Variation of the Start-Up Time of Pedestrians with Their Familiarity to the Signal Phase

P.A.S.R. Jayatilake[1], B.M.N.M. Premachandra[1] and W.M.V.S.K. Wickramasinghe[1]
[1]Department of Civil Engineering
Faculty of Engineering
University of Peradeniya
SRI LANKA
E-mail:vskw@pdn.ac.lk

Abstract: *In allocating green time for pedestrians' signal phase, most of the signal time calculations are paying attention only towards the time taken by pedestrians to traverse the crosswalk. But it may result in dangerous situations caused by pedestrian-vehicle interactions. Therefore to improve safety, consideration on the start-up time of pedestrians is important. Also the start-up time may vary with the familiarity of the pedestrians to signal phase. This research was carried out in order to find how the start-up times vary when pedestrians are familiar with the signal phase and when they are not. Data were collected at selected locations and graphical interpretation was done to find the mean and the standard deviation. Then a hypothetical test was carried to find the significance of start-up time values at different locations. Final results showed that the start-up time is highly significantly different when pedestrians are familiar with the signal phase and when they are not.*

Keywords: *Start-up time, familiarity with the signal phase*

1. INTRODUCTION

Signalized crosswalks are provided in order to allow the pedestrians to cross the road safely, avoiding interactions with the vehicles. In allocating the green time in pedestrians' signal phase, the time taken by the pedestrians to cross the road is considered. But the pedestrians have their own start-up times which also affect to the total time needed by them to cross the road. Therefore consideration on the start-up times of pedestrians is also essential. The following expression shows how to calculate the start-up time.

Start-up Time	=	The time at which pedestrian stepped off the curb to cross the road	–	Time at which pedestrian signal phase turns to green

The start-up time may be affected by the familiarity of the pedestrians to the signal phase. When the pedestrians are familiar with the signal phase, they may have a better start-up time which is safer than when the signal phase is new to the pedestrians. To analyse this, signalized crosswalks were selected in Colombo (Sri Lanka), where the pedestrians are familiar with the signal phases. Also signalized crosswalks in Kandy (Sri Lanka) were selected as the signal phases were installed recently and it is new to the pedestrians. Therefore the affect on the start-up time of pedestrians by their familiarity to the signal phase is addressed through this research with following objectives.

1.1. Objective

To find the start-up times of pedestrians crossing at signalized crosswalks and to compare the start-up times of pedestrians who are familiar with the signal phase and who are not.

2. LITERATURE REVIEW

There are many research papers related to pedestrians, their safety and their crossing time on signalized crosswalks. Existing data on walking speeds and start-up times have many shortcomings. Therefore according to Knoblauch *et al* (1996), a series of field studied was conducted to quantify the walking speed and start up time of pedestrians. Easa & Cheng (2013), have collected data to establish a correlation coefficient between start-up time and walking time of pedestrians and have presented a probabilistic method to compute minimum green time. When collecting data, Knoblauch *et al* (1996), have considered several factors like weather, age, gender, curb height etc. and data were categorized accordingly. Jain *et al* (2014), have carried out their research to examine the effect of pedestrian characteristics to the crossing speed and waiting time. But the methodology developed by Alahajyaseen & Nakamura (2010), is based on modeling total pedestrian platoon crossing time which consist of discharge and crossing times. Golani & Damti (2007), have considered the behaviour of group of pedestrians. Lipovac *et al* (2012), have considered gender, age and group size in their research where the research conducted by Galanis *et al* (2012), have considered only age and gender. Categories compared by Gates *et al* (2006), are age & disability, intersection traffic control condition, gender and group size. To have a fair conclusion, consideration on significant factors is essential to improve the safety of pedestrians.

As the data collection method, most researches have used video surveying. Golani & Damti (2007), have used video survey as the data collection method. But Knoblauch *et al* (1996), have used a hand held digital electronic stopwatch to record data. Jain *et al* (2014), have paid attention to different data collection techniques like direct observation methods, video observation methods, time lapse photographs and pedestrian opinion surveys. In the research carried by Brosseau et al. (2013), data collection was done manually for main analysis and complimentary video data was used for the validation. However, video tapping will be the most suitable method to collect data as the start-up time calculations can be done precisely after finishing data collection.

