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ACCIDENT ANALYSIS ASSESSMENT TO THE ACCIDENT INFLUENCE FACTORS ON TRAFFIC SAFETY IMPROVEMENT (CASE: PALANGKA RAYA _ TANGKILING NATIONAL ROAD

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Abstract: The objectives of this present research are to investigate the black spot and to determine the accident influence factors in order to improve traffic safety along the Palangka Raya – Tangkiling national road. Palangka Raya – Tangkiling national road is part of southern Trans-Kalimantan has 34 km in length and 6 m to 12 m in width. From 1997 to 2001, the traffic volume was increased from 2070 pcu to 2812 pcu, while the number of accidents for the last 5 years was 83. The results show the black spot was situated at STA 0 + 000 to STA 8 + 000. Road geometric and road surface condition have no influence on the number of accidents. Land-use, traffic volume and driver's characteristic was the influence factors affected the number of accidents. Rear-head collision (57.8 % out of 33 cases on black spot) was significant accident type. Motor cycle (44.27 % out of 131 cases on black spot) was indicated as the most often vehicle type involved in the accident.

Key word: Accident, driver, behavior, collision, road, season, traffic, and data

1. INTRODUCTION

The main purpose of transportation system is to provide the efficient and safe movement of freight and passenger from one place to another. The economic development is directly and strongly related to the availability of transportation. The soaring number of vehicles on the road had created a major social problem through traffic accidents due to the loss of lives and material. Moreover, in developing countries such as Indonesia traffic accidents rates are still quite high. Therefore, the issue of road safety is a major concern in transportation engineering.

The most effective way to reduce road accident is to better understand the causative road accidents hence to prevent the occurrence of road accidents. Considerable past studies were emphasized on identification of black spot. Accidents are rarely caused because of one single factor. Thus, a multi-disciplinary approach is essentially needed in understanding the problems and providing better and appropriate solutions.

1.2 EAN (EQUIVALENT ACCIDENT NUMBER) AND AR (ACCIDENT RATE) CALCULATIONS

EAN (Equivalent Accident Number) and AR (Accident Rates) are normally considered better measures of risk than accident frequencies alone, since they account for different traffic flow.

The standard equation for calculating EAN is:

EAN = 12 Death + 3 Seriously Injured + 3 Lightly Injured + 1 Material Losses (1)

The values for each accident type are shown in Table 1 below.

Table 1. Values for Accident Type

Accident Type	Value
Death	12
Seriously Injured	3
Lightly Injured	3
Material Losses	1

The standard equation for calculating AR is:

$$AR = \frac{(AF.10^8)(100MVK)}{L.n.ADT.365} \qquad (2)$$

Where AR = Accident Rate
AF = Accident Frequency
ADT = Average Daily Traffic (pcu/hour/2 lanes)
L = Road Section Length (km)
MVK = Accident per million Vehicle – Kilometers of travel
n = Number of accident years

2. STATISTICAL TESTING OF EXPERIMENTAL RESULTS

To determine the significant differences of the effects of driving license, gender and land-use data, the Root Mean Square test was used. Traffic volume and road geometric were investigated using the regression analysis. The Analysis of Variance was applied to observe the driver's characteristic (age, level of education and profession). Goodness of Fit test was used to investigate the weather and time when the accidents occurred. All the tests were done at a significance level of $\alpha = 0.05$.

Using the Root Mean Square test, the difference for each measurement must be tested first. Then the t-test can be applied (Chatfield, 1983).

$$t = \frac{\bar{d} - do}{s_d / \sqrt{n}} \qquad (3)$$

Where
t : Statistic value for t-test
do : Difference between two means
$\bar{d}$: Average difference

The Null Hypothesis is of the form Ho: $\mu_D = do$ atau $\mu_1 = \mu_2$ atau $\mu_D = \mu_1 - \mu_2 = 0$. The degree of freedom is $\nu = n - 1$. The t distribution was used to find the critical area where $t(\nu,\alpha) > t$.

