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THE COMPARATIVE SAFETY OF PEDESTRIAN CROSSINGS

by

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THE COMPARATIVE SAFETY OF PEDESTRIAN CROSSINGS

ABSTRACT

Injury accident data, pedestrian counts and vehicle flows have been studied for lengths of road on and near 140 pedestrian crossings. These crossings were located in similar conditions at sites throughout the country which were selected on the basis of having good visibility and not being close to busy junctions. Analysis of the data showed that daytime accident rates were closely related to the function $P^{¼}V$, where P is pedestrian flow and V is vehicle flow per hour, but that there was no consistent pattern between darkness accident rates and flows. There was no evidence of any differences in accident rates between Zebra crossings with and without refuges, nor of differences in pedestrian accident rates between Pelican and Zebra crossings. The analysis did provide evidence that Pelicans have a lower total injury accident rate than Zebras when the road length in the vicinity of the crossing is taken into account. It is estimated that, if operated under the same flow conditions, Pelicans would have approximately half an accident per year less than Zebras over the 100 yard length of road including the crossing.

1. INTRODUCTION

A number of different pedestrian facilities have been introduced at various times in recent decades; early striped crossings, Panda crossings and the latest zig-zag Zebras, simple stop-and-go signalised crossings, London Pedestrian Control Experiment crossings ('matchstick men'), X-Ways and finally Pelican crossings. Limited comparative measurements of accidents at these crossings have been made from time to time, but the results have often been inconclusive or have had only temporary or local validity. A nation-wide assessment of the comparative safety of the existing types of crossing seemed particularly desirable. This study is therefore concerned primarily with a comparison of Zebra and Pelican crossings.

2. PROBLEMS OF MEASUREMENT

There are various difficulties of measurement which have undoubtedly contributed to inconclusiveness of previous studies of this subject, and these problems are discussed below.

2.1 Time factors

The accumulation of personal injury road accidents at a typical urban pedestrian crossing is slow, being of the order of one or two reported accidents per year to pedestrians or vehicles near the crossing (see Appendix Tables 9 and 10). At least five years of unmodified operation of a crossing is generally desirable for the collection of a statistically reliable sample of accidents under a given regime of traffic. In recent years urban pedestrian crossings have, all too often, been either modified or re-sited or subjected to new traffic circulation or control systems. It is usually impossible to obtain accurately representative figures for the mean annual traffic and pedestrian flows for periods of a few years of accident counting,

because relevant traffic counts tend to be few and sporadic, systematic pedestrian flow counts are even rarer and reliable factors for the conversion of 'point-in-time' censuses to 'average-for-period' figures are virtually unobtainable.

2.2 Topographical factors

In urban areas road accidents are concentrated mainly at street junctions. These junctions frequently occur less than 100 yards apart, and pedestrian crossings are located between them. Road accidents reported as occurring within 50 yards, or even within 20 yards of a pedestrian crossing may often be partly or wholly attributable to the proximity of a street intersection (intersection collisions) and their relevance to the safety of the crossing is therefore slight. On the Stats. 19 Form of the national accident statistics the same accident can be reported as being within 50 yards of a pedestrian crossing and also within 20 yards of a street intersection. The re-location of a pedestrian crossing further away from a busy street junction merely serves to remove the crossing from a major source of accidents and may also modify the pedestrian flow over the crossing. Before-and-after accident studies of crossings which have been treated in this way between the accident counts often yield results which are difficult to interpret.

2.3 Accident reporting

The written or computer accident records used by local authorities contain the approximate injury accident location but often the accident cannot be classified with certainty as on the crossing walkway or within a given distance of it. The recorded distances of accidents from street intersections or other features are customarily estimated visually rather than being measured out with a tape or by a more convenient cyclometer-type wheel meter. The quoted estimates of distance were often found to disagree with the map grid references. Work on accident records for the present investigation has tended to show that map grid referencing of accidents, as currently practised, could be improved for purposes of traffic safety engineering at locations such as pedestrian crossings or street intersections. In such cases accidents need to be pinpointed by measurements, on the spot, to precisely specified permanent street features – preferably pavement kerb lines or building frontage lines nearest to the accident. At the opposite extreme, the uncritical counting of road accidents from computer prints of accidents within specified grid squares of a map seems to be the least reliable method of distinguishing the accidents to be associated with a pedestrian crossing or street intersection.

3. DESIGN OF THE INVESTIGATION

Studies of the comparative safety of pedestrian crossings are usually based on before-and-after counts of traffic accidents at groups of crossings converted from one type of operation to another. The usual procedure is to test the significance of changes in the accident counts, on the assumption that the traffic and pedestrian flows have remained unchanged. A suitable statistical control is also required. However, changes in the location and layout of crossings and in urban traffic systems render this assumption dubious for both the test and control sites.

A problem with an exercise of this scale is that there exists no central record of the numbers and locations of crossing facilities. Even if one had existed it would have been of limited value, since the widespread conversion of Zebra crossings to Pelicans meant that the populations being studied were continually changing. In addition the two crossing types tended to be located differently on the road network. Because of these factors, the comparison was limited to well-established crossings sited in what might be regarded as optimal locations, that is, away from intersections and with good visibility.

