Investigating the Effect of Pedestrian Characteristics, Land Use and Level of Vehicle Traffic on Crosswalk Speed of Pedestrians

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Abstract: Understanding the pedestrians is crucial in providing infrastructure to facilitate their needs better. The pedestrian speed depends on the characteristics of the pedestrian in demand for crossing at a particular location. While many studies have analyzed the pedestrian speeds based on sex and age, very few have considered the following scenarios that directly or indirectly affect walking speed: visible state of pregnancy or disabilities, luggage, level of traffic (peak or off-peak), and surroundings (land use). In Sri Lanka, the pedestrian speeds on crossing were not explicitly considered in providing crosswalk facilities.

Pedestrian speed data were collected using video camera footage at 5 different pedestrian crossings in Galle, Sri Lanka. Variation of crossing speeds of pedestrians according to the abovementioned scenarios was analysed in this study. A significant difference in crossing speeds was observed during peak and off-peak times. Overall crossing speed of males (78.8 m/min) is faster than that of females (75.3 m/min). The analysis reveals a significant difference in pedestrian crossing speed at different land use where the trip purpose is commercial, educational, recreational, or transport. The age-sex composition of pedestrians on demand for crossing was revealed to influence this crossing speed variation. Understanding the variation in pedestrian speed under different scenarios offers many advantages, particularly for urban planners, to aid their design of safe and inclusive pedestrian crossings.

Keywords: Pedestrian Crossings, Pedestrian Crosswalk Speed, Land Use, Pedestrian Characteristics, Pedestrian Crossing Behaviour

1. INTRODUCTION

Walking is one of the major modes used for first and last-mile connectivity in transportation. Among the various facilities designed for pedestrian movement, pedestrian crossings signify a right of way for pedestrians over vehicles. Pedestrian crossings allow pedestrians to safely walk across the roads at grade according to their travel requirements.

The average walking speed differs with demographic transitions. Therefore, establishing how the average walking speed of the pedestrians at crossings changes with the changing age and sex composition is of importance when designing pedestrian crossings.

Another factor affecting the walking speed is the land use at either end of the crossing. The demography of the users and their demand for walking space vary according to land use, leading to different average walking speeds.

The design of pedestrian crossings in Sri Lanka has considered crossings as an extension of the walkways. But in crossings, pedestrian speed profiles differ due to the perceived danger of conflicts with the motorized traffic flow. Very few researchers have attempted to study the flow characteristics on the crossings themselves. In Sri Lanka, often bicyclists also use pedestrian crossings to change lanes. No research has been done in Sri Lanka to determine the effect of visible pregnancy, disabled or carrying luggage on the overall changes in pedestrian speed and flow on a pedestrian crossing.

2. LITERATURE REVIEW

Gupta and Pundir (2015) define pedestrian speed as the "measurement of distance covered per unit of time by a pedestrian (symbol 'u', unit 'm/min')". There were few studies done on pedestrian facility design in Sri Lanka. The design standard for pedestrian walkways in "The Design of Pedestrian Facilities in Sri Lanka" was developed without considering the differences of pedestrians (Premathilaka, 2008). There, the pedestrian speed was calculated as 70.9 m/min. The average speed of the pedestrians was considered without any considerations to the effect of the physical condition. This research identifies the need to study pedestrian differences and their distribution as a gap in existing research.

In "A methodology for design of pedestrian crossing facilities in Sri Lanka", Kaluarachchi (2010) states that the appropriate dimensions are dependent on the location, purpose, and anticipated flow or demand on the facility. In this study, the variation in demand concerning the change in land use has not been considered. Therefore, in both studies, no in-depth consideration has been given to variations of pedestrian speeds at crosswalks.

Alhajyaseen and Nakamura (2010) have analysed pedestrian demand at crossings using three different age groups, middle-aged, elderly, and pupils. There, they have focused only on modelling equations to estimate the crossing speed and time. They have not focused on physical condition or accompaniment of children and luggage.

Variation in speed with pedestrian characteristics, namely age, sex, movement with or without baggage, and when moving in platoons, has been analysed in "Pedestrian Flow Characteristics in Mixed Traffic Conditions" (Laxman *et al*., 2010). The study has been done in 4 medium-sized cities in India to examine the effect of pedestrian characteristics on pedestrian speeds. The research has also concluded the effect of the location and pedestrian characteristics on the pedestrian flow characteristics by looking at the speed data collected. But it has not investigated the effect in depth.

