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Pedestrian movement characteristics at signalised intersections

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1 INTRODUCTION

This paper presents findings of an investigation of pedestrian movement characteristics at intersection signalised crossings. The main objective of the study was to obtain information on pedestrian crossing speeds used for signal timing purposes, and pedestrian movement start loss and clearance time gain parameters used in pedestrian delay calculations. The method employed for pedestrian surveys was developed in a similar study of pedestrian movement characteristics at signalised mid-block crossings (Akçelik & Associates 2001a).

Surveys were conducted at four signalised intersections of four-lane roads in busy suburban shopping strips with high volumes of vehicle traffic. The sites were located at the intersections of Kingsway and Railway Parade North in Glen Waverley, Prospect Hill Road and Burke Road in Camberwell, Balwyn Road and Whitehorse Road in Balwyn and Exhibition Street and Lonsdale Street in the Melbourne City (see *Figures 1a and 1b*).

Glen Waverley

Balwyn

Figure 1a - Views of Glen Waverley and Balwyn survey sites

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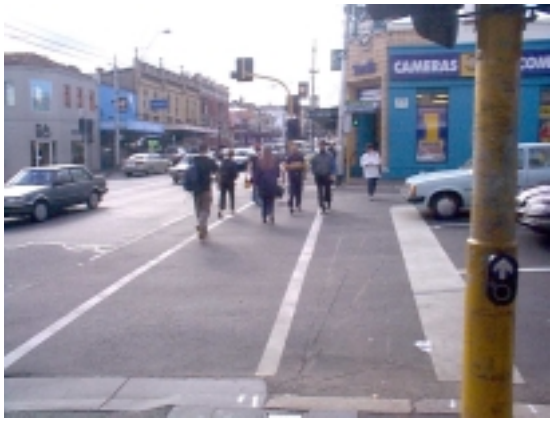

Camberwell

City

Figure 1b - Views of Camberwell and City survey sites

Crossing distances are longer than across four lanes at the Glen Waverley, Camberwell and the City sites due to an additional right-turn lane or parking area. Pedestrians using the marked foot crossing, as well as those using the area between the vehicle traffic stop line and the marked foot crossing were included in the survey. Two surveys were conducted at each site, one on the weekend and one on a weekday. Surveys were carried out during 12 noon and 4 pm. A sample size corresponding to approximately 50 signal cycles was obtained for each survey. The weather was rainy during the weekday survey periods at the Camberwell and City sites.

Pedestrian crossing speeds for different sites, weekdays and weekends, queued and unqueued pedestrians, and pedestrians with and without walking difficulty are presented in *Section 2*. Pedestrian movement start loss and clearance time gain values are given in *Section 3*.

The results of this study are compared with the findings from the study of pedestrians at mid-block signalised crossings.

2 PEDESTRIAN CROSSING SPEEDS

Pedestrian crossing speeds (average, standard deviation, 15th, 50th and 80th percentile values) obtained from surveys at the four sites are summarised in *Table 1*. The speed profile (percentage of pedestrians crossing below a given speed) for data representing all sites combined including data for both weekdays and weekends is shown in *Figure 2*.

A study of pedestrian crossing speeds at mid-block signalised crossings (Akcelik and Associates 2001a, Hill and Seidel 2000) showed that the 15th percentile speed for all pedestrians (including pedestrians with walking difficulty) is very close to the design speed of 1.2 m/s recommended for signal timing purposes in various traffic engineering guides, e.g. AUSTROADS (1993, 1995). The 15th percentile speeds shown in *Table 1* range from 1.18 to 1.59 m/s, and the value of 1.24 m/s for all sites combined is close to the recommended value.

Figure 3 shows the speed profiles for the four sites with weekday and weekend data combined for each site. Comparison of speed profiles for weekdays and weekends (data for individual sites combined for each period) is shown in *Figure 4*.

