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Accident Investigation, Blackspot Treatment, And Modeling Of Federal Route F050 Malaysia

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Abstract
Road accidents is one of the major contributors of human deaths in Malaysia. In the year 2006, 341,252 accidents were recorded, resulting in an average 18 deaths from road accidents 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 analysis and to propose countermeasures at the Pintas Puding area, and to develop an accident prediction model for Federal Route 50 by using multiple linear regression analysis. The road accident trend and blackspot ranking were established at Federal Route (F050) Batu Pahat – Ayer Hitam. It revealed that the increment of accident rates can be explained by either the rises in speed, number of major access point and traffic volume.

Keywords
Accident Analysis, 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 (World Disaster Report, 1998).

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 the 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 (Ministry of Transport Malaysia 2006).

The number of accidents on a given road section during a certain period of time is probabilistic in nature and is a non-negative integer. Despite the fact that accidents are random an unpredictable at micro level, statistical models can predict reliable estimates of expected accident by relating aggregates of accidents to various explanatory measures of flow, site characteristics, and road geometry at macro level. Numerous empirical relationship between vehicle accidents and these explanatory variables have been established in several previous studies (Miaou and Lum, 1993; Gwynn D.W ,1967; Maher and Summersgill, 1996 and Al-Masaeid, Hashem R, and Ghassan, 2004). Such accident predicting models are useful in identifying the most critical variable to safety, assessing design and management alternatives, and improving the safety standards for new roads. Because of the complex nature of accident events and the requirement of unattainable quality of accident, traffic and road data together with lack of skilled manpower and resources, such types of studies are very limited in developing countries.

A number of researchers have investigated this complex interaction in the past. One of the first of such studies had analyzed accidents and traffic flow on U.S Route 22 through the city of Newark, New Jersey (Gwynn, 1967). Crash rates were plotted against hourly volume class, and the author found a distinct U-shape relationship, with more accidents observed at higher and lower traffic volumes. Roads with higher average daily traffic (ADT) and pedestrian traffic are associated with higher accident frequencies for all highway types (Berhanu, 2004). In the report of the NHMRC Road Accident Research Unit, University of Adelaide, carried out a study on “Traveling Speed and The Risk of Crash Involvement”(CN Kloeden, AJ McLean, VM Moore and G Ponte, 1997) , the authors concluded that in a 60 kmph speed limit area, the risk of involvement in a casualty crash doubles with each 5 kmph increase in traveling speed above 60 kmph.

This study will analyse the accident data and develop an accident predictive model, concentrating on Federal Route 50 in Parit Raja. The Multiple Linear Regression method was used to relate the discrete accident data with the road and traffic flow explanatory variables.

2. Materials and Methods

The accident analysis process involves the identification of accident blackspots, establishment of general patterns of accidents, analysis of the factors involved, site studies, proposal of countermeasures and development of an accident prediction model using Multiple Linear Regression.

2.1 Data Collection

Accident data were collected from Batu Pahat Traffic Police Station, Batu Pahat Public Work Department, Bukit Aman Royal Malaysia Police, Road Transport Department, Parit Raja Health Clinic Center, Universiti Tun Hussein Onn Malaysia (UTHM) and Road Safety Research Center

UPM Serdang. The accident database was obtained from the POL27 and the crash records were collected from the year 2000 to 2005.

2.2 Analysis of Accident Data

Accident data are 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 a more detailed ranking of the blacksport sites such as:

a) Ranking accident point weightage at F0 50,
b) Ranking of the top ten accident sections,
c) Kilometers post analysis, and
d) Ranking of accident point weightage

2.3 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 enable researchers to identify possible causal factors of the accident as well as countermeasure options.

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

2.4 Countermeasures

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

2.5 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 were collected in-field. The study section used for collecting data was about 5 kilometers 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 points, 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 hrs), midday (1100 - 1300 hrs) and evening (1700 - 1900 hrs). Spot speed measurements were taken at every section using a speed radar equipment. The 85th percentile speeds were determined from spot speed measurement using SPSS program.

3. Results and Discussions

3.1 Road Accident Trends

Figure 1 shows the trend of accidents and casualties on Federal Route 50 (F050) KM 1- KM 38 from year 2000-2005. The figure shows an increase of number of accidents 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 declined to 905 in year 2005 from 1,084 in year 2004. Meanwhile in 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.