The accident rate at a reasonably well-established pedestrian crossing which is not too close to a busy junction and is not affected by poor visibility or other obvious abnormality will depend primarily on the vehicle and pedestrian flow over it. The aim of the present study was to compare the accident rates of crossings of different types installed in comparable situations.

Pedestrian crossings were selected according to the following criteria:

(i) to be in undivided urban streets with two way traffic;
(ii) to have a minimum pedestrian flow of 100/hour and a minimum vehicle flow of 600/hour in daytime conditions;
(iii) to be not less than 50 yards from any junction at which more than 100 vehicles/hour entered or left the street on which the crossing was located;
(iv) not be located near sharp bends or in other situations where road user behaviour could be affected by restricted visibility;
(v) to have been in their existing form and location for not less than four years for Zebras, and not less than three years for Pelicans.

In an extensive search for suitable crossings, these stipulations were found to be highly restrictive. Out of some 400 crossings visited by TRRL staff, less than half met the requirements above. It is important to note that since so few of the sites met the criteria, those selected are unlikely to be representative of all crossings. The aim of the exercise was to take selected samples of crossings in similar locations, rather than random samples of crossing installations. The crossings finally used are listed in the Appendix, Tables 6 to 8.

4. PROCUREMENT OF THE DATA

Measurements on the required scale and within any reasonable time period were beyond the staff resources available at TRRL, and therefore the necessary data were obtained from local authority engineers in various towns of England and Wales.

The data used in the study are described below and summarised in the Appendix, Tables 9 and 10.

4.1 Traffic census

The objective was to have a twenty-four hour traffic census on a typical weekday at each crossing selected in order to obtain values for the mean hourly flow during daylight – defined as the period between 0700 and 1900 hours, and darkness – defined as from 1900 to 0700 hours. In practice, however, twenty-four hour counts were obtained for only a quarter of the crossings in the sample. Most local authorities were able to provide eighteen hour counts (from 0600 hours to midnight), but there were many cases where only sixteen or seventeen hours of the day had been covered. Consequently, vehicle counts during the hours of darkness were restricted to a common four hour period of 0600 to 0700 hours and 1900 to 2200 hours.

It had been hoped to apply seasonal and other correction factors to the census figures obtained for each site on a local basis, but the absence of suitable data meant that only national traffic census correction factors were applied.

4.2 Pedestrian census

Wherever possible, a pedestrian count was carried out simultaneously with the traffic census. As mentioned above there was frequently only a limited coverage of the hours of darkness, and to maintain consistency the only pedestrian flows recorded in the darkness period were those occurring between 0600 and 0700 hours and between 1900 and 2200 hours.

The pedestrian counts included all those persons who crossed the road on and within 50 yards of the marked crossing. Separate counts were made of pedestrians crossing on the crossing itself, within 20 yards of the crossing, and between 20 and 50 yards from the crossing.

4.3 Parking and overtaking

While carrying out the pedestrian counts, the observers were required to record at intervals the numbers of vehicles parked within 20 yards, and between 20 and 50 yards of the crossings. A count was also made of the numbers of vehicles observed overtaking within 20 yards of the crossings.

4.4 Accidents

A record of the number of personal injury accidents occurring on the crossing walkway, within 20 yards, and between 20 and 50 yards of the crossing was required. Accidents on or within 50 yards of a pedestrian crossing are, at least nominally, recorded for the national accident statistics, but accidents within 20 yards of the crossing are not normally distinguished, and these could not be located with the desired certainty from many of the records available. Wherever computer prints of accident records containing both verbal and map grid referencing of accidents were provided, the locations of most reported accidents could be checked to some extent on the National Grid. In other cases, where only the local authority's own tabulation of selected relevant accidents was available, without grid references, the checking of locations was impossible. As already suggested, the location, and therefore the correct number, of the relevant accidents in each street zone at a crossing was regarded as perhaps the least satisfactory of the variables used in this study. However, every effort was made to maximise the accuracy of the accident data.

Some constraints which were imposed on the recording of the accident data should be noted. The major one was the introduction of zig-zag markings at Zebra crossings between 1971 and 1973 which acted as the limit to the period for which accident data for Zebra crossings could be collected. In order to avoid those accidents clearly unrelated to crossings, all accidents involving turning or junction manoeuvres were excluded, as were those associated with the boarding or alighting of public service vehicles.

A further point is that the periods for the flow counts and the accident data in darkness were not the same. It was mentioned above that it became necessary to restrict the darkness flow counts to a four hour period, but in order to avoid reducing drastically the numbers of accidents available for analysis, accidents were recorded for the entire twenty-four hour period.

5. RESULTS

Full accident and flow data were obtained for a total of 140 crossings. This total was made up of 51 Zebras without central refuges, 33 Zebras with refuges, and 56 Pelicans without refuges. The numbers of Pelicans with refuges available for study were too small to yield reliable results, and have not been included in the analysis. Data were collected for a small number of central refuges not associated with marked crossings; these have been included in the preliminary stage of the analysis.