Table 1

Pedestrian crossing speeds (m/s) at four intersection signalised crossings

	Average speed	Standard deviation	15th percentile	50th percentile	85th percentile
Balwyn Weekday	1.53	0.31	1.23	1.55	1.85
Balwyn Weekend	1.88	0.41	1.59	1.83	2.24
Balwyn Combined	1.70	0.41	1.31	1.65	2.05
Glen Weekday	1.76	0.64	1.29	1.64	2.17
Glen Weekend	1.51	0.22	1.32	1.52	1.71
Glen Combined	1.64	0.49	1.30	1.58	1.84
Camberwell Weekday	1.90	0.76	1.33	1.70	2.34
Camberwell Weekend	1.51	0.31	1.20	1.46	1.81
Camberwell Combined	1.71	0.61	1.24	1.56	2.02
City Weekday	1.56	0.39	1.29	1.49	1.68
City Weekend	1.39	0.27	1.18	1.34	1.60
City Combined	1.47	0.34	1.22	1.41	1.64
All Weekdays Combined	1.68	0.56	1.28	1.56	2.05
All Weekends Combined	1.58	0.37	1.21	1.55	1.89
All Sites Combined	1.63	0.48	1.24	1.56	1.96

Standard deviations for "combined" cases are based on aggregate data.

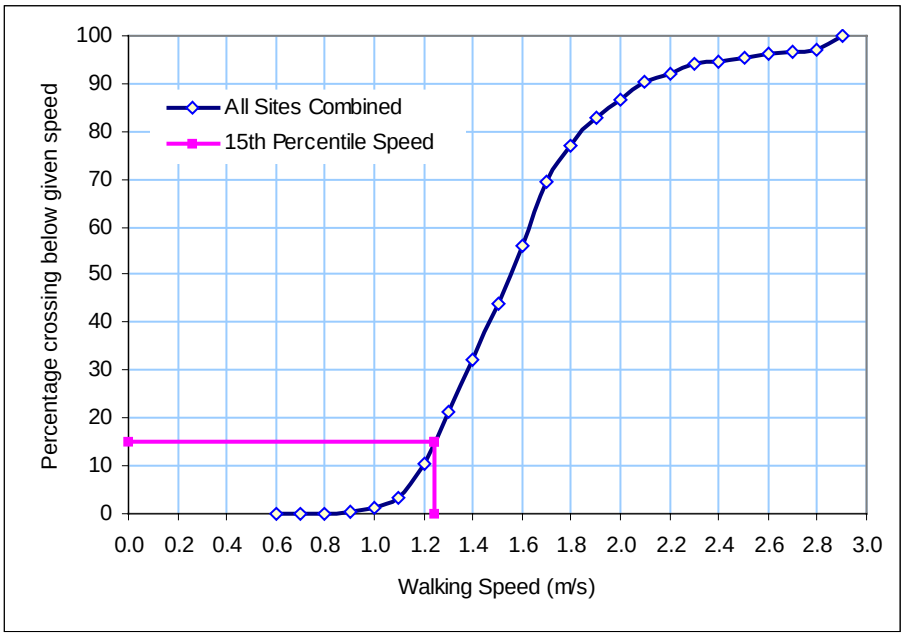

Figure 2 - Pedestrian speeds at four intersection signalised crossings: data for all sites combined