When considering the results, in the research carried by Easa & Cheng (2013), 95th percentile value of start-up time is 3.9-5.7s while the 99th percentile value is 5.3-7.6s. In the research done by Knoblauch *et al* (1996), the highest start-up was given by female of age above 65years and the value is 2.57s. However according to Golani & Damti (2007), average start-up time is 2.7s and 15th percentile value is 3.85s and it was used to include slow walkers. According to Vujanic *et al* (2014), 17.5% pedestrians have started crossing during red phase. When considering the results of those research papers, there is a significant value for start-up time. Therefore use of start-up time in green time allocation in pedestrian's signal phase is essential in order to provide more safety for pedestrians.

3. METHODOLOGY

(i) Site selection - First, sites were selected in Colombo and in Kandy in order to fulfill the objective of comparing the start-up times of pedestrians when they are familiar with the signal phase and when they are not. Having considerable pedestrian concentrations at those signalized crosswalks were considered. To capture the required details clearly, locations at a higher elevation compared to the road were selected to fix the camera and to carry out video recording. After the completion of site selection, permission required to carry out the project at those locations were taken from respective authorities.

(ii) Data collection - Video surveying was done using a stationary digital camera. Captured the signal light, the curb, pedestrians at the front line and the road section in front of the pedestrians. Video surveying was done specially during the peak hours.

(iii) Data extraction - Extracted video part from last 10 seconds of the pedestrian red phase to first 10 seconds of the pedestrian green phase. Next that was extracted into images with an accuracy of 0.1s, using 'Video to JPG converter'

(iv) Finding the start-up times of pedestrians – Considered the pedestrians at the front line who are waiting for the pedestrian's signal phase to turn into green. Start-up times were calculated using the extracted images.

(v) Analysis of start-up time – It was done mainly as statistical analysis and hypothetical analysis. In statistical analysis, graphical interpretation was done using 'Easy Fit' software. Then using the graphs mean and standard deviation values were found. As the hypothetical test, 'Z test' was carried out to check whether there is a significant difference between the data gathered from Colombo and Kandy.

4. RESULTS AND DISCUSSION

Gathered data were tabulated separately for Kandy and Colombo. Using that, statistical analysis was done.

Table 1 Number of pedestrians for each start-up time value in Kandy and Colombo

Start-up time (s)	No. of pedestrians		Start-up time (s)	No. of pedestrians	
	Kandy	Colombo		Kandy	Colombo
-4.8	1	0	-2.4	7	3
-4.7	4	0	-2.3	6	3
-4.6	1	0	-2.2	9	3
-4.5	2	0	-2.1	6	3
-4.4	4	0	-2	4	6
-4.3	3	0	-1.9	13	4
-4.2	2	0	-1.8	12	6
-4.1	3	0	-1.7	11	3
-4	3	0	-1.6	14	2
-3.9	0	1	-1.5	21	7
-3.8	2	0	-1.4	13	5
-3.7	1	0	-1.3	15	5
-3.6	1	0	-1.2	16	5
-3.5	5	0	-1.1	19	10
-3.4	1	0	-1	19	9
-3.3	1	0	-0.9	24	7
-3.2	1	0	-0.8	26	7
-3.1	8	0	-0.7	30	12
-3	4	1	-0.6	23	19
-2.9	8	2	-0.5	35	20
-2.8	10	0	-0.4	40	14
-2.7	7	0	-0.3	48	13
-2.6	6	2	-0.2	47	12
-2.5	7	3	-0.1	28	10

Table 1 (Continued)

Start-up time (s)	No. of pedestrians		Start-up time (s)	No. of pedestrians	
	Kandy	Colombo		Kandy	Colombo
0	35	9	2.1	7	12
0.1	57	9	2.2	12	15
0.2	50	14	2.3	9	13
0.3	49	14	2.4	5	10
0.4	57	13	2.5	11	7
0.5	68	16	2.6	4	7
0.6	48	15	2.7	3	4
0.7	47	20	2.8	4	5
0.8	63	27	2.9	2	4
0.9	35	22	3	2	3
1	41	21	3.1	2	3
1.1	44	20	3.2	2	6
1.2	39	23	3.3	0	3
1.3	48	23	3.4	0	3
1.4	27	19	3.5	0	0
1.5	31	30	3.6	0	2
1.6	20	21	3.7	0	0
1.7	19	13	3.8	0	3
1.8	19	19	3.9	0	0
1.9	14	15	4	0	1
2	12	11			

4.1. Statistical Analysis

Probability density curves were plotted using “Easy fit” software for start-up time values in Kandy and Colombo.