Several studies have been done to analyse the behaviour of the elderly and the disabled on pedestrian crossings (Bollard and Fleming, 2013; Pecchini, 2016; Boenke and Benjamin, 2014). The studies considered safety behaviours rather than the effect on pedestrian speed.

Rastogi et al. (Rastogi *et al*., 2012) have investigated the effect of land use, sex, and age on pedestrian speeds in India. While there has been no significant difference observed between crossing speeds in different land uses, the highest crossing speed of 1.645 m/sec (98.7 m/min) has been observed for pedestrians in shopping areas. Male pedestrians were found to cross the roads faster than female pedestrians. But in their study, the crossing speed variation during the peak and off-peak is not investigated.

It was especially noted that many of the research done to investigate the pedestrian speeds in terms of age had followed visual observation in categorizing pedestrians according to their age (Jain *et al*., 2014; Ferenchak, 2016; Thompson *et al*., 2013; Chaudhari *et al*., 2017).

3. PROBLEM STATEMENT

This research aims to determine pedestrian speed-flow characteristics according to pedestrian characteristics, level of traffic, and land use.
The research attempts to answer how does pedestrian speed-flow relationship change according to

- pedestrian characteristics in terms of age, sex, physical fitness, and luggage carried
- land use on either side of the crossing
- level of vehicle traffic (peak and off-peak times)

4. RESEARCH METHODOLOGY

CCTV cameras were placed near 5 un-signalized pedestrian crossings in Galle, Sri Lanka. The pedestrian flow data was later extracted from videos footages obtained from those cameras in a laboratory by playback.

For the study purpose, data was collected for one hour each from peak time (07:00 – 08:00) and off-peak time (15:00 – 16:00) from all 5 locations. The data collected categorized the pedestrians according to their age and sex using observations such as facial features (visible wrinkles, etc.), clothes, posture, hair, etc. The pedestrians were divided into four age categories: toddlers/pre-schoolers, school children, young/middle, and elderly. The data collection locations and sample size at each location are given in Table 1.

Table 1: Data Collection Summary

Location	**Land Use**		**Sample Size**
	End-1	End-2	
1	Bus Stand	Stadium	792
2	Expressway/Long Distance Bus Stand	Bus Stand	1180
3	Schools	City	796
4	City	Bus Stop	810
5	Railway Station	Midblock	629

The sex of the toddlers/pre-schoolers was not considered due to difficulty in determining sex through visual observation. The small children who were being carried or walking who were not wearing a school uniform were considered to belong to the category toddlers/pre-schoolers (standard school uniform is mandatory for all school students in Sri Lanka). Since the starting age of school in Sri Lanka is six years old, they were considered to be below six years old. Since school children are between 6 – 19 years old, the young/middle age category was considered to be between 20 – 60 years old. The Elderly was considered to be 60+ years old. The differences between the young/middle aged and elderly were distinguished by hair colour, posture, etc.

Special conditions such as pregnancy (visible state), disabilities (physical disabilities that visibly affect walking), and carrying luggage was also noted.

The crossing time of each pedestrian was recorded by manual data extraction using the video footage. The speed was calculated by dividing the road width by the crossing time.

The physical dimensions of the road were recorded manually. The road width was taken as the length between the two curbs on an undivided road. On a road divided by a median, the length between the curb and the median of each of the two sections in the road was totalled and considered as the road width.

This study assumed that pedestrians maintain uniform speed across the crossing. Therefore, the variation of the speed of the pedestrian while crossings is not considered.


Location 1


Location 2


Location 3


Location 4


Location 5

Figure 1: Photographs of Study Locations

5. DATA ANALYSIS

The collected data were analysed using Minitab and Excel Software. Effect of factors such as vehicle traffic peak/off-peak time, land use, sex and age, the visible physical condition of the pedestrian (pregnant, disabilities that affect walking speed) as well as carrying luggage was analysed.
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5.1 Variation of Crossing Speed at Peak/Off-Peak Time

When crossing, pedestrian speeds can differ due to the perceived danger of conflicts with the motorized traffic flow. This level of perceived danger can depend on the level of traffic. Therefore, the variation of crossing speeds with the level of traffic (peak/off-peak) was analysed. The variation of crossing speed at vehicle traffic peak and off-peak times at each location and specific land use is given in the table below. The variations in crossing speed according to Land Use were also analysed.