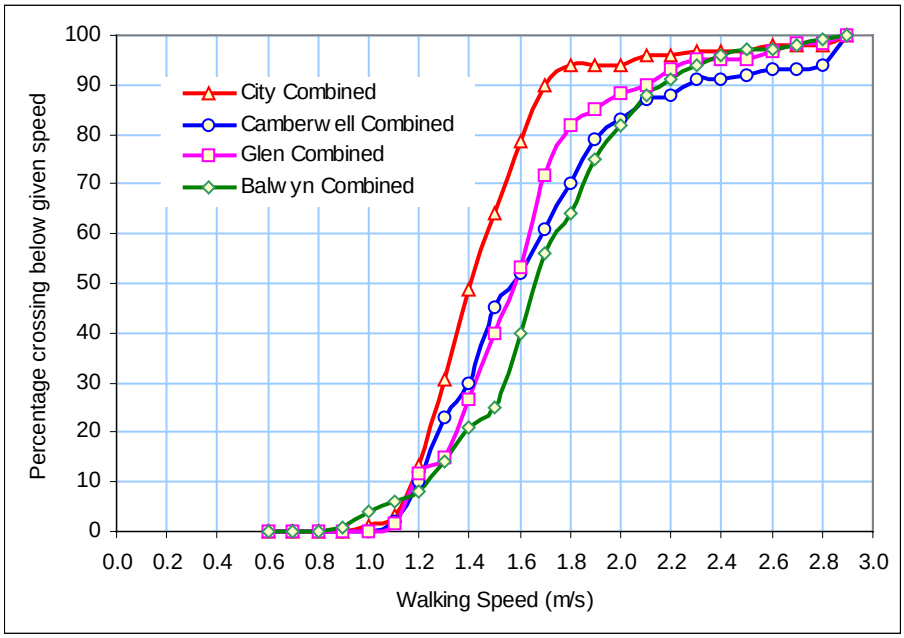

Figure 3 - Pedestrian crossing speeds for individual sites: weekday and weekend data combined for each site

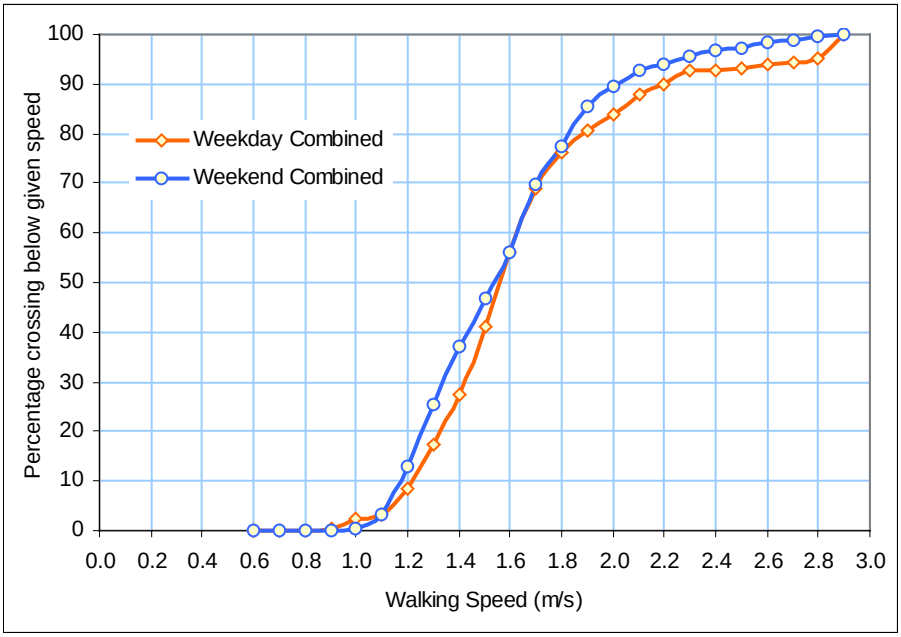

Figure 4 - Pedestrian crossing speeds for weekdays and weekends: data for individual sites combined

Speed profiles for all sites including weekend and weekday results are given together in *Figure 5*. Comparison of speed profiles for *queued* and *unqueued* pedestrians (those who arrived *before* and *during* the Walk display, respectively) with data for all sites combined is shown in *Figure 6*.

