Most pedestrian-vehicle conflicts and accidents occur at Pelican Crossings because pedestrians violate the Red-Man (RM) period. Research was conducted to investigate the reasons underlying their behaviour. In other words, this research aimed at answering the question of why pedestrians crossed the street at any time. The research was carried out at a very busy Pelican crossing in the UK. The data were collected through a combination of direct measurements and video recordings to get information on signal periods, pedestrian arrivals, pedestrian crossing times, pedestrian flows and pedestrian delays. It was found that pedestrians cross the street at any time, so that they involve in traffic conflicts or potential accidents, because they experience high signal-imposed pedestrian delays.

**METHOD OF DATA COLLECTION AND ANALYSIS**

Empirical research was carried out to investigate pedestrian arrivals and delays in the real world. The data were collected using a video camera put on the roof of a very high building. The data collected from video were transcribed in order to obtain information on signal periods, pedestrian arrivals and pedestrian crossing times, pedestrian flows and pedestrian delays. The pedestrians studied were the same as those investigated in the conflict research (Malkhamah, 2000). In order to have this information, the data listed below were transcribed from video:

- a. the beginning of each signal period (bsp)
- b. the time a pedestrian arrived at the crossing (tpa)
- c. the time a pedestrian committed to cross the street, for pedestrians crossing on and within 50 m of the Pelican
- d. the time a pedestrian committed to cross the street, for pedestrians crossing on the Pelican only (tpc)

Transcribing behaviour of every single pedestrian is not an easy task. It requires patience and a lot of efforts. For this reason most students on pedestrians do not apply such a method and as a result detailed information could not be obtained.

The research reported here has very detailed results because data of every single pedestrian has been transcribed and analysed. The transcription was carried out by using a VDS program (Marzden, 1995) in order to obtain real and exact times. The time a
pedestrian arrived at the crossing was taken as the
time a pedestrian stopped at the kerb adjacent to the
crossing with the intention to use the crossing; or the
time a pedestrian joined a pedestrian queue (when
there were pedestrians already there) with the
intention of using the Pelican. For pedestrians
experiencing no delays, \( t_p \) and \( t_p^* \) were coincident.

Usually pedestrians arrived at different times
and this made the transcription of \( t_p \) easier. However, in
many cases some pedestrians stopped at the crossing
not because they intended to cross the street but just
because they met their friends and had a chat. These
pedestrians were excluded.

For pedestrians crossing on the Pelican, it was
not very easy to transcribe the time a pedestrian
stepped-off the kerb (\( t_p \)) because usually pedestrians
stepped-off the kerb almost at the same time (when
the green man appeared) and by this time the
pedestrians were accumulated at the crossing. This
task was easier for pedestrians crossing outside the
Pelican because there were fewer pedestrians and
most of them crossed at different times (see
Makhamah, 1999a for more detail).

Pedestrian flow was the number of pedestrians
crossing the street in one minute and this information
was obtained by analysing \( t_p \). The signal imposed
pedestrian delay for each pedestrian was calculated
using Equation 1.

\[
p_{d_a} = t_{p_a} - t_p
\]

(1)

Where:

\( p_{d_a} \) = signal-imposed pedestrian delay, second
\( t_{p_a} \) = the beginning of Green-Walking-Man
period, second

\( t_p = \) the time a pedestrian arrived at the
crossing, second

The actual pedestrian delay for each pedestrian
was calculated as the difference between the time a
pedestrian arrives (\( t_p \)) and the time a pedestrian is
committed to cross (\( t_p^* \) as shown in Equation 2.

\[
p_{d} = t_{p} - t_p^* \tag{2}
\]

Where:

\( p_{d} = \) actual pedestrian delay, second
\( t_p^* = \) the time a pedestrian committed to cross
the street, second.

RESULTS AND DISCUSSIONS
Pedestrian Arrivals and Signal Imposed Delays

Pedestrians arrived at the Pelican crossing almost
at any time both in the morning and in the afternoon.
The time was related to the signal periods (period A to
G) as described in Table 1. As shown in Table 1, the
lowest pedestrian flows, i.e. 434 and 586
pedestrians/hour occurred during period G both in the
morning and in afternoon respectively. During period
E, the first flashing green to pedestrians period, the
pedestrian arrival rates were very high, i.e. 1149
pedestrians/hour (in the morning) and 1128
pedestrians/hour (in the afternoon). From the video it
could be seen that usually pedestrians tried to catch
period D or E by walking faster or running. This
pedestrian behaviour made pedestrian arrivals during
periods F and G low (611 and 434 pedestrians/hour in
the morning; 702 and 586 pedestrians/hour in the
afternoon).