5.1 Correlation of accidents with flow

In a previous limited study of pedestrian crossings in the Greater London area, the pedestrian injury accidents per year on the crossings were found to be reasonably well predicted by the formula $A = V(1 - e^{-3P})$, where V was the mean hourly traffic flow x 10^{-3}, and P was the mean hourly pedestrian flow x 10^{-3} over the crossing. For the preliminary analysis of the data from the present study, this and some other combinations of flow variables, namely PV, $(PV)^{½}$, and PV^2 were correlated with accident rates on and near the crossings. PV^2 is the basis of the criteria currently used for the installation of pedestrian crossing facilities. The results of the correlations are given in Table 1. The symbols Z^-, Z^+, P^- and R refer respectively to Zebra crossings without refuges, Zebras with refuges, Pelican crossings without refuges, and street centre refuges only. The correlations are between accidents and flows in the daylight period, ie 0700 to 1900 hours.

It can be seen from Table 1 that all the combinations of flow variables correlate almost equally well (albeit equally weakly) with accident rates. The correlation coefficients were consistently lower for Zebra crossings without refuges than for the other types of crossings. Those for central refuges alone were particularly high. All the correlation coefficients for total accidents for Zebra crossings with refuges and Pelican crossings without refuges were found to be significant at the 2 per cent level. There were high and mostly significant correlations between accidents and the flow variables within 20 yards of street refuges, but these were not significant over the 50 yard zone.

5.2 Models of accidents and flow

In the main stage of the analysis each combination of road section (on crossing, on and within 20 yards, on and within 50 yards) and accident type (pedestrian, vehicle, total) was examined separately. Of the nine possible combinations, it was found that vehicle accidents on the crossing were virtually non-existent. Accordingly, this category was omitted, together with total accidents on the crossing, since these were virtually identical to pedestrian accidents. This left seven combinations for analysis; it should be noted that these were not mutually independent.

To each of the seven sets of data a model was fitted of the form

$$\text{Accidents per year} = KLm\, P^b V^c$$

where P = pedestrian flow in thousands per hour,
V = vehicle flow in thousands per hour,
the exponents b and c are estimated from the data, and
m is a constant estimating the accident rate per year for Zebras without refuges.

In the model, K and L can be regarded as multipliers. K estimates the effect of Pelican operation, by being set at 1.0 if the crossing was a Zebra and taking a value k if the crossing was a Pelican. Similarly, L examines the effect of the presence of a central refuge, by being set at 1.0 if the crossing had no refuge and taking a value ℓ if a refuge was present.

There were thus two main areas of interest in this analysis. First, the values of the exponents b and c, which would indicate the form of the relationship between accidents and flow. Second, the values obtained for k and ℓ, where k compares the accident rate at Pelicans with that at Zebras, while ℓ compares the rate at Zebras with refuges with that of Zebras without refuges.

TABLE 1

Linear correlation coefficients of mean accidents per year at pedestrian crossings with various traffic flow functions

Limits of pedestrian crossing / Statistical data	No. of crossings observed	Type of crossing	Total accidents (ped + veh) — Linear correlation coefficient with the following functions				Pedestrian accidents — Linear correlation coefficient with the following functions				Vehicle accidents — Linear correlation coefficient with the following functions			
			$(PV)^{½}$	$PVx10^{-4}$	PV^2x10^{-9}	$V(1-e^{-3P})$	$(PV)^{½}$	$PVx10^{-4}$	PV^2x10^{-9}	$V(1-e^{-3P})$	$(PV)^{½}$	$PVx10^{-4}$	PV^2x10^{-9}	$V(1-e^{-3P})$
Within 50 yards	51	Z^-	0.251	0.223	0.271	0.293	0.247	0.205	0.239	0.278	0.141			
of the crossing	33	Z^+	0.519	0.520	0.590	0.569	0.451	0.442	0.443	0.462	0.401	0.411	0.529	0.474
(including the	56	P^-	0.472	0.503	0.500	0.462	0.424	0.449	0.432	0.418	0.258	0.272	0.305	0.248
walkway)	11	R	0.611	0.488	0.582	0.550	0.583	0.565	0.541	0.565				
Within 20 yards	51	Z^-	0.217	0.191	0.216	0.242	0.264	0.235	0.238	0.279	0.009	0.004	0.124	0.033
of the crossing	33	Z^+	0.488	0.481	0.589	0.562	0.413	0.388	0.418	0.441	0.361	0.382	0.567	0.463
(including the	56	P^-	0.374	0.403	0.370	0.352	0.322	0.334	0.302	0.309	0.211	0.229	0.234	0.189
walkway)	11	R	0.803	0.590	0.804	0.731	0.808	0.744	0.827	0.769				
	51	Z^-					0.352	0.329	0.353	0.365	(Insufficient accidents)			
On the crossing	33	Z^+					0.369	0.340	0.358	0.389				
walkway	56	P^-					0.126	0.102	0.063	0.120				
	11	R					0.084			0.009				

Note: The full underlined values are significant at 0.02 or better. Broken underlines significant at 0.05 only.

5.2.1 Daylight accidents. Table 2 gives the results of the analysis for daylight accidents, that is, those recorded between 0700 and 1900 hours. In this Table the values of k and ℓ are marked with an asterisk if they are significantly different from unity at the 10 per cent level or better.