For the Analysis of Variance test, the Null Hypothesis is H_0: all variances are equal ($\mu_1 = \mu_2 = ... = \mu_n$), against the Alternative Hypothesis H_1: the variances are not equal. Then the following equations must be computed (Blank, 1982).

$$SS_T = \sum_{i=1}^{k}\sum_{j=1}^{n_i} y^2{}_{ij} - \frac{T^2{}_{..}}{N} \quad (4)$$

$$SS_{Tr} = \sum_{i=1}^{k} \frac{T^2{}_i}{n_i} - \frac{T^2{}_{..}}{N} \quad (5)$$

$$SS_E = SS_T - SS_{Tr} \quad (6)$$

Where

SS_T : Total sum of squares

SS_{Tr} : Between-treatment sum of squares

SS_E : Error of sum squares

Table 2. General form of ANOVA table

Source of variation	**Sum of squares**	**Degrees of freedom**	**Mean squares**	f **value**
Between treatments	SS_{Tr}	k-1	$s^2{}_i = \frac{SS_{Tr}}{k-1}$	$f = \frac{s^2{}_i}{s^2}$
Error	SS_E	$k(n$-1)	$s^2 = \frac{SS_E}{k(n-1)}$	
Total	SS_T	nk –1		

Where

$\sum_{j=1}^{n_i} y^2{}_{ij}$; : Square of sum of sample j for each treatment i

$T^2...$: Square of sum of total sample value

N : Total number of sample

$T^2{}_i$: Square of number of sample for each factor i

K : Number of location

n_i : Sample size for each factor i

Then Reject H_0 jika $f > F_{(k\text{-}1);(k(n\text{-}1)}^{(\alpha)}$

The Kolmogorov-Smirnov (K-S) Goodness of Fit test does not use an approximate distribution to test the Null Hypothesis which is the form of H_0: data is from a specified distribution with stated parameter values (Blank, 1982). The test is not reliable if the parameters must be estimated from the sample. The cumulative distribution function (cdf) of the observed sample and the hypothesized distribution must be determined to carry out a K-S test. The test statistic D_n is the maximum absolute difference between the two cdf's over all observed values.

$$D_n = \max \left| F(x) - S_n(x) \right| \qquad (7)$$

Where $F(x)$ is hypothesized cdf at x and $S_n(x)$ is observed cdf at x.

$$S_n(x) = \begin{cases} 0 & x < x_1 \\ \frac{k}{n} & x_k \le x < x_{k+1} \\ 1 & x \ge x_n \end{cases} \qquad (8)$$

Critical values for this K-S test are:

$$D_n^{5\%} \text{ is } \frac{1{,}36}{\sqrt{n}} \qquad (9)$$

$$D_n^{1\%} \text{ is } \frac{1{,}63}{\sqrt{n}} \qquad (10)$$

Where

$D_n^{5\%}$: Deviation critical value at a significance level of 5%

$D_n^{1\%}$: Deviation critical value at a significance level of 1%

n : Number of sample

3. DATA COLLECTION

3.1. Location of the Site Observation

This research was conducted in West Kalimantan, more precisely in Palangka Raya – Tangkiling national road which is part of southern Trans-Kalimantan. This road has 34 km in length and the width were varies from 6 m to 12 m in width. The design speed of this particular road is 80 km/h. Figure 1. presents the location of site observation while Figure 2. presents the detailed site observation