The data shows an apparent reduction in the crossing speeds of pedestrians in off-peak time compared to peak times. One factor that contributes to this reduction in speed is the level of vehicle traffic present. At peak times, due to the inherent unsafe nature of walking through busy vehicular traffic, pedestrians tend to speed up to reach the curb quickly. The presence of police provides them with a safe passage by stopping the stream of traffic, so pedestrians walk without pausing out of caution for incoming vehicles. Therefore, pedestrians' crossing speeds are higher during peak hours. The significance of the difference of crossing speeds of varying level of traffic of the day was tested to a 95% confidence level. The results showed a p-value of 0.04. Therefore, it can be concluded that there is a significant difference in crossing speeds at peak and off-peak times.

It was observed during the data collection, at off-peak times, vehicles often drive through manoeuvring instead of stopping for pedestrians on the crossing. This causes the pedestrians to often pause or slow down in the middle until the vehicle passes them or gives way for them to finish the crossing. This causes decreases in the crossing speed of pedestrians in off-peak hours. This finding is consistent with the finding of Chaudhari *et al*., (2017) where the speed of the pedestrians was found to increase when a vehicle is approaching.

Table 2: Variation of Crossing Speeds at Peak and Off-Peak

Location	**Peak Speed (m/min)**			**Off-Peak Speed (m/min)**		
	Mean	Std. dev.	Sample size	Mean	Std. dev.	Sample size
1	85.53	19.03	318	79.32	20.69	474
2	75.46	21.27	804	73.61	19.64	376
3	93.42	29.92	734	68.07	11.94	62
4	63.67	12.87	602	64.82	11.76	208
5	83.96	18.9	387	72.11	20.26	242
Land Use						
1. Recreational	61.65	34.43	684	66.02	24.85	246
2. Education	95.35	30.68	734	74.45	13.34	27
3. Commercial	65.50	14.41	690	64.59	11.16	231
4.Transport Terminals						
4.1 Bus	80.35	20.01	347	77.04	21.49	543
4.2 Rail	84.34	22.56	306	70.56	17.63	186

One other factor that can influence the crossing speed is the flow. In pedestrian crossings, as there is no continuous flow, the flow can be considered in terms of platoon size. The platoon sizes of pedestrians crossed at each location in terms of no. of platoons belonging to each LOS proposed by Premathilaka (2009) is given in Table 3 below. As in most locations, the no. of pedestrians crossing at the peak is higher than that of off-peak, a higher flow is assumed. The data shows that in peak, the no. of platoons with lower LOS is higher than that of off-peak. That is, in peak, the platoon sizes are generally higher than that of off-peak. This could also be a potential cause of the difference in crossing speeds with different level of traffic.

Table 3: Platoon formation in terms of LOS

LOS	**Location 1**		**Location 2**		**Location 3**		**Location 4**		**Location 5**	
	Peak	**Off-Peak**	**Peak**	**Off-Peak**	**Peak**	**Off-Peak**	**Peak**	**Off-Peak**	**Peak**	**Off-Peak**
A	73	93	60	62	37	25	8	36	53	49
B	34	53	49	69	40	15	8	17	67	65
C	8	14	30	22	6	1	4	16	17	5
D	2	2	15	6	1	0	11	16	7	0
E	0	0	10	5	4	0	6	1	3	1
F	0	1	24	1	20	0	41	2	5	0

In terms of land use, the highest variation in crossing speeds between peak and off-peak hours was observed at educational land use compared to other land uses considered in this research. It was observed that at the peak hour, the majority of the pedestrians using this crossing were school children who almost run across the pedestrian crossing while the police have stopped the vehicle traffic. It was observed that 16% of the school children ran through the pedestrian crossing to reach the other side of the road. This points to an apparent relationship between pedestrian composition and average crossing speed, highlighting the importance of investigating the variations of crossing speed with varying pedestrian characteristics.

5.2 Variation of Crossing Speed with Land Use

In most of the locations, between the land use at the two ends of the crossing, one land use was observed to be dominant than the other in attracting pedestrians. In the peak hour, the passenger flow towards this dominant land use was much higher than the passenger flow away from this dominant land use. The crossing speeds at each of the land uses are given in Table 4 below. The cumulative distribution of the crossing speeds at each land use is given in Figure 2.

