Effects of Age and Sex on Pedestrian Crossing Speed Southern Sri Lanka

Terrance M. Rengarasu¹, H.N. Jayawansa², and G.P.W. Perera²
¹Department of Civil and Environmental Engineering, Faculty of Engineering
University of Ruhuna
Hapugala Galle
SRI LANKA
²Faculty of Engineering,
University of Ruhuna
Hapugala Galle
SRI LANKA
E-mail: rengarasu@cee.ru.ac.lk

Abstract: This paper gives the findings of study carried out to find pedestrian crossing speed (PCS), and PCS’s variation with age and sex of the pedestrian. Pedestrian crossing events were videotaped at zebra crossing in Galle using digital camcorder which was placed in a hidden place. The video was decomposed into its frames and these frames were used to track a certain pedestrian through his/her crossing event; data such as crossing time, apparent age group of pedestrians (young <20, middle-aged 20-50, and elderly Over 50). In total, data for 2,046 pedestrian crossing events were extracted from the video. Analysis of data showed that general pedestrians crossed with mean speed of 1.401 m/s, and a 15th percentile of 1.22 m/s; while the elderly pedestrians crossed with slower mean speed 1.29 m/s and a 15th percentile of 1.12 m/s. In all elderly female pedestrian has a slowest mean crossing speed.

Keywords: Pedestrian Crossing Speed, Video, Elderly Pedestrians

1 INTRODUCTION

Pedestrian crossing speed at cross walks is an important and essential parameter in intersection design. Pedestrian crossing speed dictates time required by a pedestrian to cross the road safely. To make sure that at least 85% of the pedestrian can safely cross the road 15th percentile of the pedestrian walking speed distribution is used. Many studies have concentrated on evaluating the pedestrian crossing speeds. A 1952 unpublished study by Exnicios (Exnicios, 1952) showed that the pedestrian crossing speed is 1.2 m/s. Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways (Federal Highway Administration, 2009) published by the Federal Highway Administration USA, suggest a pedestrian crossing speed of 1.2 m/s (4 ft/s). The use of 1.2 m/s (4 ft/s) was first introduced in the year 1961’s version of MUTCD. According to a literature review by LaPlante and Kaeser (LaPlante & Kaeser, 2007) the speed of 1.2 m/s is based on the unpublished study by Exnicios in 1952.

A 1986 study by Tanaboriboon et al. (Tanaboriboon et al.1986) in Singapore showed that that the Singaporeans walked slower that the USA citizens. The study found that Singaporeans walked at a mean speed of 1.23 m/s (74 m/min) and elderly walked at a speed of 0.9 m/s (54 m/min) from this 15th percentile can be calculated as 1.03 m/s for the combined population and 0.76 m/s for the elderly. Values of 4.0 fps (1.2m/s) at intersections, and 3.3 fps (1.0m/s) at midblock crosswalks and intersections near senior housing and nursing homes were recommended by a 1995 study by Coffin and Morrall (Coffin and Morrall, 1995) concerning elderly pedestrians at crosswalks. A 2002 study by Golani and Damti (Golani and Damti, 2002) indicated a 15th-percentile walking speed for younger pedestrians (ages14 to 64) as 1.25 m/sec (4.09 ft/sec); for older pedestrians (ages 65 and over) it was 0.97 m/sec (3.19 ft/sec). All of these suggest a common value; however, a 1996 study by Knoblauch (Knoblauch et al., 1996) found that a 1.19 m/s speed is appropriate for younger pedestrians while 0.91 m/s was suggested for older pedestrians.