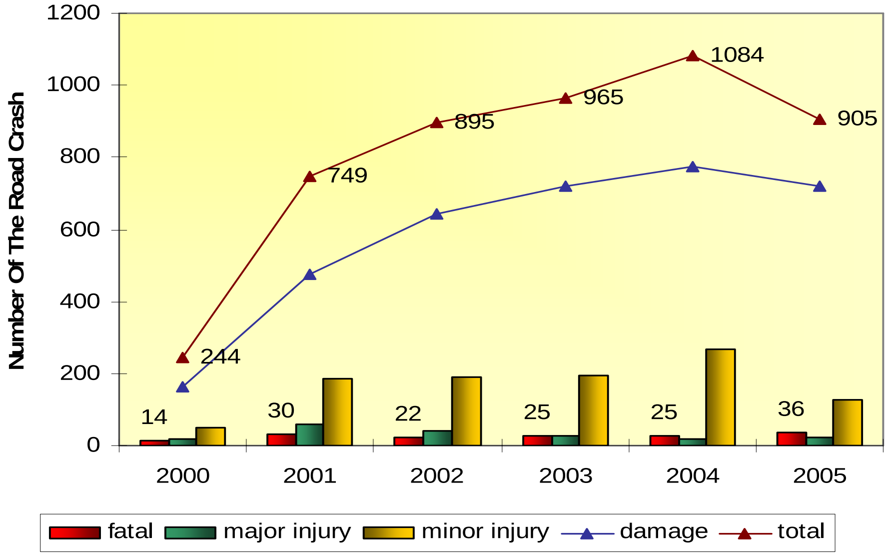

Figure 1: Accident and casualty along F050 (KM 1-38)

3.2 Accident by Hours of the Day Year 2005

Figure 2 shows the worst accident by hours of the day begin from the midday to midnight. The highest number of accidents happened from 16.01 to 18.00, recording 138 accidents. Second highest was at 18.01-20.00 involving 121 cases and the third highest at 14.01-16.00 with 117 accidents. The fatigues factor of the road users and high density of traffic plus to many conflict along the road probably contribute the accident to happen.

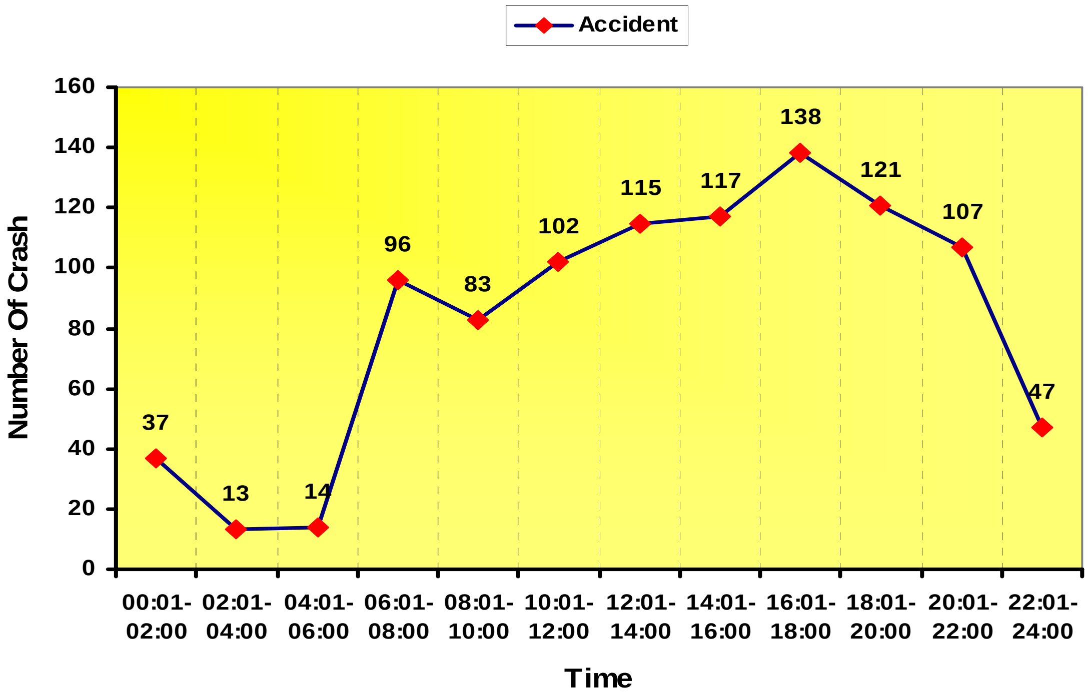

Figure 2: Accidents by Hour of the Day at F050 (2005)

3.3 Total Number of Accident by Light Condition

Figure 3 shows the number of accident by light condition year 2005 were the most accident happen at the day time 43% followed by 42% at the night time and 1% at the morning. This is because the higher number of vehicle on the road is at the day time compare than other.

