ACCIDENT INVESTIGATION, BLACKSPOT TREATMENT AND ACCIDENT PREDICTION MODEL AT FEDERAL ROUTE FT50 BATU PAHAT-AIR HITAM

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Abstract

Road accidents is one of the major contributors of human deaths in Malaysia. In the year 2005, 326,850 accidents were recorded, resulting in an average 17 deaths from road accident every single day. Federal Route 50 from Batu Pahat to Ayer Hitam experienced 4,842 road accidents between the years 2000 and 2005, killing 244 people and injuring 1,644 people. The purpose of this study is to perform an accident investigation and propose improvements at Pintas Puding area, and to develop an accident prediction model for Federal Route 50 by using multiple linear regression. The road accident trend and blackspot ranking were established at Federal Route (FT 50) Batu Pahat – Ayer Hitam. It was revealed that the increment of accident rates can be explained by either the rise in speed, number of major access point and traffic volume.

Keywords: Accident investigation, blackspot ranking, accident prediction model.

1 Introduction

In Asia alone, 400,000 people are killed on the roads annually and more than four million injured. According to the World Health Organization, every year, nearly one million people are killed, three million are severely disabled for life and thirty million are injured in road accidents. In 1990, death by road accidents remained 9th in ranking and by the year 2020, it has been predicted that road accidents will be the third leading cause of death worldwide (1).

Malaysia has experienced a remarkable period of economic expansion and growth in population, industrialization and economic stability. Statistics released by the Transport Ministry showed that a total of 14,816,407 million vehicle were registered in the country until end of 2005, which is nearly twice as those registered in 1996 (7,686,684 vehicle). Despite the marked increase in the number of vehicle over the last 10 years, there was a drop in fatality index with 8.2 deaths for every 10,000 vehicles in 1996, followed by 7.37 (1997), 6.28(1998), 5.83 (1999), 5.69 (2000), 5.17 (2001), 4.9 (2002), 4.9 (2003), 4.52(2004) and 4.18 (2005). To be on par with developed countries, we need to reduce the average fatality index to 2 deaths for every 10,000 vehicles (2).

2 Methodology

The accident analysis process involves the identification of accident blackspot locations, establishment of general patterns of accident, analysis of the factor involved, site studies, proposal of countermeasures and development of an accident prediction model using Multiple Linear Regression. The overall process applied for this study is as follows:

(i) Data Collection

Accident data were collected from Balai Polis Traffic Batu Pahat, JKR Daerah Batu Pahat, Polis Diraja Malaysia (PDRM) Bukit Aman, Jabatan Pengangkutan Jalan (JPJ), Klinik Kesihatan Parit Raja, Kolej Universiti Tun Hussien Onn (KUiTTHO) and Road Safety Research Center UPM Serdang. The accident database was obtained from the POL27 and the crash record was collected from the year 2000 to 2005.

13 ms

(ii) Analysis of Accident Data

Accident data is required to determine the nature of the accident problem at the study area. The analysis of the accident needs to look for the accident pattern. Accident data analysis provides more detail to rank the blacksport sites such as:

a) Ranking accident point weightage at FT 50,
b) Ranking of the top ten accident section,
c) Kilometers post analysis, and
d) Ranking accident point weightage

(iii) Field Investigation

Field investigation involves site, route and area inspection. These include traffic counts, origin destination surveys, vehicle classification survey, spot speed studies and observation studies. Preceding analysis work will enable researchers to identify possible causal factors of the accident as well as countermeasures option.

The site route or area inspection should include both a drive-over and walk-over inspection. The drive-over allows to correlate accident behaviour and driver perception while walk-over inspection is a more detailed examination of the location and driver behaviour.

(iv) Countermeasures

After the process of identifying common features and contributory factors, the next process is to develop and apply countermeasures. These countermeasures have to be assessed and a number of countermeasures may appear both feasible and effective.

(v) Accident Prediction Model

The model consists of several independent or explanatory variables, encompassing elements from road geometry to traffic condition. For this study, the variables which have considerable effect are 85th percentile speed, volume study and number of access points per kilometer. The data was collected on the field work.

The study section used for collecting data was about 5 kilometer long, it Involves KM 19, KM 20, KM 21, KM 22 and KM 23 of Federal Route 50. By traversing the entire length of the road to observe the number of access point, the number of major access point per kilometer for every section is obtained. Traffic volume and spot speed were obtained over 2-hour time periods of field survey at each section, namely the morning (0800-1000 h), midday (1100-1300 h) and evening (1700-1900 h). Spot speed measurement were taken at every section using a speed radar equipment. The 85th percentile speeds were determined from spot speed measurement using SPSS program.