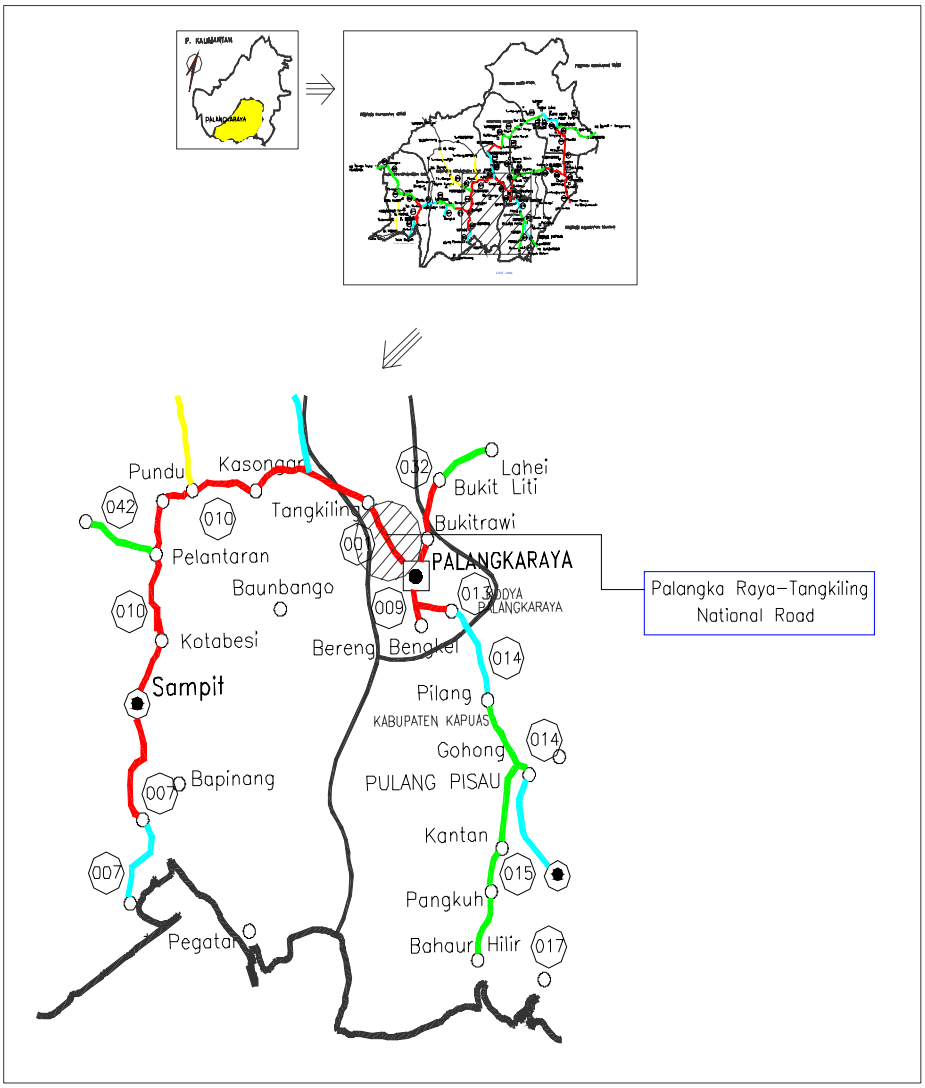

Figure 1. Location of site observation

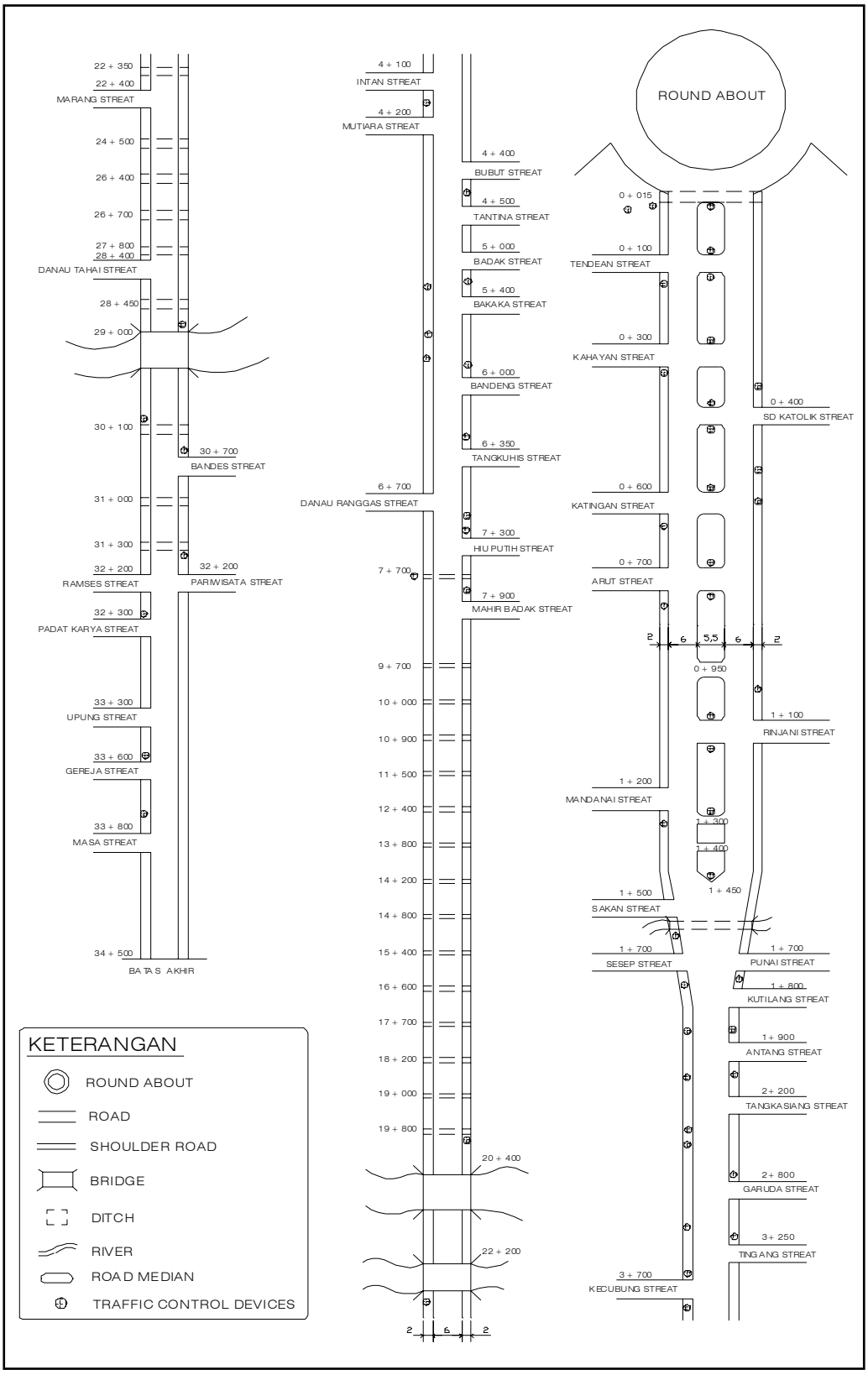

Figure 2. Detailed Site Observation

3.2. Accident Data

Accident data from 1997 to 2001 and driving license data collections were provided by Police Department. Public Works Department provided IRMS (Integrated Road Management System) and traffic volume. All the data provided in section 2 had been summarized by Bahat (Bahat, 2003). Accident location in Palangka Raya – Tangkiling National Road is presented in Table 3. Figure 3. presents accident location in Palangka Raya – Tangkiling National Road

Table 3. Accident location in Palangka Raya – Tangkiling National Road.

No.	Location (STA)			Number of Accidents					Number
				1997	1998	1999	2000	2001	