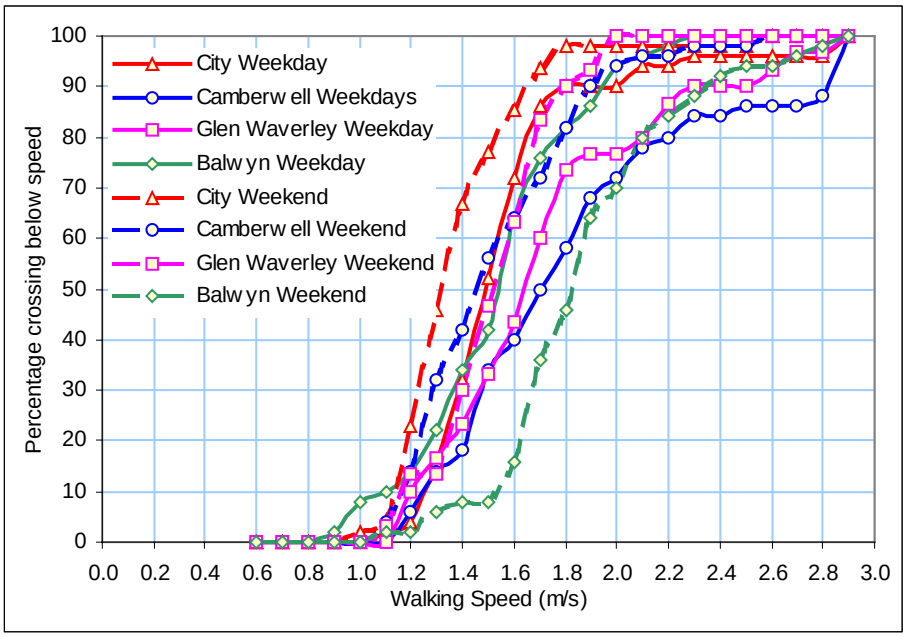

Figure 5 - Pedestrian crossing speeds for individual sites: all data

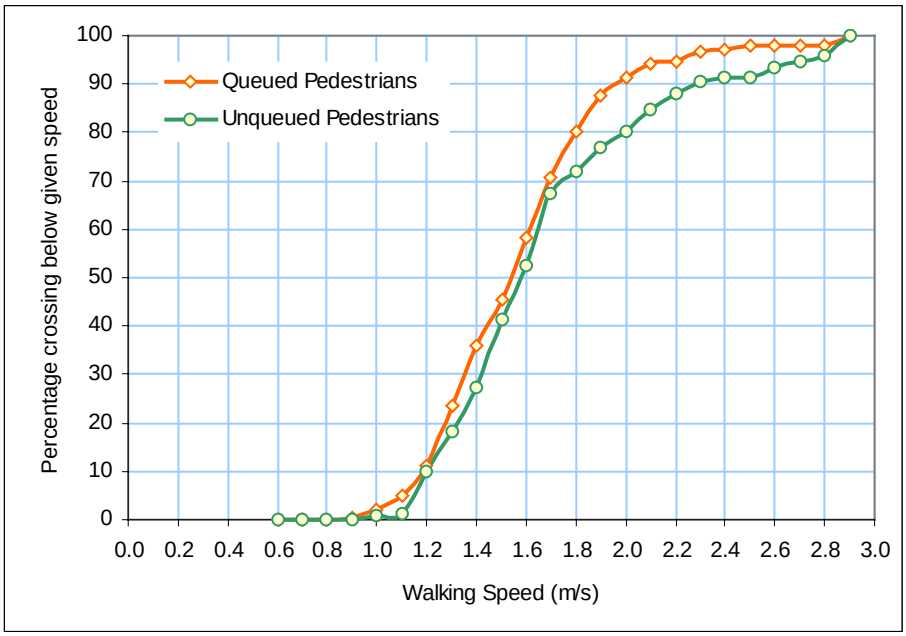

Figure 6 - Pedestrian crossing speeds for queued and unqueued pedestrians: data for individual sites combined

Crossing speeds for pedestrians with and without walking difficulty and for all pedestrians (with data for individual intersection signalised crossing sites combined) are summarised in *Table 2* and shown in *Figure 7*. The "pedestrians with walking difficulty" were identified irrespective of their age. This group included elderly persons, people with physical disability, parents pushing a pram and/or paying attention to a young child walking alongside, and constituted 6 per cent of the total sample size.

The 15th percentile speed (1.14 m/s) for this group is a little higher than the design speed of 1.0 m/s recommended by AUSTROADS (1993, 1995) for accommodating slower pedestrians.