3 Road Accident Trends

Figure 1 shows the trend of accidents and casualties in Federal Route 50 KM 1- KM 38 from year 2000-2005. The figure represents the increasing number of accident from year 2000 to 2004, but the number of accident decreased in year 2005. This means the impact of upgrading the route from a two-lane road to a four-lane road increased the accident number especially during its construction stage from year 2002-2004. The number of accidents however have declined to 905 in year 2005 from 1084 in year 2004. Meanwhile in year 2005, fatal cases were at its highest at 36 compared to the previous years. A total of 4,842 accident cases occurred, of which 152 were fatal, 182 serious injuries, 1010 slight injuries and 3,498 were damage only.

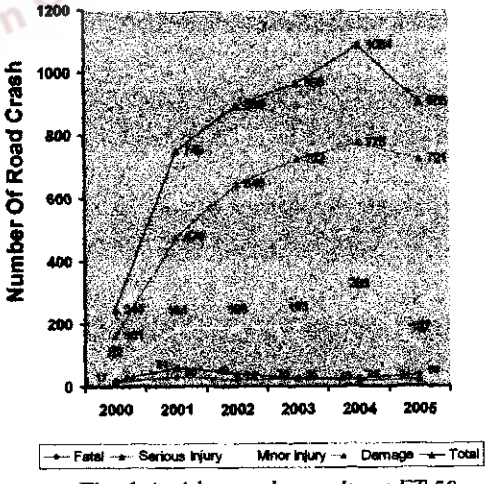

Fig. 1 Accident and casualty at FT 50

3.1.1 Accidents by Hours of the Day Year 2004

Figure 2 show the worst accident by hours of the day beginning from the midday to midnight. The highest number of accidents occurred between 16:01 to 18:00, recorded at 135. Second highest was at 14:01-16:00 involving 132 cases and the third highest at 12.01-14.00 with 124 accidents. The fatigue factor of the road users, high density of traffic and too many conflicts along the road were the probable causes of the accidents.

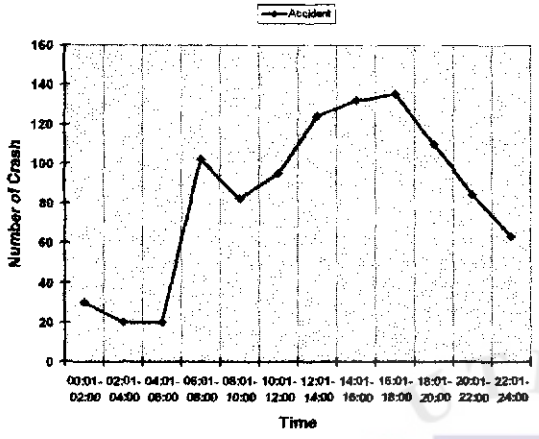

Fig. 2 Accidents by Hour of the Day at FT 50 (2004)

3.1.2 Total Number of Accidents by Light Condition

Figure 3 shows the number of accident by light condition in the year 2004. Most accidents happened during the day (47%), followed by 34% during the night, and 19% in the morning. This is due to the higher number of vehicles on the road during the day time compared to other hours of the day.

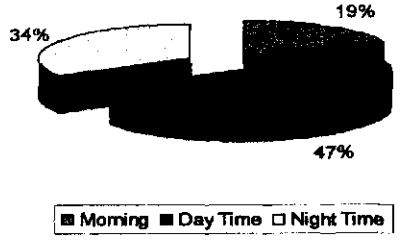

Fig. 3 Total Number of Accident by Light Condition at FT 50

3.2 Ranking Accident Point Weightage

Taking this a step further, the severity of accidents is taken into account by weighting factors (which are normally related to the average accident cost of each severity level), and damage-only accident are also included (having a real cost), the results in ranking shown in Table 1.

This system can also be used as an alternative to rank blackspots, using the accident data from the year 2002 to 2005. Section 5, Parit Haji Noor at Batu Pahat registered the highest with 146.8 weighting point, ranking it in first place based on the total number of accident. This was followed by Section 2 (Mesjid Batu Pahat), Section 1 (Klinik Kesihatan Batu Pahat), Section 10 (SHARP Factory, Batu Pahat), Section 20 (Pintas Punding) and Section 6 (Gillmill Industry).

3.2.1 Accident Maps

The accident blackspots map at FT 50 is shown in (Appendix A), has been establish to represent spatial distribution of accident data. As can be seen, the size of the circle is proportional to the accident point weightage. This feature allows a quick visual identification and ranking of the problematic location of area concerned.

