

Analysis of Speed Management in Accident Prone Areas (Case Study: Marunda Access Road, Cilincing, North Jakarta)

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Abstract

Marunda Access Road is a national road with primary arterial function, and road conditions are unsafe and dangerous for road users due to damage and potholes. The purpose of this study is to analyze the level of traffic accidents and vehicle speed before and after the simulation of the installation of speed management devices and provide recommendations for the best speed management devices on the Marunda Access Road section. This study used a simulation method of installing speed management devices to compare vehicle speeds before and after simulating the installation of speed management devices. The study also conducted a field survey to calculate vehicle speed when implementing a speed management device simulation. Analysis of vehicle speed data used the 85th percentile method. The results of the 85th percentile analysis were compared with the percentage of speed reduction. Comparison test using Independent Sample T - Test with JASP Software. The comparison test results showed the best recommendation for speed management on the Marunda Access Road section was used signs and noise tape, which has a greater percentage of speed reduction, namely 25-45%, and p-value <0.05, which means there is a significant difference in speed between vehicle speeds—existing by simulating signs and noise tape.

Keywords: *Speed Management; 85th Percentile; Independent Sample T - Test*



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INTRODUCTION

Traffic accidents are still one of the biggest contributors to death rates in Indonesia. Traffic accidents are the dominant cause of death, injury, and disability worldwide. Based on data from the NTSC, it is known that around 1.3 million people die, and 20-50 million people are injured in road accidents every year (National Transportation Safety Committee, 2021). Minister of Transportation Budi Karya Sumadi said that the number of traffic accidents in Indonesia contributed to three to four deaths every hour (Fiansyah, 2021). The most common types of vehicles involved in traffic accidents in Indonesia are motorcycles.

The Marunda Access Road is an urban road with the function of a primary arterial road located in the Cilincing District, North Jakarta. The condition of traffic movement on the Marunda Access Road is always in busy state because apart from being a trade route, it is also used as the main route for other daily activities such as work, school, and so on. However, at certain times the traffic movement on the Marunda Access Road is not busy, and many motorcyclists tend to be disorderly, such as not wearing a helmet, carrying more than one passenger, and driving at an unsafe speed. The amount of traffic volume which is dominated by large vehicles, causes the Marunda Access Road to suffer a lot of road damage, such as potholes. The road condition on the Marunda Access Road, Cilincing, is unsafe and dangerous for road users because of the damaged

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and potholed road conditions (Tobing, 2021). The Marunda Access Road has a lot of road damage that can cause accidents for motorists who do not know the road condition and drivers who drive at night (Permana, 2021). At night, the Marunda access road is very vulnerable to accidents due to poor street lighting, road damage, and road users who tend to be disorderly and not alert at night. The risk of traffic accidents on the Marunda Access Road is relatively large accompanied by the possibility of a high accident fatality rate which is also influenced by driver disorder, such as driving at an unsafe speed.

Based on traffic accident data obtained from the National Police of the Republic of Indonesia, the Traffic Unit of the North Jakarta Metro Police in 2019-2021 for the City of North Jakarta, 2203 accidents occurred due to various causes of accidents. It includes road damage factors, as many as 48 incidents (2.18%) and the driving factor for crossing the speed limit, and the speed is too high for local traffic conditions, as many as 276 accidents (12.5%). Accidents that usually occur on the Marunda Access Road are when motorcyclists drive a fairly high vehicle speed when traffic is light, then fall down due to a lack of vigilance or carelessness when passing through a damaged or potholed road. In addition, on the Marunda Access Road section, there are several intersections that are directly related to residential areas, markets, large vehicle garages, and three schools. Marunda Access Road also has various side barriers that are at risk of causing accidents, such as pedestrians, pedestrians, vehicles that stop or break down, vehicles exiting or entering the main route, etc.

LITERATURE REVIEW

Definition of Road

Roads are all parts of the road, including complementary buildings and equipment which is intended for general traffic. It is on the ground surface, above the ground surface, below the ground and/or water surface, as well as above the water surface, except for rail and cable roads (Republic of Indonesia Law No. 22 of 2009 concerning Traffic and Road Transport). Marunda Access Road functions as a primary arterial road. According to Government Regulation No. 34 of 2006 concerning Roads, primary arterial roads effectively connect national activity centers or between national and regional activity centers.