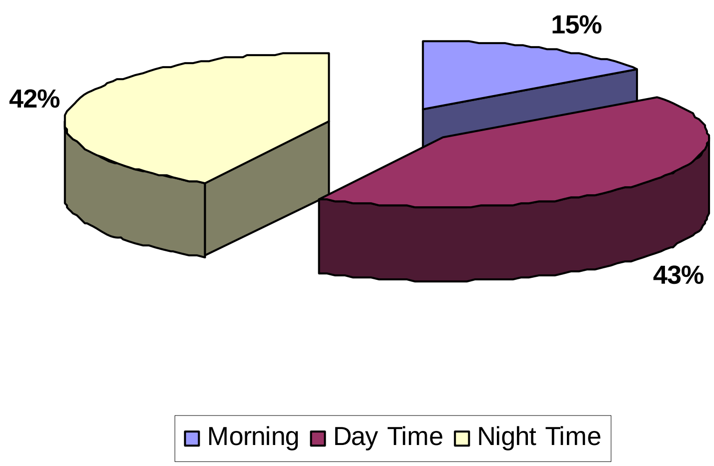

Figure 3: Total Number of Accident by Light Condition at F 050 (2005)

3.4 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 accidents. 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).

Table 1: Ranking Accident Point Weighting Along a Route F050 (KM 1-38) Over a 3 Years Period (2002-2005)

Section	Accident Severity					Weightage	
(KM)	Fatal	Serious	Slight	Damage	Total	Point	Rank
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

3.4.1 Accident Maps

The accident blackspots map at F050 is shown in (Appendix A), has been established 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.

3.4.2 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 F050 (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 2: Cost of Accident along a Route F050 (KM 1-38) Over a 3 Year Period (2002-2005)

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

3.4.3 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 total accidents for each section. Figure 4 shows the ten worst accident sections at F050. The analysis was based on data compiled over three year starting from January 2002 to December 2005.

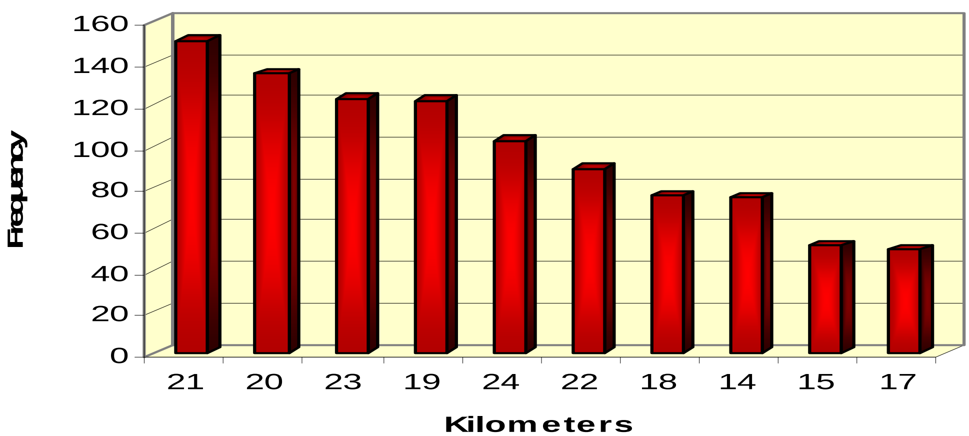

Figure 4: Ranking of top ten section accident at F050 over 4 year period (2002-2005)

3.4.4 Kilometer Post Analysis

Kilometer post analysis of accident for the 11 km stretch of Federal Route F050 over a period of three years is shown in figure 5 (specified in 1 km lengths).With reference to Table 3 it can be seen that the worst sections are:

