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IDENTIFICATION OF BLACK SPOT AND EQUIVALENT ACCIDENT NUMBER USING UPPER CONTROL LIMIT METHOD

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ABSTRACT

Traffic accident is one of the serious problems faced by the Indonesian Government. The traffic accident rate in Indonesia is still considerably high. In 2014, 28,297 people died in road traffic accidents, 26,840 people severe injury and 109,741 people minor injury. The aim of this research is to identify black spot location and equivalent accident number using Upper Control Limit (UCL) method. The study location is in Purbalingga, Central Java, Indonesia. Database of traffic accidents from January 2010 to December 2013 were obtained from Purbalingga Police. The results showed that the equivalent accident number for death victims or fatality is 10, a severe injury is 4.25, a minor injury is 2.33, and property damaged only is 1. Seven roads have weighted accident number value greater than the upper control limit value and identified as a black spot location. Black spot location in Purbalingga regency are Jln. Raya turut Desa Bojongsari, Jln. Raya turut Desa Jetis, Jln. Raya Bayeman, Desa Tlahab Lor; Mayjend. Sungkono Street, Blater; Jln. Raya turut Desa Penaruban; Jln. Raya turut Desa Kembangan and Jln. Raya turut Desa Gembong.

Keywords: black spot, equivalent accident number, traffic accident, road safety, upper control limit.

INTRODUCTION

Traffic injury severity is an important safety concern of the transportation system. Traffic accident is one of the serious problems faced by the Indonesian Government. Data from the Police Department shows that 28,297 people died in traffic accidents, 26,840 people suffered severe injury, and 109,741 people suffered minor injury in 2014 [1]. The traffic accident rate in Indonesia is still considerably high, as reported by the national police, with around 262 accident casualties per day in 2014. To estimate the economic cost of traffic accidents, availability of traffic accident data will be necessary. Obtaining the kind of data that could properly represent the impact of traffic accidents on national economic indicators is far from easy. Traffic accident cost is one of the externality costs which are forgotten by road users [2]. According to a national police report, the total loss resulting from accidents was IDR 41 billion in 2002 [3].

The majority cause of the accident in Indonesia was male and the majority of vehicles are motorcycles. The highest accident causal is the human error factor [4]. Global Road Safety Partnership (GRSP) is a partnership between business, civil society, and government dedicated to the sustainable reduction of death and injury on the roads in developing and transition countries. The aim is to increase awareness of road safety [5]. The World report on road traffic injury prevention, launched jointly in 2004 by the World Health Organization(WHO) and the World Bank, identified improvements in road safety management that have dramatically decreased road traffic deaths and injuries in industrialized countries that have been active in road safety. The report showed that the use of seat belts, helmets and child restraints has saved thousands of lives. The introduction and enforcement of appropriate speed limits, the creation of safer infrastructure, the enforcement of blood alcohol concentration limits and improvements in vehicle safety, are all interventions that have been tested and repeatedly shown to be effective [5]. One of the alternatives to reduce the accident cost is identification of black spot location [6].

Traffic accident locations have an effect on the severity of accidents. Abdel-Aty distinguishes between different locations looking at roadway segments, intersections, and toll stations [7]. Study about the differences between accidents in rural and urban areas when trucks are involved and find significant differences for the two areas was done by [8]. Manner and Wünsch-Ziegler stated that accidents during daylight and at interchanges or construction sites are less severe. Accidents caused by the collision with roadside objects, involving pedestrians and motorcycles, or caused by bad sight conditions tend to be more severe [9].

Factors influencing the accident frequency may sometimes be different from the ones influencing the severity and it may therefore be reasonable to analyse the two separately. For example, guardrails have been found to affect the severity but not the frequency of accidents [10]. Study about accident severities when motorcycles are involved was done by[11, 12].

Accident costs can be reduced by reducing accident frequency and reducing injury severity. Primary safety measures reduce accident frequency e.g. improved road geometry, determination of speed limit, installation of signs and road markings, and relocation of poles [13]. There are four basic strategies for accident reduction using countermeasures. These are [14]:

a) Single site (black spot programs)-the treatment of specific types of accident at a single location.

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b) Mass action plans-the application of a known remedy to locations with a common accident problem.

c) Route action plans-tile application of known remedies along a route with a high accident rate.

d) Area with schemes-the applications of various treatments over a wide area of town/city, i.e. including traffic management and traffic calming (speed reducing devices).