Table 4: Variation of Crossing Speeds with Land Use

Land Use	**Speed (m/min.)**		**Percentile Speed (m/min)**		**Sample Size**	**Considerations**
	Mean	Std. dev.	15th	85th		
1. Recreational	84.19	16.65	69.11	95.03	301	Playgrounds and Stadium
2. Education	87.00	17.66	73.26	100.73	668	Schools
3. Commercial	63.94	12.06	55.28	73.70	1677	Shops
4. Transport Terminal						
4.1. Bus	80.63	20.40	69.11	95.03	1317	
4.2. Rail	77.01	15.28	63.09	91.13	450	

The highest crossing speed was observed near educational land use. This is due to the high composition of young people and school children using the pedestrian crossings near this land use (of whom 16% ran across the road). For transport terminals, bus and rail were separately analysed for the benefits of the urban planners. Crossing speeds for commercial land use show the lowest crossing speeds. This also could be due to the majority of the pedestrian composition near commercial land use belonging to the young/middle or elder age category. This also hints at the influence of pedestrian composition on average crossing speed at each land use. The Cumulative Distribution Functions (CDF) for each land use are given in Figure 2.

The significance of the difference of crossing speeds of varying land use was tested to a 95% confidence level using a t-test. The resulting p-values are included in Table 5 below. A significant difference in pedestrian crossing speeds was observed among many land uses. Significant differences were observed between transport terminals, and other land uses such as education and recreation. A significant difference in speed was also observed between bus and railway stations.

Table 5: Significance of Difference in Crossing Speeds Variation with Land Use

	Education	**Commercial**	**Bus**	**Rail**
Recreational	0.06	0.00	0.04	0.00
Education	-	0.00	0.00	0.00
Commercial	0.00	-	0.00	0.00
Bus	0.00	0.00	-	0.00

Not Significant   Significant

These significant differences observed proves that special attention needs to be given to land use when planning for pedestrian crossings. According to the results of this study, different design speeds should be used when planning for crossings at different land uses.

There is no significant difference observed between Recreational and Educational land use. One possible reason for this is the similar pedestrian composition. The recreational land uses observed in this study are the stadium and playgrounds. Therefore, it can be hypothesized that both recreational and education land uses attract similar types of pedestrians that are youths. However, further research is needed to solidify this finding.