3.2.2 Ranking by Accident Costs

An alternative method of obtaining the priority listing is by ranking the blackspots according to the total costs of accidents. The figure proposed by the Economic and Social Commission Asia Pacific (ESCAP) in 1996 can be used as a guideline to compute the economic loss due to accidents (Table 2). Using this recommendation, a sum of RM763,158, RM76,316 and RM4,421 were allocated for fatal, serious or slight and damage-only accident, respectively.

Using the same data, the KM 5 (Parit Haji Noor), again appeared to be one of the worst sections along stretch FT 50 (Table 2). The economic loss due to accident using the earlier ESCAP estimates was RM 12,996,532.00. One of the main advantages of this system is that the authority can easily perceive and experience the economic loss incurred due to accidents and thus perhaps help to justify the allocation of funds needed for the countermeasures.

***Table 1** Ranking Accident Point Weighting Along a Route FT 50 (KM 1-38) Over a 3 Years Period (2002-2005)*

5	11	6	47	126	190	146.8	1
2	5	4	34	237	280	116.6	2
1	4	3	53	198	258	115	3
10	5	7	37	112	161	103	4
20	7	2	36	90	135	94.8	5
6	3	6	44	107	160	92.6	6
4	3	4	32	168	207	89.2	7
19	5	5	32	80	122	86.6	8
8	5	3	34	88	130	83.8	9
3	4	1	28	154	187	80.2	10

***Table 2** Cost of Accident along a Route FT 50 (KM 1-38) Over a 3 Years Period (2002-2005)*

5	**Parit Haji Noor**	11	6	47	126	190	146.8	12,996,532	1
20	**Pintas Puding**	5	4	34	237	280	116.6	8,640,004	2
1	**Klinik Kesihatan**	4	3	53	198	258	115	8,201,686	3
2	**Masjid Baru Batu Pahat**	5	7	37	112	161	103	7,763,575	4
10	**Kilang SHARP**	7	2	36	90	135	94.8	7,668,846	5
8	**Tmn Bahagia Baru**	3	6	44	107	160	92.6	7,028,530	6
19	**KUITTHO**	3	4	32	168	207	89.2	6,993,162	7
6	**Gillmill Industry**	5	5	32	80	122	86.6	6,578,321	8
3	**Jln Parit Besar**	5	3	34	88	130	83.8	5,946,630	9
4	**Maktab Perguruan BP**	4	1	28	154	187	80.2	5,779,578	10

1= fatal, 2=serious,3=slight,4=damage, AWP= accident weihtage point

3.2.3 Ranking of the Top Ten Accident Section

The simplest way of ranking sites, and the one currently recommended for use in Malaysia, is to list them in descending order of accident total for section. Table 3 shows the worst ten accident sections at FT 50. The analysis was based on data compiled over three year starting from January 2002 to December 2005.

Table 3 Ranking of top ten section accident at FT 50 over 4 years period (2002-2005)

Junction Name	Section (KM)	Accident Frequency	Rank
Taman Maju	21	151	1
Pintas Puding	20	135	2
Taman Manis	23	123	3
KUiTTHO	19	122	4
Mesjid Sabak Uni	24	103	5
Parit Raja	22	89	6
Bandar Universiti	18	76	7
JPJ	14	75	8
Sek. Men. Sri Gading	15	52	9
Parit Jelutung	17	50	10

3.2.4 Kilometer Post Analysis

Kilometer post analysis of accident for a 10km stretch of Federal Route FT 50 over a period of three years is shown in Table 4 (specify 1km lengths) .With reference to Table 4 it can be seen that the worst kilometers are:

- KM 21 – Taman Maju (include 1 fatal and 150 non-fatal accident)
- KM 20- Pintas Puding (include 7 fatal and 128 non-fatal accident)
- KM 23- Taman Manis (include 1 fatal and 122 non-fatal accident)
- KM 19- KUiTTHO (include 5 fatal and 117 non-fatal accident)
- KM 24- Masjid Sabak Uni (include 4 fatal and 99 non-fatal accident)

3.3 Accident Data at Pintas Puding KM 20

The accident data recorded for over almost a 4-year period from January 2001 to Disember 2004 were reviewed in attempt to identify recurring accident types. These sites were inspected during the time period where accidents most frequently occurred to investigate and identify possible causes of accidents. The accident history data were collected from Balai Polis Traffic Batu Pahat. All the accident case reports at Federal Route stretch KM1 to KM38 were handled by Batu Pahat Polis Station. The analysis included an assessment of the accident time of occurrence, weather condition, vehicle type(s), lighting, road surface condition, year, accident severity and type of collision. KM20 (Pintas Puding) was selected as the study location based on it being the worst site and the blackspot site.