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

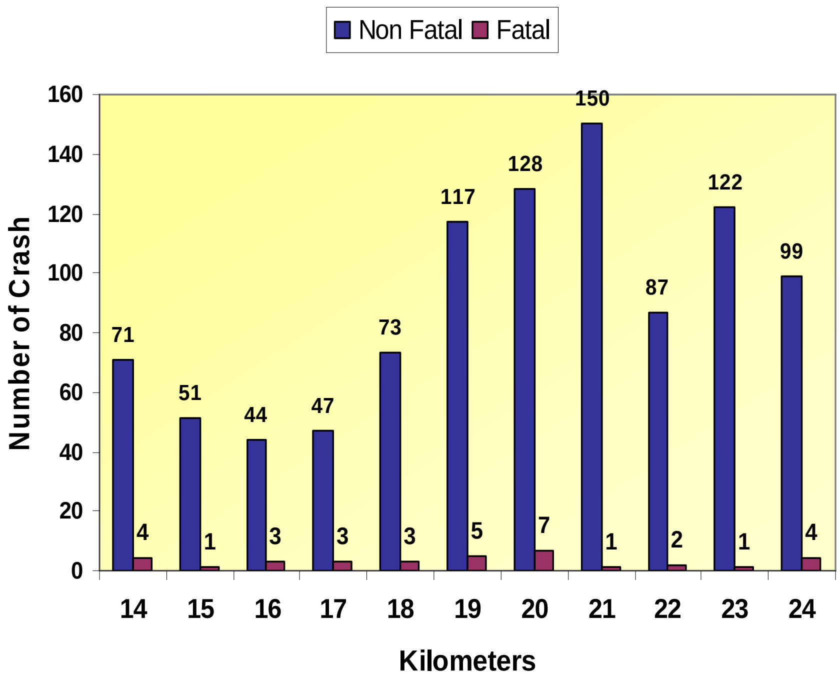

Figure 5: Histogram of Injury Accident at 11 KM Length of Federal Route 50 Over 4 Years Period (2002-2005)

3.5 Accident Data at Pintas Puding KM 20

The accident data recorded over almost a 4-year period from January 2001 to December 2005 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 Batu Pahat Traffic Police Station. All the accident case reports at Federal Route stretch KM1 to KM38 were handled by the Batu Pahat Police Station. The analysis includes 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.

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

Figure 6 shows the accidents by type of faults at KM 20 from year 2001 to the year of July 2004. The highest rank of faults were 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 one accident. Therefore there is a need to focus more attention on driving too close and accident at junctions.

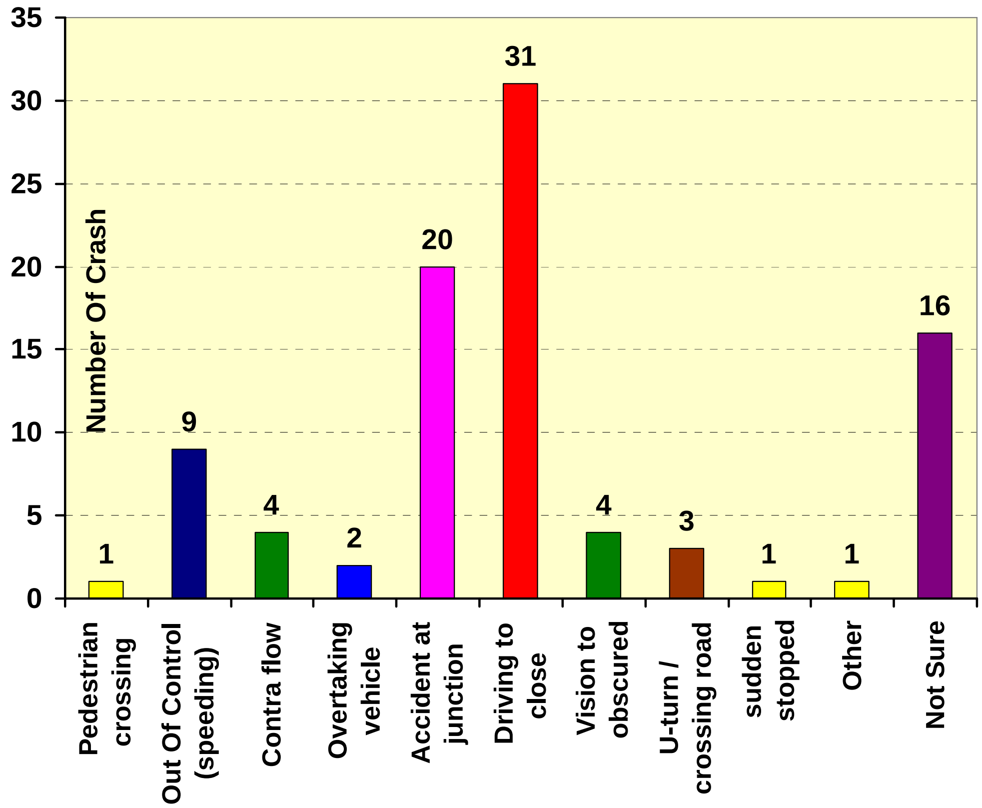

Figure 6: Number of Drivers/Riders involved in Accident

3.5.2 Type of Vehicle involved Accident

Figure 7 shows the type of vehicles involved in accidents at KM 20 from year 2001 to July 2004. Motorcars and motorcyclists 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.

