CRASH PREDICTION MODEL FOR RURAL ROADWAY.

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ABSTRACT: This paper present the development of crash-prediction model for Malaysia, multilane rural roads. The crash–prediction models for a four-lane two way undivided roadways were constructed base on accident data observed over 5-year period (2006-2010). Multiple non-linear regression method was used to relate the discrete accident data with geometric road and traffic flow. The dependent variable was modeled as the number of crashes namely accident frequency and accident point weighting. The finding shows that multiple non-linear regression models as tested appear to be valuable for many applications such as identification of factor crash reduction due to road safety infrastructure.

Key words*: crash prediction model, traffic flow, multiple non-linear regressions.*

1. INTRODUCTION

Traffic accidents have been recognized as one of the major causes for human and economic losses both in developed and developing countries. In the year 2009, Malaysia has recorded 397,194 accidents, resulting in an average 18 deaths from road accident every single day. Meanwhile in year 2006 there were 23.6 deaths in Malaysia for every 100,000 populations recorded according to (Royal Malaysia Police), which is among the highest figures in the world compare to Netherlands and Japan has 4.5 and 5.7 deaths per 100,000 people respectively. In Malaysia, motorcycles constitute nearly half than total registered vehicle in the country with 49% meanwhile cars stated second place consist 45%. Cars casualties contribute the highest rate with 67% followed by motorcycles recorded more than 16% of the total casualties in traffic crashes (Royal Malaysia Police, 2009). Malaysia rural roadways from Batu Pahat to Ayer Hitam were among the rural road in Malaysia that has experienced 8,475 road accidents between the years 2000 and 2010, killing 234 people and injuring 1,703 people.

The most common accident indicator that have so far been used are the number of accident per year (accident frequency) and the number of accident per 10,000 kilometer vehicle travelled (accident rate), however accident point weighting have rarely been account in the road accident prediction Models.

Many independent variables affect accident rate, and are generally related to traffic flow, road geometric characteristic, driver behavior and weather. Consequently from the wider set of independent parameters normally authors extort a reduced number of variables for insertion in the accident model. Hence this research will considered the following variables: motorcycle, car, approach speed, access point, road geometric, motorcycle crossing, vehicles gap and pedestrian.

2. MODEL DEVELOPMENT

A 5 year observation period from 2006 to 2010 was carried out on a four lane undivided roadways. This infrastructure stretch about 47 kilometer with high density of driveways and property access. Direct access from frontage properties along the multilane roads such as housing area, school, university, factory, commercial building and office lot will influence the safety aspect. Most of the infrastructure didn`t provide the road median except for same kilometer section

Accident data were obtained from Royal Malaysia Police (RMP). The accident database consisted records for each casualty receiving fatal, serious or slightly injury and damage. Base on the **Fig. 1**, some 2,540 accident were considered in this study, 64 of which were fatal and 253 were injury while 2,223 were damage only accident.

By traversing the entire stretch of the road to observe the number of access point, median and signalized opening in every selected section were obtained. Variables such as traffic volume, approach speed, gap and vehicles movement were obtained over 2 hour time period namely morning (0800-1000), midday (1200-1400) and evening (1600-1800) by using the video camera on each kilometer section at the eleven corresponding access point.

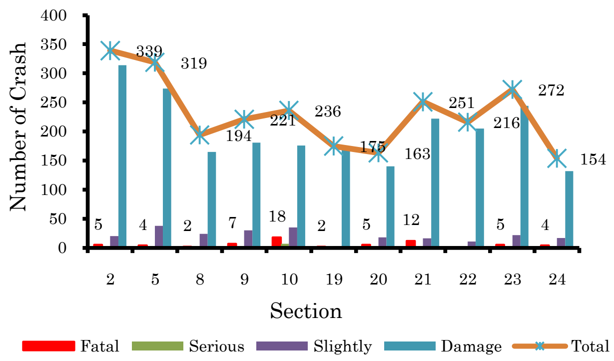

Fig.1 Number of accident according its type at study location (2006-2010)

(2) Site Selection

In this study, a total of 11 kilometers involve section 2,5,8,9 and 10 at Batu Pahat, meanwhile section 19, 20, 21,22 ,23 and 24 at Parit Raja as shown in Figure 2. From **Fig. 1**, represent the number of accident at 11 selected kilometers section which classified as fatal, serious, slightly and damage over 5 years period (2006:2010). The highest number of crash is section 2 with 339 toll accident, followed by section 5 with 319 cases. Third higher accident frequency were section 23 with 272 cases. The highest number of fatal accident is at section 10 with 18 cases followed by section 21 with 12 deaths recorded and next was section 9 with 7 deaths toll.