TABLE 2

Daylight accidents = $KLm\,P^bV^c$

Road length	Para-meter	Total accidents		Pedestrian accidents		Vehicle accidents	
		Best estimate	95% confidence limits	Best estimate	95% confidence limits	Best estimate	95% confidence limits
On and within 50 yards of crossing	k	0.76*	0.56, 1.03	0.87	0.62, 1.21	0.56*	0.33, 0.95
	ℓ	0.93	0.67, 1.30	0.94	0.64, 1.37	0.90	0.53, 1.56
	m	1.52	1.06, 2.18	1.01	0.69, 1.49	0.51	0.29, 0.91
	b	0.27	0.10, 0.44	0.27	0.08, 0.46	0.27	–0.01, 0.55
	c	1.05	0.62, 1.48	0.92	0.48, 1.36	1.31	0.56, 2.06
On and within 20 yards of crossing	k	0.69*	0.48, 1.01	0.76	0.50, 1.14	0.57*	0.31, 1.05
	ℓ	0.95	0.64, 1.41	1.02	0.65, 1.60	0.80	0.42, 1.53
	m	0.93	0.59, 1.45	0.66	0.40, 1.10	0.26	0.13, 0.55
	b	0.22	0.02, 0.42	0.24	0.02, 0.46	0.17	–0.14, 0.48
	c	1.14	0.60, 1.68	0.98	0.38, 1.58	1.49	0.59, 2.39
On crossing	k			0.72	0.47, 1.13		
	ℓ			0.91	0.56 1.47		
	m			0.51	0.30, 0.89		
	b			0.16	–0.07, 0.39		
	c			1.00	0.35, 1.65		

It can be seen that for all seven sets of data the values b = 0.25, c = 1 lie well within the confidence limits for those parameters, indicating that $P^{1/4}V$ is a good working formula for relating flow to accident rates in this sample.

There is evidence from this Table that Pelicans have a lower accident rate than Zebras, but that this effect is largely due to the lower rate of vehicle accidents at Pelicans. Values of k for pedestrian accidents are below unity for all three road lengths, implying lower accident rates, but none of the differences is significant. Similarly, although six out of the seven values of ℓ given in the Table are less than unity, none of these differences is significant. There is thus no statistical evidence of a difference in accident rates between Zebras with refuges and Zebras without refuges.

5.2.2 Darkness accidents. Table 3 gives the results of the analysis for darkness accidents, that is those recorded between 1900 and 0700 hours. These accounted for only a quarter of the total number of accidents. Again, values of k and ℓ are marked with an asterisk if they are significantly different from unity at the 10 per cent level or better.

TABLE 3

Darkness accidents = $KLmP^bV^c$

Road length	Parameter	Total accidents		Pedestrian accidents		Vehicle accidents	
		Best estimate	95% confidence limits	Best estimate	95% confidence limits	Best estimate	95% confidence limits
On and within 50 yards of crossing	k	0.68*	0.43, 1.06	0.72	0.44, 1.17	0.58	0.26, 1.27
	ℓ	1.19	0.74, 1.90	1.15	0.68, 1.95	1.19	0.55, 2.55
	m	3.03	1.40, 6.59	4.01	1.69, 9.51	0.25	0.07, 0.87
	b	0.54	0.30, 0.78	0.79	0.52, 1.06	0.07	–0.28, 0.42
	c	0.88	0.41, 1.35	0.58	0.07, 1.09	1.56	0.76, 2.36
On and within 20 yards of crossing	k	0.79	0.47, 1.31	0.76	0.42, 1.37	0.84	0.32, 2.20
	ℓ	1.32	0.78, 2.25	1.19	0.63, 2.22	1.63	0.62, 4.26
	m	1.80	0.75, 4.36	2.59	0.90, 7.45	0.12	0.02, 0.59
	b	0.47	0.22, 0.72	0.70	0.39, 1.01	0.04	–0.37, 0.45
	c	0.95	0.42, 1.48	0.75	0.12, 1.38	1.38	0.44, 2.32
On crossing	k			0.82	0.43, 1.56		
	ℓ			1.03	0.51, 2.09		
	m			1.48	0.46, 4.79		
	b			0.56	0.23, 0.89		
	c			0.55	–0.16, 1.26		

It is apparent that the confidence limits for these parameters are often very wide, reflecting the small numbers of accidents available for analysis. The consistent pattern found earlier when relating flow to daylight accidents is quite absent from this Table, where a different model is found for each accident type. Thus total accidents in darkness are roughly proportional to $P^{½}V$, pedestrian accidents approximate to $(PV)^{2/3}$, and the best fit with vehicle accidents is given by $V^{3/2}$. Pedestrian flow is virtually irrelevant to vehicle accidents in darkness over the ranges considered in this sample.

All values of k are less than unity, implying lower accident rates at Pelicans, and all values of ℓ are greater than unity, implying higher accident rates at Zebras with refuges. However, only one of these differences is statistically significant. Thus the only conclusion that can reliably be drawn from the analysis of darkness accidents is that over the whole length of road studied Pelicans have a lower total accident rate than Zebras.