1	0	-	1	0	1	2	2	3	8
2	1	-	2	2	4	3	3	3	15
3	2	-	3	4	4	2	2	0	12
4	3	-	4	0	1	0	0	0	1
5	4	-	5	1	1	0	0	1	3
6	5	-	6	0	0	2	2	5	9
7	6	-	7	0	0	0	0	1	1
8	7	-	8	3	3	1	1	2	10
9	8	-	9	0	0	0	0	1	1
10	9	-	10	0	1	0	1	1	3
11	10	-	11	1	0	0	0	1	2
12	11	-	12	0	0	0	1	0	1
13	12	-	13	0	0	1	0	0	1
14	13	-	14	1	0	0	0	0	1
15	14	-	15	0	0	0	0	0	0
16	15	-	16	1	0	0	0	0	1
17	16	-	17	0	0	0	0	0	0
18	17	-	18	0	0	0	0	0	0
19	18	-	19	0	0	0	0	1	1
20	19	-	20	1	1	0	0	0	2
21	20	-	21	0	1	0	0	0	1
22	21	-	22	0	0	0	0	0	0
23	22	-	23	0	1	0	0	0	1
24	23	-	24	0	1	0	0	0	1
25	24	-	25	0	0	0	0	0	0
26	25	-	26	0	1	0	0	0	1
27	26	-	27	0	1	0	0	0	1
28	27	-	28	0	0	0	0	0	0
29	28	-	29	1	0	0	0	0	1
30	29	-	30	0	0	0	0	1	1
31	30	-	31	1	0	0	1	0	2
32	31	-	32	1	0	0	0	0	1
33	32	-	33	0	0	0	0	0	0
34	33	-	34	1	0	0	0	0	1
				18	21	11	13	20	83