The aim of traffic accident analysis is to identify factors that can be influenced by policymakers in order to reduce the frequency and severity of accidents or to study the effectiveness of certain measures. Kim, *et al*. empirically show that speed limits can have large effects on accidents involving cars and bicycles finding a threshold effect for the speed of 32.2 km/h. [15] Lee and Mannering analyse the effect that roadside conditions have on the frequency and severity of accidents. They note that the marginal effect of these factors is computed to provide an indication of the effectiveness of potential countermeasures [16].The effectiveness of ice warning signals on accidents caused by icy conditions is rejected by [17].

Based on Law 22, 2009 (Traffic and Land Transport), traffic accident is classified in three categories, fatal accidents, severe accidents, and slightly or minor accidents [18]. The severity of accidents should be taken into account, as accidents with fatal and severe injuries are more costly in both social and economic terms. If sufficient research has been carried out to identify the costs of accidents of different types and with different severity, then they can be weighted relative to their cost. Thus, if a fatal sideswipe accident costs a society 20 times more than a similar slight/minor injury accident, then it can be counted as 20 accident units. Using weightings, however, has the disadvantage that a few, random fatal accidents can sometimes dominate the selection. Alternatively, if such cost information is not available, qualitative weighting can be applied. For example, in South Korea and in Trinidad and Tobago, the Equivalent Accident Numbers (EAN) used for initial ranking purposes are 12 for a fatal; 3 for an injury accident and 1 for a damage-only accident. An EAN score can thus be awarded to each site, based on the sum of EAN values [14].

The aim of this study is to analysis the black spot location and equivalent accident number using Upper Control Limit (UCL) method. The study location is in Purbalingga Regency, Central Java, Indonesia.

LITERATURE REVIEW

Equivalent accident number (EAN)

Equivalent accident number is numbers that are used to grade the weighting accident; this value is based on the value of an accident with damage or loss of material [19]. EAN is a numeric economic scale to weigh the degree of accidents. It is calculated by comparing the estimated economic loss caused by various degrees of accident, namely death victims or fatality (FAT), serious injuries or severe injury (SVI), slight or minor injuries (MNI), or property damaged only (PDO). Technique of identifying the ranking of crash site is carried out by determining the Weighted Accident Number (WAN). There are several types or degrees of accident based on the victim severities so the accident number needs to be weighted by equivalent accident number to become WAN. The ranking by weighting the accident rates using a conversion cost of accidents.

a) Using a comparison of the monetary value of the costs of accidents, shown in equation 1.

$$M : B : R : K = M/K : B/K : R/K : 1 \quad (1)$$

With:
M is meninggal dunia or fatality (FAT).
B is luka berat or severe injured (SVI).
R is luka ringan or minor injured (MNI).
K is kerugian materi or property damage only (PDO).

b) Using the equivalent accidents number with the weighting system, which refers to the cost of the accident: M: B: R: K=12: 3: 3: 1, shown in equation 2 [19].

$$WAN = 12xFAT + 3xSVI + 3xMNI + 1xPDO \quad (2)$$

Weighted Accident Number is calculated by counting the accidents at every kilometre long road then multiplied by the weight value or Equivalent Accident Number (EAN) according to the severity. Weightage accident number are 12 for death victims or fatality (FAT), 6 for a severe injury (SVI), 3 for minor injuries (MNI) and 1 for property damaged only (PDO). The formula of equivalent accident number based on Directorate General of Land Transportation is shown in equation 3 below [20].

$$WAN = 12xFAT + 6xSVI + 3xMNI + 1xPDO \quad (3)$$

Weighting accident number with Accident Point Weightage (APW) method, within the guidelines of Operation Accident Black spots Investigation Unit (ABIU)-Traffic Accident Research 2007. Weightage accident number for death victims or fatality (FAT) is 6, a severe injury (SVI) is 3, minor injuries (MNI) is 0.8, and property damaged only (PDO) is 0.2, shown in equation 4 [21].

$$WAN = 6xFAT + 3xSVI + 0.8xMNI + 0.2xPDO \quad (4)$$

There are several EAN values suggested as shown in Table-1. Using the rationalized average value of EAN shown in Table-1 below:

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Table-1. Equivalent accident number in Indonesia.

