AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

The Effect of Access Points on Motorcycle Accident Rates on Surabaya Arterial Roads

[1]Machsus, [2]Harnen Sulistio, [3]Achmad Wicaksono and [4]Ludfi Djakfar

[1]Doctor Candidate in Civil Engineering Dept, University of Brawijaya, Malang, and Lecture at Dept. of Civil Engineering, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia
[2]Professor in Civil Engineering Department, University of Brawijaya, Faculty of Engineering, Malang. Indonesia
[3,4]Associate Professor in Civil Engineering Dept., University of Brawijaya, Faculty of Engineering, Malang. Indonesia

ARTICLE INFO

Article history:
Received 25 April 2014
Received in revised form
8 May 2014
Accepted 20 May 2014
Available online 17 June 2014

Keywords:
Access points, speed, traffic flow, prediction models, motorcycle accident, arterial roads

ABSTRACT

The traffic flow in arterial roads in Surabaya can enter or exit the arterial roads directly, without going through the frontage road in advance, so that it could potentially cause traffic accidents. Therefore, the relationship between the number of openings, speed and traffic volume, and its influence on the motorcycle accident is very important to be studied**.** To examine the effect of the access points on the motorcycle accident with arterial roads in Surabaya-Indonesia. Every addition of 5 access points per-km on the arterial roads effects the increase in the number of motorcycle accidents by 9.9%. The increase of speed has implications on the increasing number of accidents at each access point variation where any increase of the average speed of 5 km/hour, the number of accidents increases by 29.38%. Similarly, the increase in traffic volume is also affecting the increase motorcycle accidents which if the volume of traffic increases twice from the previous, the number of accidents will increase by 32.5% per year according to the model prediction**.** A recommendation for the action program of accident reduction related to the effect of access points is that the implementation of access points limitation policy and frontage road development strategy on the arterial roads especially for primary arterial roads**.**

To Cite This Article: Machsus, Harnen Sulistio, Achmad Wicaksono, and Ludfi Djakfar., The Effect of Access Points on Motorcycle Accident Rates on Surabaya Arterial Roads. ***Aust. J. Basic & Appl. Sci.,*** *8(10): 38-43, 2014*

INTRODUCTION

Access points in this study are defined pathways on the road layout that enable the movement of vehicular traffic from minor roads or local streets to join the major road or highway, and the reverse also applies. Visual illustration of the definition of the access points is shown in Figure 1 below**.** The level of traffic accidents that occurred in Surabaya-Indonesia increases from year to year. One of the causes is that traffic conflicts that occur due to the number of access points on arterial roads. The impacts of the existance of access points to the arterial road function have been widely recognized**.**

The characteristics of arterial roads in Surabaya-Indonesia there are many access points. The traffic flow can enter or exit the arterial roads directly, without passing through road frontage. These kinds of characterictis could potentially cause traffic accidents. Some studies reported that the rate of traffic accidents is directly proportional to the number of per kilometer access points. The variations of access points density effects reflect there are factors influencing, especially the traffic volume and speed (Levinson, 2000). Road conditions and environmental factors affect the rate of transport accidents, besides the reliability factor of the driver, vehicle, and the other factors.

Motorcycle is the type of transportation that has the highest accident potential compared to other vehicle types. The high potential of these motorcycle accidents is in line with the population size which is also large when compared to other types of transportations. Directorate General of Land Transportation (2012) noted that the population motorcycles in 2011 amounted to 73.52% (65,724,861 units) of the total number of motor vehicles in Indonesia, while the rest is divided on other types of motor vehicles.

The high frequency of motorcycle accidents on arterial roads in urban areas becomes the basic arguments, in order to conduct a study on the prediction of traffic accidents on the roads. Therefore, the presence of access points along arterial roads is important to study its influence on the rate of motorcycle accidents (Papayannoulis *et al.*, 2000).

Corresponding Author: Machsus, Doctor Candidate in Civil Engineering Dept., University of Brawijaya, Malang. Indonesia., and Lecture at Dept. of Civil Engineering, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia.
E-mail: machsus@ce.its.ac.id

Australian Journal of Basic and Applied Sciences, 8(10) July 2014, Pages: 38-43

Accident prediction models are used to estimate the frequency of traffic accidents. In addition, it can also be used to identify and determine the relationship among the factors that influence it, such as geometric, environmental and operational factors (Nambuusi *et al.*, 2008; Machsus *et al.*, 2013). Development of prediction models on the road needs to consider the level of accidents, so that the output obtained can be used in the planning and implementation of the action programs for the improvement of road safety.