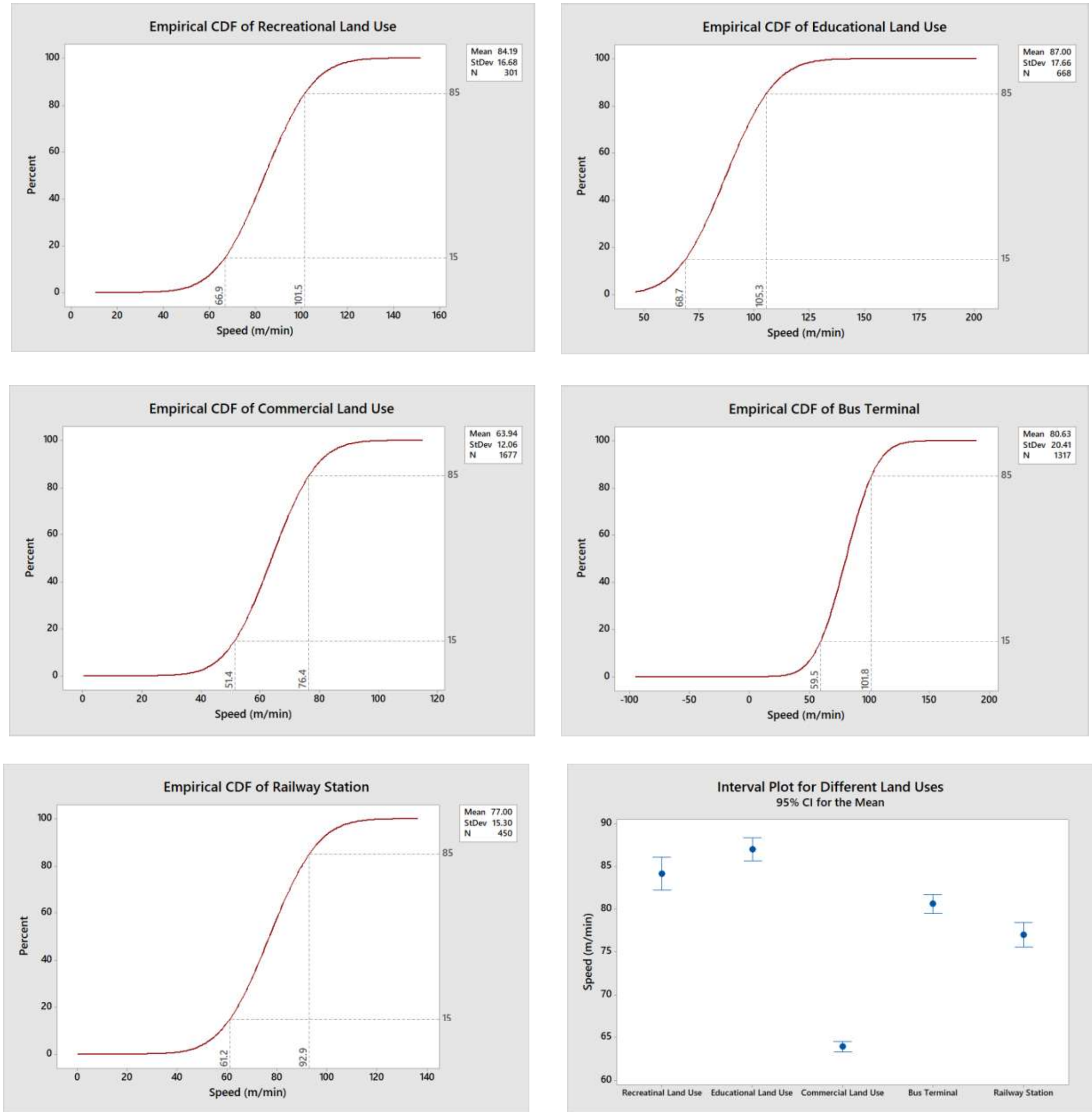

Figure 2: CDF of Different Land Use

5.3 Variation of Crossing Speed with Pedestrian Characteristics

5.3.1 Variation of Crossing Speed with Sex

Table 5 shows the pedestrian crossing speed variation for each sex at each location. The male population crossing speed is higher than the crossing speed of the female population in all locations except location 3. A 1.8–10.13 m/min difference was observed between the crossing speeds of males and females. Overall, males show higher crossing speeds than females. The mean crossing speed of males is 78.88 m/min with a standard deviation of 19.45 m/min while the crossing speed of females is 75.30 m/min with a standard deviation of 19.16. The significance of this difference was tested to a 95% confidence level, which resulted in a p-value of 0.01. Therefore, the crossing speed of males is significantly different from females.

Table 6: Variation of Crossing Speeds with Sex

Location	Land Use		Male (m/min)		Female (m/min)	
	End-1	End-2	Mean	Std. dev.	Mean	Std. dev.
1	Bus Stand	Stadium	87.71	20.85	77.57	16.73
2	Long Distance Bus Stand	Bus Stand	76.17	20.83	73.32	20.31
3	Schools	City	88.13	24.38	96.35	35.65
4	City	Bus Stop	64.94	13.23	63.11	11.79
5	Railway Station	Midblock	84.70	21.42	75.23	18.08
		Overall Average	**78.88**	**19.45**	**75.30**	**19.16**

To understand the variation observed at location 03, the composition of pedestrians at each location in terms of their sex was analysed. Since the level of traffic was found to significantly affect the walking speeds, pedestrians were further analysed under the level of traffic as well. The composition is given in Figure 3 below.