A 2001 study by Tarawneh (Tarawneh, 2001) showed that the 15th percentile pedestrian walking speed for general public in Jordan is 1.11 m/s and 0.97 m/s for old age people. A 2006 study by Gates et al. (Gates et al. 2006) using 1,947 pedestrian crossing events measured at eleven intersections in Madison and Milwaukee, Wisconsin, recommended pedestrian walking speed values base on percentage of old
age pedestrians. According to Gates et al. when the proportion of pedestrians over the age of 65 exceeds 20, 30, 40, and 50 percent of the total pedestrians at a location, walking speeds of 3.6, 3.5, 3.4, and 3.3 ft/s, respectively, are recommended as design pedestrian walking speed. A 2006 study by Fitzpatrick et al. (Fitzpatrick et al. 2006) showed that for the general public; a pedestrian walking speed of 3.5 ft/s and for older pedestrians walking speed of 3.0 ft/s is suitable. In 2011, The Public Rights-of-Way Access Advisory Committee of USA (Public Rights-of-Way Access Advisory Committee 2011) has released draft guidelines for public comment. For pedestrian signal phase timing, maximum pedestrian walking speed of 1.1 m/s (3.5 ft/s) was recommended. Pedestrian crossing speeds obtained from previous studies is shown in Figure 1.

Figure 1: Pedestrian crossing speed obtained from previous studies

In addition to evaluation the 15th percentile speed previous studies have shown interest to find the 15th percentile crossing speed of pedestrians with age. With increase in elderly population in the world crossing speed of elderly pedestrian get more attention. Studies such as by Tanaboriboon et al.1986, Golani and Damti, 2002, Knoblauch et al., 1996, Tarawneh, 2001, and Fitzpatrick et al. 2006 evaluated pedestrian crossing speed of elderly and reported speed much lower than 1.2 m/s which is recommended by MUTCD. MUTCD’s pedestrian crossing speed is used in most of the world to design the traffic signals. Apart from initial study by Exnicios1952 and Coffin & Morral 1995 all other studies indicated that the MUTCDs recommendations may be too high.

In Sri Lanka, there is no clear national guideline on pedestrian walking speeds. Instead, signal designs in Sri Lanka depend on foreign guidelines originated from USA or UK. Being a developing country in tropics, Sri Lankan road environment is very different from USA or UK. Further, Sri Lankan pedestrians’ ergonomics and reason for crossing might be different from those of USA and UK. Therefore, suitability of guidelines originated in USA or UK to Sri Lankan conditions is questionable. Need for a national guideline on pedestrian walking speed was not felt in the past because of very limited installations of traffic signals in Sri Lanka. At present, with the economic growth, the number of traffic signal installation in Sri Lanka is in the rise. Therefore, the need for a national guideline on pedestrian walking speed is also increases. This intern derives the need to find the pedestrian walking speeds for Sri Lankan pedestrians under prevailing conditions. A study to find the pedestrian crossing speed was carried out in 2012 by Rengarasu et al. (Rengarasu et al. 2012). This study by Rengarasu et al. showed that the general population crossed the road at a 15th percentile speed of 1.2 m/s. But this study used only a small amount of data however speed of elderly pedestrians were not considered.

This study will build to any knowledge gained from the pilot study by Rengarasu et al. in 2012. There are
two aims to this study (1) to find the 15\textsuperscript{th} percentile speed of the general public of Sri Lanka and (2) to find the 15\textsuperscript{th} percentile speed of the elderly vs. young population and male vs. female population.

2 METHODOLOGY

Pedestrian crossing in front of the Galle bus stand was selected for this study. This pedestrian crossing was selected because of the high rate of pedestrian crossing events taking place at this pedestrian crossing. Figure 2 shows the map around the Galle bus stand indicating the study location and camera coverage angle. Pedestrian crossing events were videotaped using a digital camcorder with PAL video system. Test subjects were not selected nor screened; all individuals using the pedestrian crossing at time of study were videotaped. In addition, test subjects were not informed of the study; this is to make sure that there is no artificial behaviour by the pedestrians. For the same reason, camera was placed in not readily visible place on the first floor of the bus stand.

The digital camcorder used in this study used a PAL video system with AVI file output format. Road width, w, number of travel lanes, Pedestrian signal type, Street classification and Channelization were measured before the videotaping session. Pal video system yields a video with 25 frames per second. This give a 1/25 s accuracy in the time measurement. Video was kept at an angle to the test stretch. Keeping at an angle induce some parallax error. It is believed that parallax error can be eliminated using legs of the test subjects as the reference point. Audio Video Interleaved format produced by Microsoft Inc. was used as the video format. Multiple pedestrian crossing events were videotaped at single stretch. Maximum time for a single stretch was limited to 10 min: so that the resulting video file was easy to handle.