Definition of Traffic Volume

According to Republic of Indonesia Law no. 22 of 2009 concerning Road Traffic and Transportation, Traffic is the movement of vehicles and people in the Road Traffic Room. Meanwhile, traffic volume is the number of vehicles passing a point on a certain road segment at a certain time. According to the Indonesian Road Capacity Manual (1997), in measuring traffic volume, it is expressed in vehicles per hour, passenger car units (pcu) per hour, or Annual Average Daily Traffic (LHRT). Calculating traffic volume has many benefits in terms of planning, operating, and improving traffic movement on a certain road so that traffic continues to run in an orderly, safe and smooth manner. In carrying out transportation, one must have careful planning and take into account all related aspects, such as planned speed, traffic volume, and traffic density (Abdi *et al.*, 2019)

Passenger Car Equivalent

Calculating the amount of traffic volume needed in this study uses a car unit of passengers per hour (pcu/hour). According to the Indonesian Road Capacity Manual (1997), the Passenger Car Unit (pcu) is a traffic flow unit where the flow of various types of vehicles has been converted into light vehicles (including passenger cars) using emp. Passenger Car Equivalence (EMP) is the conversion factor of various types of vehicles compared to passenger cars or other light vehicles to their impact on traffic behavior (for passenger cars and other light vehicles, emp = 1.0).

The calculation of traffic volume is only based on 3 (three) types of vehicles, namely motorcycles (*MC*), light vehicles (*LV*), and large vehicles (*HV*). The traffic volume of non-motorized vehicles is not needed because they are considered to have a safe speed still. Besides, non-motorized vehicles are rarely found crossing the Marunda Access Road, Cilincing, North Jakarta.

Traffic Accident

A traffic accident is an event on the road that is unexpected and unintentional involving a vehicle with or without other road users resulting in human casualties and/or property loss (Republic Indonesia Law No. 22 of 2009 concerning Road Traffic and Transportation). Traffic accidents are still one of the biggest contributors to the death toll in Indonesia. There are 4 (four) factors that cause traffic accidents, namely driver factors, vehicle factors, road environmental factors, and weather factors (Gloria, 2021).

Vehicle Speed Management

Speed is the ability to cover a certain distance in a unit of time, expressed in kilometers per hour (Regulation of the Minister of Transportation No. 111, 2015). Vehicle speed that is too high or too low is one of the factors causing traffic accidents on the road. The speed of the vehicle can be directly controlled by the driver, but the factors that affect the speed of the vehicle itself are not only from the driver but there are several other factors. Speed management is a procedure for managing speed in order to achieve a balance between safety and vehicle speed efficiency.

Percentile 85

Percentile is the value of the quotient of the data from the smallest to the largest to be 100 (one hundred) equal parts. The 85th percentile analysis method was used in this study to analyze vehicle speed data before and after simulating the installation of speed management devices. According to Abraham (2001) in Laksmana *et al.* (2020), the purpose of using the 85th percentile analysis method on vehicle speed data is to find out the desired speed by 85% of motorists in traffic without being influenced by an obstacle, such as heavy traffic or bad weather. Kawulur *et al.* (2013) in Laksmana *et al.* (2020) explained that the 85th percentile speed is expected to represent the overall speed that motorists often use on a certain road segment.

RESEARCH METHOD

The study used a simulation method directly in the field by installing speed management devices in the form of speed limit signs and noise tapes to compare vehicle speeds before and after the simulation of installing speed management devices. The installation of speed management devices is carried out in the road segment, which is declared an accident-prone area based on the analysis using the EAN and Z-Score methods. The implementation of speed surveys in accident-prone areas is carried out as many as 4 (four) instantaneous vehicle speed surveys, namely during existing conditions, simulation of signs, simulation of noise tape, and simulation of signs and noise tape. The sample of each type of vehicle was determined from the total population in both directions (vehicle/hour) using the Slovin formula with an error rate of 10%. The vehicle speed survey was conducted outside peak hours (off-peak) and hours with the lowest side drag. Analysis of vehicle speed data used the 85th percentile method. The results of vehicle speed in each condition were tested using JASP software.

Determination of Accident-Prone Areas

Determination of accident-prone traffic areas needs to be done to determine the level of traffic accidents on certain roads. Identification or determination of the accident-prone regions in this study used the *Upper Control Limit (UCL)* method and the *Z-Score*.

1. Method *Equivalent Accident Number (EAN)*

The *Equivalent Accident Number (EAN)* method is an accident-prone area identification method that uses equivalent numbers based on accident victims. According to Soemitro (2005) in Putra & Desrimon (2018), the standard weight value used for victims of death (MD) is 12 (twelve), seriously injured (LB) is 6 (six), minor injuries (LR) is 3 (three), and material loss (K) of 1 (one). A location is declared as an accident-prone area if the *EAN* at that location is greater than the *BKA* and *UCL* values.

a. Value of *Equivalent Accident Number (EAN)*

$$EAN = 12 (MD) + 6 (LB) + 3 (LR) + 1 (K) \quad (1)$$

Description:

EAN = *EAN*

MD = number of dead victims

LB = number of seriously injured victims

LR = number of lightly injured victims

K = amount that only causes material loss

b. Upper Control Limit (*BKA*)

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

Description:

C = average accident rate *EAN*

c. Value *Upper Control Limit (UCL)*

$$UCL = +\psi \times \sqrt{[(C/m) + ((0.829)/m) + (\frac{1}{2} \times m)]} \quad (3)$$

Description:

UCL = value of *UCL*

λ = average accident rate *EAN*

ψ = probability factor (2,576)

m = number of road accidents that reviewed (*EAN*)

2. Method *Z - Score*

The *Z - Score* method identifies accident-prone areas based on the calculation of the number of accidents per road section minus the average overall accident rate, then divided by the standard deviation of the overall accident rate. The following formula is used for the *Z-Score*.

a. Standard Deviation Value

$$= \sqrt{\frac{\sum (Xi - \mu)^2}{N}} \quad (4)$$

Description:

σ = deviation of the total number of traffic accidents

N = the number of all roads containing accident data

X_i = the number of traffic accidents per road segment

μ = the average number of all traffic accidents

b. Z-score

$$= \frac{Xi - \mu}{\sigma} \quad (5)$$

Description:

Z = Z value - Score the number of traffic accidents per road section

X_i = the number of traffic accidents per road section

μ = the average number of all traffic accidents

σ = standard deviation of the total number of traffic accidents

Value of Z - Score is generated with positive and negative numbers. A positive number indicates that a road segment has an above-average accident rate and is said to be a "blacklink" or accident-prone area otherwise if a negative number indicates that a road segment has an accident rate below the average and is said to be "not a blacklink" or not an accident-prone area.

Determination of Sample

The sample is part of the population that can describe the overall characteristics of the population. The sample in this study is part of the total traffic volume obtained through direct surveys in the field per each type of vehicle. Technique *sampling* used in the study used the Slovin formula. The Slovin formula is a formula or formula to calculate the minimum number of samples if the behavior of a population is not known with certainty. This formula was first introduced by Slovin in 1960. This Slovin formula is commonly used in survey research where the number of samples is usually very large. A formula is needed to get a small sample but can represent the entire population (Rahmah, 2022). The following is the formula for the *sampling* Slovin

$$n = \frac{N}{1 + Ne^2} \quad (6)$$

Information:

n = number of samples

N = total population

e = error level (*error margin* = 10 %)

Percentile Analysis 85

The 85 percentile speed data obtained can be used to determine the ideal speed limit on the road that is reviewed based on the vehicle's average speed. The following is the formula for the 85th percentile analysis method.

$$Psi = b + p \frac{\left\{ \left(\frac{i}{100} \cdot n \right) - Fk \right\}}{f} \quad (7)$$

Information:

- Psi = 85th percentile
- b = lower edge of class interval Psi (b = lower limit - 0.5)
- p = length of class interval
- i = location of Psi
- n = number of data
- Fk = cumulative frequency before class Psi
- f = frequency in class Psi

Comparative Test Using JASP Software

Jeffreys's Amazing Statistics Program (JASP) is a modern statistical analysis *Department of Psychological Methods, University of Amsterdam*, the Netherlands, which is *open-source*, which users can download and use for free (Yulianto, 2019). *JASP software* has many analytical features compared to software, one of which is assumption testing. The assumption test in the *JASP software* is quite complete with normality and homogeneity tests required in this study which will use a comparison test (*Independent Sample T-Test*). A comparison test (*Independent Sample T-Test*) in this study was conducted to test whether there is a difference between vehicle speed before and after the simulation of the installation of speed management devices. *JASP software* was chosen as a comparison test tool because it is easier, and *flexible*, and the results provided are quite clear. If the data meet the assumptions of normality and homogeneity, then the hypothesis in this study is:

- Ho : there is no difference between the vehicle speed before and after the simulation of the installation of speed management devices.
- Ha : there is a difference between the speed of the vehicle before and after the simulation of the installation of the speed management device.

FINDINGS AND DISCUSSION

Analysis of Accident-Prone Areas

Analysis of accident-prone areas was carried out on several roads using the EAN and Z-Score methods. Based on the analysis that has been carried out, it is found that the Marunda Access Road is ranked 1 as an accident-prone area. Then a simulation of the placement of speed management devices in the form of providing speed limit signs and rumble strips is carried out on that segment. The EAN and Z-Score values are described in the following Table 1.