Table 2

Crossing speeds (m/s) of pedestrians with and without walking difficulty (data for all INTERSECTION signalised crossing sites combined)

	Average speed	Standard deviation	15th percentile	50th percentile	85th percentile
Pedestrians with walking difficulty	1.35	0.25	1.14	1.29	1.63
Pedestrians without walking difficulty	1.70	0.50	1.31	1.60	2.04
All pedestrians	1.63	0.48	1.24	1.56	1.96

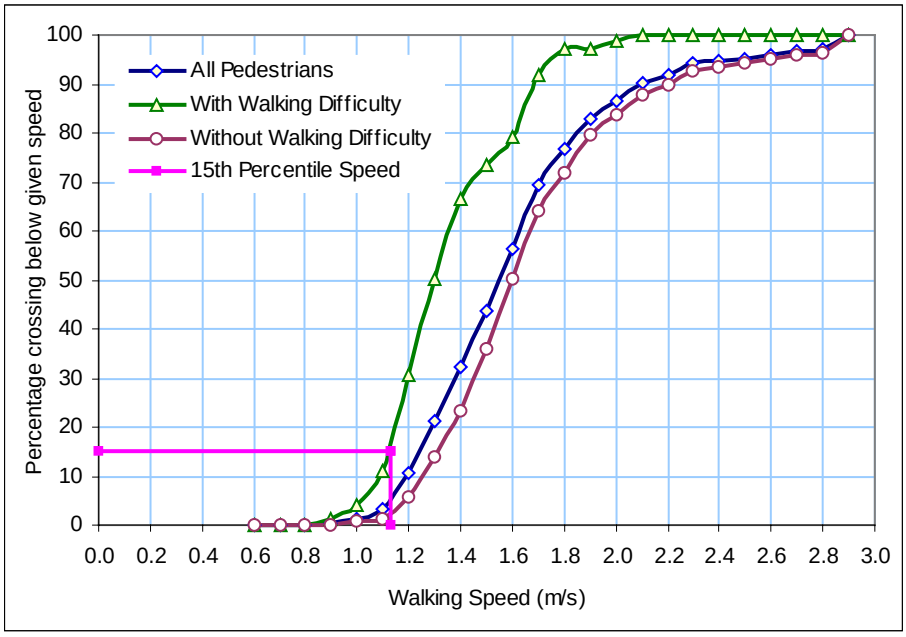

Figure 7 - Crossing speeds for pedestrians with and without crossing difficulty and for all pedestrians: data for individual sites combined

Crossing speeds for pedestrians with and without walking difficulty and for all pedestrians (with data for individual ***mid-block*** signalised crossing sites combined) are summarised in *Table 3* (from Akcelik and Associates 2001a). A comparison of speed profiles for intersection and mid-block signalised crossings is shown in *Figure 8*. Comparison of data in *Tables 2 and 3* as well as the speed profiles in *Figure 8* indicate that crossing speeds are higher at signalised intersections. This could be due to a perception of less safe environment, especially due to turning vehicle conflicts. However, the speed distributions for mid-block and intersection sites are closer for slower (below-average) crossing speeds.

Table 3

Crossing speeds (m/s) of pedestrians with and without walking difficulty (data for all MID-BLOCK signalised crossing sites combined)

	Average speed	Standard deviation	15th percentile	50th percentile	85th percentile
Pedestrians with walking difficulty	1.29	0.28	1.00	1.31	1.52
Pedestrians without walking difficulty	1.45	0.22	1.23	1.44	1.66
All pedestrians	1.42	0.24	1.18	1.42	1.65