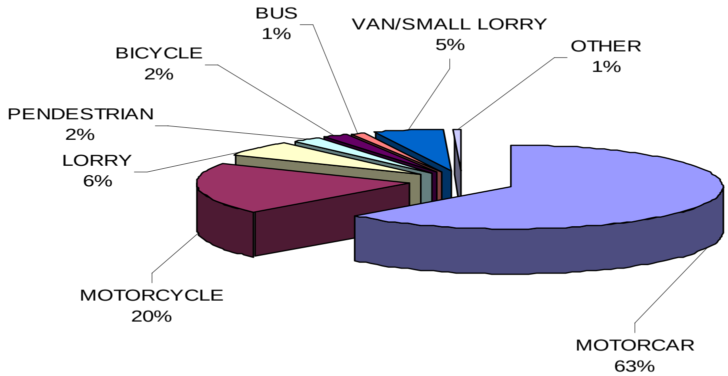

Figure 7: Number of Vehicles involved by type of Accidents at KM 20

3.5.3 Analysis of Accident Data

Figure 8 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 were four nose-to-tail accidents, three right turns to Ayer Hitam, three pedestrian accidents in the Ayer Hitam direction and three double cross overs in the Batu Pahat direction. The remaining accidents appeared to be random and typical of a busy junction.

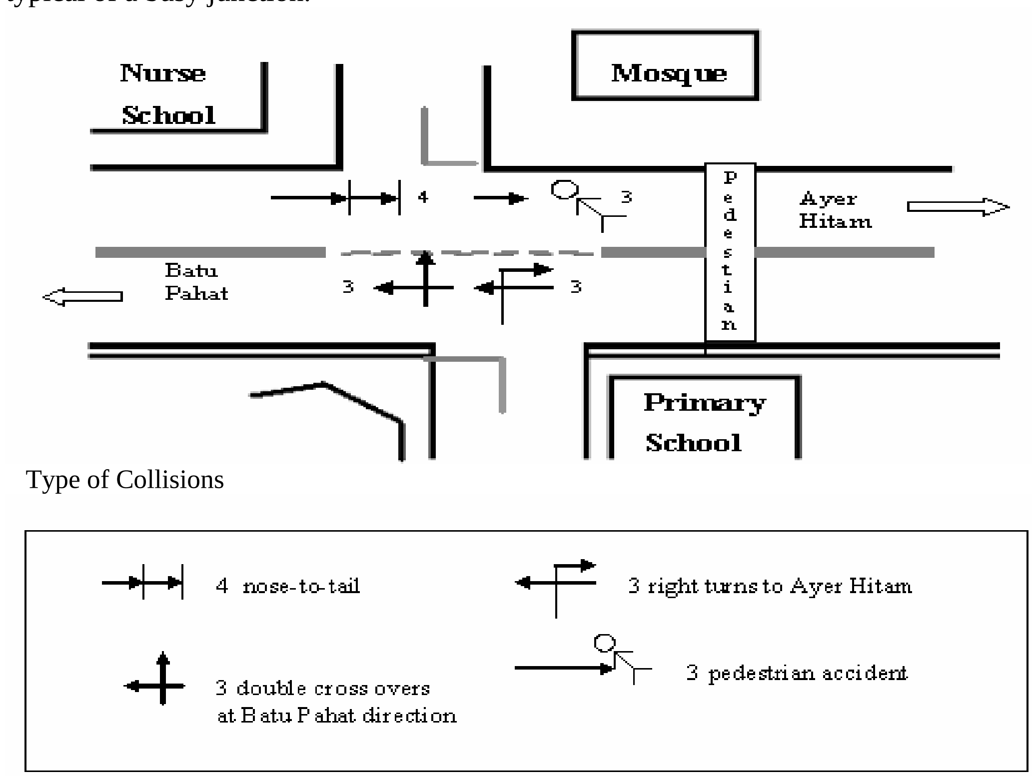

Figure 8: Collision diagram at Pintas Puding

3.4.4 Traffic Studies

The purpose to carry out traffic studies is to identify the peak hour volume and to identify the volume of vehicle classes 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 were no reported traffic incidents or major construction in the area. The traffic studies took into consideration all movements of vehicles. Pintas Puding have 12 movements of the vehicles for both mainstreams (Ayer Hitam and Batu Pahat direction).