Table 1. Highest Accident Prone Areas in 2019 - 2021 (EAN Method)

Street Name	Number	Number of Accident Victims			AEK Value			Total AEK	C	UCL	BKA	Information	Ranking
		MD	LB	LR	MD (*12)	LB (*6)	LR (*3)						
Marunda Access Road	70	27	0	52	324	0	156	480	7.23	7.57398	15.2966	BLACKLINK	1
Jalan Raya Cacing	74	26	0	56	312	0	168	480	7.23	7.57398	15.2966	BLACKLINK	2
Jalan RE. Martadinata	64	18	1	67	216	6	201	423	7.23	7.59643	15.2966	BLACKLINK	3
Jalan Raya Cilincing	50	20	1	39	240	6	117	363	7.23	7.62555	15.2966	BLACKLINK	4
Jalan RE. Martadinata	41	14	0	34	168	0	102	270	7.23	7.68864	15.2966	BLACKLINK	5

Table 2. Highest Accident Prone Areas in 2019 - 2021 (Method Z - Score)

Street Name	(X)	(X) - (Average X)	$((X) - (\text{Average } X))^2$	S	Z	Information	Rank
Marunda Access Road	90	48.1053	2314.1163	12953.8	0.00371	BLACKLINK	1
Jalan RE. Martadinata	88	46.1053	2125.6953	12953.8	0.00356	BLACKLINK	2
Cacing Road	83	41.1053	1689.6427	12953.8	0.00317	BLACKLINK	3
Yos Sudarso Street	68	26.1053	681.48476	12953.8	0.00202	BLACKLINK	4
Cilincing Highway	67	25.1053	630.27424	0.00194	12953.8	12953.8	5,27424

Vehicle Speed

Vehicle Speed survey was conducted at non-busy vehicle speeds where the traffic is not congested, and the side barriers are low so that at the time of the survey, the researchers get the maximum vehicle speed survey results. This survey was conducted by taking samples from each type of vehicle. By using the Slovin formula, the following samples were obtained.

Table 3. Samples of each type of vehicle

Type	Vehicle
Heavy Vehicle	84
Light Vehicle	81
Motorcycle	94

The vehicle speed survey was conducted on several samples of the above vehicles based on existing conditions, simulation using speed limit signs, simulation using noise tape, and simulation using speed limit signs and rowdy tape.

Table 4. Min, Max, and Mean Speeds for each condition

Heavy	Vehicle Speed (Km/h)			Light Vehicle Speed (Km/h)			Motorcycle Speed (Km/h)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Existing Condition	28	65	46	37	79	54	34	87	64
Simulation of Speed Signs	28	62	46	36	71	52	40	80	61
Simulation of Rumble Strip	21	51	37	26	58	40	26	66	40
Simulation of Speed Signs and Rumble Strip	20	50	35	26	58	40	23	63	39

Table 5. Percentile Velocity 85 at each condition

Condition	Percentile Speed 85 (km/h)		
	Heavy Vehicle Speed (Km/h)	Light Vehicle Speed (Km/h)	Motorcycle Speed (Km/h)
Existing Condition	56	64	77
Simulation of Speed Signs	56	62	72
Simulation of Rumble Strip	44	49	47
Simulation of Speed Signs and Rumble Strip	42	49	48

From the tables above, it can be seen that simulation of signs can reduce vehicle speed by 0-19%, simulation of rumble strip can reduce vehicle speed by 21-36%, and simulation of speed sign and rumble strip can reduce vehicle speed by 25 – 45%.

Comparative Test Results Using JASP Software

Test comparison *Independent Sample T*- speed of large vehicles (HV), light vehicles (LV), and motorcycles (MC) was conducted when the existing condition with the sign simulation shows a p-value > 0.05. It means there is no difference in vehicle speed when the *existing condition with sign simulation*. Then, the results of the *Independent Sample T comparison test - Test* the speed of large vehicles (HV), light vehicles (LV), and motorcycles (MC) when the *existing with the simulation of rumble strip or existing with the simulation of signs and rumble strip* showed p value < 0 0.05. It means that there is a significant difference in vehicle speed between the existing simulated with rumble strip and the *existing with simulation signs and rumble strip*.

CONCLUSION

Marunda Access Road, Cilincing, North Jakarta is a national road segment with the first rank traffic accident rate. It is in terms of the highest Accident Equivalent Score value of 480, obtained from the number of factoring of victims of minor injuries, serious injuries, and deaths. It also in terms of the highest number of accident incidents and the highest Z value of 0.00371 in the 2019-2021 time period. The comparison results from the simulation of speed installation management devices on the Marunda Access Road section showed that the combination of speed management device simulations in the form of speed limit signs and rumble strips provides a percentage of speed reduction greater, it was 25-45%. Then, when tested with JASP (*Independent Sample T-Test*) software, the simulation of speed limit signs and rumble strip has a more significant difference with a p-value < 0.001. Then it can be determined that the best recommendation for speed management on the Marunda Access Road is the installation of speed limit signs and noise tape. It is because they are effective in reducing vehicle speed, both large vehicles (HV), light vehicles (LV), and motorcycles (MC). In addition, the combination of speed management tools in the form of speed limit signs and noise tape is better because the driver can reduce the vehicle's speed through the noise tape. The driver can also understand that the road section has a speed limit of up to 40 km/hour through speed limit signs. This research can be developed using other types of speed management tools.

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