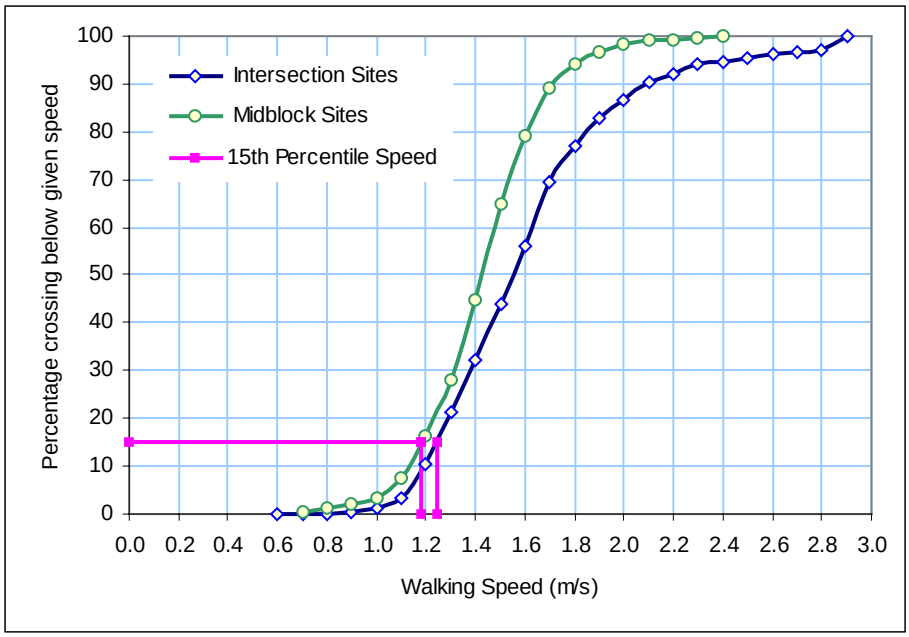

Figure 8 - Pedestrian speeds at intersection and mid-block signalised crossings

Figure 9 shows the speed profile for all data for intersection and mid-block signalised crossings combined. For all data combined, the average crossing speed = 1.53 m/s, standard deviation = 0.40 m/s, 15th percentile speed = 1.22 m/s, 50th percentile speed = 1.47 m/s, and 85th percentile speed = 1.80 m/s were found.

These results indicate that the design speed of 1.2 m/s which is commonly used for signal timing purposes represents the 15th percentile crossing speed, with the corresponding average crossing speed being 1.5 m/s (15th percentile speed is generally around 80 per cent of the average speed).

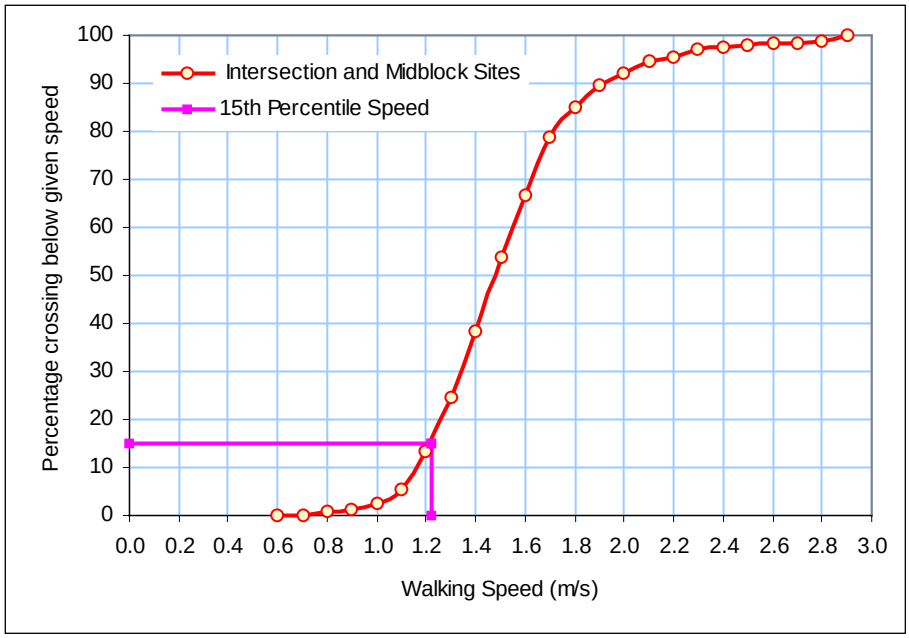

Figure 9 - Pedestrian crossing speeds for intersection and mid-block signalised crossing data combined

3 PEDESTRIAN START LOSS AND CLEARANCE TIME GAIN

The aaSIDRA software package (Akcelik and Associates 2001b) employs the pedestrian *start loss* and *clearance time gain* parameters for determining an *effective green time* for each pedestrian movement, which is needed for modelling pedestrian performance measures such as delay, queue length and number of stops.