3.3.1 Number of Drivers/Riders involved in Accidents by type of Faults

Figure 4 shows the accident by type of faults at KM 20 from year 2001 to the year of July 2004. The highest rank of faults was driving too close (31 accidents), followed by accidents at junction (20), out of control speeding (9). contra flow and obscured vision (4), and U-turn/crossing road (3). Pedestrians contributed 1 accident. Therefore there is a need to focus more attention on driving too close and accident at junctions.

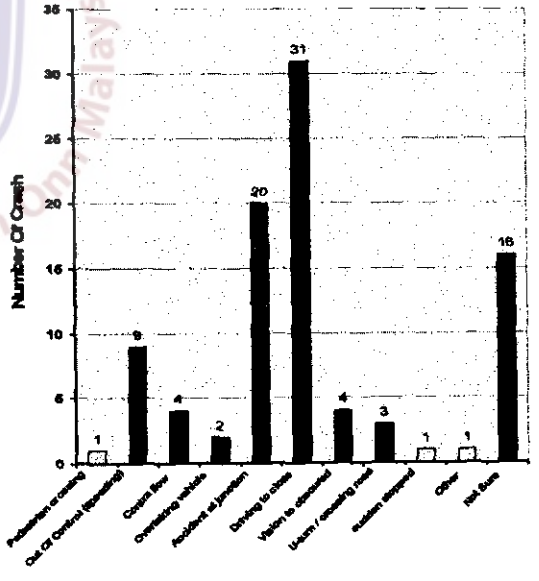

Figure 4 Number of Drivers/Riders involved in Accident by types of Fault

Table 4 Histogram of Injury Accident at 10KM Length of Federal Route 50 Over 4 Years Period (2002-2005)

Kilometeres	Total	Accident
14	75	**** xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx x
15	52	* xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx x
16	47	*** xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxx
17	50	*** xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxx
18	76	*** xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxx
	122	***** xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx
		xxxxxxxxx xxxxxxxxx xxxxxx
	135	******* xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx
		xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxx
	151	* xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx
		xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxx
22	89	** xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx
		xxxxxx
	123	* xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx
		xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xx
	103	**** xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx xxxxxxxxx
		xxxxxxxx
Total	**920**	*** = Fatal** **x = Non-Fatal**

3.3.2 Type of Vehicle involved Accident

Based on the Figure 5, it shows the type of vehicle involved in accidents at KM 20 from year 2001 to July 2004. The motorcars and motorcyclist formed a huge portion of the total number of accidents. Motorcars contributed the highest number of accidents with 63 % of the total vehicles involved in the accident, followed by motorcyclists (20%) and third highest were lorries which (6%) of vehicles involved.

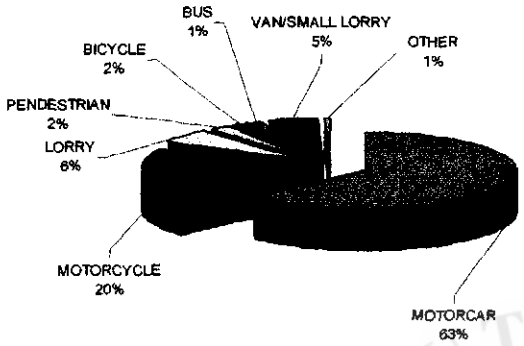

Fig. 5: Number of Vehicles involved by type of Accidents at KM 20

3.3.3 Analysis of Accident Data

Figure 6 shows the collision diagram at Pintas Puding. The accident data records for a four year period from the year (1998-2001). There were four types of collisions involved. They are 4 nose-to- tail accidents, 3 right turns to Ayer Hitam, 3 pedestrian accidents at Ayer Hitam direction and 3 double cross overs at Batu Pahat direction. The remaining accidents appeared to be random and typical of such a busy junction.

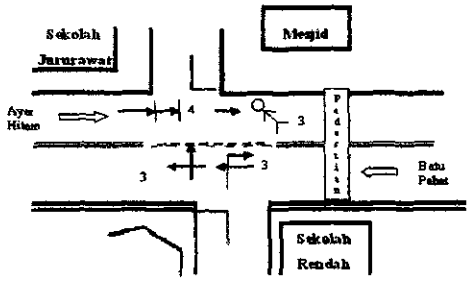

Fig. 6 Collision diagram at Pintas Puding

3.3.4 Traffic Studies

The purpose to carry out traffic studies is to identify the peak hour volume and to identify the volume of vehicle classification at the study area. The traffic study was conducted at KM20 (Pintas Puding) on 7th of February 2005 between 7:30 and 17:00. The weather condition was fine and there was no reported traffic incidents or major construction in the area. The traffic studies considered every movement of the vehicle. Pintas Puding have 12 movements of the vehicle for both mainstream (Ayer Hitam and Batu Pahat direction).