<table>
<thead>
<tr>
<th>Period</th>
<th>Signal to Pedestrian</th>
<th>Signal to Driver</th>
<th>Morning</th>
<th>Afternoon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>No. of Ped</td>
<td>Pedestrian</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>/hour</td>
<td>/hour</td>
</tr>
<tr>
<td>D</td>
<td>green walking man</td>
<td>steady red</td>
<td>132</td>
<td>818</td>
</tr>
<tr>
<td>E</td>
<td>flashing green man</td>
<td>steady red</td>
<td>57</td>
<td>1149</td>
</tr>
<tr>
<td>F</td>
<td>flashing green man</td>
<td>flashing amber</td>
<td>155</td>
<td>611</td>
</tr>
<tr>
<td>G</td>
<td>red standing man</td>
<td>flashing amber</td>
<td>20</td>
<td>434</td>
</tr>
<tr>
<td>A</td>
<td>red standing man</td>
<td>steady green</td>
<td>491</td>
<td>645</td>
</tr>
<tr>
<td>B</td>
<td>red standing man</td>
<td>steady amber</td>
<td>67</td>
<td>969</td>
</tr>
<tr>
<td>C</td>
<td>red standing man</td>
<td>steady red</td>
<td>29</td>
<td>629</td>
</tr>
<tr>
<td>All Periods</td>
<td></td>
<td></td>
<td>947</td>
<td>685</td>
</tr>
</tbody>
</table>
The mean signal-imposed pedestrian delays would be around 25 seconds as presented in Table 2. The signal-imposed delays varied depending on the arrivals with the minimum of 0 second, for those arrived during period D, and the maximum of 53 seconds for the ones arrived at the beginning of period E. The standard deviation values were high, i.e. between 17.6 (in the morning) and 19.9 seconds (for all situations).

Table 2. Signal-Imposed Pedestrian Delays (seconds)

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Morning</th>
<th>Afternoon</th>
<th>All Situations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>25.29</td>
<td>25.43</td>
<td>25.37</td>
</tr>
<tr>
<td>SD</td>
<td>18.45</td>
<td>17.55</td>
<td>19.91</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>7.00</td>
<td>8.00</td>
<td>7.00</td>
</tr>
<tr>
<td>50th Percentile</td>
<td>26.00</td>
<td>27.00</td>
<td>27.00</td>
</tr>
<tr>
<td>75th Percentile</td>
<td>42.00</td>
<td>41.00</td>
<td>41.00</td>
</tr>
</tbody>
</table>

Around 50% of pedestrians experienced signal-imposed delays of above 26 seconds in the morning and 27 seconds in the afternoon; and around 25% suffered signal-imposed delays more than 42 seconds in the morning and 41 seconds in the afternoon. Partly because of these high signal-imposed delays, 51.4% in the morning and 61.0% in the afternoon of pedestrians crossed during the RM period. Pedestrians would be impatient if they had to wait for more than 30 seconds (DoE, 1973), and Hunt (1990) suggested that the maximum waiting times should be kept below 30 seconds, or at most 40 seconds. This research found that on average, as shown in Table 3, those experiencing signal-imposed pedestrian delays more than 30 seconds were 45%. While on average, 29 per cent of pedestrians experienced more than 40 seconds of signal-imposed pedestrian delays.

Table 3. Pedestrians Experiencing Signal-Imposed Pedestrian Delays (%)

<table>
<thead>
<tr>
<th>Imposed Pedestrian Delay (second)</th>
<th>Morning</th>
<th>Afternoon</th>
<th>All Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 30</td>
<td>45</td>
<td>45</td>
<td>44</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>30</td>
<td>27</td>
<td>29</td>
</tr>
</tbody>
</table>

Pedestrian Actual Delays

As presented in Table 4, the maximum actual delays were high, i.e. 41.2 seconds (in the morning), 43.4 seconds (in the afternoon), and 42.5 seconds (overall). However, as pedestrians crossed the street at any time by taking the gap opportunities provided, the mean delays actually experienced by them were much lower than the signal-imposed pedestrian delays, i.e. 5.6 compared to 25.3 seconds (in the morning), and 5.1 compared to 25.4 seconds (in the afternoon). Overall, it was 5.4 compared to 25.4 seconds. In more detail the actual delays experienced by the pedestrians are presented in Table 5 and are explained below.

Theoretically, pedestrians who arrive at period D are not supposed to experience any delays. However, some did because they had to queue behind the pedestrians who had already been there. This happened when the number of pedestrians waiting was high and they had to queue.

It was also discovered that pedestrians who arrived at period E did not always experience the highest delay, some even crossed the street immediately when it was thought to be safe. Furthermore, all pedestrians arriving at period E would have found gap crossing opportunities before period D commenced. On average, pedestrian delays experienced by pedestrians arriving at period E were 1.6 and 1.3 seconds/pedestrian in the morning and afternoon respectively. In the morning, the mean delay incurred by pedestrians who arrived at period E was lower than those arriving at period D. This was because at period E there were few pedestrians waiting so that pedestrians who wanted to cross were able to do so almost immediately, while those arriving at period D often had to queue.