Source: Palangka Raya Police Dept.

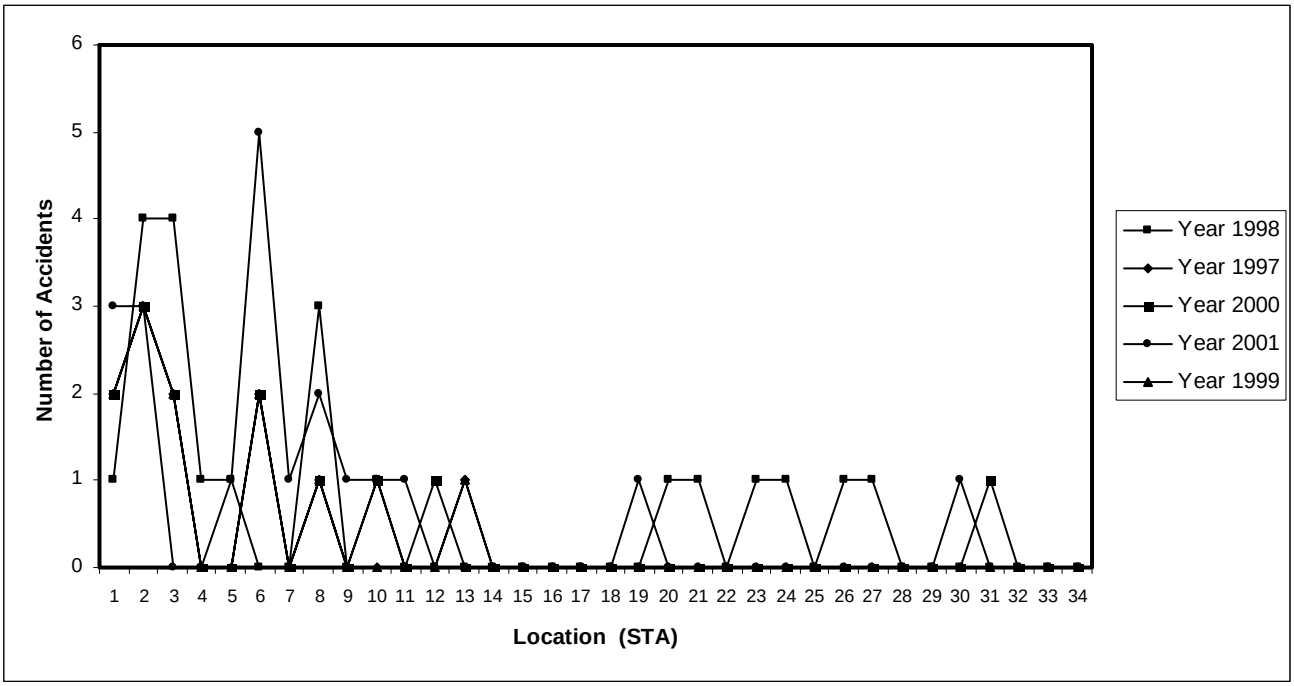

Figure 3. Accident location in Palangka Raya – Tangkiling National Road

Type of collision is shown in Table 4.