Figure 7 shows the traffic temporal fluctuations in traffic volumes along Federal Route 50 throughout the typical weekday. The highest traffic volumes recorded were 912 vehicles at 6.00p.m to 6.15p.m. The second highest was 870 vehicles recorded at 1.15p.m to 1.30p.m. In the morning the highest traffic volume was 697 vehicle recorded at 7.45a.m to 8.00a.m.

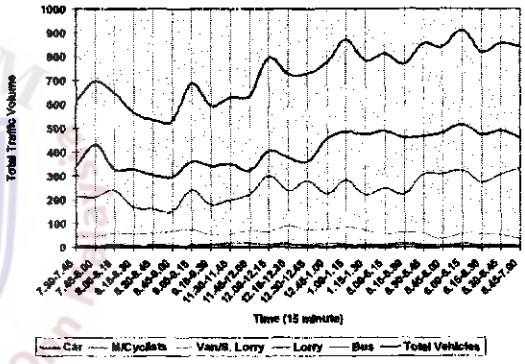

Fig. 7 The Temporal Fluctuations in Traffic Volumes throughout a typical Weekday

3.4 The Accident Prediction Model

From the data shown in Appendix B , a regression analysis was run using Microsoft Excel and the result of analysis were obtained as shown in Appendix C. Based on the results of the analysis, the accident prediction model for Federal Route 50 takes the following equation:

$$\ln(APW) = (1.1640952 \log AP + 0.001727(HTV^{0.75} + V_{p85}^{1.25}))^2$$

Where,

APW = Accident Point Weightage
AP = Number of Access Points per kilometer
HTV = Hourly Traffic Volume
V_{p85} = 85th percentile speed

The model has an R-square of 0.995, which means that 99.5% of the variation in the number of accidents has been explained the regression line. The T-test also indicates that the model is significant and can be used for the prediction of the accidents (refer to Appendix D). The coefficients of each explanatory variable have been found to be significant and hence, they can be used in the regression equation (refer to Appendix D)

From the model development in this study, it is noted that the factors which contribute to accidents at Federal Route 50 are:

- Number of access points
- Vehicle speed
- Traffic volume

The effect of each contributory factor on the number of road accidents is as follows:

- A greater number of access points per length increases accidents
- Speed reduction contributes to accident reduction
- An increase in traffic volume raises the number of accidents

4 Recommendation and Conclusion

The upgrading of this road to 4-lane undivided road increased the number of accidents and casualties. Data over the last 4 years (2000-2004) have shown that a total of 3,937 accidents which resulted in 116 fatalities, 161 injuries, 883 slight injuries and 2,757 damage-only. Meanwhile the fatalities in year 2005 were 36 cases, stated the higher number from the previous years. The government should look into this issue seriously to overcome this problem.

This study has established the accident point weightage as the ranking tool of the blackspot section by kilometer along the FT 50 stretch (1KM-38KM). Based on the accident point weightage, a further study is deemed necessary to determine the action to improve safety at the blackspot area.

4.1 Development of Accident Countermeasures

Based on the accident data which were analysed and observation of the traffic behaviour at the site, the following are deemed to be the main/dominant factors contributing to accidents at Pintas Puding study area:

- The high volume of traffic does not allow side traffic to enter the main stream safely resulting in twenty (20) accidents at junctions.
- Inadequate protection for right turning vehicles. The intersections do not have a properly designed separate right turn protection lane, resulting in thirty one (31) accidents of driving too close at the junction.

Motorcars and motorcyclists formed a big proportion of the total number of accidents. Accidents involving motorcar is 63% and it is the highest, and followed by motorcyclist at 20%. It is recommended that by constructing a separate exclusive motorcycle lane it can reduce the rate of accident.