Figure 9 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.

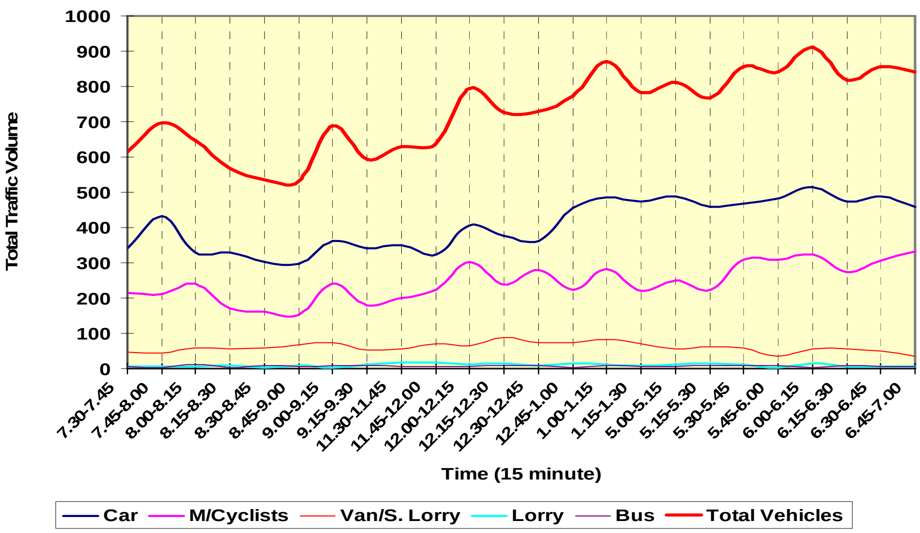

Figure 9: The Temporal Fluctuations in Traffic Volumes throughout a typical Weekday

3.6 The Accident Prediction Model

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

$$\ln(APW)=(1.1640952 \log AP + 0.001727(HTV^{0.75} + V_{p85}{}^{1.25}))^2 \quad \ldots\ldots\ldots\ldots(1)$$

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^2 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). Appendix D also indicates, the coefficients of each explanatory variable have been found to be significant and hence, they can be used in the regression equation.

From the model developed in this study, it can be 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 Discussion and Recommendation

The upgrading of this road to 4-lane undivided road increased the number of accidents and casualties. Data between 2000 to 2004 showed that a total of 3,937 accidents which resulted in 116 fatalities, 161 injuries, 883 slight injuries and 2,757 damage-only cases. Meanwhile the fatalities in year 2005 were 36 cases, which was higher than 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 F050 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 the observations of traffic behaviour at the site between year 2000 to 2004, the following are considered to be the 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, followed by motorcyclists at 20%. It is recommended that by constructing a separate exclusive motorcycle lane it can reduce the rate of accident.

4.2 Countermeasure 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 as shown in Figure 10. 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 installation of speed limit sign and slow sign. Standard marking is 90 yellow transverse line applied over about 400 meters, the spacing between which progressively reduced towards the hazards (Figure 10).

Accidents relating to the three double cross over in the Batu Pahat direction was due to vehicles trying to cross the four lane road from the 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 installing reflective collapsible poles as shown in Figure 10, This will prohibit right turning at the junction. Vehicles traveling from Ayer Hitam direction will need perform U- turn maneuvers at specified areas in order to access the school junction.