The start loss time is measured as the time lag for stepping on the crossing after the start of the Walk display. The clearance time gain is measured as the first part of the pedestrian clearance (Flashing Don't Walk) interval when the pedestrians continue to step-on and use the crossing.

Table 4 summarises the pedestrian start loss and clearance time gain values for the *intersection* signalised crossing survey sites. *Table 5* compares the pedestrian start loss and clearance time gain values for the *intersection* and *mid-block* signalised crossing sites (from Akcelik and Associates 2001b). It is seen that, while the clearance time gains are similar for intersection and mid-block signalised crossings, the start loss values are larger for intersection signalised crossings. This again could be as a result of a perception of less safe environment, due to turning vehicle conflicts in particular.

Table 4

Pedestrian movement start loss and clearance time gain values for INTERSECTION signalised crossing sites

	Start loss		Clearance time gain		Clearance time gain less start loss
	Average	Standard deviation	Average	Standard deviation	
Balwyn Weekday	2.60	1.08	2.10	0.69	-0.50
Balwyn Weekend	1.89	1.02	2.70	0.62	0.81
Balwyn Combined	2.26	1.10	2.40	0.68	0.14
Glen Weekday	3.31	1.60	4.48	4.45	1.17
Glen Weekend	2.75	1.21	0.00	0.00	-2.75
Glen Combined	3.01	1.41	4.48	4.45	1.47
Camberwell Weekday	2.45	1.84	2.47	N/A	0.02
Camberwell Weekend	3.49	1.72	5.60	N/A	2.11
Camberwell Combined	3.06	1.82	4.03	2.22	0.97
City Weekday	2.92	1.78	1.70	1.70	-1.22
City Weekend	2.16	1.12	0.00	N/A	-2.16
City Combined	2.51	1.55	1.70	1.70	-0.81
All Weekdays Combined	2.79	1.57	2.84	2.64	0.05
All Weekends Combined	2.57	1.45	2.05	1.43	-0.52
All Sites Combined	2.68	1.51	3.02	2.31	0.35

Table 5

Comparison of pedestrian movement start loss and clearance time gain values for INTERSECTION and MID-BLOCK signalised crossing sites

	Start loss		Clearance time gain		Clearance time gain less start loss
	Average	Standard deviation	Average	Standard deviation	
INTERSECTION signalised crossing sites					
All Weekdays Combined	2.79	1.57	2.84	2.64	0.05
All Weekends Combined	2.57	1.45	2.05	1.43	-0.52
All sites combined	2.68	1.51	3.02	2.31	0.35
MID-BLOCK signalised crossing sites					
All Weekdays Combined	1.35	0.57	2.75	2.38	1.4
All Weekends Combined	1.27	0.53	3.08	2.17	1.8
All sites combined	1.30	0.55	2.93	2.25	1.6

4 CONCLUSION

The findings of this study of pedestrian movement characteristics at intersection signalised crossings complemented by the earlier findings of the study of pedestrian movement characteristics at mid-block signalised crossings (Akcelik and Associates 2001b, Hill and Seidel 2000) indicate some significant differences at these two types of crossing.

Further studies are recommended to investigate pedestrian movement characteristics at intersection and mid-block signalised crossings to cover a greater variety of conditions (e.g. different intersection sizes, different road types, different locations, staged crossings, etc). Study of pedestrian movement characteristics at unsignalised (Zebra) pedestrian crossings is also recommended.

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DISCLAIMER

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