A location model for pedestrian crossings in arterial streets

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Abstract

Preliminary studies showed that the direct application of the well-known PV² model, as a quantitative criterion for the traffic justification of pedestrian crossings, does not give satisfactory results in arterial streets due to the socio-economic and safety features in Tehran, Iran. Therefore, attempts were made to calibrate the model for both at-grade and grade-separated crossing. Accordingly the data for various parameters such as pedestrian volume, vehicle volume, crossing time and vehicle headways was gathered and analyzed for both at-grade and grade-separated crossings. The PV² model was calibrated and warrants for different types of at-grade crossings, and also for locating grade-separated crossings in arterial streets was proposed.

Keywords: pedestrian crossing, at-grade crossing, grade-separated crossing, location model.

1 Introduction

Safety of the pedestrians in urban roads is an important issue in Iran. Pedestrian accidents statistics show such figures as 10000 deaths or injures per year. Proper design of crossings, especially in high-volume streets can reduce these figures effectively. In spite of existing limitations on budget and necessary resources of the municipalities, unsafe crossing of pedestrians imposes much delay on the passing traffic; thus the construction of safe crossings is justifiable.

Locating at-grade and grade-separated pedestrian crossings in urban roads usually is based on the engineering judgment or such experimental models as the PV² model. This study is planned to evaluate the efficiency of existing methods
of locating pedestrian crossings in high-volume streets and, if necessary, calibrate them for the conditions governing Tehran streets and finally the suitable warrants for locating and justifying crossings be proposed.

## 2 Background

Different quantitative and qualitative warrants for locating and construction of pedestrian crossings can be found, which mostly are base on the engineering judgment. For locating grade-separated crossings threshold, economic, points, political and system warrants have been proposed [1], but for at-grade crossing less warrants maybe found in the literature. The U.K. experience recommends the PV² model, in which P is the main pedestrian volume during a peak period of 4 hours and V is the vehicular volume in both directions for the same period, as a quantitative model to justify the location of a type of at-grade crossing. Fig.1 shows the warrants to justify the zebra, separated zebra, and signaled crossing based on the PV² model in the U.K. [2]

![Figure 1: U.K. warrants for pedestrian crossing facilities.](image-url)
Because of the following difference in the behavior of the pedestrians and driving habits of the people, the existing warrants can not be used to locate the crossing in Iran:

1- Generally the Iranian pedestrians are more talented in crossing the streets, and make use of short gaps and accept a higher level of risk.
2- Drivers do not come to a complete stop at the crossing and pass through the pedestrians at a lower speed.
3- Because of higher population densities, pedestrian and vehicular volumes are high and construction of at-grade and grade-separated crossing is not possible according to the existing warrants due to the limited resources. Fig.2 shows pedestrian and traffic conflict in Tehran.

3 Data gathering

A total of 30 crossings, 23 at-grade and 7 grade-separated, in different types of Tehran arterials were chosen to get their statistics, such as pedestrian and vehicular volumes, number of headways greater than the minimum necessary to cross the street and the geometric and control characteristics of the crossing. Video shooting was used in this process.

Figure 2: Pedestrian and traffic conflict in Tehran.

Pedestrian and vehicular volumes were determined during 4 hours of the morning and evening peak period. Pedestrian speed was calculated by measuring
the time to cross a marked fixed distance. The number of safe time headways for
the pedestrians in the traffic flow was measured during peak 8 hours and in 3
minutes consecutive intervals.

4 Data analysis

Minimum crossing time, G, of pedestrians was calculated using the following
equation and considering a mean speed $V=1.3$ m/sec, a perception- reaction time
of 3 seconds, and a safety factor of $a=1.2$:

$$G = a \left( \frac{D}{V} + P \right)$$  \hspace{1cm} (1)

where D is the total length of crossing. Number of safe headways $h \geq G$, in all
under study crossings, was calculated by averaging the measured values.

![Figure 3: Vehicle versus pedestrian volume data dispersion point.](image)

Fig. 3 presents the dispersion of points with their information of vehicular
and pedestrian volume; the curves for $PV^2 = 1 \times 10^8$ and $PV^2 = 2 \times 10^8$
are also presented. As it is shown the difference between the suggested zones and
actual behavior of crossing is noticeable. Therefore, the constant parameters
were determined such that the points locate at their correct position relative to
the type of crossing. Thus the new curves were obtained as:

$$PV^2 = 5 \times 10^9$$  \hspace{1cm} (2)

$$PV^2 = 2 \times 10^9$$  \hspace{1cm} (3)
which had the maximum possible fitness as it is shown in fig 4. The analyze also showed a close relation between the number of safe headways in 3 min consecutive periods, \( h \), and the type of crossing. A linear regression model was calibrated between the traffic volume, \( V \), and \( h \) as:

\[
h = 5.64 - 0.0007v \quad \text{(R}^2 = 0.83) \quad (4)
\]

Figure 4: Proposed PV\(^2\) curves and pedestrian crossing warrants for Iran.

With this relationship another index to determine the type of crossing (i.e., \( h \)) is obtained. Table 1 shows the warrants for locating various pedestrian crossings in Tehran arterials.

Table 1: The proposed criteria for pedestrian crossing facilities in arterial streets.

<table>
<thead>
<tr>
<th>( \text{PV}^2 )</th>
<th>( p )</th>
<th>( v )</th>
<th>( h )</th>
<th>Preliminary recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over ( 2\times10^9 )</td>
<td>50 to 500</td>
<td>2000 to 4000</td>
<td>3 to 4</td>
<td>Zebra</td>
</tr>
<tr>
<td>Over ( 5\times10^9 )</td>
<td>50 to 500</td>
<td>3000 to 6000</td>
<td>2 to 3</td>
<td>Divided zebra</td>
</tr>
<tr>
<td>Over ( 2\times10^9 )</td>
<td>50 to 500</td>
<td>Over 3000</td>
<td>Over 3</td>
<td>Pelican</td>
</tr>
<tr>
<td>Over ( 2\times10^9 )</td>
<td>Over 500</td>
<td>Over 2000</td>
<td>Over 4</td>
<td>Pelican</td>
</tr>
<tr>
<td>Over ( 5\times10^9 )</td>
<td>Over 500</td>
<td>4000 to 6000</td>
<td>2 to 3</td>
<td>Divided oilcan</td>
</tr>
<tr>
<td>Over ( 5\times10^9 )</td>
<td>50 to 500</td>
<td>Over 6000</td>
<td>Under 1</td>
<td>Grade separated</td>
</tr>
</tbody>
</table>
5 Conclusions

The study of vehicular and pedestrian volumes at pedestrian crossings shows that there is no coincidence between what happens in Tehran and similar cities in Western countries. Behavioral differences and resource limitations are the main reasons. The results of this study show that the PV² model can be used to determine the location and type of crossing if the constant of model is changed. Base on field studies the proper constant value was obtained and practical warrants to justify the necessary type of pedestrian crossing were determined.

References