Degree of accident	Puslitbang jalan	Ditjen hubdat	Polri	ABIU-UPK	Average value
	(1)	(2)	(3)	(4)	(5)=(1+2+3 +4)/(4)
Fatality (FAT)	12	12	10	6	10
Severe injury (SVI)	3	6	5	3	4.25
Minor injury (MNI)	3	3	1	0.8	2.33
PDO	1	1	1	0.2	1

Source:

(1) Puslitbang Jalan or Institute of Road Engineering Ministry of Public Works and Housing, 2005 [19]
(2) Direktorat Jenderal Perhubungan Darat or Directorate General of Land Transportation in [20]
(3) Korps Lalu Lintas Kepolisian Republik Indonesia, Indonesian National Police in [22].
(4) Accident Black spots Investigation Unit (ABIU)-Traffic Accident Research, 2007 [21]

UPPER CONTROL LIMIT (UCL)

According to the Guidelines for Handling Accident Prone Area (Pd. T-09-2004-B) in [19], the accident-prone location determination using statistical quality control chart Upper Control Limit (UCL), shown in equation 5.

$$UCL = \lambda + \Psi \text{ x } \sqrt{\left(\frac{\lambda}{m} + \frac{0.829}{m} + \left(\frac{1}{2} xm\right)\right)} \quad (5)$$

Where:

λ = score of average accident.
Ψ = probability factor = 2.576
m = score accidents in each segment.

Segment of roads with accident rate is above the UCL is defined as an accident-prone locations. Probability factor (Ψ) value is determined by the probability, which the accident rate is large enough so that this accident cannot be regarded as random events [23]. Probability factor (Ψ) value as shown in Table-2 below. The most commonly used value of Ψ is 2.576 with a probability of 0.005 (or significance 99.5%) and 1.645 with probability 0.05 (or 95% significance).

Table-2. Probability factor values.

Probability	0.005	0.0075	0.05	0.075	0.10
Ψ	2.576	1.960	1.645	1.440	1.282

METHOD

The study location

The study location is in Purbalingga Regency, Central Java Province, Indonesia. The locations of study are arterial road and collector road. Traffic accident data from Purbalingga Police atJanuary 2010 to December 2013 [24].

Analysis approach

To perform the analysis of the accident-prone points (black spot) is required historical data of accidents for four years (2010-2013). In processing, the accident data classified per segment for the next black spot area is determined based on the road. Upper Control Limit (UCL) method will be used to determine the location of the black spot. A segment will be identified as the location of the critical points of the road when the accident occurred UCL line that crosses the line.

Six steps being taken in the UCL method is as follows:

a) Make a tabulation of accidents for each road based on severity i.e. death victim or fatality, severe injury, minor injury, and property damaged only.

b) Calculate the total of weighted accident number (WAN) for each road or score accidents in each segment (m) and total of WAN for all roads.

c) Calculate the average of equivalent accident number or score of average accident (λ).

d) Calculate the value UCL for each road using equation 5 with probability factor (Ψ) is 2.576.

e) Make an Upper Control Limit (UCL) chart

UCL chart is a graph that shows the combination of charts score accidents in each segment (m) and UCL value. UCL value will be the boundary line in the identification of black spots.

f) Determination of the location of black spot

From the UCL chart has been created, it can be determined the location of the accident-prone. A segment is referred as the location of the black spot where the accident rate in this segment is over the UCL line.

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RESULT AND DISCUSSIONS

Traffic accident in Purbalingga

Based on the analysis of traffic accident data from Purbalingga Police during 2010-2013 occurred 1,336 accidents with the fatality of casualties is 183 fatal (27 in 2010, 23 in 2011, 42 in 2012 and 91 in 2013). Traffic accident in Jln. Raya turut Desa Bojongsari, Purbalingga from January 2010-December 2013 is 29 with number of victims is death victims or fatality (FAT) is 5 and minor injury (MNI) is 54. Traffic accident and number of victims in 23 arterial road and collector road in Purbalingga Regency is shown in Table-3.

Table-3. Traffic accident and number of victims in Purbalingga.

