CHAPTER 7

PREDICTING ROAD ACCIDENTS WITH REGARDS TO GEOMETRIC FACTORS AND OPERATIONAL SPEED AT UNSIGNALIZED INTERSECTIONS

7.1 INTRODUCTION
As the number of vehicles on road increases, the frequency of road accidents also increases. The Malaysian road accident statistics indicate that about 22% of the total accidents occurred at road intersections [1]. In year 2009, there are a total of 397,194 road accidents in Malaysia with 6,218 fatalities [2].

Accident prediction model is frequently used in road safety studies. It is used to identify the major contributing factors or establish relationship between crashes and parameters such as traffic flow, type of traffic control and road geometric variables.

The aim of this study is to develop a model using multiple regressions to predict the risk of accident at 10 blackspot intersections along Federal Route 1 (FT001) and Federal Route 24 (FT024) of Johor. The intersections are ranked based on the level of accident risks, determined from the accident point weightage (APW).

In this study, the road geometric factors are considered in the development of the accident prediction model. Major contributing accident factors at these unsignalized intersections are then identified based on the model. These contributing factors can be taken into consideration when tackling the road safety issue especially at unsignalized intersection.

7.2 RELATED WORKS
An accident prediction model has been developed by [3] based on the generalized linear modeling approach of Poisson and negative Binomial for 53 intersections in urban areas of four Selangor districts is as shown in Equation 7.1.

\[ MCA = 0.01315Q_{NMm}^{0.1597}Q_{NMn}^{0.0973}Q_{Mm}^{0.1071}Q_{Mn}^{0.1336} \exp^z \]  

(7.1)
Where, $MCA$ is motorcycle crashes per year, $Q_{NMm}$ is non-motorcycle flow on major road (nmpd), $Q_{NMn}$ is Non-motorcycle flow on minor road (nmpd), $Q_{Mm}$ is motorcycle flow on major road (mpd), $Q_{Mn}$ is motorcycle flow on minor road (mpd), and $z$ is shown in Equation 7.2.

$$z = 0.0242SPEED - 0.0967LW_m - 0.0907LW_n - 0.011LN_m - \beta_6 SHDW + \beta_7 LU$$ (7.2)

Where, $SPEED$ is approach speed (km/hour), $LW_m$ is average lane width on major road (m), $LW_n$ is average lane width on minor road (m), $LN_m$ is number of lanes on major road (lanes/traffic direction), $SHDW$ is average shoulder width on major and minor road, $LU$ is land-use category, $\beta_6 = 0.0$, 0.01755, and 0.02554 for $SHDW = 1$, 2, and 3, respectively, $\beta_7 = 0.0$ and 0.01591 for $LU = 1$ and 2, respectively.

The model accounts for multivariate data on motorcycle crashes, traffic flow, pedestrian flow, traffic speed, intersection geometry, number of intersecting legs, and land-use. Mustakim et al. [4] has proposed an accident prediction model based on traffic data obtained for Federal Route 50, stretches from Batu Pahat to Air Hitam, as shown in Equation 7.3.

$$\ln(APW)^{0.5} = 0.0212AP + 0.0007(HTV^{0.75} + GAP^{1.25}) + 0.021(85^{th}PS)$$ (7.3)

Where, $APW$ is accident point weightage, $AP$ is number of access points per kilometer, $HTV$ = hourly traffic volume, $GAP$ is amount of time, between the end of one vehicle and the beginning of the next in second, and $85^{th}PS$ is 85$^{th}$ percentile speed.

Model (7.3) has the $R$-squared of 0.9987, which means that 99.87% of the variation in the number of accidents can be explained by the regression line. It t-test also indicates that the model was significant and can be used for the prediction of the number of accidents. Reduction in vehicle speed, access point, traffic volume and increment of gap are likely to reduce the number of road accidents.