5.2.3 Estimated accident rates. Using the parameter values obtained from the analysis of the daylight and darkness data shown in the previous two tables, it is possible to estimate the accident rates per year of the three types of crossing if they were operated at the same flow level. The mean pedestrian and vehicle flows for the total sample were used for this purpose. The results are given in Table 4.

TABLE 4

Estimated accident rates per year at mean flow levels

Road length	Crossing type	Total accidents			Pedestrian accidents			Vehicle accidents		
		All	Day	Dark	All	Day	Dark	All	Day	Dark
On and within 50 yards	Z^-	1.80	1.34	0.46	1.18	0.86	0.32	0.61	0.48	0.13
	Z^+	1.80	1.25	0.55	1.17	0.81	0.36	0.58	0.43	0.15
	P^-	1.33	1.02	0.31	0.98	0.75	0.23	0.34	0.27	0.07
On and within 20 yards	Z^-	1.17	0.88	0.29	0.79	0.58	0.21	0.36	0.29	0.07
	Z^+	1.21	0.83	0.38	0.84	0.59	0.25	0.35	0.23	0.12
	P^-	0.84	0.61	0.23	0.60	0.44	0.16	0.23	0.17	0.06
On crossing	Z^-				0.68	0.50	0.18			
	Z^+				0.64	0.46	0.18			
	P^-				0.51	0.36	0.15			

In most cases the total accident rates are not the same as the sum of the pedestrian and vehicle rates. This is because separate models were used in all three cases, the best estimate being given by the total accidents model rather than the sum of the other two.

The results show apparently lower accident rates for Pelicans in all combinations of circumstances. The presence of a refuge at a Zebra crossing gives rise to marginally lower accident rates in daylight, and marginally higher ones in darkness. However, of all the values of k and ℓ given in Tables 2 and 3, only one was significantly different from unity under both daylight and darkness conditions, that which measured the difference between Pelicans and Zebras for accidents of all types on and within 50 yards of the crossing. Conclusions should therefore be restricted to that cell of the Table.

The results show that over this road length Pelicans would have approximately one half on an injury accident per year less than Zebras if operated at the same levels of pedestrian and vehicle flow. This represents a difference of 26 per cent. The effects of the variability in the data should be noted; the 95 per cent confidence limits for the 0.47 accidents per year difference between Pelicans and Zebras are 0.85 and –0.08 accidents per year. It should also be emphasised that this conclusion is restricted to the locations and flow levels studied in this investigation; it would be unwise to draw inferences from these data about the performance of crossings in general.

5.3 Parking and overtaking

Table 5 summarises the results of the counts made of parking and overtaking incidents near the crossings. Within 20 yards of the crossings, there were markedly more vehicles parked at Pelicans than at Zebras, in both the daylight and darkness periods. Further away from the crossing there was little difference in the levels of parking.

For crossings without refuges the number of vehicles observed overtaking within 20 yards of the crossing was over three times greater at Pelicans than at Zebras. This can be seen as indicating the effectiveness of zig-zag markings in reducing the incidence of this behaviour. The relatively high rate at Zebras with refuges is probably attributable to the fact that the greater road width provides more opportunities for overtaking. Although the number of Pelicans with refuges available for study was too

small to yield very reliable results, the indications are that the level of overtaking near such crossings was very high, between six and ten times greater than at Zebras with refuges.

TABLE 5

Parking and overtaking near pedestrian crossings
(I_h mean incidents per hour)

Time and location			Daylight (7 am–7 pm)			Darkness (6 am–7 am and 7 pm–10 pm)		
			Zebra without refuge	Zebra with refuge	Pelican without refuge	Zebra without refuge	Zebra with refuge	Pelican without refuge
PARKING	Within 20 yards of the crossing	Number of sites	48	32	49	48	32	49
		I_h	2.2	3.6	4.4	0.8	1.2	2.0
	Between 20–50 yards from crossing	Number of sites	48	32	49	48	32	49
		I_h	9.4	10.7	7.7	3.1	4.3	4.0
Overtaking within 20 yards of the crossing		Number of sites	50	33	56	50	33	56
		I_h	3.4	31.1	11.4	1.5	5.5	5.4

6. CONCLUSIONS

Accidents and flow characteristics have been examined in detail for a sample of 140 pedestrian crossings throughout the country. The sample was made up of 51 Zebras without central refuges, 33 Zebras with refuges, and 56 Pelicans without refuges. In an attempt to control for locational factors, the crossings studied were restricted to those sited in similar 'optimal' conditions. The sample was therefore selected and this point should be borne in mind when considering the conclusions.

A series of models relating injury accident rates, flow and crossing type were fitted to the data. The results of this analysis can be summarised as follows:

1. The function $P^{1/4}V$, where P is pedestrian flow per hour and V is vehicle flow per hour, provided a good fit with daylight accident rates of all types, and over all the road lengths studied. No consistent pattern was found between darkness accident rates and flows.

2. There was no evidence of differences in accident rates between Zebras with refuges and Zebras without refuges.

3. There was no evidence of differences in pedestrian accident rates between Pelicans and Zebras.

4. The analysis did provide evidence that Pelicans have a lower total accident rate than Zebras, and that this difference is mainly due to lower vehicle accident rates at Pelicans.