Table 4. Type of Collision

No	Type of Collision	1997	1998	1999	2000	2001	Total
1	Head on Collision	0	0	1	1	0	2
2	Back - Head Collision	3	2	0	0	4	9
3	Rear - Head Collision	4	3	3	5	4	19
4	Rear - Rear Collision	0	1	0	0	0	1
5	Lost of Control Collision	1	0	0	0	1	2
							33

Drivers involved in the accidents on the black spot were classified based on age, driving license, education, sex and profession. Table 5 shows the driver's classification.

Table 5. Driver's Classification

No	Driver	1997	1998	1999	2000	2001	Total
I	Age						
1	05 - 15 years	0	1	1	1	2	5
2	16 - 21 years	1	3	1	1	5	11
3	22 - 30 years	2	3	3	5	5	18
4	31 - 40 years	6	1	4	3	2	16
5	41 - 50 years	1	2	1	2	3	9
II	Driving License						
1	A	1	4	2	2	4	13
2	B	3	4	3	3	2	15
3	C	3	0	1	1	2	7
4	No Driving License	3	5	4	5	6	23

No	Driver	1997	1998	1999	2000	2001	Total
III	Education						
1	Elementary School	3	5	1	3	1	13
2	Junior High School	4	6	3	2	4	19
3	Senior High School	2	2	6	4	7	21
4	University	1	0	1	2	2	6
5	Drop Out	0	0	0	0	0	0
IV	Sex						
1	Male	12	13	10	10	14	59
2	Female	0	0	0	0	0	0
V	Profession						
1	Civil Service, Army and Polic	1	1	3	2	2	9
2	University Student	0	0	1	2	2	5
3	High School Student	0	2	1	1	3	7
4	Driver	3	3	3	2	2	13
5	Private	5	5	4	5	6	25

Vehicle type involved in the accidents on the black spot is shown in Table 6.

Table 6 Vehicle type involved in the accidents on the black spot

No	Type of Collision	1997	1998	1999	2000	2001	Total
1	Non Motorized	3	2	2	0	3	10
2	Motor Cycle	16	11	10	10	11	58
3	Passenger Car	5	8	8	4	6	31
4	Bus	1	0	0	0	0	1
5	Small-Medium Truck	6	8	6	8	3	31
6	Heavy Vehicle	0	0	0	0	0	0

Accident victim condition is shown in Table 7.

Table 7. Accident Victim Condition

No.	Victim condition	1997	1998	1999	2000	2001	Total
1	Mortal Injured	7	9	6	8	7	37
2	Seriously Injured	3	2	3	2	3	13
3	Lightly Injured	2	8	1	3	5	19

Average daily Traffic is presented in Table 8.

Table 8. Average Daily Traffic

No	Years	ADT	Number of Accidents
1	1997	2070	9
2	1998	2123	10
3	1999	2355	7
4	2000	2744	7
5	2001	2812	8

Number of accidents on curve and straight line roads is shown in Table 9.

Table 9. Number of Accidents on Curve and Straight Lines Roads

No.	Black Spot (STA)	Number of Accidents	
		Curve Lines	Straight Lines
1	0 + 000 – 1 + 000	3	5
2	1 + 000 – 2 + 000	0	15
3	2 + 000 – 3 + 000	8	4
4	5 + 000 – 6 + 000	4	5
5	7 + 000 – 8 + 000	5	5

Number of accidents on the black spot is presented in table 10.

Table 10. Number of Accidents on the Black Spot

No	Black Spot	Number of Accident	
	(STA)	Intersection	Non Intersection
1	0 + 000 - 1 + 000	3	8
2	1 + 000 - 2 + 000	8	15
3	2 + 000 - 3 + 000	1	12
4	5 + 000 - 6 + 000	6	9
5	7 + 000 - 8 + 000	3	10

Horizontal alignment characteristics on black spot are presented in Table 11.

Table 11. Horizontal Alignment Characteristics on Black Spot

No	Location (STA)	Angle Δ	Radius (m)	Design Speed km/jam	LS (m)	Elevation (%)	L' (m)
1	0 + 950	30°.00'.00	410	80	70	7,5	354,6
2	1 + 950	09°.30'.00	340	80	70	8,2	196,4
3	6 + 000	21°.00'.00	330	80	80	8,5	280,9
4	7 + 970	29°.30'.00	420	80	70	7,1	356,1

Accident number in Urban road and Rural road is presented in Table 12.