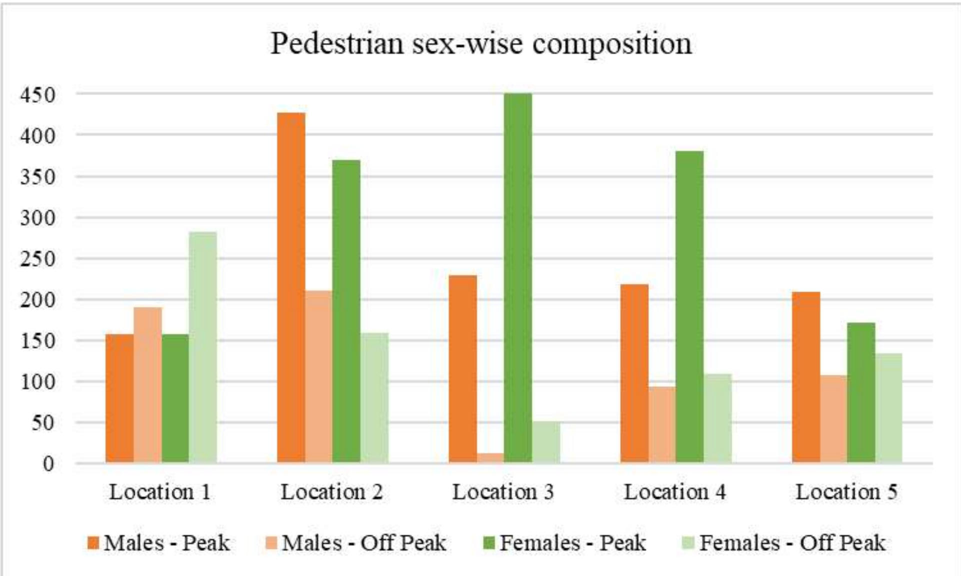

Figure 3: Sex-wise composition of pedestrians at each location

Location 3 is located near a girls' school, where 16% of the students ran to cross the street, thus showing an increase in crossing speed. The pedestrian composition at location 3 at peak consisted of 66% females at peak. Therefore, this variation of higher female speeds observed in location 3 could be attributed to the high pedestrian composition of females, of whom 16% ran, at peak.

However, similarity is observed at location 4 where the no. of females are higher than that of males at peak. But at location 4, the crossing speeds of males were higher than that of females, indicating the influence of other factors. One of the major differences among the locations was the age composition of the pedestrians who belonged to each sex. Therefore, this hints at the influence of age-sex composition on the crossing speeds of pedestrians.

5.3.2 Variation of Crossing Speed with Sex and Age

Table 6 shows the pedestrian crossing speed variation according to their sex and age. Males show a higher crossing speed than females for all age groups. Toddler/Pre-Schoolers and the school-aged population shows the highest crossing speeds. It is observed that the crossing speed decreases with the increasing age.

Table 7: Variation of Crossing Speeds with Sex and Age

Age	**Sex**	**Average Speed (m/min)**	**Std. dev. (m/min)**
Toddler/ Pre-Schooler		82.26	17.97
School	M	85.57	16.84
	F	83.24	20.05
Young/Middle	M	78.44	19.80
	F	72.76	18.09
Elderly	M	67.81	16.79
	F	68.01	15.72

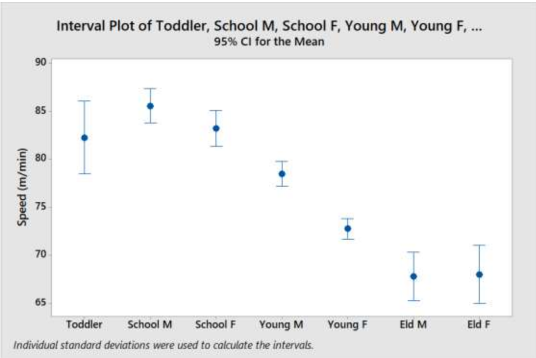

Figure 4: Interval Plot of Crossing Speed Variation with Age-Sex Composition
*here Young means Young/Middle age group

The speeds observed in this study also matched the speeds put forth by Rengarasu et al. (2012). In their study, they have calculated the crossing speed using university students as a sample. The speeds calculated by them (79.8 m/min for males, 78.6 for females) for a sample who falls under the young/middle age category is in a similar range to speeds calculated by this study.

Between each age-sex group, the difference in average speed was tested to a 95% confidence level. The p-values of the t-tests are given in Table 7 below.

Table 8: Significance of Difference in Crossing Speeds Variation with Age-Sex composition

Test	**p value**	**Significance**
Toddler vs School Male	0.06	Not Significant
Toddler vs School Female	0.27	Not Significant
School Male vs School Female	0.02	Significant
School Male vs Young Male	0.00	Significant
School Female vs Young Female	0.00	Significant
Young Male vs Young Female	0.00	Significant
Young Male vs Elderly Male	0.00	Significant
Young Female vs Elderly Female	0.00	Significant
Elderly Male vs Elderly Female	0.39	Not Significant

Even though the difference between Toddler/Pre-Schoolers and School-aged males and females is not statistically significant, they were analysed as a separate group due to difficulty in identifying their sex through visual observation. The large range of Toddler/Pre-Schooler crossing speed reflects their tendency to match the speed of accompanying adults as well as run.