From the results of this analysis it was possible to predict the estimated accident rates of crossings of different types if operated at the same flow level. For the length of road on and within 50 yards of crossings, the results showed that Pelicans would have one half of an accident per year less than Zebras. It should be emphasised that this figure is a predicted injury accident rate; that is, it estimates the difference in the future performance between the two types of crossings if installed and operated under the same conditions. It should not be interpreted as measuring the difference between existing crossings.

The observations which were made at the time of the traffic counts showed that parking and overtaking in the vicinity of crossings occurred more frequently at Pelicans than at Zebras, indicating that the zig-zag markings continue to have their desired effect.

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8. APPENDIX

DETAILS OF SITES STUDIED

TABLE 6

List of uncontrolled (Zebra) crossings studied

R & T region	Town	Street	Location (near)	Centre refuge (R)
London Highways	Harrow	Kenton Rd	Upton Gdns, Willowcourt Rd	R
	Ealing	Uxbridge Rd	Percy Rd	R
	Brent	Kingsbury Rd	Kingsbury Station	R
	Greenwich	Eltham High St	Hind's Store	R
	Tottenham	High Rd	Scotland Green	
	Hammersmith	Uxbridge Rd	Loftus Rd	R
	Croydon	Purley Way	Foss Avenue	R
	Camden	Haverstock Hill	Belsize Avenue	R
	Bromley	Bromley High St	Market Place	R
	Walthamstow	Hoe St	Priory Avenue	
	Walthamstow	Forest Rd	Walthamstow Town Hall	R
	Chingford	Old Church Rd	Albert Crescent	
	Chingford	Station Rd	Richmond Rd	R
	Morden	London Rd	Abbotsbury Rd	R
	Stockwell	Clapham Rd	Lingham Rd	R
	Bromley	Orpington High St	Walnuts Shopping Centre	
	Islington	Upper St	Town Hall	R
	Sutton	Rose Hill	Wrythe Lane	
	Thornton Heath	Brigstock Rd	Thornton Heath Station	R
	Westminster	Wellington Rd	Wellington Place	R
South Eastern	Aldershot	High St	White's Store	
	Blackwater	A30 – London Rd		R
	Brighton	Kings Rd	Montpelier Rd and Bedford Sq	R
	Fleet (Hants)	Fleet Rd	Post Office	
	Folkestone	Cheriton High St	Marler Rd	R
	Gravesend	Rochester Rd	Abbey Rd	R
	Portslade	Station Rd	Vale Rd and Portland Rd	
	Southampton	Shirley High St	Emsworth Rd	
	Southsea	Albert Rd	Fawcett Rd	
Eastern	Cambridge	Regent St	Park Terrace	
	Cambridge	Mill Rd	Wollaston Rd	
	Cambridge	Parkside	Markworth Terrace	
	Dunstable	High St	Albion St	R
	Norwich	Dereham Rd	Mancroft St	

TABLE 6 (continued)

R & T region	Town	Street	Location (near)	Centre refuge (R)
West Midland	Birmingham (Kings Heath)	High St	Bank St	
	Birmingham (Park Hill)	Stratford Rd	Greswolde Rd	
	Walsall	Bridge St	Goodall St	
	Evesham	Vine St	–	
East Midland	Leicester	Walnut St	Burnmoor St	
	Leicester	Hinkley Rd	Westcotes Drive	
	Leicester	Uppingham Rd	Humberstone Drive	
North Western	Blackburn	Copy Nook	Trustee Savings Bank	R
	Liverpool	Great Homer St	St Martins Market	
	Liverpool	Breck Rd	The Richmond Arms	
	Liverpool	Upper Parliament St	Clevedon Arms Hotel	
	Liverpool	Allerton Rd	Hallville Rd	R
	Wigan	Wigan Lane	Clifton Crescent	
Yorkshire and Humberside	Doncaster	Thorne Rd	Church Lane	
	Doncaster	Thorne Rd	Boundary Avenue	R
	Doncaster	Bawtry Rd	St Augustines Rd	R
	Doncaster	Bawtry Rd	Boswell Rd	R
	Doncaster	Waterdale Rd	Coal House Rd and College Rd	
	Doncaster	Bennetthorpe St	Roman Rd	R
	Hull	Anlaby Rd	Wheeler St and Northfield Rd	
	Hull	Anlaby Rd	Midland St and Tower Cinema	
	Hull	Alfred Gelder St	Quay St	
	Hull	Hessle Rd	Eton St	
	Hull	Newland Avenue	Marshall St	
	Hull	Beverley Rd	Leonard St	
	Hull	Holderness Rd	Morrill St	
	Hull	Beverley High Rd	Endsleigh College Convent	
	Hull	Cottingham Rd	University of Hull	
	Market Weighton	Main St	Londesborough Rd	
	Market Weighton	Main St	Post Office	
	Leeds	Beckett St	St James' Hospital	
	Leeds	Lincoln Green Rd	Lindsey Rd	
	Leeds	Harrogate Rd	Montreal Avenue	R
	Leeds	Harrogate Rd	Stainburn Drive	
	Leeds	Roundhay Rd	Harehills Terrace	R
	Leeds	Roundhay Rd	Gledhow Lane	
	Leeds	Harrogate Rd	Stainbeck Lane	