No.	Name of road and location	No. of accident	No. of victims			
			FAT	SVI	MNI	PDO
1.	Jln. Raya turut Desa Bojongsari, Purbalingga	29	5	0	54	0
2.	Jln. Raya turut Desa Jetis, Kemangkon	19	7	1	43	1
3.	Jln. Raya Bayeman, Desa Tlahab Lor, Karangreja	12	4	1	47	2
4.	Jln. Raya Mayjend. Sungkono, Blater, Kalimanah	17	2	0	40	1
5.	Jln. Raya turut Desa Penaruban, Kec. Bukateja	14	5	1	19	0
6.	Jln. Raya turut Desa Kembangan, Kec. Bukateja	14	3	0	28	0
7.	Jln. Raya turut Desa Gembong, Kec. Bojongsari	15	1	0	34	0
8.	Jln. Raya turut Desa Panican, Kec. Kemangkon	11	3	0	23	0
9.	Jln. Raya turut Desa Penolih, Kec. Kaligondang	7	6	0	7	0
10.	Jln. Raya turut Desa Sinduraja, Kec. Kaligondang	9	4	1	13	0
11.	Jln. Raya turut Kel. Bojong, Purbalingga	13	3	0	19	0
12.	Jln. Raya turut Desa Karangduren, Kec. Bobotsari	9	2	0	21	0
13.	Jln. Raya turut Desa Gandasuli, Kec. Bobotsari	12	1	0	25	0
14.	Jln. Raya turut Desa Toyareka, Kec. Kemangkon	6	4	0	12	0
15.	Jln. Raya turut Desa Kalitinggar, Kec. Padamara	7	2	0	20	0
16.	Jln. Raya turut Desa Banjarsari, Kec. Bobotsari	9	3	0	14	0
17.	Jln. Raya turut Desa Selaganggeng, Kec. Mrebet	9	2	1	15	0
18.	Jln. Raya turut Desa Gumiwang, Kec. Kejobong	7	2	0	13	0
19.	Jln. Raya turut Pagutan Desa Bojongsari	5	2	0	9	0
20.	Jln. Raya turut Desa Klapasawit, Kec. Kalimanah	6	1	0	13	0
21.	Jln. Raya turut Desa Kutasari, Purbalingga	4	2	0	5	0
22.	Jln. Raya turut Desa Panunggalan, Kec. Pengadegan	2	2	0	3	0
23.	Jln. Raya turut Desa Brobot, Kec. Bojongsari	1	2	0	0	0
	Total	189	56	4	380	3

EQUIVALENT ACCIDENT NUMBER (EAN)

Weighted accident number in this study using the average value from four equivalent accident numbers in Indonesia. Equivalent accident number for death victims or fatality (FAT) is 10, a severe injury (SVI) is 4.25, a minor injury (MNI) is 2.33, and property damaged only (PDO) is 1, shown in equation 6.

$$WAN = 10xFAT + 4.25xSVI + 2.33xMNI + 1xPDO \quad (6)$$

Weighted accident number is the sum of the value of the weighting of each road. An example of the calculation of weighted accident number in Jln. Raya turut Desa Bojongsari, Purbalingga with death victims is 5, serious injuries is 0 and slight injuries is 54. The weighted accident number is calculated as follows:

$$WAN = 10xFAT + 4.25xSVI + 2.33xMNI + 1xPDO$$
$$WAN = (10*5) + (4.25*0) + (2.33*54) + 1x0$$
$$WAN = 175.82.$$

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The weighted accident number for Jln. Raya turut Desa Bojongsari, Purbalingga is 175.82. The weighted accident number for 23 roads in Purbalingga is shown in Table-4. After the total WAN value calculation is obtained, then be calculated to obtain the average value of the accident. Average value accident is the results of calculation of the amount of total WAN divided by the number of arterial and collector roads. The average value accident (λ) is 71.34.

Black spot analysis using UCL

Black spot analysis using upper control limit is done to determine the limits of the vulnerability of road accidents in each segment. Each road has a limit level of vulnerability of different accidents. This calculation is a reference to determine the accident-prone roads or black spot in Purbalingga regency. An example of the calculation of upper control limit value on Jln. Raya turut Desa Bojongsari, Purbalingga with the data score of average accident (λ) is 71.34, probability factor (Ψ) is 2.576, and weighted accident number (m) is 175.82. Upper control limit value in Jln. Raya turut Desa Bojongsari is 95.55. A road segment is referred as the location of the black spot where the accident rate in this segment or weighted accident number is over the UCL value. The upper control limit value for 23 roads in Purbalingga regencyis shown in Table-4 below. Chart of upper control limit and weighted accident value in 23 roads in Purbalingga is shown in Figure-1.

Table-4. Weighted accident number and upper control limit.