4.2 Countermeasures Options at Pintas Puding

The countermeasures identified for this intersection at Pintas Puding have been developed to address the specific accidents based on the collision diagram and other accident data. The countermeasures are:

- Accident relating to Ayer Hitam direction, vehicles had 4 nose-to-tail collisions at the mosque junction. This collision happened because there is no line marking or channelisation forcing the driver to turn left before the junction, while vehicle at the main stream drove in excessive speeds. When the front vehicle decided to turn left at the last minute it will cause the nose-to-tail collision.
- It is advisable to provide chanelisation for vehicles to turn left from the intersection. It will reduce the general area of conflict by causing opposing traffic streams to intersect.
- To reduce the speed from the both main stream by using speed reduction markings and the speed limit sign or slow sign. Standard marking is 90 yellow transverse line applied over about 400 meters, the spacing between which progressively reduce toward the hazards Figure 7.
- Accident relating to the 3 double cross over at Batu Pahat direction because of the vehicle trying to cross the four line road from school junction to mosque junction. To prevent vehicles from crossing the road, there is a need to provide double white line

markings according to standards or construct a central median / tactile dividing strip or putting median barriers as shown in Figure 7, so that the vehicle coming from Ayer Hitam direction need to do U- turn to access to the school junction at other place. Therefore it will also overcome the right turn collision to Ayer Hitam direction.

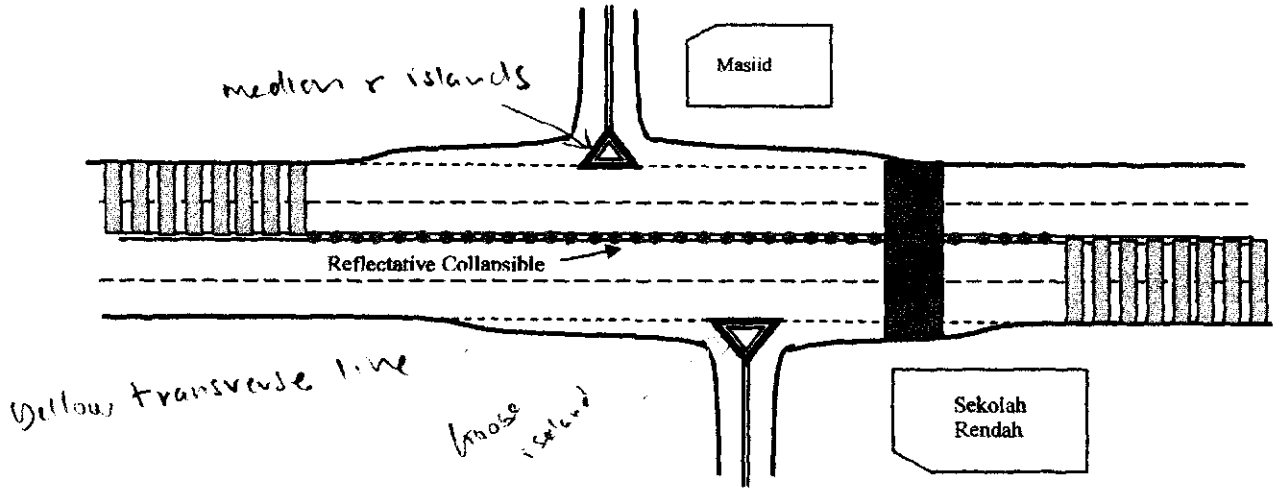

Fig. 7 Countermeasure Diagram at Pintas Puding KM20

4.4 Accident Prediction Model

A further study of this research was to develop predictive model relating traffic accidents with the road environment and traffic flows. Multiple regression techniques were used to estimate the model parameters. The regression equation that can be used to predict accident rates as developed from this study takes the following form:

$$\ln(APW)=(1.1640952 \log AP +0.001727(HTV^{0.75} + V_{pm}{}^{1.25}))^2$$

The result of the analyses provide sufficient evidence to support the hypothesis that the existence of a high density of junctions, an increase in traffic volume and vehicle speed in Federal Route 50 may contribute significantly to traffic accidents. Reduction of vehicle speed, access point and traffic volume are likely to have an influential effect on the road accidents. The percent accident reduction by changing the measures of each parameters are, one access point per kilometer reduction can reduce accident by 28.05%, 5 kilometer per hour reduction can reduce accident by 14.31%, and 100 vehicle per hour reduction can reduce accident by 7.50%.

More importantly, the significant accident predictive model developed in this study is applicable in road safety improvement and could serve as a basis for further research work of Federal Route in Malaysia.