Pedestrian delays varied and they depended not only on the pedestrian arrival times but also on other factors, such as: the pedestrian flows, the Pelican cycle and window times, the presence of gap crossing opportunities (or vehicle flows), and gap acceptance or the pedestrian's willingness to take risks. As seen in Table 5, on average, the highest delays were experienced by pedestrians arriving during period G (7.9 seconds/pedestrian) in the morning and period A (7.9 seconds/pedestrian) in the afternoon. Pedestrians arriving during period E in the morning, i.e. 1.6 seconds/pedestrian and period D in the afternoon, i.e. 0.0 second/pedestrian, experienced the minimum delays, on average.

Table 4. Characteristics of Actual Pedestrian Delays (second)

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Morning</th>
<th>Afternoon</th>
<th>All Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.56</td>
<td>5.08</td>
<td>5.37</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>41.17</td>
<td>43.44</td>
<td>42.54</td>
</tr>
<tr>
<td>SD</td>
<td>7.55</td>
<td>7.68</td>
<td>7.61</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>50th Percentile</td>
<td>2.34</td>
<td>0.91</td>
<td>1.77</td>
</tr>
<tr>
<td>75th Percentile</td>
<td>9.23</td>
<td>7.26</td>
<td>8.66</td>
</tr>
</tbody>
</table>

MEDIA TEKNIK No.1 Tahun XXIII Edisi Februari 2001 No. ISSN 0216-3012
Why Pedestrian-Vehicle Accidents and Conflicts Happen at Pelican Crossings and Implications to Future Research

Most accidents happen because of a combination of different factors, i.e. human failings, road deficiencies and vehicle defects. In-depth multi-disciplinary studies have found that human factors contribute in 95 per cent of accidents in urban areas, road factors in about 20 per cent and vehicle factors in one percent (HIT, 1997). Shinar (1982) that a pedestrian accident very seldom has a single cause and suggested that the mutual causes of pedestrian accidents are:

a. pedestrian behaviour, i.e. pedestrian’s poor choice of a place or time to cross the road and pedestrian’s failure to search and detect the oncoming vehicle,

b. driver’s failure to search and detect the crossing pedestrian.

Similar findings are reported by Carsten et al. (1989). They suggested that in accidents involving pedestrians, failures amongst both pedestrians and drivers are evident. The main factors that are most likely to increase the chances of accidents are drivers travelling too fast (43 per cent) and pedestrians crossing without looking (16 per cent), i.e. pedestrians fail to give way and drivers are not able to anticipate their actions. In some accidents, both drivers and pedestrians misjudge distance and speed.

Brown (1982) suggested that drivers adjust their behaviour, especially their speeds, to the hazards they expect and perceive:

Where drivers’ expectancies are incorrect, their safety margin will be small, at best, and may well be negative. Pedestrian crossing their path during these decreased or absences of a safety margin will, by definition, be seriously at risk and dependent upon their own actions to prevent collision.

Another in-depth study of a sample of pedestrian accidents at Pelican Crossings on non-residential roads by Davies and Winnet (1993) showed that the main contributory factors of accidents were pedestrian non-compliance (26 per cent), driver non-compliance (25 per cent) and human error (41 per cent).

Malkhamah (1999a) found that most pedestrian conflicts happened because of pedestrian non-compliance. The percentages of drivers crossing the stop line outside the green to driver period (period A) was much lower than the percentage of pedestrians crossing outside the green to pedestrian period (period D), i.e. 28.28 per cent compared to 69.70 per cent. The research presented here investigated the reasons underlying the pedestrian behaviour or the basic reasons why pedestrian-vehicle conflicts or potential accidents happen. Pedestrians cross the street at anytime because pedestrian delays imposed by the signals are high. Almost 50% pedestrians incurred 30 seconds of signal-imposed delays. This finding is very important in developing Pelican operation strategies, especially when people are not patient to wait for their right-of-way, such as those in Indonesia. As explained by Hermawan (2000), who conducted his research in Yogyakarta Indonesia, most road users (both drivers and pedestrians), especially those who cross the street.
CONCLUSIONS

Pedestrians cross the street at any time so that they involve in traffic conflicts or potential accidents because if they waited until period 2 commenced they would experience high delays. The mean signal-imposed pedestrian delay were around 25 seconds and those experiencing signal-imposed pedestrian delays more than 30 seconds were 45 per cent. A high proportion of pedestrians, i.e. 29 per cent experienced more than 40 seconds of signal-imposed pedestrian delays. Because of their crossing behaviour, the actual delay experienced by pedestrians was much lower than the signal-imposed delay, i.e. 5.4 compared to 25.4 seconds.

REFERENCES


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