![Figure 2 Map around the Galle Bus stand (study area) indicating camera coverage angle](image)

2.1 Data Collection

Video containing the pedestrian crossing events decomposed into its frames using commercially available video editing software. Video was used to collect data for number of yellow and black bands crossed by a pedestrian, the time taken for the pedestrian to cross the set of yellow and black bands, apparent age group of the pedestrian and the sex of the pedestrian. The total length (L) of the crossing event was calculated using the number of yellow and black bands in the pedestrian crossing event (N). Each band was measured to be 0.50 m. Time taken to cross the set of yellow and black band by a pedestrian was calculated by tracking the pedestrian through the video frames. Initial time when the pedestrian entering
the set of yellow and black band was recorded this was done using the time stamp in the video \((t_0\) s). Next, the time of the pedestrian leaving the set of yellow and black band was recorded \((t_1\) s). Since the video has 25 frames per second; time can be measured using an accuracy of 1/25 s. Using the notation s defined above the pedestrian crossing speed in m/s can be calculated using Equation 1. Example such a data collection process is shown in Figure 3.

\[
V = \frac{N \times 0.5}{t_1 - t_0}
\]  

(1)

When collecting data pedestrians walking with dogs or other pets, pedestrians walking with bikes, roller skates, skateboards, or any other similar device, people using wheelchairs, canes, or any other kind of assistive device, people whose gender or age could not easily be determined, pedestrians running for part of the way or for the entire distance of interest, pedestrians not following the crosswalk alignment (i.e., crossing diagonally), pedestrians not completing the crossing (i.e., stopping in the median) for unknown reasons, pedestrians who crossed the street away from the intersection; and pedestrians who were accompanied by someone else and who seemed to be distracted by carrying on a conversation were not considered.

Although some of these exclusions may be self-explanatory, it is important to explain the reason for excluding from the data collection process people walking together. Because the purpose of this research was to investigate walking speed as a function of age and gender in real-life conditions, it was important to consider only people who were walking alone. In other words, when a person walks accompanied by someone (either a child or someone else), the walking speed may be different from what it would be if the person were walking alone. In such cases in which children were walking with an adult, it was not possible to determine if the child was walking faster to keep up with the adult or if the adult was walking slower to accommodate the child. The same situation applies to people who was walking together and carrying on a conversation. Therefore, to avoid biases in the walking speed analysis, it was decided to exclude these situations from the data collection process for find relationship of factors and walking speed. But it was taken into account for calculate 15th percentile speed.

2.2 Data Description

In total data for 2046 pedestrian crossings were collected; out of which 1212 were male pedestrians and the rest 834 was female. There were 194 young pedestrians (age less than 20), 1620 middle aged pedestrians (age 20 to 50) and 232 elderly pedestrians (age greater than 50). Table 1 shows the percentages and number of data according to age and sex of the pedestrian.

2.3 Data Analysis

Data was analysed using classification tables, with sex and age group as variables. Analysis of variance ANOVA was used to find the significance in the difference of speed between variables. Probability level of 95% was used as the cut off value for the significance. ANOVA was performed using the SPSS programme.
Figure 3 Tracking a pedestrian through the frames to get the time to cross the set of yellow and black bands
Table 1: Percentages and number of data according to age and sex of the pedestrian

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>1212</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>834</td>
<td>41</td>
</tr>
<tr>
<td>Age group</td>
<td>20 &gt;</td>
<td>194</td>
<td>09</td>
</tr>
<tr>
<td></td>
<td>20 - 50</td>
<td>1620</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>50 &lt;</td>
<td>232</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2046</td>
<td>100</td>
</tr>
</tbody>
</table>

3 RESULTS

Statistical properties of pedestrian crossing speed are shown in Table 2. According to this table it is clear that the elderly age group (age above 50) has lowest 15th percentile speed. Middle aged pedestrians crossed the road with 15th percentile speed of 1.24 m/s, when compared with the elderly middle age there is a significant difference. Young pedestrians crossed the road with 15th percentile speed of 1.18 m/s, when compared with the elderly middle age there is a significant difference. When compared to the male pedestrian female pedestrian crossed the road slower.