Reference

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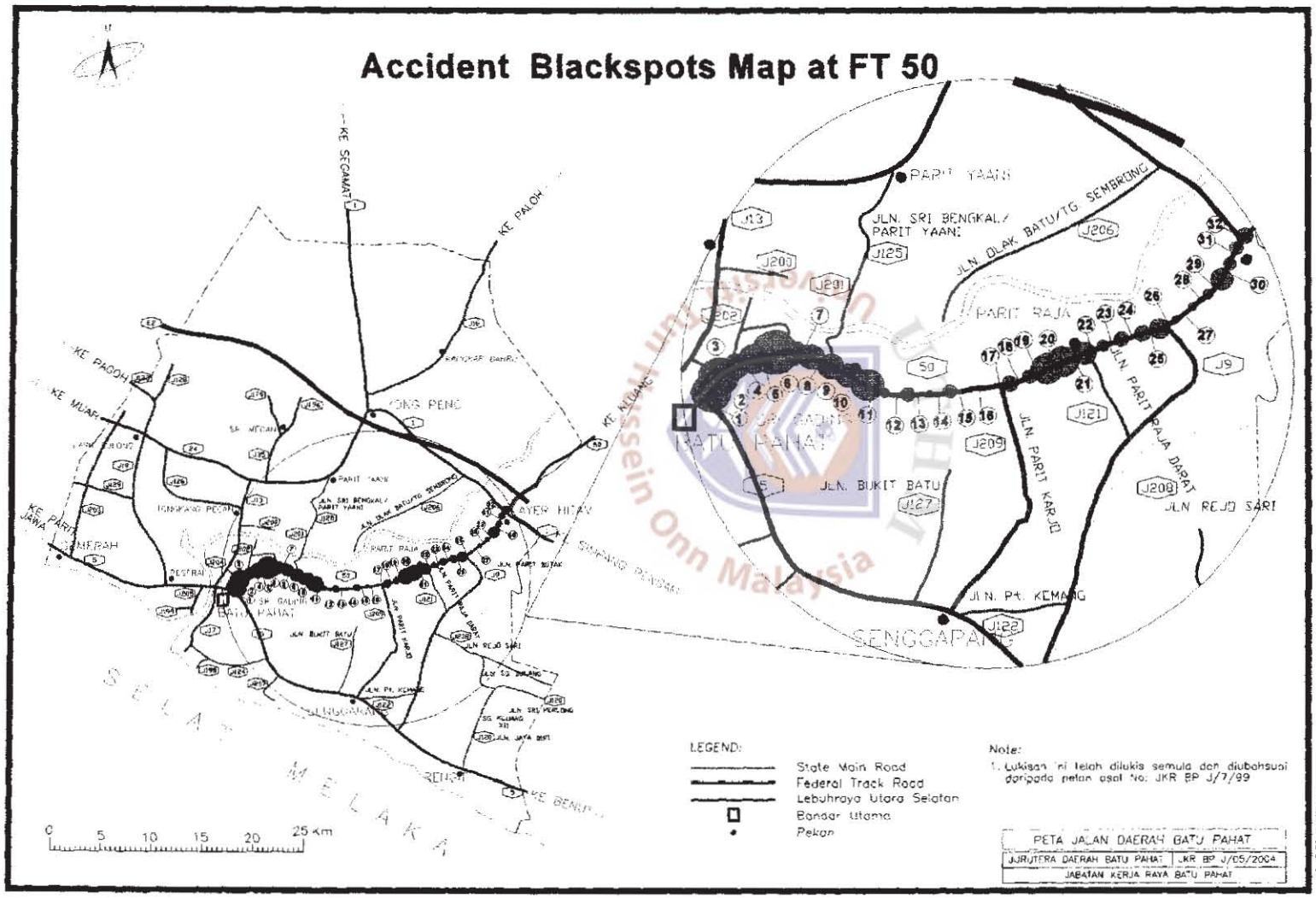
APPENDIX A


Accident Blackspots Map at FT 50
PARIT YAAN
JLN. SRI BENGKALI/ PARIT YAAN
JLN. DLAK. BATU/TG. SEMBRONG
PARIT RAJA
JLN. PARIT RAJA DARAT
JLN. PARIT KARJO
JLN. REJO SARI
JLN. BUKIT BATU
JLN. PT. KEMANG
BATU PAHAT
SENGGARANG
KE SEGAMAT
KE PAGOH
KE MUAR
KE KLUANG
KE BENUT
SELAT MELAKA
LEGEND:
State Main Road
Federal Track Road
Lebuhraya Utara Selatan
Bandar Utama
Pekan
Note:
1. Lukisan ini telah dilukis semula dan diubahsuai daripada peta asal No: JKR BP J/7/99
PETA JALAN DAERAH BATU PAHAT
JURUTERA DAERAH BATU PAHAT
JKR BP J/05/2004
JABATAN KERJA RAYA BATU PAHAT
0 5 10 15 20 25 km