The influence of the age-sex composition was investigated to understand the dissimilar crossing speeds of males and females observed at location 3 (Table 5). Since location 4 had a similar sex-wise composition, the age-sex composition of both locations is given in figure 5.

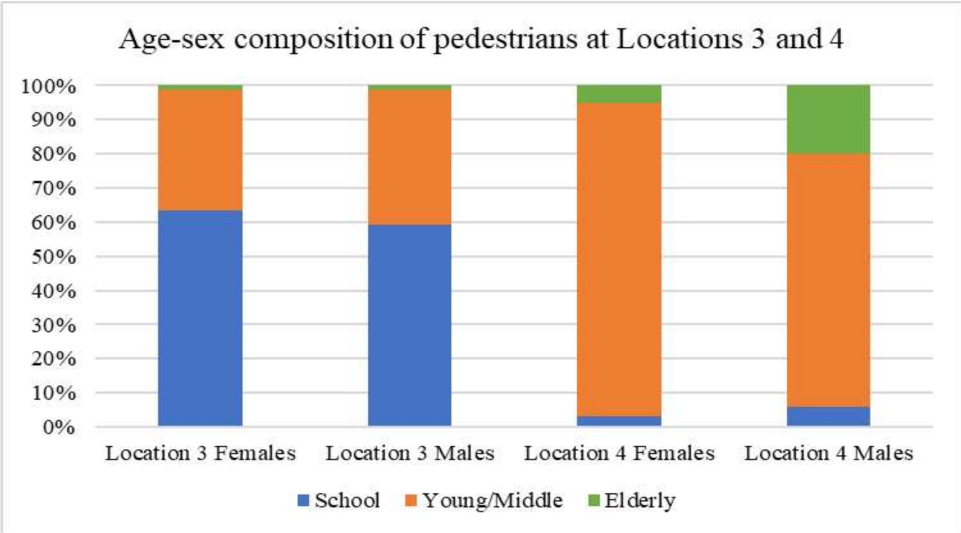

Figure 5: Age-Sex composition of pedestrians at locations 3 and 4

The figure shows that the age composition of females at both locations are different from each other. Location 3 has a majority of school-aged females while location 4 majorly has young/middle aged females. The percentage of elderly pedestrians are also higher at location 4. Since the crossing speeds decreases with age, the increase of crossing speeds of females at location 3, despite being of similar sex-wise composition to location 4 can be explained as the influence of age-sex composition of crossing speeds.

Premathilaka (2008) used the value 70.9 m/min for designing pedestrian facilities. The average walking speed of the elderly population is lower than this proposed speed at 67.81 - 68.01 m/min. This means that more than 50% of the elderly population will not cross safely using facilities designed using the speed proposed by Premathilaka (2008). Therefore, in locations where high demand for crossing by elderly pedestrians appears, special considerations should be given when designing crossings. This is especially true when deciding the green time for a pedestrian crossing at signalized crossings.

5.3.3 Variation of Crossing Speeds with Special Conditions

The average crossing speeds of the pedestrians with visible physical conditions are given in Table 8 below. It should be noted that the sample size was not enough to conclusively quantify the speed reductions, beyond the obvious reduction.

The data shows an apparent reduction in speed. However, further studies are needed to conclusively investigate the crossing times of pedestrians with the abovementioned conditions.

Table 9: Variation of Crossing Speeds with Special Conditions

Condition	Sample Size	Average Speed (m/min)	Std. dev. (m/min
Luggage Carrying	53	71.03	13.10
Male	37	70.34	11.98
Female	16	72.66	15.26
Pregnant	23	70.00	12.08
Disabled	8	51.04	9.84
Cyclists	3	74.06	5.03

5.4 Pedestrians with Special Conditions

5.4.1 Composition

During data collection, notes were made if the pedestrian had a special condition that would impact their crossing speeds. These were carriage of heavy luggage (duffel bags, etc.), visible stage of pregnancy, visible physical disabilities that affect walking (walking aids, etc.) as well as walking with a bicycle. The no. of pedestrians with each condition at each location is given in Table 9 below.