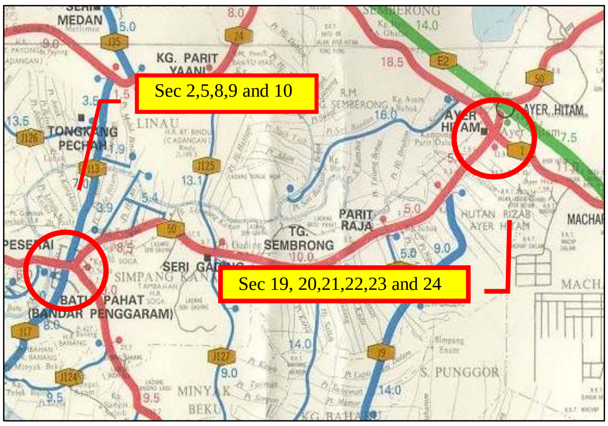

Fig. 2 Study location for model development.

(1) Dependent variable

Accident frequency (AF) and accident point weighting (APW) data were used in this study. Both dependent variable in this modals, described as accident data consisted fatal, serious, slightly and damage base on 2 hour period which is morning (08:00-10:00) midday (12:00-14:00) and evening (16:00-18:00). APW is based on the value contribute by the Transport Research Laboratory (TRL) and it has been used in the Highway Planning Units United Kingdom. APW considering weighting for fatal (6 points), serious injury (3 points), slight injury (0.8 points) and damage (0.2 points), the system include:

$$APW = X_1(6.0) + X_2(3.0) + X_3(0.8) + X_4(0.2) \quad (1)$$

Therefore each sections kilometer have three AF and APW, hence they are thirty three AF and APW in 11 section kilometers were consider in this model as shown in Figure 3. The accident frequency range from 7 to 42 while accident weighting point range from 2.2 to 33.

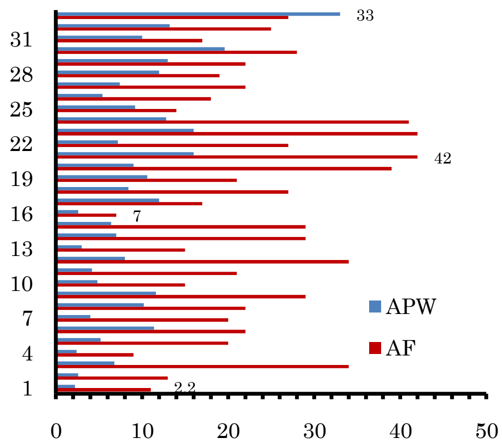

Fig.3 33 Accident frequency and accident point weighing at the 11 section kilometer (2006-2010)

(2) Independent variable

Approach speed is defines by the 85th percentile speed measured at a range 50 meter distance from the related access point. Speeds were measured of vehicles selected a random by using video camera until a total 100 vehicles were carried out during the morning peak from 0800-0900hrs, afternoon peak 1200-1300hrs and evening peak from 1700-1800hrs. It was ranges from 59 to 99 km/hr.

Traffic study data used in this paper were based on the hourly traffic volume. Cars and motorcycles data were collected from the hourly traffic volume (disaggregated by non cars and motorcycles), counted on each kilometer section at the selected access point. The cars (car, per hour) on the rural highway range from 1,797 to 6,177, while for motorcycles (Mc, per hour) range from 165 to 1193. Pedestrian crossing counts were also carried out parallel as vehicle counts. Figure 4 shows the traffic temporal fluctuations in traffic volumes at section 5. The highest traffic volumes recorded were 1751 vehicles at 5.45 p.m. to 6.00 p.m. The second highest was 1316 vehicles recorded at 12.15p.m to 12.30 p.m. While in the morning the highest traffic volume was 1089 vehicles recorded at 8.15a.m to 8.30a.m.