APPENDIX B

Data for the Multiple Linear Regression Analysis

No	Section	$[\ln(AWP)]^{0.6}$	log(AP) (per km)	$HTV^{0.75}+V_{P85}^{1.25}$
1	19	2.0909	0.9542	457.61
2	19	2.0909	0.9542	495.30
3	19	2.0909	0.9542	489.36
4	19	2.0909	0.9542	478.56
5	19	2.0909	0.9542	580.18
6	19	2.0909	0.9542	509.50
7	20	2.0879	0.9031	522.18
8	20	2.0879	0.9031	599.60
9	20	2.0879	0.9031	582.96
10	20	2.0879	0.9031	617.22
11	20	2.0879	0.9031	648.65
12	20	2.0879	0.9031	663.59
13	21	2.0116	1.0792	523.10
14	21	2.0116	1.0792	516.75
15	21	2.0116	1.0792	515.64
16	21	2.0116	1.0792	548.35
17	21	2.0116	1.0792	585.16
18	21	2.0116	1.0792	551.68
19	23	1.9031	0.7782	466.22
20	23	1.9031	0.7782	491.40
21	23	1.9031	0.7782	469.21
22	23	1.9031	0.7782	448.59
23	23	1.9031	0.7782	521.09
24	23	1.9031	0.7782	533.11
25	22	1.8331	0.8451	418.71
26	22	1.8331	0.8451	473.48
27	22	1.8331	0.8451	514.31
28	22	1.8331	0.8451	526.17
29	22	1.8331	0.8451	553.56
30	22	1.8331	0.8451	576.98

APW = accident point weightage, AP = Access Point,

HTV = hourly traffic volume, V_{p85} = 85th percentile speed.

APPENDIX C

Result for the Multiple Linear Regression Analysis

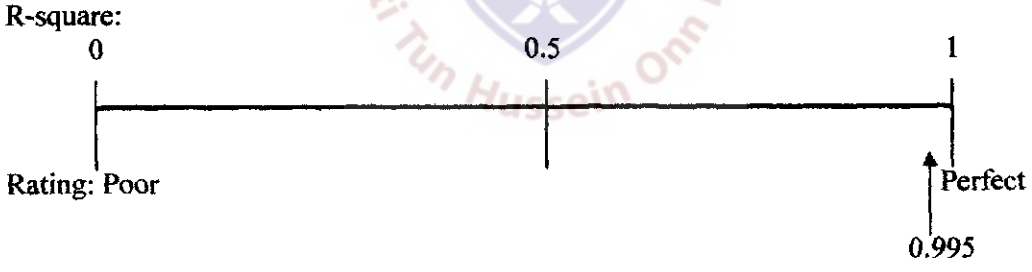
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997650984
R Square	0.995307485
Adjusted R Square	0.95942561
Standard Error	0.140959031
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	118.0036554	59.00183	2969.475	2.24769E-32
Residual	28	0.556344553	0.019869		
Total	30	118.56			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0	#N/A	#N/A	#N/A
log(AP)	1.164095209	0.205916475	5.65324	4.67E-06
$HTV^{0.75}+V_{P85}{}^{1.25}$	0.001727366	0.000354919	4.866934	3.99E-05

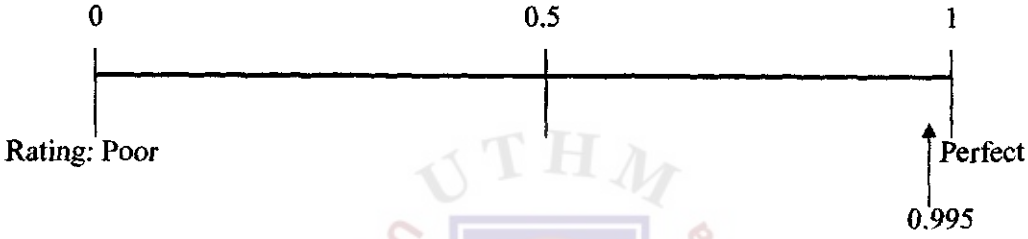


APPENDIX D

Result of the Validation of The Prediction Model

Regression Statistics	
Multiple R	0.997650984
R Square	0.995307485
Adjusted R Square	0.95942561
Standard Error	0.140959031
Observations	30

R-square:



T-Test

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	118.0036554	59.00183	2969.475	2.24769E-32
Residual	28	0.556344553	0.019869		
Total	30	118.56			

(From Microsoft Excel)

$$T = \sqrt{\frac{59.00183}{0.019869}} = 54.494 \text{ ; Critical value, } t = 1.703$$

T > t : The model is significant and can be used for prediction

t-Statistic

Explanatory Variable	t-stat	|t Stat| ">"or "<" Critical value	Significance of coefficient
log(AP)	5.65324	>1.703	Significance
$HTV^{0.75}+V_{P85}{}^{1.25}$	4.866934	>1.703	Significance

(From Microsoft Excel)