Table 12. Accident number in Urban road and Rural road

Years	Accident in Urban Road	Accident in Rural Road
1997	13	6
1998	12	9
1999	7	4
2000	8	4
2001	14	6

Accident time in the Black Spot is presented in Table 13.

Table 13. Accident Time in the Black Spot.

No.	Black Spot (STA)	Time				
		06.00 – 10.00	10.00 – 14.00	14.00 – 18.00	18.00 – 22.00	22.00 – 24.00
1	0 + 00 – 1 + 00	2	2	2	2	0
2	1 + 00 – 2 + 00	3	4	6	2	0
3	2 + 00 – 3 + 00	2	2	4	4	1
4	5 + 00 – 6 + 00	1	2	3	3	0
5	7 + 00 – 8 + 00	0	2	4	3	1

Accident number during rainy and dry season is shown in Table 14.

Table 14. Accident number during rainy and dry season

Year	Rainy Season	Dry Season
1997	8	11
1998	13	8
1999	7	4
2000	7	5
2001	13	7

3.3. Driver Characteristics.

Interview survey had been conducted to get better overview of driver characteristics. 1620 drivers had been interviewed; and the results were tabulated and classified according to their age, level of education, type of driving license, possession of driving license. These are presented into Table 15 to Table 20.

Table 15. Driver Age Classification

No	Type of Vehicle	Age (Years)						
		5-15	16-21	22-30	31-40	41-50	51-60	Total
1	Motor Cycle	10	212	268	230	256	24	900
2	Passenger Car	-	26	152	220	145	3	540
3	Truck & Bus		16	56	69	54	0	180
TOTAL								1620

Table 16. Driver Education Classification

No	Type of Vehicle	Elementary School	Junior High School	Senior High School	University	Total
1	Motor Cycle	36	132	275	97	540
2	Passenger Car	37	85	58	0	180
3	Truck & Bus	41	203	467	189	900
TOTAL						1620

Table 17. Driver Profession Classification

No	Type of Vehicle	Civil Service	University Student	High School Student	Driver	Private	Total
1	Motor Cycle	342	62	91	44	361	900
2	Passenger Car	144	6	10	328	322	540
3	Truck & Bus	0	0	0	177	3	180
TOTAL							1620

Table 18. Possession of Driving License Classification

No	Type of Vehicle	No Driving License	Motor Cycle	Heavy Vehicle	Passenger Car	Total
1	Motor Cycle	146	751	-	-	900
2	Passenger Car	40	-	-	400	540
3	Truck & Bus	12	-	168	-	180
TOTAL						1620

Table 19. Driver Gender classification

No	Type of Vehicle	Man	Woman	Total
1	Motor Cycle	672	228	900
2	Passenger Car	453	87	540
3	Truck & Bus	180	0	180
TOTAL				1620

Table 20. Duration of Driving License Possession

No	Type of Vehicle	Driving License Posession (years)				Total
		0 - 5	6 - 10	11 - 20	> 21	
1	Motor Cycle	395	255	198	52	900
2	Passenger Car	179	231	109	21	540
3	Truck & Bus	79	85	13	2	180
TOTAL						1620

To better understand the driver behavior on the blackspot, an observation to investigate the traffic law infraction had been carried out and summarized in Table 21.

Table 21. Driver Behavior on the Blackspot

No	Type of Vehicle	Road Marking Infraction	Overtaking From The Left	Over Speed	Stop at The Forbidden Site	Number of Drivers
1	Motor Cycle	102	100	36	31	1703
2	Passenger Car	75	73	17	26	1043
3	Medium Size Vehicle	17	9	5	4	322
4	Truck & Bus	0	0	0	0	28

3. ACCIDENT ANALYSIS

3.1. Blackspot Identification

The EAN and AR had been calculated using equation 1 and 2 respectively. The blackspot had been identified using the number of accident presented in Table 3 together with the consideration of EAN and AR along the road. Land use, road geometric and road surface condition were investigated along this road. The straightforward process of plotting accident on road location remains an important means of identifying accident blackspot in many countries.