Generalized linear models (GLMs) is one of the methods of analysis often used in modeling traffic accident. This is because the use of GLMs assuming a poisson or negative binominal distribution, and logarithmic link function is able to describe the events at random, discrete, non-negative and to represent the characteristics of the traffic accidents (McCullagh and Nelder, 1989; Harnen *et al.*, 2006).

Fig. 1: Visual illustration of the presence of access points on arterial streets in Surabaya.

This paper discussed the implications of a motorcycle accident prediction models that take into account the presence of access points on arterial roads. In addition, it also discussed the volume of vehicles, length of roads and 85th percentile speed of vehicles. Access points are used as predictive variables or explanatory variables because their presences affect the rate of motorcycle accidents.

At the location of the access point, a conflict and friction of traffic flow happens. The movement of vehicles entering or exiting the arterial road through an access point has implications for vehicle traffic delays. In addition, the speed difference among vehicles that will pass, and turn, raises the potential for accidents. Therefore, it is important to discuss the extent of the influence of the number of access points to the rate of accidents on arterial roads.

MATERIALS AND METHODS

The location of this case study is on the arterial roads in Surabaya - Indonesia. The variables used in this study include the dependent variable is the annual number of motorcycle accidents (MCA, accident), while the predictive variable or the explanatory variables including: traffic volume (FLOW - pcu/hour), length of roads (LR - meters), the number of access points (AP - number/km) and speed (SPEED - km/hour). Motorcycle accident prediction models using generalized linear models approach (GLMs) with a poisson distribution and logarithmic link function.

To determine the effect of the number of access points per-km to a motorcycle accident, then in this paper, a simulation of relationshipns between the dependent variable with several explanatory variables, including: the number of access points, vehicle speed and traffic volume was conducted. This simulation is divided into three parts: Firstly, a simulation model of a motorcycle accident prediction by changes in the number of access points, while the other explanatory variables are assumed to have fixed value.

Secondly, the simulation model of a motorcycle accident prediction by a combination of changes in the number of access points and speed, while the other explanatory variables are assumed to have fixed value. Thirdly, prediction simulation model of motorcycle accidents by a combination of changes in the number of access points and vehicle volumes, while the other explanatory variables are assumed to have fixed value. A recommendation was made for the action program to reduce the number of accidents after the interpretation to model simulation output was done.

RESULTS AND DISCUSSION

Motorcycle Accident Prediction:

By using a Generalized Linear Model (GLM) approach and poisson distribution assumption distribution and logarithmic link function and then we obtained the prediction model of motorcycle accidents on arterial roads in Surabaya, as the following equation (Machsus *et al.*, 2013):

$$\mathbf{MCA = 0{,}000008501 FLOW^{0.567} LR^{0.7171} e^{(0.02085\,AP + 0.06958\,SPEED)}} \quad (1)$$

where:
MCA = the number of motorcycle accidents per year
FLOW = volume of vehicle (pcu/hour)
LR = length of arterial roads (meters)
AP = number of access points per kilometer
SPEED = 85th percentile vehicle speed (km / hour)

The above equation was obtained after univariate and multivariate analysis of the predictive or explanatory variableswere used in the formation model, including: the volume of vehicles, road length, number of access points, and speed. The explanatory variable was determined significant by univariate and multivariate analysis. Furthermore, the final model is used to predict the rate of accidents and also the deviation verification among estimation and observation or observation result value**.**

The Effects of Changes in Access Points:

a. The Simulation of Change in Access Point:

The influence of the number of access points can be predicted by observing the relationship between the number of access points, and the number of accidents. In this simulation, several explanatory variables are assumed to have fixed value; traffic volume of 5000 pcu/hour, the length of 1000 meters of roads and traffic speed by 40 km/hour. While the number of access points (APs) starting from the condition of no access point (null = 0), and then it was increased every 5 access points per kilometer, as shown in Table 1 and Figure 2 below.

Table 1: The effect of Access Points on Motorcycle Accident.