Male pedestrians had a 15th percentile speed of 1.25 m/s while females had 15th percentile speed of 1.18 m/s. Results of ANOVA showed that the sex had a significant (F=118, P=0.00) effect on the pedestrian crossing speed. When looking at the Table 2 it is clear that elderly pedestrians crossed the road at a slower speed this is a significantly lower (F=92, P=0.00) speed when compared with all other age groups combined.

Table 2: Statistical properties of pedestrian crossing speed with respect to age and gender

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level</th>
<th>Pedestrian Crossing Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>1.436</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.349</td>
</tr>
<tr>
<td>Age</td>
<td>Less than 20</td>
<td>1.351</td>
</tr>
<tr>
<td></td>
<td>20 to 50</td>
<td>1.422</td>
</tr>
<tr>
<td></td>
<td>Greater than 50</td>
<td>1.294</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1.401</td>
</tr>
</tbody>
</table>

When comparing the combination effect of age and sex it is clear that the elderly female pedestrians have lower crossing speed than the elderly male pedestrians; this trend is also true for young pedestrians too. 15th Percentile of pedestrian walking speed with respect to age and sex is shown in Table 3.
Table 3: The 15\textsuperscript{th} Percentile of pedestrian walking speed (m/s)

<table>
<thead>
<tr>
<th></th>
<th>Young</th>
<th>Elderly</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>1.21</td>
<td>1.13</td>
<td>1.25</td>
</tr>
<tr>
<td>Female</td>
<td>1.16</td>
<td>1.13</td>
<td>1.18</td>
</tr>
<tr>
<td>Total</td>
<td>1.18</td>
<td>1.12</td>
<td>1.22</td>
</tr>
</tbody>
</table>

4 CONCLUSIONS AND DISCUSSIONS

Results of this study indicate that pedestrians in southern Sri Lanka crossed the road at speed of 1.22 m/s. This speed is similar to the same as the values obtained by the previous studies such as Coffin and Morrall (Coffin and Morrall, 1995) and Exnicios (Exnicios, 1952). Due to this study’s limited geographical coverage in data collection it is too early to suggest that MUTCD’s value can be used in Sri Lanka. However results of this study might be true and can be used for southern Sri Lanka.

The State of World Population 2011 shows that Sri Lanka has fastest ageing populations in the developing world. Currently 10 percent of the population is over the age of 60 and by 2025 the elderly will account 20 percent of the population with women outnumbering men. According to the results of this study 15\textsuperscript{th} percentile crossing speed of the elderly pedestrians was 1.12 m/s; significantly lower that the value of 1.2 m/s. Use of 1.2 m/s does provide clearance interval for 85% of the general population. Although timing pedestrian clearance intervals based on slower walking speeds may improve pedestrian safety, doing so may also have a negative effect on vehicular traffic flow because slower pedestrian walking speeds translates to longer pedestrian clearance times.

In this study 2046 Pedestrian crossing events were used. Considerably good results were achieved using collected data. Better results can be achieved by using more pedestrian crossing data. The Pedestrian crossing in front of the Galle bus stand was used for the study. Collected pedestrian data consisted of various types of pedestrians. It was an almost fairly data sample which consisted of all kind of pedestrians. This result might not be applied to design clearance time for crosswalks near special locations like schools, hospitals, etc. Pedestrian’s data was obtained in sunny weather conditions. Better results can be achieved by collecting data in different weather conditions for further studies. Using a high quality video camera with high resolution and frame rate will improve the accuracy of future studies.

5 ACKNOWLEDGEMENTS

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6 REFERENCES