It can be noted that the blackspot had not been changed from the year 1997 to 2001. The blackspot found to be situated in five locations: STA 0 + 000 – 1 + 000, STA 1 + 000 – 2 + 000, STA 2 + 000 – 3 + 000, STA 5 + 000 – 6 + 000 and STA 7 + 000 – 8 + 000. Surprisingly, all the blackspot locations situated in the two separate lanes having 6 m in width for each lane and 5 m median width. There are 19 intersections on this location, with offices, market, schools having direct access to that national road. It can be clearly understood that national road having 80 km/h design speed should only be intersected with traffic-signal control of junction. This is in accordance with the previous investigator that found that the road intersections are often accident blackspot (Ross et al., 1991). The other section having only 6 m in width was tended to have lower accident rates. This evidence is thought to be due that the unfavorable condition of road contributing to trigger the awareness of the driver leading to the decrease of the number of accident.

3.2. Accident Analysis

Having identified a blackspot or problem locations along the road, the next step is to establish the nature of the problems leading to the road accident occurrence. The statistical testing method described in the section 2 had been applied to analyze the accident data provided on the section 3.

Some statistical tests were applied to investigate the different influence factors to the accidents. Root mean square test was conducted on driving license, gender and land-use data. Traffic volume and road geometric were investigated using the regression analysis. Analyze of variance was performed to observe the influence of driver's characteristic (age, level of education and profession). Goodness of fit test was applied to understand the influence of weather and time when the accident occurred.

The results show the black spot was situated at STA 0 + 000 to STA 8 + 000. It has been indicated that road geometric and road surface condition have no influence on the number of accidents. Land-use, traffic volume and driver's characteristic was the influence factors significantly affected the number of accidents.

For road geometric, road condition, land-use (urban road and rural road), time (day and night), the T test was employed. The results were: no significant differences between the mean scores of accident happened in the curve and straight line roads, intersection and non intersection and road condition. There were significant differences between the mean scores of accident happened in the urban road and rural road, and on the day time and night time.

The accident happened in the difference climate and weather, between the monsoon and dry season was investigated using the Kolmogorov-Smirnof Goodness-of-fit test. The result was there significant difference between the numbers of accidents happened in the monsoon and dry season.

The influence of traffic volume augmentation was observed using the regression analysis and it can be obviously seen that the traffic volume decreased resulted in the significant number of accident.

Applying the Analysis of Variance test to the driver's characteristic involved in the accident resulted in the conclusion that age of driver (16-40 years), level of education (high school graduates), sex and profession of driver had significant differences in the number of accidents. On the contrary the possession in the driving license had no significant difference in the number of accidents.

A simple proportion percentage to understand the significant accident type and vehicle type involved in the accident had been carried out. It can be observed that rear-head collision (57.8 % out of 33 cases on black spot) was a significant accident type. Motor cycle (44.27 % out of 131 vehicle involved in the accident on black spot) was indicated as the most often vehicle type involved in the accident.

An important remark should be made upon findings on the interview to 1620 drivers on the black spot. This observation shows that most of the drivers have the following characteristic: 75.5 % were 16 – 40 years old; 46.54 % had motor cycle driving license; 74.45 % were secondary level graduate and 40.11 % were private employees. Moreover, the large influence of land-use, traffic volume and driver's characteristic are thought to be due to influence factors mostly affecting the accidents.

4. CONCLUSIONS

An interesting finding is that the blackspot location is situated in the two separate lanes having 6 m in width for each lane and 5 m median width. While the other section having only 6 m in width having very much lower accident occurrence. This evidence is thought to be due that the unfavorable condition of road contributing to trigger the awareness of the driver leading to the decrease of the number of accident. This finding might be contributed to more careful driving under such circumstances.

Overall, from 1997 to 2001, the traffic volume was increased from 2070 pcu to 2812 pcu, while the number of accidents for the last 5 years was 83. The large influence of land-use, traffic volume and driver's characteristic are thought to be due to influence factors mostly affecting the accidents.

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