TABLE 6 (continued)

R & T region	Town	Street	Location (near)	Centre refuge (R)
Yorkshire and Humberside (continued)	Leeds	New York St	Central Bus Station	
	Leeds	Roundhay Rd	Karnac Rd	R
	Scunthorpe	Ashby Rd	Lloyds Avenue	R
	Scunthorpe	Ashby High St	Victoria Rd	
Northern	Newcastle	Percy St	Morden St	
	Newcastle	Westgate St	Westgate Hill School	
	Newcastle	Ponteland Rd	Whitehorn Crescent	R
	Newcastle	West Rd	Benwell Post Office	R
	Wallsend	High St	Forum Shopping Centre	
South Western	Bristol	Fishponds Rd	Huyton Rd	R
	Bristol	Gloucester Rd	Brockfield Avenue	
Welsh Office	Swansea	Walter Rd	Humphrey St	
	Swansea	St Helens Rd	Russell St	

TABLE 7

List of Pelican crossings studied

R & T region	Town	Street	Location (near)	Centre refuge (R)
London Highways	Brent	High Rd	Wembley Central Station	
	Ealing	The Vale	Larden Rd	
	Kensington	Kensington Gore	Royal Albert Hall	R
	Lambeth	Lambeth Palace Rd	St Thomas' Hospital	R
	Lambeth	New Cross Rd	New Cross Gate Station	R
	Merton	Kingston Rd	Gladstone Rd	
	Islington	Holloway Rd	Loraine Rd	R
	Haringey	High Rd	Colraine Rd and Courcy Rd	
	Camden	Haverstock Hill	Howitt Rd and Belsize Park Stn.	
	Lewisham	Sydenham Rd	Larkbere Rd	
	Harrow	The Broadway	Cornwall Rd	
	Hammersmith	Goldhawk Rd	Wells Rd	R
	Hackney	Stamford Hill	Lampard Grove	
	Brent	Preston Rd	Preston Rd Station	
	Hillingdon	Cold Harbour Lane	Minet Drive	R
	Haringey	Muswell Hill B/Way	Woodberry Crescent	
	Lewisham	Lewisham High St	C & A Modes	
	Croydon	London Rd	Beatrice Avenue	
	Balham	Bedford Hill	Byrne Rd	
South Eastern	Haywards Heath	South Rd	Haywards Rd	
	Haywards Heath	South Rd	Sussex Rd	
Eastern	Luton	Dunstable Rd	Fine Fare and Woolworth	
	Luton	Dunstable Rd	Ivy Rd	
	Norwich	Coleman Rd	Jessop Rd	
	Dunstable	High St	Queensway	
	Cambridge	Hills Rd	Bateman St	
	Watford	St Albans Rd	Buckingham Rd	
West Midland	Worcester	Barbourne Rd	Somers Rd and Brook St	
	Evesham	Port St	—	
East Midland	Leicester	Fosse Rd	Tudor Rd	
	Leicester	Narborough Rd	Imperial Drive	R
	Nottingham	Derby Rd	Hillside Close	R
	Nottingham	Ilkeston Rd	Norton St	
	Nottingham	Lenton Boulevard	Ashburnham Avenue	
	Nottingham	Mansfield Rd	Tavistock Drive	
	Nottingham	Mansfield Rd	Edwards Lane	
	Nottingham	Radford Rd	Berridge Rd	

TABLE 7 (continued)

R & T region	Town	Street	Location (near)	Centre refuge (R)
North Western	Blackburn	Copy Nook	Lambeth St	
	Blackburn	Furthergate	Printers Arms and Co-op	
	Liverpool	Townsend Lane	Winchester Arms Hotel	
	Liverpool	Kensington	Albany Rd	
	Liverpool	Longmoor Lane	Barlows Lane	R
	Liverpool	Stanley Rd	Macbeth St	
	Liverpool	St James St	Hardy St	
	Liverpool	Prescott Rd	Lilley Rd	
	Liverpool	Picton Rd	B R Parcels Depot	
	Liverpool	Ullet Rd	Cumberland Avenue	
	Manchester	Quay St	Opera House	
	Manchester-Levenshulme	Stockport Rd	Delamere Rd and Alma Rd	
	Manchester-Salford	Bury Old Rd	Thomas St	
	Rochdale	Halifax Rd	Rothwell St	
	Rochdale	Oldham Rd	Crawford St	
Yorkshire and Humberside	Hull	Hessle Rd	West Dock Avenue	
	Hull	Ings Rd	James Reckitt Avenue	
	Hull	George St	Bond St	
	Goole	Boothferry Rd	Woolworths and Marks and Spencers	
	Goole	Boothferry Rd	Dunhill Rd and Henry St	
Northern	Newcastle-Gosforth	High St	Hawthorn Rd	
	Gateshead-Lowfell	Durham Rd	Albert Drive	
South Western	Bath	London Rd	Snow Hill	R
	Bath	George St	Milsom St	
	Bristol	Wells Rd	Talbot Rd and Broad Walk	
	Swindon	Cricklade Rd	Bright St	
	Saltford	Wansdyke	–	
	Wootton Bassett	High St	Keymarket	
Welsh Office	Cardiff	North Rd	Canada Rd and New Zealand Rd	