Table 10: Pedestrians with Special Conditions

		Location 1		Location 2		Location 3		Location 4		Location 5	
		Peak	Off Peak	Peak	Off Peak	Peak	Off Peak	Peak	Off Peak	Peak	Off Peak
With special conditions	**Luggage Carrying**	10	1	18	20	0	0	0	0	3	1
	Pregnant	2	3	8	0	5	0	0	1	2	2
	Disabled	2	0	3	2	0	0	1	0	0	0
	Cyclists	0	0	0	0	2	0	0	0	0	1
Without special conditions		290	465	1023	412	826	64	611	213	554	247
Pedestrians with special conditions as a % of total		5%	1%	3%	5%	1%	0%	0%	0%	1%	2%

Data showed that the no. of pedestrians with the abovementioned special conditions are significantly lower when compared to the total no. of pedestrians that crossed at the particular location. This can be due to two reasons. Either they tend to not cross the road or do so when the level of traffic is low. The determination of a cause requires further research because a conclusive statement cannot be made as only one hour in the off-peak was observed in this study.

5.4.2 Influence on crossing speeds of other pedestrians

The effect of these pedestrians on the crossing speed of other pedestrians should not be ignored. In pedestrian crossing, the pedestrian flow is in terms of platoons. Therefore, a pedestrian with a special condition can influence the pedestrian speed of the whole platoon. Table 10 below summarizes the no. of platoons that had pedestrians with each special condition as well as the no. of pedestrians whose crossing speeds they have influenced.

Overall, the crossing speed of only 7% of the total pedestrians could have been affected by the pedestrians with special conditions. Therefore, the effect of pedestrians with special conditions on the crossing speed of other pedestrians was considered negligible in this study.

Table 11: Pedestrians affected by Pedestrians with Special Conditions

	Location 1		**Location 2**		**Location 3**		**Location 7**		**Location 11**	
	Peak	**Off Peak**	**Peak**	**Off Peak**	**Peak**	**Off Peak**	**Peak**	**Off Peak**	**Peak**	**Off Peak**
Luggage Carrying	5	4	14	19	0	0	0	0	3	1
Pregnant	1	1	7	0	5	0	0	1	2	2
Disabled	1	3	3	1	0	0	1	0	0	0
Cyclists	0	0	0	0	2	0	0	0	0	1
No. of pedestrians affected	15	18	103	39	39	0	9	2	8	2
No. of pedestrian affected as a % of pedestrians without special condition	5%	4%	10%	9%	5%	0%	1%	1%	1%	1%

6. CONCLUSION

The crossing speed of pedestrians at peak times is significantly higher than that of off-peak times. This finding was consistent with the findings of Chaudhari *et al*., (2017). The average crossing speed of pedestrians was also found to significantly found to vary with varying land use. Namely, education, recreation, commercial, transport terminals. The highest crossing speeds were observed near education land use while the lowest was observed near commercial land use. These variations of speed at peak/off-peak at different locations as well as land use showed to be potentially caused by variation of speed with the age-sex composition of pedestrians in demand for crossing at the locations/land uses.

Males, whose average crossing speed is 78.88 m/min, have a higher crossing speed than females (75.3 m/min). The analysis showed that there is a significant difference in the average speed between different age-sex compositions. A significant difference was observed between each of the age-sex groups except toddler/preschoolers and school pedestrians as well as elder male and female pedestrians. The crossing speeds of pedestrians decrease as age increases. The crossing speeds of the females of each age group were found to be lower than its males. This difference in speeds is statistically significant for every age group except the elderly. Furthermore, the speeds calculated in this study was similar to speeds calculated by Rengarasu et al. (2012) for pedestrians of a similar age-sex group.

The average crossing speed of elders around 68 m/min is much lower than the design speed suggested by previous studies conducted in Sri Lanka (Premathilake, 2008), which is 70.9 m/min. This signified the importance of considerations to the age-sex composition of pedestrians and their respective crossing speeds when designing safe and inclusive crossings.

These speed variations should be considered by urban planners when designing pedestrian crossings. As the pedestrian composition influences the average crossing speed of the pedestrians, special attention should be given to identifying the pedestrian composition when designing the crossing to understand the user requirements.

This study had the limitation of insufficient sample to quantify the differences in speeds of pedestrians due to special conditions such as visible state of pregnancy, disabilities, etc. but only to establish that there is a noticeable difference. The effect of these conditions on pedestrian speeds must be quantified through further research. This will be especially useful for planners when designing crosswalks for land use such as hospitals, nursery schools, etc. where a majority of the users have such special conditions.

7. RECOMMENDATIONS

Recommendations for further research include investigating and quantifying the variation in crossing speeds due to special conditions and determining standards for design speeds for crossings near different land uses.

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