Jusoh et al. [5] proposed a multiple regression model for accident prediction along two-lane federal route of Johor based on road accident statistics along FT001 (Johor Bahru - Labis), FT005 (Johor Bahru - Melaka), and FT024 (Yong Peng - Muar),
\[
\ln(\text{APW}) = 0.000098 \times \text{HTV} + 0.00469 \left(85^{\text{th}} \text{PS}\right) + 0.0476 \times \text{AP} + 0.137 \times \text{ST} \\
- 0.4386 \times \text{HI} - 0.17 \times \text{LW} - 0.0602 \times \text{SW} + 3.49
\]  

(7.4)

Where, \(\text{APW}\) is accident point weightage, \(\text{HTV}\) is hourly traffic volume, \(85^{\text{th}} \text{PS}\) is 85\textsuperscript{th} percentile speed, \(\text{AP}\) is number of access points per km, \(\text{ST}\) is straight road geometry, \(\text{HI}\) is hilly road geometry, \(\text{LW}\) is lane width, and \(\text{SW}\) is shoulder width.

The developed model has an \(R\)-squared of 0.994 and adjusted \(R\)-squared of 0.993, which means 99.4\% and 99.3\% of variation in the number of accidents, has been explained in the regression line.

### 7.3 METHODOLOGY

#### 7.3.1 ROAD ACCIDENT DATA

Road accidents record was obtained from the Batu Pahat Traffic Police Department and the Royal Malaysian Police Department between year 2007 and May 2010 for FT001 Johor Bahru-Labis and FT024 Yong Peng-Muar, which include:

- i. Road accident statistics for year 2007 to May 2010,
- ii. Accidents and casualties for year 2007 to May 2010, and
- iii. Accidents by hour of the day for year 2007 to May 2010

Figure 7.1 shows the hourly number of accidents along routes FT001 and FT024 between 2007 to May 2010. Accident data collected also include information on the location, date, time, number of death cases, injury cases, and number of vehicle involved. The intersections were categorized based on the street names.
7.3.2 ACCIDENT POINT WEIGHTAGE (APW)

The risks of road accident occurrence can be explained using an accident point weightage (APW). The APW equation is given as follows:

$$APW = 6.0X_1 + 3.0X_2 + 0.8X_3$$  \hspace{1cm} (7.5)

Where, $X_1$ = number of fatal, $X_2$ = number of serious injury, $X_3$ = number of slight injury.

Higher APW value shows greater risk of serious road accident. Figures 7.2 and 7.3 show the number of fatal, serious injury and slight injury cases based on the road accident record from the Batu Pahat Traffic Police Department between 2007 and May 2010 for routes FT001 and FT024, respectively.
7.3.3 IDENTIFICATION OF BLACKSPOT INTERSECTION

Blackspot intersections to be studied are identified by ranking the intersections along route FT001 and route FT024 according to APW. An accident which occurred within 80 m of an intersection was considered intersection-related accident [6]. The top ten blackspot intersections were chosen.
7.4 THE RESULTS OUTCOME AND CONTRIBUTIONS

This study used accident point weightage and listed them into top ten accidents to recognize the hotspot area. The top 5 accident was ranked into Accident Point Weightage for each Federal Routes are as shown in Table 7.1 and Table 7.2.

**Table 7.1:** Top 5 accident section for FT001

<table>
<thead>
<tr>
<th>Rank</th>
<th>Section No.</th>
<th>Fatal</th>
<th>Serious Injury</th>
<th>Slight Injury</th>
<th>Total number of accidents</th>
<th>APW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>112</td>
<td>3</td>
<td>0</td>
<td>8</td>
<td>156</td>
<td>53.4</td>
</tr>
<tr>
<td>2</td>
<td>113</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>108</td>
<td>49.0</td>
</tr>
<tr>
<td>3</td>
<td>111</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>101</td>
<td>23.2</td>
</tr>
<tr>
<td>4</td>
<td>106</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>18</td>
<td>21.6</td>
</tr>
<tr>
<td>5</td>
<td>88</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>11</td>
<td>20.2</td>
</tr>
</tbody>
</table>