No.	Name of road	Weighted accident number				Total of WAN	UCL
		10*FAT	4.25*SVI	2.33*MNI	1*PDO		
1.	Jln. Raya turut Desa Bojongsari, Purbalingga	50	0	125.82	0	175.82	95.550
2.	Jln. Raya turut Desa Jetis, Kemangkon	70	4.25	100.19	1	175.44	95.524
3.	Jln. Raya Bayeman, Desa Tlahab Lor, Karangreja	40	4.25	109.51	2	155.76	94.142
4.	Jln. Raya Mayjend. Sungkono, Blater, Kalimanah	20	0	93.2	1	114.2	90.914
5.	Jln. Raya turut Desa Penaruban, Kec. Bukateja	50	4.25	44.27	0	98.52	89.555
6.	Jln. Raya turut Desa Kembangan, Kec. Bukateja	30	0	65.24	0	95.24	89.258
7.	Jln. Raya turut Desa Gembong, Kec. Bojongsari	10	0	79.22	0	89.22	88.701
8.	Jln. Raya turut Desa Panican, Kec. Kemangkon	30	0	53.59	0	83.59	88.166
9.	Jln. Raya turut Desa Penolih, Kec. Kaligondang	60	0	16.31	0	76.31	87.449
10.	Jln. Raya turut Desa Sinduraja, Kec. Kaligondang	40	4.25	30.29	0	74.54	87.270
11.	Jln. Raya turut Kel. Bojong, Purbalingga	30	0	44.27	0	74.27	87.243
12.	Jln. Raya turut Desa Karangduren, Kec. Bobotsari	20	0	48.93	0	68.93	86.692
13.	Jln. Raya turut Desa Gandasuli, Kec. Bobotsari	10	0	58.25	0	68.25	86.620
14.	Jln. Raya turut Desa Toyareka, Kec. Kemangkon	40	0	27.96	0	67.96	86.590
15.	Jln. Raya turut Desa Kalitinggar, Kec. Padamara	20	0	46.6	0	66.6	86.446
16.	Jln. Raya turut Desa Banjarsari, Kec. Bobotsari	30	0	32.62	0	62.62	86.018
17.	Jln. Raya turut Desa Selaganggeng, Kec. Mrebet	20	4.25	34.95	0	59.2	85.642
18.	Jln. Raya turut Desa Gumiwang, Kec. Kejobong	20	0	30.29	0	50.29	84.622
19.	Jln. Raya turut Pagutan Desa Bojongsari	20	0	20.97	0	40.97	83.491
20.	Jln. Raya turut Desa Klapasawit, Kec. Kalimanah	10	0	30.29	0	40.29	83.406
21.	Jln. Raya turut Desa Kutasari, Purbalingga	20	0	11.65	0	31.65	82.302
22.	Jln. Raya turut Desa Panunggalan, Kec.Pengadegan	20	0	6.99	0	26.99	81.699
23.	Jln. Raya turut Desa Brobot, Kec. Bojongsari	20	0	0	0	20	80.844
	Total	560	17	885.4	3	1640.84	

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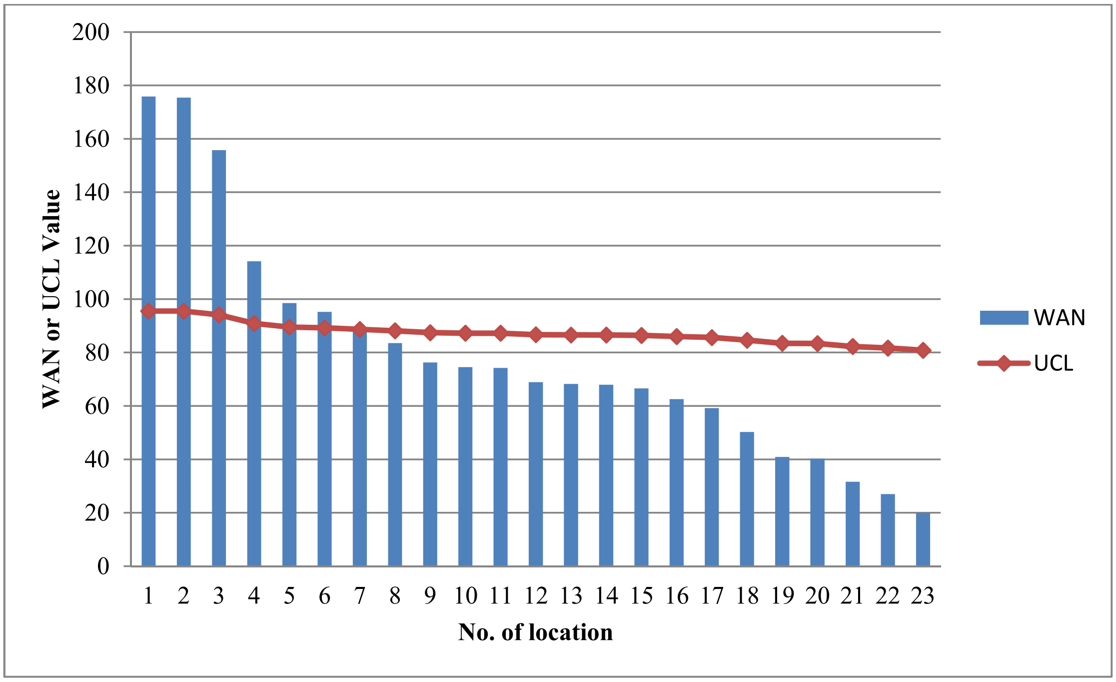