NO	MCA	Flow (pcu/hour)	LR (meter)	AP	Speed (km/hour)	Rate of Increase* (%)
1	2.44	5000	1000	0	40	-
2	2.70	5000	1000	5	40	9.9
3	3.00	5000	1000	10	40	9.9
4	3.33	5000	1000	15	40	9.9
5	3.70	5000	1000	20	40	9.9
6	4.10	5000	1000	25	40	9.9
7	4.55	5000	1000	30	40	9.9
8	5.06	5000	1000	35	40	9.9
9	5.61	5000	1000	40	40	9.9

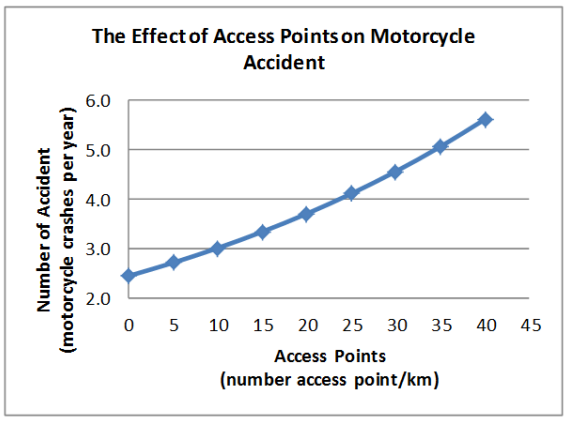

Fig. 2: The effect of Access Points on Motorcycle Accident.

Table 1 and Figure 2 shows that the increase in the number of access points has implications for the growing number of motorcycle accidents. If there is no access point in an arterial road, the potential for an accident is only 2.44 per year, whereas if there are up to 40 access points per kilometer, the potential for accidents occurring reach 5.61 per year. It also means that every addition of 5 access points per kilometer on arterial roads, there will be an increase in the number of motorcycle accidents by 9.9%. The influence of the access point on a motorcycle accident is consistent with the findings reported in the previous studies (Levinson, 2000; Papayannoulis *et al.*, 2000; Tarko *et al.*, 1999).

b. The Simulation of Change in Speed and Access Point:

The influence of this access point also appears more clearly by examining the relationship between changes in speed, and the number of accidents on some variations of the number of access points. In this simulation calculations, it is assumed that some variables have fixed value; the traffic volume of 5000 pcu / hour, and the long road of 1000 meters, while the velocity variation increased each 5 km / h, and variation of access point (AP) was determined starting from 0, 10, 20 and 30 access points per kilometer, as in Table 2 and Figure 3 below.

Table 2: The effect of speed on a motorcycle accident on the variation of the access point.

No	Flow (pcu/hour)	LR (meter)	Speed (km/hour)	Motorcycle Accident Rates (motorcycle crashes per year)				Rate of Increase* (%)
				AP=0	AP=10	AP=20	AP=30	
1	5000	1000	30.0	1.2152	1.4969	1.8439	2.2713	-
2	5000	1000	35.0	1.7208	2.1197	2.6111	3.2164	29.38
3	5000	1000	40.0	2.4368	3.0017	3.6976	4.5548	29.38
4	5000	1000	45.0	3.4507	4.2507	5.2361	6.4500	29.38
5	5000	1000	50.0	4.8865	6.0193	7.4148	9.1337	29.38
6	5000	1000	55.0	6.9197	8.5239	10.5000	12.9342	29.38
7	5000	1000	60.0	9.7989	12.0706	14.8689	18.3160	29.38

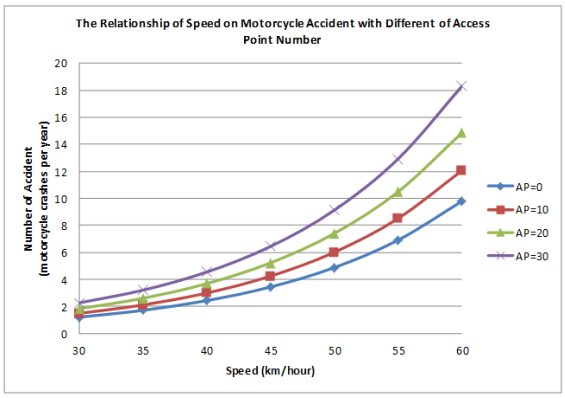

Fig. 3: The effect of speed on a motorcycle accident on the variation of the access point.