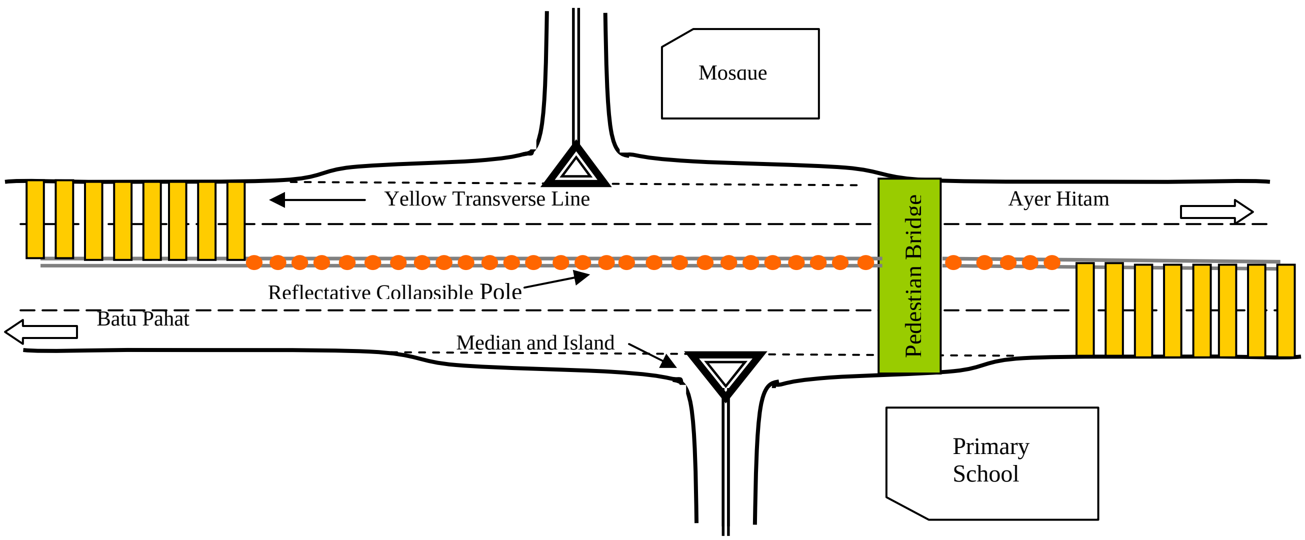

Figure 10: Countermeasure Diagram at Pintas Puding KM20

5 Conclusion

The objective 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 (1) can be used to predict accident rates as developed from this study.

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 has contributed significantly to traffic accidents. Reduction of vehicle speed, access point and traffic volume are likely to have an influential effect on the road accidents. Based on this study, the percent accident reduction by changing the measures of each parameters are; one access point per kilometer reduction can reduce accidents by 28.05%, 5 kilometer per hour speed reduction can reduce accidents by 14.31%, and 100 vehicle per hour volume reduction can reduce accidents by 7.50%.

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

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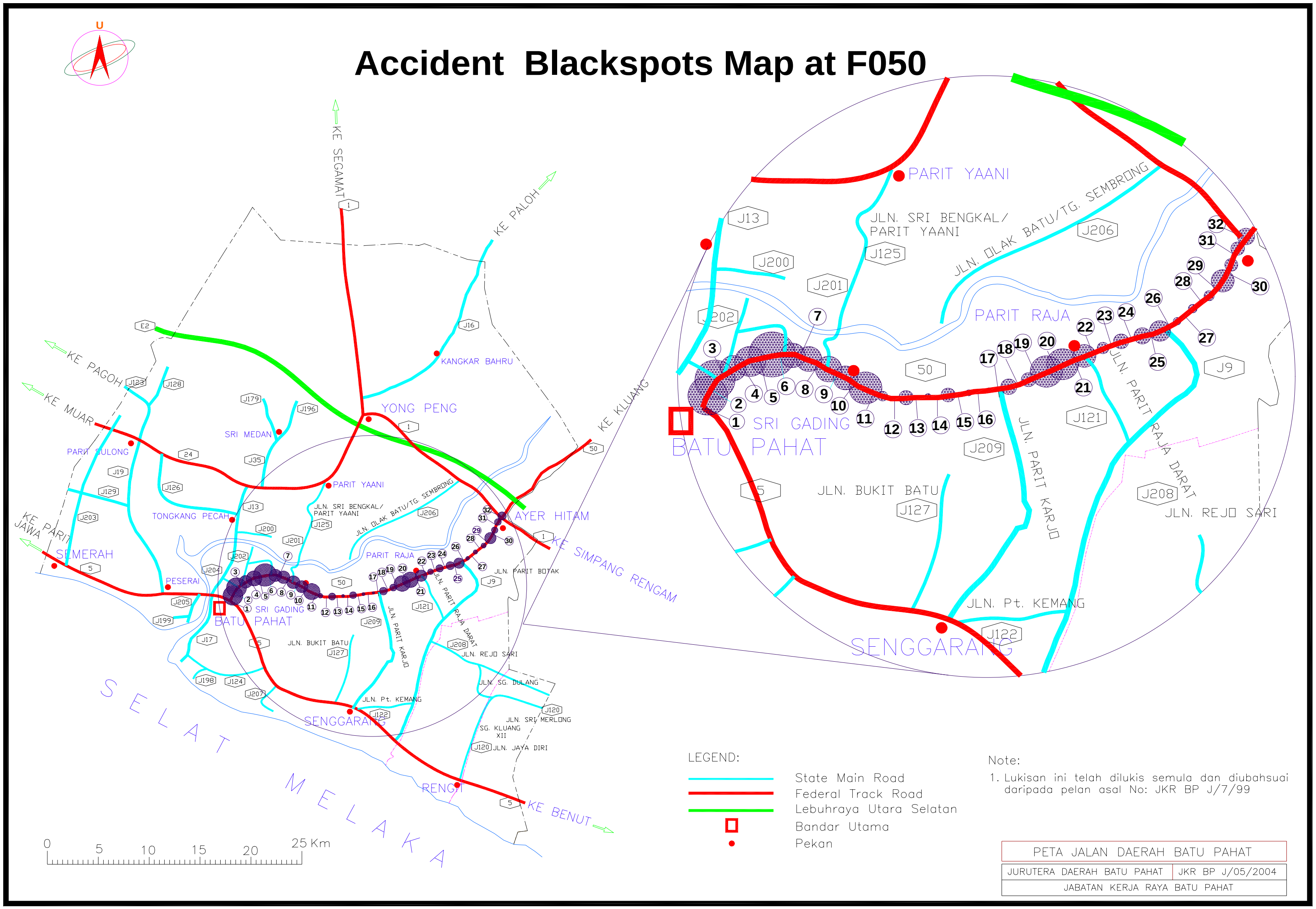
APPENDIX A