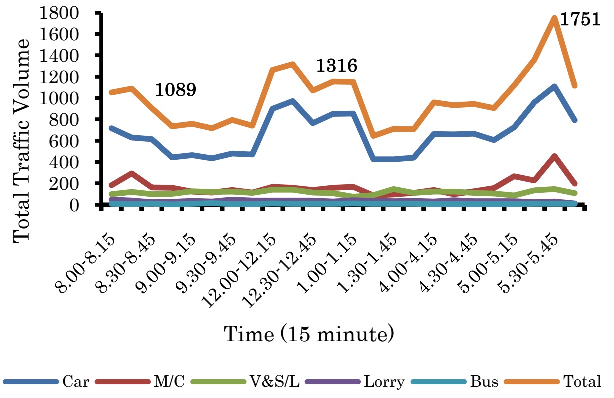

Fig.4 The temporal fluctuations in traffic volumes throughout a typical weekday

Fig. 5, illustrate the quantity of traffic volume by vehicle classification at 11 kilometers section for 6 hour survey period. Motorcar and motorcycle contribute the largest proportion of traffic volume with average 61% and 20% respectively. The highest 6 hours traffic volume were section 5 with 39,954 vehicles while section 2 stated second place with 22,206 vehicles and next were section 22 account for 20,555 vehicles. However section 24 recorded lowest traffic volume with 11,223 vehicles.

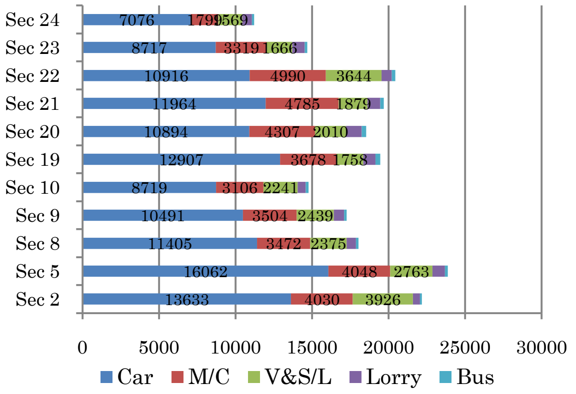

Fig.5 Traffic volume by vehicles classification at 11 kilometer section for 6 hours survey period.

Access points in this study were describe as un-signalized T junction and it was a road that provides access to a specific destination such as housing area, industrial part, commercial building and schools. Access point (AP, per kilometer section) was range from 1 to 13 on the four lane rural roadway.

6 hours traffic movements data has been undertaken at the eleven corresponding T-junction as shown in **Fig.6**. Every motors vehicle such as motorcar, motorcycle, van and lorry, and bus were counted separately. There are 6 possible vehicles movement, each movement vehicles describe as type 1: vehicle from minor road turning right into major road, type 2: vehicles turning right from major road into minor road, type 3: vehicles turning left into minor road while type 4: vehicles turning left form the minor road into major road, type 5: vehicles through eastbound and type 6: vehicles through westbound. Out of four turning vehicles only 2 were selected associate with accident and thus include in the model, they are type 1 and type 2. At the same time motorcycles has been chosen to represent for both movement. This parameter named as motorcycles crossing (McCrs per hour) and it ranges from 7 to 142.

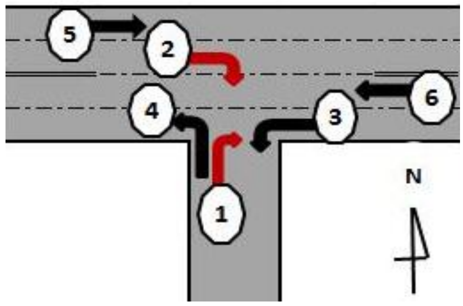

Fig. 6 Traffic movements at the typical T junction.

Gap in this study defines as the time between the back of the successive motor vehicles and the in front of the following motor vehicles at the corresponding access point. Total gap involved in this study were 3,300 and the range for the average gap were1.1 seconds to 2.3 seconds.

3. THE ACCIDENT PREDICTION MODEL

This research applies the "Multiple Regression Method" in order to develop a model which relates accident rate to the road geometry and traffic situation. The theoretical model of accident rate is represented by the following equation:

$$Y_i = b + b_1 X_{1i} + b_2 X_{2i} + \ldots\ldots + b_{ni} X_{ni} + \varepsilon_i \qquad (2)$$

Where Y_i is the accident frequency or accident point weighting (dependent variable) while all the independent variable are X_1, X_2 and X_{ni}. The $b, b_1,$ b_2 and b_{ni} are the regression coefficients to be estimated and ε_i term is the error representing the residual difference between observed and predicted model value. Explanatory variables and the description are presented in **Table 1**.