Table 2 and Figure 3 show that the increase in speed has implications for the increasing potential of accidents on any variation of the number of access points. The lowest rate of accidents occurred on roads with no access points and the lowest average speed of the vehicle is 1.2512 /year. The highest accident rate is on the combination of the highest average speed with highest numbers of of access points is 18.3160/year**.** On arterial roads with 10 access points/kilometer and vehicle speed of 30 km/hour, the potentialof accidents happens is 1.4969 per year, whereas if the vehicle speed is 35 km/hour, the potential of accidents that occur is 2.1197per year. It also means that any increase in speed of 5 km/h on arterial roads, there will be an increase in the number of motorcycle accidents by 29.38%. The influence of traffic speed in a motorcycle accident is consistent with the findings reported in previous studies (Ackaah and Salifu, 2011; Amiruddin *et al.* 2011; Taylor *at al.* 2002).

c. The Simulation of Change in Traffic Flow and Access Point:

The influence of the access points is also indicated by examining the relationship between the changes in volume of the vehicle and the number of accidents on some variation of the number of access points. In the calculation simulation, it is assumed that some variables have fixed-value, such as length of roads is 1000 meters, and the speed of 40 km/h, while the volume of traffic increased every twice, from the previous, and variations of the access points (AP) were determined from 0, 10, 20 and 30 access points per kilometer, as illustrated in Table 3 and Figure 4 below.

Table 3 and Figure 4 show that the increase of traffic volume has implications for the increasing potential of accidents, on any variation of the number of access points. When the traffic volume is 4000 pcu/h on arterial roads without openings (AP = 0), the potential accidents are 2.1472 per year. Furthermore, the condition of roads with AP = 10 per year is 2.6449, AP = 20 is 3.5281 per year, and AP = 30 is 4.0134 per year. It also means that every addition of 10 access points per kilometer on arterial roads have contributed to the increase in the number of motorcycle accidents by 23.18%.

Table 3: The effect of traffic volume on motorcycle accident on the variation of the access point.

No	Flow (pcu/hour)	LR (meter)	Speed (km/hour)	Motorcycle Accident Rates (motorcycle crashes per year)				Rate of Increase* (%)
				AP=0	AP=10	AP=20	AP=30	
1	0	1000	40.0	0	0	0	0	-
2	250	1000	40.0	0.4458	0.5491	0.6764	0.8333	100.0%
3	500	1000	40.0	0.6604	0.8135	1.0021	1.2344	32.5%
4	1000	1000	40.0	0.9784	1.2052	1.4846	1.8287	32.5%
5	2000	1000	40.0	1.4494	1.7854	2.1993	2.7092	32.5%
6	4000	1000	40.0	2.1472	2.6449	3.2581	4.0134	32.5%
7	8000	1000	40.0	3.1809	3.9183	4.8267	5.9457	32.5%

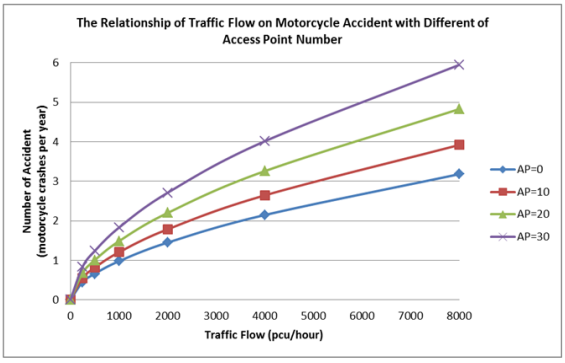

Fig. 4: Effect of traffic volume on motorcycle accident on the variation of the access point.

Increased traffic volumes on arterial roads affect the increasing number of motorcycle accidents. If the traffic volume increased twice from the previous, model would predict there will be an increase in the number of motorcycle accidents by 32.5%. The influence of traffic volume in a motorcycle accident is consistent with the findings reported in the previous studies (Xin Pei *et al*., 2011; Polus and Cohen, 2011; Chengye and Ranjitkar, 2013).