TABLE 8

List of street centre refuges studied

R & T region	Town	Street	Location (near)
London Highways	Richmond	Upper Richmond Rd	Waitrose Supermarket
	Welling	High St	Nags Head Lane
Eastern	Southend-on-Sea	London Rd (A13)	Stirling Avenue
West Midland	Malvern	Barnards Green Rd	
South Eastern	Sandgate	High St	Gough Rd
	Hove	Church Rd	Vallance Rd and Connaught Rd
North Western	Stockport	Wellington Rd	Grosvenor Rd and St Thomas' Place
	Manchester	Wilmslow Rd	Furness Rd
South Western	Bristol	Whiteladies Rd	Alma Rd
	Bristol	Whiteladies Rd	Hurle Rd
	Wootton Bassett	High St	Station Rd

TABLE 9

Traffic and accident data – daylight conditions

Limits of the observed length of street near the crossing	Type of crossing	Symbol	Number of sites	Vehicular traffic			Pedestrian traffic			Total personal injury accidents/crossing/year			Pedestrian personal injury accidents/crossing/year		
				Mean vehicles per hour for all sites	Standard deviation of the mean VPH	Coefficient of variation (per cent)	Mean pedestrians per hour for all sites	Standard deviation of the mean PPH	Coefficient of variation (per cent)	Mean	Standard deviation	Coefficient of variation (per cent)	Mean	Standard deviation	Coefficient of variation (per cent)
Within 50 yards of the crossing (including the crossing walkway)	Zebra without refuge	Z^-	51	1089	319	29	223	120	54	1.21	1.04	85	0.73	0.74	100
	Zebra with refuge	Z^+	33	1470	447	30	221	180	82	1.33	1.17	88	0.85	0.73	85
	Pelican without refuge	P^-	56	1393	392	28	237	184	78	1.07	0.79	74	0.79	0.65	83
	Street refuge only	R	11	1277	445	35	201	158	79	1.13	0.84	75	0.52	0.42	81
Within 20 yards of the crossing (including the crossing walkway)	Zebra without refuge	Z^-	51	1089	319	29	179	91	51	0.72	0.70	97	0.49	0.56	115
	Zebra with refuge	Z^+	33	1470	447	30	197	170	86	0.90	1.04	116	0.63	0.75	119
	Pelican without refuge	P^-	56	1393	392	28	212	171	81	0.66	0.60	91	0.48	0.49	103
	Street refuge only	R	11	1277	445	35	165	153	93	0.58	0.53	92	0.35	0.29	85
On the crossing walkway	Zebra without refuge	Z^-	51	1089	319	29	162	84	52				0.43	0.50	118
	Zebra with refuge	Z^+	33	1470	447	30	188	167	89				0.49	0.54	110
	Pelican without refuge	P^-	56	1393	392	28	197	166	84				0.40	0.44	109
	Street refuge only	R	11	1277	445	35	121	134	111				0.14	0.14	100

TABLE 10

Traffic and accident data – darkness conditions

Limits of the observed length of street near the crossing	Type of crossing	Symbol	Number of sites	Vehicular traffic			Pedestrian traffic			Total personal injury accidents/crossing/year			Pedestrian personal injury accidents/crossing/year		
				Mean vehicles per hour for all sites	Standard deviation of the mean VPH	Coefficient of variation (per cent)	Mean pedestrian per hour for all sites	Standard deviation of the mean PPH	Coefficient of variation (per cent)	Mean	Standard deviation	Coefficient of variation (per cent)	Mean	Standard deviation	Coefficient of variation (per cent)
Within 50 yards of the crossing (including the crossing walkway)	Zebra without refuge	Z^-	51	594	243	41	52	34	64	0.37	0.46	124	0.27	0.38	140
	Zebra with refuge	Z^+	33	930	369	40	46	42	91	0.61	0.67	110	0.38	0.57	149
	Pelican without refuge	P^-	56	781	304	39	49	45	91	0.28	0.37	131	0.21	0.29	141
	Street refuge only	R	11	612	292	48	50	78	154	0.30	0.40	133	0.04	0.08	200
Within 20 yards of the crossing (including the crossing walkway)	Zebra without refuge	Z^-	51	594	243	41	37	21	58	0.22	0.33	148	0.17	0.29	173
	Zebra with refuge	Z^+	33	930	369	40	37	35	95	0.46	0.55	119	0.30	0.50	167
	Pelican without refuge	P^-	56	781	304	39	38	36	94	0.21	0.31	142	0.15	0.26	174
	Street refuge only	R	11	612	292	48	37	62	166	0.16	0.17	106	0.02	0.06	300
On the crossing walkway	Zebra without refuge	Z^-	51	594	243	41	29	20	67				0.14	0.23	163
	Zebra with refuge	Z^+	33	930	369	40	33	32	98				0.20	0.35	173
	Pelican without refuge	P^-	56	781	304	39	31	32	103				0.13	0.24	184
	Street refuge only	R	11	612	292	48	21	38	181				0.02	0.06	300

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