Figure-1. Chart of upper control limit and weighted accident value in 23 roads in Purbalingga.

Black spot location

From the analysis of accident data in January 2010-December 2013 to determine the accident-prone or black spot location using UCL (Upper Control Limit) method, seven roads have weighted accident number value greater than the UCL value. There are seven roads was classified as an accident-prone or black spot location.

Based on the calculations of control limits using UCL method (shown in Figure-1), seven roads in Purbalingga are classified as black spot location, as follows:

a) Jln. Raya turut Desa Bojongsari, Purbalingga, with a value of WAN at 175.82 is greater than the value of the control limit UCL 95.55.
b) Jln. Raya turut Desa Jetis, Kemangkon, with a value of WAN at 175.44 is greater than the value of the control limit UCL 95.52.
c) Jln. Raya Bayeman, Desa Tlahab Lor, Karangreja, with a value of WAN at 155.76 is greater than the value of the control limit UCL 94.14.
d) Jln. Raya Mayjend. Sungkono, Blater, Kalimanah, with a value of WAN at 114.20 is greater than the value of the control limit UCL 90.91.
e) Jln. Raya turut Desa Penaruban, Kec. Bukateja, with a value of WAN at 98.52 is greater than the value of the control limit UCL 89.55.
f) Jln. Raya turut Desa Kembangan, Kec. Bukateja, with a value of WAN at 95.24 is greater than the value of the control limit UCL 89.26.
g) Jln. Raya turut Desa Gembong, Kec. Bojongsari, with a value of WAN at 89.22 is greater than the value of the control limit UCL 88.70.

CONCLUSIONS

The identification of equivalent accident number and black spot location using upper control limit is presented in this paper. From the analysis and results, it can be concluded as follows:

a) Equivalent accident number for death victims or fatality is 10, a severe injury is 4.25, a minor injury is 2.33, and property damaged only is 1.
b) Seven roads have weighted accident number value greater than the upper control limit value.
c) Black spot location in Purbalingga Regency are Jln. Raya turut Desa Bojongsari, Jln. Raya turut Desa Jetis, Jln. Raya Bayeman, Desa Tlahab Lor; Jln. Raya Mayjend. Sungkono, Blater; Jln. Raya turut Desa Penaruban; Jln. Raya turut Desa Kembangan and Jln. Raya turut Desa Gembong.

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REFERENCES

[1] Korps Lalu Lintas (Korlantas) Polri.2014. Polantas dalam Angka 2014.Jakarta: Korlantas Kepolisian Negara Republik Indonesia.

[2] Sugiyanto, G. 2016. The Impact of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle to the City of Yogyakarta, Indonesia. Journal of Engineering and Applied Sciences. 11(8): 1740-1746.

[3] Asian Development Bank (ADB). 2005. The Cost of Road Traffic Accidents in Indonesia. ADB-Association of Southeast Asian Nations (ASEAN) Regional Road Safety Program, Accident Costing Report AC 03: Indonesia.

[4] Sugiyanto, G. 2010. Kajian Karakteristik dan Estimasi Biaya Kecelakaan Lalu Lintas Jalan di Banyumas, Indonesia dan Vietnam.Jurnal Berkala Transportasi Forum Studi Transportasi antar Perguruan Tinggi (FSTPT). 10(2): 135-148.

[5] Global Road Safety Partnership (GRSP). 2008. Speed Management (Road Safety Manual for Decision-Makers and Practitioners). Switzerland: Geneva.