Conclusion & Recommendation:

Conclusion:

The results of this study indicate that the number of access points contribute to the growing number of motorcycle accidents on arterial roads. Every addition of 5 access points per kilometer affects the increasing number of motorcycle accidents by 9.9% per year. The increase in speed has implications for the increasing potential for accidents at each variation of the number of access points, which is, if the increase in 85th percentile speed is 5 km/h, the number of accidents increases by 29.38% per year. Similarly, the increase in traffic volume is also affecting the increasing number of accidents on each variation of the number of access points, which is, if the volume of traffic increases twice from the previous, the number of accidents will increase by 32.5% per year.

Recommendations:

Based on the results of studies on the effect of the access point to the motorcycle accident, it is recommended that traffic safety action program on arterial roads are as follows:

1. The need ofaccess point limitation policy on the arterial roads. This policy is important to reduce the potential of traffic accidents. The results of this study showed that the greater number of access points, the greater the potential of accidents. The number of traffic movement's conflict would also be diminished, along with the implementation of access point limitation policy.
2. The implementation of policy limiting access points can be done with frontage road development strategy on the arterial roads, especially in primary arterial roads. The existence of frontage road would cause traffic movement consequences can be reducedby managing the access point. Thus, the vehicle cannot go directly to the main line on the arterial road, but through the frontage road first instead.

REFFERENCES

Ackaah, W. and M. Salifu, 2011. Crash prediction model for two-lane rural highways in the Ashanti region of Ghana. IATSS Research, 35: 34-40.

Amiruddin, I., A. Ali, A.H. Rahim, A. Riza, O.K. Rahmat, 2011. Crashes and Effective Safety Factors within Interchanges and Ramps on Urban Freeways and Highways. Australian Journal of Basic and Applied Sciences, 5(7): 397-404. ISSN 1991-8178.

Chengye, P. and P. Ranjitkar, 2013. Modelling Motorway Accidents using Negative Binomial Regression, Proceedings of the Eastern Asia Society for Transportation Studies, 9.

Directorate General of Land Transportation, 2012. Land Transport in Figures. Ministry of Transportation, Jakarta. http://hubdat.dephub.go.id/data-a-informasi/pdda/1416-tahun-2012

Harnen, S., Radin R.S.Umar, S.V. Wong and Wan W.I. Hasim, 2006. Motorcycle Accident Prediction Models for Junctions on Urban Road in Malaysia. Journal of Advances in Transportation Studies, Section A, 8: 31-40.

Levinson, H.S., 2000. Access Spacing and Accidents, A Conceptual Analysis. In Transportation Research Circular E-C019: Urban Street Symposium Conference Proceedings, Dallas, TX, 28-30, 1999. Washington, DC: TRB, NRC, December 2000.

Machsus, Harnen S., A. Wicaksono and L. Djakfar, 2013. The Prediction Models of Motorcycle Accidents on Surabaya Arterial Roads Using Generalized Linear Models. Middle-East J. Sci. Res., 18(12): 1859-1866. ISSN 1990-9233, © IDOSI Publications.

McCullagh, P. and J.A. Nelder, 1989. Generalized Linear Models, 2nd edition. London, England: Chapman and Hall.

Nambuusi, et.al., 2008. A review of accident prediction models for road intersections. Steunpunt Mobiliteit & Openbare Werken – Spoor Verkeersveiligheid, mei. RA-MOW-2008-004.

Papayannoulis, V., J.S. Gluck, K. Feeney and H.S. Levinson, 2000. Access Spacing and traffic Safety. In Transportation Research Circular E-C019: Urban Street Symposium Conference Proceedings, Dallas, TX, June 28-30, 1999. Washington, DC: TRB, NRC, December 2000.

Polus, A. and M. Cohen, 2011. A new, non-canonical Poisson regression model for the prediction of crashes on low-volume rural roads. IATSS Research, 35(2): 98-103.

Tarko, A.P., S. Eranky, K.C. Sinha and R. Scinteie, 1999. An Attempt to Develop Crash Reduction Factors Using Regression Technique. The 78th Annual Meeting of Transportation Research Board, Washington D.C.

Taylor, M.C., A. Baruya and J.V. Kennedy, 2002. The Relationship between Speed and Accidents on Rural Single-Carriageway Roads, Report TRL 511. Berkshire, England: TRL Limited.

Xin Pei, S.C. Wong and N.N. Sze, 2011. A joint-probability approach to crash prediction models. Accident Analysis and Prevention, 43: 1160-1166.