The (*Sig*), which indicates the meaningful level to obtained coefficient for the model parameters. Generally, variables with *Sig* value of 0.10, 0.05 and 0.01with confident interval (CI) of 0.90, 0.95 and 0.99 are statistically meaningful in the model.

Table 1 Description of the study variable

Abbr.	**Description**	**Coding**
AF	Accident Frequency	AF(per hour)
APW	Accident point weighting	APW (per hour)
AP	Access point	AP(per km)
Pd	Pedestrian	Pd (per hour)
Mc	Motorcycle	Mc (per hour)
Car	Car	Car (per hour)
AS	Approach speed	AS (km per hour)
Gp	Vehicle gap	Gp (second)
MD	Median	MD(divided=1, undivided=0)
SO	Signelized Opening	SO(install=1, uninstall =0)
McCrs	Motorcycle Crossing	McCros per hour

Table 2 Model Summary

Model	Multiple R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.745	0.555	0.492	4.348
2	0.788	0.621	0.495	6.607

Table 3 Model ANNOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	661.160	4	165.290	8.745	0.000
	Residual	529.248	28	18.902		
	Total	1190.407	32			
2	Regression	1718.499	8	214.812	4.921	0.001
	Residual	1047.561	24	43.648		
	Total	2766.061	32			

Table 4 Coefficient

Model		Unstand. Coeff. Beta	Std. Error	t
1	(Constant)	-10.830	4.043	-2.679
	$(AP)^{0.5}$	4.904	1.025	4.782***
	So	-6.012	1.918	-3.134***
	McCrs	0.031	0.016	1.954*
	Car	0.002	0.001	2.597***
2	(Constant)	-18.616	12.538	-1.485
	$(AP)^{0.5}$	4.374	2.079	2.104**
	Mc	0.012	0.004	2.792***
	(AS)(Gp)	0.119	0.058	2.049**
	Pd	-0.116	0.076	-1.528
	MD	8.588	4.961	1.731*
	SO	-3.286	3.062	-1.073
	McCrs	0.012	0.029	0.416
	Car	0.001	0.002	0.353

*,**,***=Significant at the 90%,95% and 99% level, respectively

The final models of accident prediction are formulated from equation (3a) and (3b) by using non-linear regression model:

Model 1

$$APW = -10.830 + 4.904(AP)^{0.5} - 6.012(SO) + 0.031 (McCrs) + 0.002(Car) \quad (3a)$$

Model 2

$$AF = -18.616 + 4.374(AP)^{0.5} + 0.012(Mc) + 0.119 (AS)(Gp) - 0.116(Pd) + 8.588(MD) - 3.286(SO) + 0.012(McCrs) + 0.001(Car) \quad (3b)$$

Table 2 and **Table 4** for model 1 shown the value multiple R and R^2 are 74.5% and 55.5% respectively. The effect of the access point, signalized opening and car were statistically significant (beyond 1% level) whereas motorcycles crossing variable influenced at 10% level. Model 2 represent the value of multiple R and R^2 were 62.13% and 49.5% respectively. The impacts of motorcycles were highly effected with significant at 1 % level meanwhile approach speed, gap and median influenced at 10 % significance level.

4. DISCUSSION AND CONCLUSION

By using Model 1, the percent accident reduction through changing the measures of each parameter are, one access point per kilometer reduction can reduce accident by 18% and installing of 1 signalized opening at the access point would reduce number of crash by 42 %. Meanwhile using the model 2, 10 kilometer per hour reduction in speed equated to a 9% drop in crash, per long the 0.1 second in gap will cut down number of accident by 3%. Furthermore constructing the median would lessen the accidents by 35%.

The model developed in this paper appear to be useful for many application such as the existing number of access point, increasing number of motorcycle and motorcycle crossing, rise in speed and shorted in gap are among the potential contribute of increment accident rate. Moreover this paper revealed that by constructing the road median and installing the opening signalized at the hazardous access point would drastically reduce the number of accident. Thus, these studies are realistically convinced that this latter may contribute a point of reference for the engineer in improving or designing multilane rural roads.

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