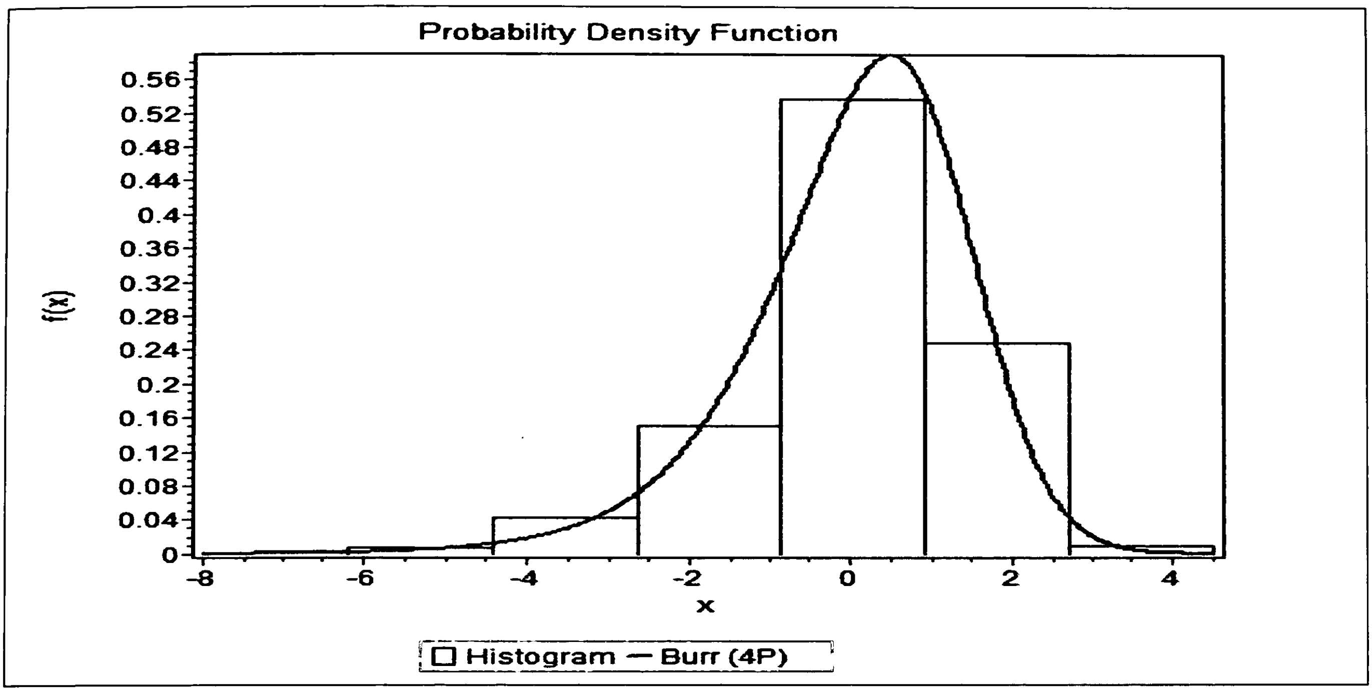

Figure 1 The probability density graph for start-up times of pedestrians in Kandy