**Table 7.2:** Top 5 accident section for FT024

<table>
<thead>
<tr>
<th>Rank</th>
<th>Section No.</th>
<th>Fatal</th>
<th>Serious Injury</th>
<th>Slight Injury</th>
<th>Total number of accidents</th>
<th>APW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
<td>4</td>
<td>0</td>
<td>13</td>
<td>98</td>
<td>50.6</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>42</td>
<td>32.2</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>39</td>
<td>31.6</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>65</td>
<td>28.8</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>22</td>
<td>28.8</td>
</tr>
</tbody>
</table>

In this study, multiple regression analysis is conducted using Minitab and the result of analysis are obtained. After considering the best fitted model, the $APM$ produced is as shown in Equation 7.6. However, this model can be used based on the ranges shown in Table 7.3.

$$APW = 64.6 - 0.00246(Q_{mn}) + 0.0240(S_{mn}) + 0.00236(Q_{mj}) + 0.0373(S_{mj}) - 1.40(L_{mn}) - 5.26(L_{mj}) + 2.33(SH_{mn}) + 3.38(SH_{mj}) + 1.39(COMM) \quad (7.6)$$

where, $APW$ is accident point weightage, $Q_{mn}$ is $AADT$ minor roads, $Q_{mj}$ is $AADT$ major roads, $S_{mj}$ is speed on major roads, $AADT$ is annual average daily traffic, $S_{mn}$ is speed on
minor roads, $L_{mj}$ is lane width major roads, $L_{mn}$ is lane width minor roads, $SH_{mj}$ is shoulder with major roads, $SH_{mn}$ is shoulder with minor roads, and $COMM$ is land use.

**Table 7.3**: Range of values for independent variables in developed APM

<table>
<thead>
<tr>
<th>Factors</th>
<th>Range of value</th>
</tr>
</thead>
<tbody>
<tr>
<td>APW</td>
<td>50.6 – 53.4 veh/h</td>
</tr>
<tr>
<td>AADT major roads</td>
<td>0 – 198 veh</td>
</tr>
<tr>
<td>AADT minor roads</td>
<td>0 – 235 veh</td>
</tr>
<tr>
<td>Speed on major roads</td>
<td>17 – 52 km/h</td>
</tr>
<tr>
<td>Speed on minor roads</td>
<td>12 – 61 km/h</td>
</tr>
<tr>
<td>Lane width major roads</td>
<td>3.2 – 4.1 m</td>
</tr>
<tr>
<td>Lane width minor roads</td>
<td>1.4 – 3.4 m</td>
</tr>
<tr>
<td>Shoulder with major roads</td>
<td>1.2 – 1.9 m</td>
</tr>
<tr>
<td>Shoulder with minor roads</td>
<td>0.2 – 1.2 m</td>
</tr>
</tbody>
</table>

The developed APW model has an $R$-squared of 0.979 and adjusted $R$-squared of 0.975, which means 97.9% and 97.5% of the variation in the number of accidents has been explained by the regression line.

### 7.5 CONCLUSION AND DISCUSSION

In this study, 8 intersections along km-112 at FT001 and km-27 at FT024 were selected based on top 5 accident ranking. The following concluding remarks were drawn:

i. The number of traffic flow is significant in explaining the APW at non-signalized intersections and vehicle flow on major and minor roads associated with increase of accident. Vehicles traveling on minor roads are of higher total volume and this influence the probability of accident.

ii. In terms of mean speed, higher relative speed is recorded on minor road, i.e. at the locations where accidents tend to occur. Most of the minor road users are motorcycle riders, where increase in traveling speed leads to increase in number of accidents.

iii. Lane width, shoulder width of road, and the number of road lanes also are significant in explaining the number of accident crashes. Wide road lanes, more numbers of lanes, and wide road shoulders can be attributed to the reduction of accident crashes.
iv. Land use within the vicinity of the intersection also contributes to the number of accidents. Accidents are prone to occur at intersections located in a commercial area than in a non-commercial area.

Results of this study provide sufficient evidence to support the hypothesis that the existence of a larger major junction density, an increase in traffic volume and vehicle speed along Federal Route 001 and Federal Route 024 are the contributors to traffic accidents. More important, the significant accident predictive model developed in this study may apply in road safety improvement plan, and could serve as a basis for future research work on federal roads in Malaysia.
REFERENCES