Accident Blackspots Map at F050
LEGEND:
State Main Road
Federal Track Road
Lebuhraya Utara Selatan
Bandar Utama
Pekan
Note:
1. Lukisan ini telah dilukis semula dan diubahsuai daripada pelan 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
BATU PAHAT
SRI GADING
PARIT RAJA
PARIT YAANI
SENGGARANG
AYER HITAM
YONG PENG
SELAT MELAKA

APPENDIX B

Data for the Multiple Linear Regression Analysis

No	Section	$[\ln(AWP)]^{0.5}$	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} = 85^{th} percentile speed.

APPENDIX C

Result for the Multiple Linear Regression Analysis

SUMMARY OUTPUT

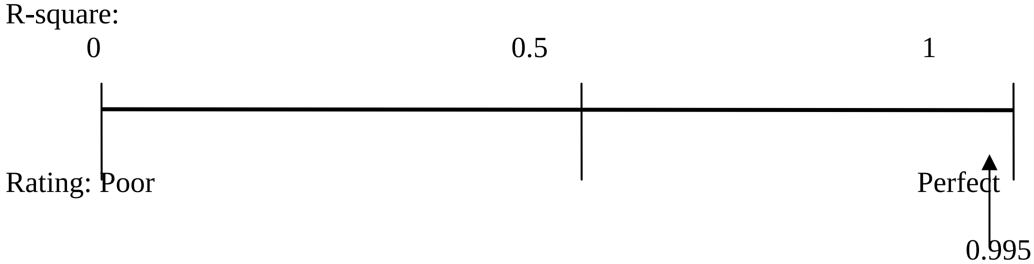
Regression Statistics	
Multiple R	0.997650984
R Square	0.995307485
Adjusted R Square	0.95942561
Standard Error	0.140959031
Observations	30

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

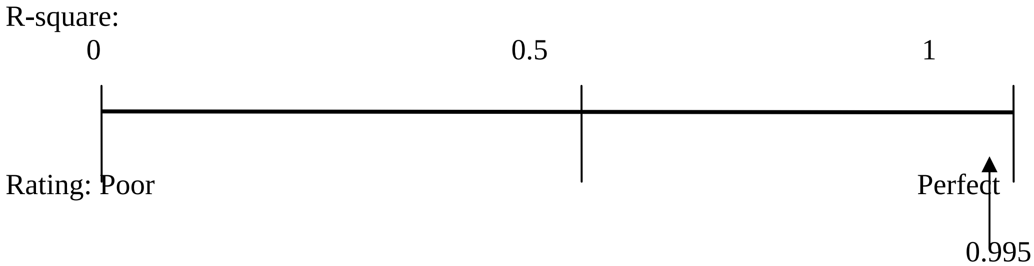
R-square:



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



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; 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)