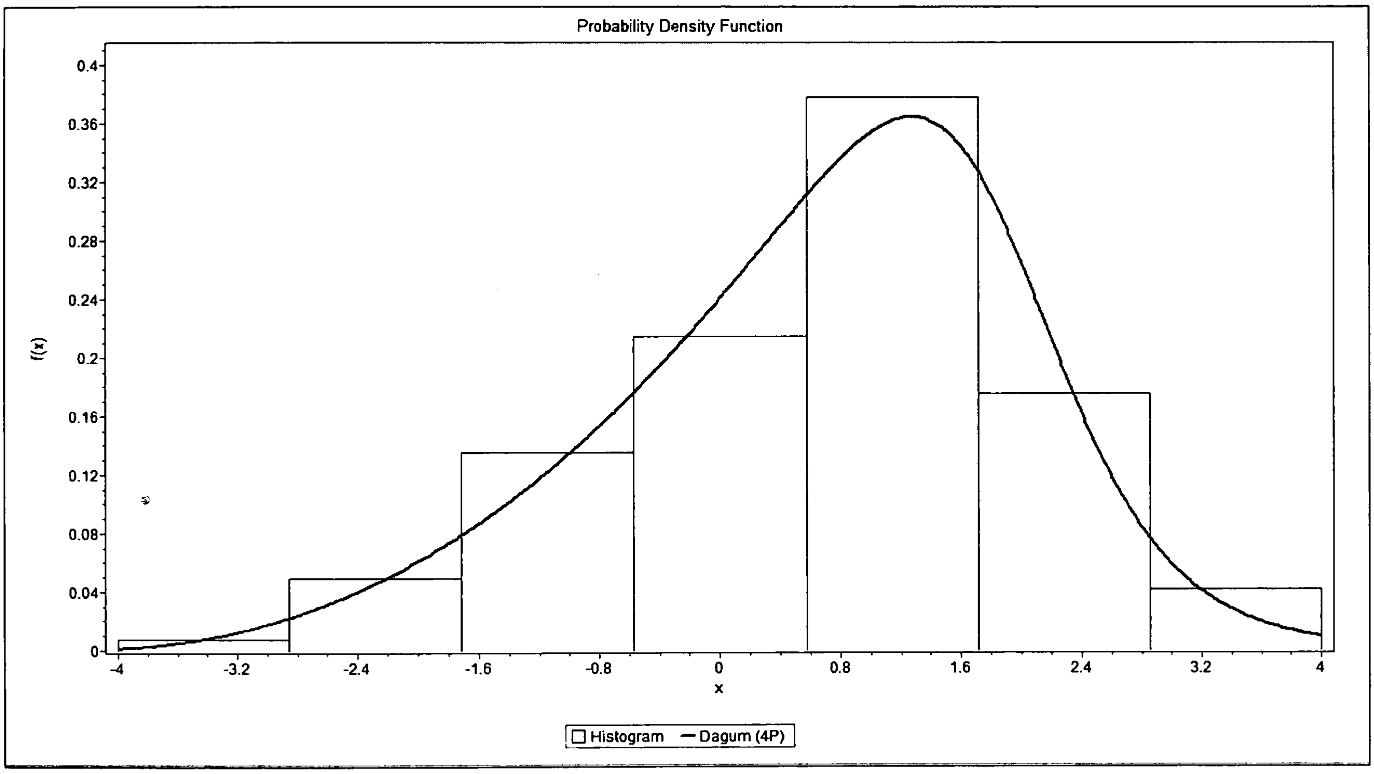

Figure 2 The probability density graph for start-up times of pedestrians in Colombo

Table 2 Mean and Standard deviation for start-up time values

	Start-up time (s)	
	Mean	Standard Deviation
Kandy	0.05	1.43
Colombo	0.69	1.36

4.2. Hypothetical Analysis

As our objectives is to compare the start-up time of pedestrians when they are familiar with the pedestrian signal phase and when they are not, we carried out "Z test" to find whether there is a significant difference between the start-up time values obtained at the two locations, Colombo and Kandy. Test was carried out separately under each category and z value was calculated using Eq. (1). Mean & standard deviation values obtained under statistical analysis were used in that equation.

$$Z = \frac{X1 - X2}{\sqrt{(\partial 1^2 + \partial 2^2)}} \tag{1}$$

Where,

- X1 – Mean value of sample from Kandy
- X2 – Mean value of the sample from Colombo
- $\partial 1$ – Standard deviation of the sample from Kandy divided by the square root of the number of data points
- $\partial 2$ – Standard deviation of the sample from Colombo divided by the square root of the number of data points

If the modulus of the Z statistic is less than 2, the two samples are the same

If the modulus of the Z statistic is between 2 and 2.5, the two samples are marginally different

If the modulus of the Z statistic is between 2.5 and 3, the two samples are significantly different

If the modulus of the Z statistic is more than 3, the two samples are highly significantly different

When substituting the values in table 4.2, 'Z' value is 9.9, which is greater than 3. Therefore the start-up times between Kandy and Colombo are highly significantly different.

