 km/hour	Longitudinal Marking
96.05	96.10	Straight	No Sign	Longitudinal Marking
96.10	96.15	Straight	U-Turn Prohibited	Longitudinal Marking
96.15	96.25	Straight	No Sign	Longitudinal Marking
96.25	96.45	Straight	Right Curve Warning	Longitudinal Marking
96.45	97.00	Right Curve	Right Curve Warning	Longitudinal Marking
97.00	97.05	Right Curve	Right Curve Warning & Uphill Warning	Longitudinal Marking
97.05	97.10	Right Curve	Right Curve Warning	Longitudinal Marking
97.10	97.15	Right Curve	Right Curve Warning & Caution Warning	Longitudinal Marking
97.35	97.40	Straight and Uphill	No Sign	Longitudinal Marking
97.55	97.60	Left Curve and Uphill	Left Curve Warning	Symbol Marking
97.60	97.90	Left Curve and Uphill	Left Curve Warning	Longitudinal Marking
97.90	97.95	Left Curve and Uphill	Left Curve Warning & Manditory Use of Left Lane	Symbol Marking
97.95	98.00	Left Curve and Uphill	Left Curve Warning & Call Center 14080	Longitudinal Marking

Table 2. The Results of Data collection of road Inventory Observation

Road to Jakarta				
KM	Road Condition		Sign	Marking
100.00	99.90	Straight and Uphill	No Sign	Longitudinal Marking
99.90	99.85	Straight and Uphill	Minimum Speed Limit 60 km/hour and Maximum Speed Limit 80 km/hour	Longitudinal Marking
99.85	99.80	Straight and Uphill	Caution Warning	Longitudinal Marking

99.80	99.75	Straight and Uphill	Height Limit of 5m Warning	Longitudinal Marking
99.75	99.70	Straight and Downhill	Curve and Dohill Warning	Longitudinal Marking
99.70	99.60	Straight and Downhill	No Sign	Longitudinal Marking
99.60	99.55	Straight and Downhill	Rest Area Sign	Longitudinal Marking
99.55	99.50	Straight and Downhill	Picking-Up and Dropping-Off Passengers Prohibited	Longitudinal Marking
99.50	99.45	Straight and Downhill	Stop Prohibited	Longitudinal Marking
99.45	99.35	Straight and Downhill	No Sign	Longitudinal Marking
99.35	99.30	Straight and Downhill	Maximum Speed Limit 80 km/hour	Longitudinal Marking
99.30	99.20	Straight and Downhill	No Sign	Longitudinal Marking
99.20	99.15	Straight and Downhill	Fog Warning	Longitudinal Marking
99.15	99.10	Straight and Downhill	U-Turn Prohibited & Maximum Speed Limit 80 km/hour	Longitudinal Marking
99.10	99.05	Straight and Downhill	Rest Area Sign	Longitudinal Marking
99.05	99.00	Straight and Downhill	Caution Warning and Height Limit of 4.2m Warning	Longitudinal Marking
99.00	98.95	Straight	No Sign	Longitudinal Marking
98.95	98.90	Straight	Use Light during Foggy Conditions	Longitudinal Marking
98.90	98.80	Straight	No Sign	Longitudinal Marking
98.80	98.75	Straight	Left Curve Warning	Longitudinal Marking
98.75	98.65	Straight	No Sign	Longitudinal Marking
98.65	98.60	Straight	Left Curve Warning, Maximum Speed Limit of 80 km/hour	Longitudinal Marking
98.60	98.55	Left Curve	Rest Area Sign	Longitudinal Marking
98.55	98.45	Left Curve	Left Curve Warning	Longitudinal Marking
98.45	98.40	Left Curve	Downhill Slope Warning	Longitudinal Marking
98.40	98.35	Left Curve	Left Curve Warning & Use Left Lane Sign	Longitudinal Marking
98.35	98.30	Left Curve	Left Curve Warning	Longitudinal Marking
98.30	98.25	Left Curve	No Sign	Longitudinal Marking
98.25	98.20	Left Curve	Right Curve Warning & Maximum Speed Limit 80 km/hour	Longitudinal Marking
98.20	98.15	Straight and Uphill	Right Lane only for Preceding	Longitudinal Marking
98.15	98.10	Straight and Uphill	Speed Warning of 20 km/hour	Longitudinal Marking
98.10	98.05	Straight and Uphill	No Sign	Longitudinal Marking
97.40	97.35	Straight and down hill	No Sign	Longitudinal Marking

Although in the actual conditions there is a shortage of signs on the many location in direction of Jakarta , a driver who passes Cipularang more than 4 times in 1 year don't have an effect on their driving comfort . This indicates , the driver does not fully attention to the presence of road signs or markings in any road conditions indicating that they are not aware of the lack of signs or markings in certain locations. [11]This became known when conducting direct interviews with drivers at the rest area of the Km 72 in the direction of Bandung and Km 97 in the direction of Jakarta.

From the factual conditions that exist in the Cipularang Toll , data from the table made to clearly road characteristics data, for example, the KM 97 + 35 in the direction from Jakarta to Bandung , on area accident-prone catagory, that even though the road conditions began to up hill, there were no warning signs indicating those road conditions. Based on [7] article 39 paragraph 2, before reaching potentially dangerous road section , there shall be a warning sign installedat least 80 meters for roads with a design speed of 60km/h to 80km/h and at least 100 meters for roads with design speeds of 80km/h to 100km/h. The absence of signs on Km 97 + 35, on area accident-prone catagory, is a form of violation of the regulation [7]. However, the results of processing the perception of the driver's data on the signs indicate a fairly good level of satisfaction. This indicates the driver does not fully pay attention to the presence of road signs or markings in any road conditions, that mean they are not aware of the lack of signs or markings in certain locations.

4. Conclusion

The conclusions drawn from the analysis results in this study are:

From the table made based on the actual conditions on the Cipularang Toll Road, that can be concluded , a lack of warning signs on KM 97 + 35direction to Bandung , that indicate the road is began uphill. This is not in accordance with regulation [6] Article 39 Paragraph 2 concerning the placement of warning signs that require warning signs to be installed at least 80 meters for roads with a design speed of 60 km/h to 80 km/hour and at least 100 meters for roads with a design speed of 80 km/h to 100 km/hour.

Comparisons between the exist Road Inventory data and driver's perception show that even though in actual conditions there is a lack of signs on the Km 97 + 35 in direction of Jakarta 9 downhill), the driver who passes Cipularang more than 4th times a year doesn't have their driving comfort affected, so even if there are locations that lack warning signs, the driver's perception still showed a good level of satisfaction. It can be concluded that the unavailability of signs doesn't affect the driver in reaching their

destination. This happens mainly because of ignorance or lack of attention of the driver in driving on the Cipularang Toll Road.

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