[6] Sugiyanto G., B. Mulyono, and M.Y. Santi. 2014. Karakteristik Kecelakaan Lalu Lintas dan Lokasi Black Spot di Kabupaten Cilacap.Jurnal Teknik Sipil Universitas Atma Jaya Yogyakarta. 12(4): 259-266.

[7] Abdel-Aty, M. 2003. Analysis of driver injury severity levels at multiple locations using ordered probit models. Journal of Safety Research. 34(5):597-603.

[8] Khorashadi, A., D. Niemeier, V. Shankar, and F. Mannering. 2005. Differences in rural and urban driver-injury severities in accidents involving large-trucks: an exploratory analysis. Accident Analysis and Prevention. 37: 910-921.

[9] Manner, H. and L. Wünsch-Ziegler. 2013. Analysing the severity of accidents on the German Autobahn. Accident Analysis and Prevention. 57: 40-48.

[10] Savolainen, P., F. Mannering, D. Lord, and M. Quddus. 2011. The statistical analysis of highway crash-injury severities: a review and assessment of methodological alternatives. Accident Analysis and Prevention. 43(5): 1666-1676.

[11] Savolainen, P. and F. Mannering. 2007. Probabilistic models of motorcyclists' injury severities in single- and multi-vehicle crashes. Accident Analysis and Prevention. 39(5): 955-963.

[12] Shankar, V. and F. Mannering. 1996. An exploratory multinomial logit analysis of single-vehicle motorcycle accident severity. Journal of Safety Research. 27(3): 183-194.

[13] Sugiyanto, G. and M.Y. Santi. 2017. Road Traffic Accident Cost using Human Capital Method (Case study in Purbalingga, Central Java, Indonesia). Jurnal Teknologi (Sciences and Engineering). 79(2)

[14] World Bank. 2016. Road Safety: Accident Counter Measures at Hazardous Locations. Retrieved on 2016-08-26, available from https://www.worldbank.org/transport/roads/saf_docs/haz_locs.htm.

[15] Kim, J.K., S. Kim, G.F. Ulfarsson, and L.A. Porrello. 2007. Bicyclist injury severities in bicycle-motor vehicle accidents. Accident Analysis and Prevention. 39: 238-251.

[16] Lee, J. and F. Mannering. 2002. Impact of roadside features on the frequency and severity of run-off-roadway accidents: an empirical analysis. Accident Analysis and Prevention. 34(2): 149-161.

[17] Carson, J. and F. Mannering. 2001. The effect of ice warning signs on ice-accident frequencies and severities. Accident Analysis and Prevention. 33: 99-109.

[18] Undang-Undang No. 22 Tahun 2009 tentang Lalu Lintas dan Angkutan Jalan. Jakarta: Ministry of Transportation Republic of Indonesia.

[19] Pusat Litbang Prasarana Transportasi. 2005. Penanganan Lokasi Rawan Kecelakaan Lalu Lintas: Pd.T-09-2004-B. Jakarta: Departemen Permukiman dan Prasarana Wilayah, Ministry of Public Works Republic of Indonesia.

[20] Soemitro and R.A Aryani. 2005. Accident Analysis Assessment to the Accident Influence Factors On Traffic Safety Improvement (Case: Palangkaraya-Tangkiling National Road). Proceedings of the Eastern Asia Society for Transportation Studies (EASTS). 5: 2091-2105.

[21] Direktorat Jenderal Perhubungan Darat. 2007. Pedoman Operasi Accident Black Spot Investigation Unit/Unit Penelitian Kecelakaan Lalu Lintas (ABIU/UPK), Jakarta: Direktorat Jenderal Perhubungan Darat, Direktorat Keselamatan Transportasi Darat, Ministry of Transportation Republic of Indonesia.

[22] Susilo, B.H. 2016. Guideline for Survey, Investigation, and Design of Black Spot Location (SID-BSL) and Its Application in Lampung Province, Indonesia.Civil Engineering DimensionPetra Christian University Surabaya. 18(2): 49-56.

[23] Khisty, C.J. andB.L. Kent. 2003. Dasar-dasar Rekayasa Transportasi (Transportation Engineering: An Introduction). Jakarta: Erlangga.

[24] Polres Purbalingga. 2014. Data Kecelakaan Lalu Lintas di Purbalingga Tahun 2010-2013. Unpublished. Purbalingga: Kepolisian Resor Purbalingga.