4.3. Discussion

From gathered data, we can see that start-up times of pedestrians are varying within a range of around -4s to 4s. The results given after statistical analysis shows that pedestrians in Kandy are having early start-up when compared with the start-up time of pedestrians in Colombo. Also z statistics shows that there is a highly significant difference between the start-up time values obtained in Kandy and Colombo. As the pedestrian signal phase is new to the pedestrians in Kandy and as the pedestrians in Colombo are familiar with the signal phase, we can state that the pedestrian's familiarity with the signal phase effects to the start-up time of pedestrians.

5. CONCLUSION

Variation of start-up time to a considerable range shows the importance of start-up time. In many instances, designing of pedestrian signal times do not pay much attention towards pedestrians start-up time and designing is carried out mainly focusing on crossing time of pedestrians. But that can lead to pedestrian-vehicle interactions and can cause severe impacts on pedestrians. That can be eliminated by paying attention towards the start-up time. The start-up time is effected by several factors. In this paper, main consideration is given to the affect of familiarity of pedestrians to signal phase. In a developing country like Sri Lanka, signal phases are now emerging and therefore, the safety of pedestrians at signal phases will be affected by their familiarity to the signal phase. The results of this research have showed that there is a significant difference between the start-up times of pedestrians when they are familiar with the signal phase and when they are not. So by that it is clear that there is an effect on the start-up times of pedestrians by their familiarity to the signal phase. Therefore start-up times are important to be considered in pedestrian signal phase designing as it can have a major impact on the pedestrians who are crossing the road at signalized crosswalks.

6. ACKNOWLEDGMENTS

We would like to acknowledge all the staff members of the Faculty of Engineering, University of Peradeniya, who helped us in carrying out this research successfully. Also we are thankful to the Police, for giving us the permission to carry out this research at signalized crosswalks in Kandy and Colombo. We would like to express our gratitude to all the others who helped us in many ways in making this research a success.

7. REFERENCES

Alahajyaseen, W.K.M. & Nakamura, H., 2010, 'Estimating the Minimum Required Width of Signalized Crosswalks Considering Bi-directional Pedestrian Flow and Different Age Groups', *Asian Transport Studies*, Volume 1, Issue 2, pp181-198

Brosseau, M., Zangenehpour, S., Saunier, N. and Miranda-Moreno, L., 2013, 'The impact of waiting time and other factors on dangerous pedestrian crossings and violations at signalized intersections', A case study in Montreal. *Transportation research part F: traffic psychology and behaviour,21*, pp.159-172.

Easa, S.M. & Cheng, J., 2013, 'Reliability Analysis of Minimum Pedestrian Green Interval for Traffic Signals', *In Journal Transportation Engineering*, 139(7), pp651-659

Galanis, A. and Nikolaos, E., 2012, 'Pedestrian Crossing Behaviour in Signalized Crossings in Middle Size Cities in Greece'. na.

Gates, T.J., Noyce, D.A., Bill, A.R., Van Ee, N. and Gates, T.J., 2006, January., 'Recommended walking speeds for pedestrian clearance timing based on pedestrian characteristics', In *Proceeding of TRB 2006 Annual Meeting*.

Golani, A. & Damti, H., 2007, 'Model for Estimating Crossing Times at High Occupancy Crosswalks', *In* Transportation Research Record No.2002*, Journal of the Transportation Research Board,* National Academies, Washington. *D.C.*, pp125-130.

Jain, A., Gupta, A. and Rastogi, R., 2014. 'Pedestrian crossing behaviour analysis at intersections', *International Journal of Traffic and Transportation Engineering*, *4*(1), pp.103-116

Knoblauch, R.L., Pietrucha, M. & Nitzburg, M., 1996, 'Field Studies of Pedestrians Walking Speed and Start-up Time', In Transportation Research Record 1538*, Journal of the Transportation Research Borad*, National Research Council, Washington. D.C., pp27-38

Lipovac, K., Vujanic, M., Maric, B. and Nesic, M., 2012, 'Pedestrian behavior at signalized pedestrian crossings', *Journal of transportation engineering,139*(2), pp.165-172.

Vujanic, M., Pesic, D., Antic, B. & Smailovic, E., 2014, 'Pedestrian Risk at the Signalized Pedestrian Crossing Equipped with Countdown Display', *International Journal for Traffic and Transport Engineering*. Volume 4(1), pp52-61